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A TEACHER'S JOURNEY

INTO PROBLEM SOLVING MATHEMATICS

WITH DEAF LEARNERS

R. SCOTT-WILSON

A TEACHER'S JOURNEY

INTO PROBLEM SOLVING MATHEMATICS

WITH DEAF LEARNERS

BY

RINA SCOTT-WILSON

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ABSTRACT

The main objective of this study was to explore how Deaf learners orientate to a problem solving mathematics curriculum. The study took the form of an autoethnography situated in critical pedagogy. Purposeful sampling was used to select Grade 9 learners from a local school for the Deaf as participants. Data was collected from the learners using a structured questionnaire, viz. Students Orientation to Mathematics (SOM), as well as through focus group sessions and personal interviews. In addition, teachers' and parents were interviewed to ascertain the general orientation of Deaf learners to mathematics and to identify barriers that may prevent these learners from progressing optimally in their studies of mathematics. Although the learners had difficulties in accessing particular pedagogical aspects of problem solving mathematics, the findings showed a slight increase in the learners' study attitude and study habits towards mathematics and in their problem solving skills. Moreover, the learners particularly enjoyed the activity element of the problem solving curriculum. At the end of the study the learners indicated that they preferred a modeling problem solving approach to a more traditional way of teaching mathematics. Although the study points out that implementing a problem solving curriculum into a Deaf classroom is not necessarily straightforward, it does suggest that with exposure Deaf learners can develop a propensity for working within a cognitively rich problem solving environment.

KEY TERMS:

Deaf, problem solving mathematics, reform mathematics, barriers to mathematics, orientation to mathematics

DECLARATION

I, Rina Scott-Wilson, Student no, 061 5857K, declare that A TEACHER'S JOURNEY INTO PROBLEM SOLVING WITH DEAF LEARNERS is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.



SIGNATURE
(Rina Scott-Wilson)

15/09/2009
DATE

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CHAPTER 1

BACKGROUND AND OVERVIEW OF THE STUDY

'Some activities primarily affect future well-being; the main impact of others are in the present' (Becker, 1993, p. 11).

In this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed…All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding.
Principles and Standards (pg 5)

1.1 INTRODUCTION

This dissertation discusses pedagogical practices currently implemented during mathematics classes in a school for the Deaf with the principal objective of affecting the future well-being of Deaf learners. It is posited that the future well-being of Deaf learners is partly dependent on their mathematical achievement at school level. Improved mathematical results may facilitate upward social mobility in so far as individuals with higher mathematical results more readily access tertiary education and particular career possibilities. Essentially, the notion of improved social and economic conditions as a function of achievement in mathematics is tied to human capitalism and its proposed linked that investing in education carries ramifications for a variety of economic phenomena, including personal earnings and age-wealth profiles. The need to educationally invest in the mathematics of Deaf learners is thus imperative and further detailed below.

1.2 PROBLEM IDENTIFICATION

Delays of about three years exist worldwide in mathematics amongst Deaf learners in terms of mathematical performance compared to hearing youth (Nunes & Morena, 1998; Nunes & Morena, 2002; Zarfaty, Nunes and Bryant, 2004, Bull, Marschark & Blatto-Vallee, 2005). Research pertaining specifically to the South African situation was not found. This shows a gap in literature that could warrant further research efforts. Experience within the classroom, however, seems to affirm that deaf learners in South African are experiencing similar delays in their mathematical competencies. Low achievement calls for a reform in mathematics. Bottge, Heinrichs, Chan & Serlin (2001) remarks as follows:

> There is little disagreement *whether* mathematics instruction should improve. Rather the debate seems to center on how to accomplish it without losing the successful methods special educators have used to augment student skills to current levels. (Bottge et al., 2001, p. 102, Bottge's emphasis)

Current research foundations address the "how" of reform by urging that mathematical instruction in a Deaf classroom should be along the following lines:

> Deaf learners ought to be provided with complex and cognitively challenging problem solving opportunities in order to develop analytical strategies, critical thinking and reasoning. These problems should be unfamiliar and multi-dimensional, rather than simple and straightforward (Kelly, Lang & Pagliaro, 2003); be based on real-life situations (Easterbrook & Stephenson, 2006; Kelly *et al.* 2003); and, reflect a network of relationships that allows for synthesis of information (Bull *et al*. 2005). Moreover, problems can be presented as a way to learn the basics, rather than to learn the basics first and thereafter apply them to a problem (Pagliaro & Ansell, 2002).

In addition, problems must be represented in a variety of modes of which the visual mode is considered the most significant (Nunes & Moreno, 2002; Kelly, Lang and Pagliaro, 2003; Adamo-Villani, Doublestein & Martin, 2005; Bull *et al.* 2005; Chen, 2005; Lang and Steely, 2006). Visual representation involves the use of visual organizers such as pictures, graphs, tables, drawings, colour schemes and the use of colour to convey concepts and technology such as CD's or graph calculators. Visual representation also includes having teachers who are fluent signers in schools where the medium of instruction is sign language i.e. teachers who are able to interact with learners through a visual mode of communication (Easterbrook & Stephenson, 2006).

Yet, learners also need exposure to written presentation of the problem (Pagliora & Ansell, 2002; Kelly, Lang, Mousley & Davis, 2003). This means that ultimately a variety of language structures ought to be involved. The language structures may require that learners receive additional instruction to master them. Sometimes it is necessary for materials to be scaffolded to allow for better understanding (Easterbrook & Stephenson, 2006). Furthermore, a learner-centred approach should be followed in the classroom, where learners are encouraged to take the initiative and become self-reliant rather than be dependent on the teacher (Kelly, Lang and Pagliaro, 2003).

The appeal of mathematics of the nature described above is acknowledged, but at the same time it is questioned how such mathematics apply to Deaf students who receive instruction through the medium of Sign Language. The main concern is that there is no strong research foundation, yet there is pressure to proceed with the implementation of these interventions. In other words, there is not enough research done to show how Deaf students orientate to mathematics of this calibre. Closer attention must be paid to how theory and practice converge (Markey, Power & Booker, 2003).

International efforts, however, indicate that generally teachers of the Deaf do not structure their mathematical teaching to provide opportunities for real world orientated activities (Kelly, Lang &

Pagliaro, 2003 ; Markey *et al*. 2003; Pagliaro & Kritzer, 2005). Rather, teachers of the Deaf tend to adhere mostly to traditional instruction methods such as applying a procedure, practicing an algorithm and superficial problem solving. Hence, a limited mathematics curriculum remains prominent in Deaf classrooms despite literature and workplace demands that call for mathematical reform along the lines of authentic problem solving based on real life activities (Allen, 1998; Ramnarain, 2003,Van der Walle, 2007); and despite emerging South African research in mainstream schools which seem to suggest that it is possible to modify pupils' beliefs about the role of real-world knowledge in problem solving in mathematics, and to develop in them a propensity and ability towards realistic modeling of written problems (De Corte, 2000).

The reluctance of teachers to relinquish the status quo in Deaf classrooms is largely attributed to a lack of formal certification in mathematics (Kelly, Lang & Pagliaro, 2003); lack of exposure to reform mathematical activities (Pagliaro & Kritzer, 2005); and low expectations which support beliefs that Deaf students are not capable of engaging in more complex mathematical problem solving (Pagliaro & Kritzer, 2005). In other words, teachers believe that Deaf learners cannot function effectively at the 'high' level proposed by reform mathematics. Authors argue that low expectancies amongst teachers stem from a high prevalence of 'audism' in society and from socialisation into specific university materials during teacher training (Simms & Thumann, 2007).

1.3 RATIONALE OF THE RESEARCH

As mentioned previously, there exists little South African research on mathematics in classrooms for Deaf learners. In the light of this, Andrews & Cowell (473, p. 2007) argue that it is critical for 'the deaf education knowledge base to be enlarged through applied social science research'. The value of this research lies in, firstly gaining an insight into what is currently happening in mathematics education in SA and secondly its potential to make a contribution to tackling low performance in

mathematics among Deaf learners in the interest of social equality. Positive adjustments in mathematical orientations can help Deaf learners move on in terms of further education and employment. Stated differently, people who are Deaf require the same skills in mathematics as hearing people for them to participate in certain sectors of society (Markey et al. 2003). The Department of Education's statement (2003) provides a more detailed reference of which sectors of society require mathematics as an entrance requirement:

> Mathematics is an essential element in the curriculum of any learner who intends to pursue a career in the physical, mathematical, computer, life, earth, space and environmental sciences or in technology. (DoE, 2003, p. 21)

Despite the argument that improved mathematical results may enhance Deaf learners' future career options, Johnston (1995) warns that the empowering process of research is generally limited and any extravagant claims are unrealistic. In other words, the capacity of this research to bring about social transformation should be considered pragmatically.

One aspect of this research, which is immediately useful, is that it brings to light certain orientation factors of learners. Should these orientation factors be negative, it implies that the learner is at risk of poor performance in mathematics and therefore in need of remedial assistance. Factors such as the language proficiency of the student, the student's attitude towards mathematics, anxiety about mathematics and study habits in mathematics lend themselves to intervention in that they can be addressed by teachers once they are identified (Eiselen, 2006).

Looking for orientation factors such as are described above implies that this research is essentially an investigation into the 'other' aspects of mathematics than mere assessment of cognitive achievement. Hence, the data analysis focuses on essential support structures that facilitate adequate cognitive achievement in mathematics. Although several support structures can be taken account, analysis has been limited to the following three areas of focus:

- attitudes and emotions towards mathematics including how learners experience the teacher;
- study habits, with special reference to parental support and expectation;
- problem solving behaviour, including adjustment to group work, class atmosphere and the use of metacognitive strategies.

Ultimately, the objective in undertaking this research is to make contributions to critical theory by creating a vision for a possible future where Deaf learners attain a form of equity in mathematics; and, by acting as a resource to help teachers understand and change the learning experiences of Deaf learners by improving conditions at the grassroots level i.e. in the mathematics classroom. In addition, this research provides what Ausubel, Novak & Hanesian, (1978) refer to as a "a psychological rationale for teachers for discovering more efficacious teaching methods on their own or for choosing more intelligently among new teaching methods". It gives teachers of the Deaf an alternative to simply resorting to traditional prescriptions available or to the precepts and examples of their own teachers. The alternative that is implied in this context is a non-routine problem solving mathematics curriculum. Hence, it is necessarily to know how Deaf students respond to reform mathematics.

1.4 CRITICAL QUESTIONS

The primary research question concerns itself with how Deaf and hard-of-hearing students orientate themselves to non-routine problem solving.

Yet there are secondary research questions that need to be taken into account to support a fuller understanding of Deaf learners' orientation to mathematics in general.

1. What are Deaf learners' orientation towards mathematics in general?
2. Based on Deaf learners' orientation, what barriers (if any) are Deaf learners experiencing?
3. What are the factors that contribute to certain barriers (or lack thereof) in Deaf learners?

1.5 DEFINITION OF KEY CONCEPTS

1.5.1 Deaf

There are two major paradigms within which to define deafness or the aspect of being hearing impairment, namely the medical model and the socio-cultural model.

Simeonsson (2006) describes the medical model as follows:

> Reference to the medical model implies that the locus of the disability is in the person, and that disability is defined by the manifestation of a health condition in the form of anomalies or impairment of physical or mental structures or function. Documentation of disability usually takes the form of recording the diagnoses, syndromes, or signs or symptoms that meet the criteria for assignment to a category. (Simeonsson, 2006, p. 73)

Stated differently, the medical model reflects the audiological perspective that hearing is normal, and that deafness is therefore a deviation form the norm (Lewis, 2007). Moreover, a person's hearing is impaired because of a physical defect within the body which must be corrected by a medical approach of working on the person or by devices such as hearing aids or cochlear implants (Lewis, 2007). The level of the learners' hearing loss serves as basis for classification and for determining the child's needs and eligibility for services and support (Simeonsson, 2006).

Current South African educational policy (DoE, 2001) adopts a medical model with regards to deafness. This is reflected in White Paper 6 where Section 1.2.3 states that the White Paper "will retain the internationally acceptable terms of 'disability' and 'impairments' when referring specifically to those learners whose barriers to learning and development are rooted in organic/medical causes".

In contrast, the socio-cultural perspective rejects seeing disability as a characteristic within the person. Rather, Marks (1997, in Simeonsson, 2006) states that the socio-cultural perspective approaches disability as a social construction marked by discrimination and exclusion from mainstream society. The emphasis is on environmental barriers and denial of human rights that Deaf people experience. Subsequently, this model is associated with political action and advocacy to promote social justice and equity for Deaf people.

It is interesting that the United Nation in its Convention on the Rights of Persons with Disabilities (2006) appears to moving towards a socio-cultural paradigm of disability. The following excerpt is taken from their website:

> The Convention marks a "paradigm shift" in attitudes and approaches to persons with disabilities. It takes to a new height the movement from viewing persons with disabilities as "objects" of charity, medical treatment and social protection towards viewing persons with disabilities as "subjects" with rights, who are capable of claiming those rights and making decisions for their lives based on their free and informed consent as well as being active members of society'. (UN Convention on the Rights of Disabled People website)

This study will align itself with the United Nations view of disability. Hence, the term Deaf will be defined in lines with the socio-cultural view which considers the Deaf population to be a minority group with their own language and culture. In other words, Deafness is not a disability, but a particular subculture. Linked to their culture is a history of majority oppression (Higgens, 1987; Dolnick, 1993; Erting, Johnson & Smith, 1994; Gertz, 2008). The majority in this context refers to experiences of oppression by hearing people.

The distinction between a medical approach and a socio-cultural paradigm is often conveyed in literature through using a 'small d' to represent the former and a 'capital D' for the latter. In other words, deaf (with a small "d") refers to the audiological aspect of being hearing impaired and Deaf [with a capital D] refers to deaf people as part of a particular culture in the same way as Afrikaners are part of the Afrikaans culture or Zulus are linked to a Zulu culture.

1.5.2 Problem solving mathematics

Problem solving mathematics is a division of contemporary reform mathematics and cognitive science. Its nature corresponds to Pagliaro & Kritzer's (2005) description of discrete mathematics, which incorporates authentic problem solving experiences and synthesis of mathematical concepts towards a purposeful goal. The materials require students to take the initiate in interpreting, exploring, and abstracting mathematical ideas from contextualized problems, rather than follow step-by-step rules or examples given beforehand.

Certain aspects of problem solving mathematics are emphasised in this study. Firstly, it incorporates the element of multi-representation, which refers to the mathematics being represented linguistically, numerically, visually and symbolically at the same time. The focus on the linguistic and symbolic together with numeric and graphic is very deliberate. It is justified by the lack of recognition in Deaf classrooms of the importance of using language in developing mathematical understanding and skill (Markey *et al.* 2003).

Secondly, a contextualised approach to mathematics is followed. In other words, mathematics is presented in scenarios that simulate real world settings and that have practical applications in every day life. In addition, this mathematics has a form of openness, in that the instructional tasks have no obvious solution and thus can be solved in various ways.

1.5.3 Orientation

The notation of study orientation as applicable in this study has been taken from the definition of Steyn (2002).

> Study orientation refers to the consistency of a learner's (or student's) approach to learning and includes elements of the motive or intention to study (i.e. the 'why') and the approach to study (i.e. the 'how'). Study orientation thus includes elements of attitude towards study which in turn includes the student's motivation to study as well as the study habits or methods adopted by the student or learner. It also includes further elements of the affective domain such as beliefs, confidence and attitude to study. (Steyn, 2002, in Eiselen, 2006, p. 44)

Following on from the given definition, the concept orientation as used in this research encompasses the following markers (adapted from Eiselen, 2006 and Smith III and Star, 2007):

a) Study attitude

Study attitude is concerned with the learners' personal expressions of likes or dislikes about mathematics. This category also include beliefs involve or convictions about the nature of mathematics and of learning mathematics.

b) Mathematical anxiety

Mathematical anxiety refers to a judgement or reaction to mathematics, with particular emphasis on noting signs of anxiety. In other words, the extent to which anxiety is experienced while doing mathematics.

c) Study habits

Study habits refer to the display of acquired study methods in mathematics.

1.6 OUTLINE OF KEY ARGUMENT

By way of summary, the assumptions of this research can be detailed and referenced in terms of the following key points.

1. Currently there are two teaching approaches that are generally used in a mathematics classroom, viz. the traditional approach to mathematics and the reform approach. The traditional approach generally involves practicing algorithms in a decontextualised setting. The reform approach incorporates problem solving mathematical scenarios that simulate real life settings.

2. Reform mathematics is considered a more complex and authentic type of problem solving than traditional mathematics. In addition, reform mathematics tends to have a larger language component.

3. Research suggests that teachers of the Deaf are reluctant to implement reform mathematics because of the low expectations of Deaf learners in light of the aforementioned level of complexity and language elements.

4. The research proposes to monitor how Deaf learners orientate to reform mathematics.

5. The particular argument of this research is that in general Deaf learners are not psychologically and pedagogically ready for reform mathematics. Rather, they need to be prepared. On the other hand, it is proposed that certain Deaf learners will be able to orientate successfully to reform mathematics. Should this be observed, the myth of homogeneity i.e. that all Deaf learners are not capable of reform mathematics should be challenged.

This argument is developed across several chapters.

1.7 PROGRESSION OF THE STUDY

Chapter 1 provides a broad introduction to the current mathematical situation found in classroom for the Deaf.

Chapter 2 deals with the conceptual theoretical background, covering literature on the important theories relevant to the teaching of mathematics.

Chapter 3 is a description of the methodology that was used in carry out the research. It provides detailed descriptions of the research design, procedure, sample, data analysis and ethical considerations.

Chapter 4 contains a report on the findings and emergent themes are outlined.

Chapter 5 provides a discussion of the results in relation to conceptual frameworks.

Chapter 6 gives a conclusion and recommendations to improve mathematical achievement amongst Deaf learners.

CHAPTER 2

THEORETICAL FRAMEWORK

This dissertation concerns itself with change in mathematics education amongst Deaf learners. Ernest (Jaworski, 1994, p.xi) states that critical scrutiny of theory 'is the practitioner's most powerful tool in understanding and changing practice.' Essentially educational philosophy implicate on the issues of the teaching and learning of mathematics, the underlying aims and rationales of this activity, the roles of the teacher, learner, and mathematics in society and the underlying values of the relevant social groups. Hence, it is considered worthwhile to investigate the philosophical position of government policy with regards to education and the nature and purpose of mathematical knowledge.

2.1 EDUCATION POLICY

The official start of democracy in South Africa in 1994 along with changes in leading political powers have lead to large-scale transformations being instituted in the South African schooling system. These changes were shaped by the unique circumstances left by Apartheid, as well as by the common global context and its demands of international organisations and transnational labour (Young, 2005).

The South African Education Department in their Strategic Plan (2003 - 2005) document (DoE, 2003b) recognises a number of policies that create and legislate a framework for transformation in education. Since the impetus behind these developments is social justice (Muller, 2005), the policies are concerned with political issues of redress, overcoming inequalities, extending participation to

previously excluded groups and, expanding and redistributing resources (Bennie, Olivier, Linchevski, 1999).

Amongst these regulations are the SA Constitution (1996) that identifies education as a basic human right, and that calls for the values of human dignity and non-discrimination to be re-established in education; the South African School Act (1996) which promotes access, quality and democratic governance at school level; and, the Educators Employment Act (1998) which regulates the professional, moral and ethical conduct of educators and allows for one professional council - the South African Council for Educators (SACE) (DoE, 2003b).

For the purpose of this article, two policies are of particular relevance viz. the South African Qualification Authority (SAQA) Act (1995) that makes provision for the National Qualifications Framework (NQF); and Curriculum 2005. Curriculum 2005 has since been updated by the Revised National Curriculum Statement (RNCS). These policies address pedagogic and curricular issues, the achievement of particular educational goals, and the processes of learning and teaching. In particular, the NQF authorised that both Curriculum 2005 and the RNCS follow an outcomes-based approach. Through this directive, outcomes-based education (OBE) became foundational in the transformation of education. Moreover, Curriculum 2005 has been developed with the explicit goal to "move away from a racist, apartheid, rote model of learning and teaching, to a liberating, nation-building and learner-centred outcome-based initiative" (DoE, 2003b, p. 2). A pertinent element of OBE found in the quote from Curriculum 2005, is that it encourages a learner-centred and activity-based approach to education (DoE, 2003b).

In addition to Curriculum 2005 being outcomes-based and promoting a learner-centred pedagogy, Harley & Wedekind (2004) allocate a third design feature to Curriculum 2005, namely the directive of an integrated knowledge system.

With respect to the last design feature, Adler, Pournara & Graven (2000) elaborate on how the learning area of Mathematical Literacy, Mathematics and Mathematical Science (MLMMS) adapted to the directive to integrate. MLMMS is integrating mathematical knowledge within the subject domain by collapsing the boundaries between pure maths, applied maths and statistics (Adler, Pournara & Graven, 2000). Moreover, government policy (DoE, 2003a) requested 'the establishment of proper connections between mathematics as a discipline and the application of mathematics in real-world contexts'. In other words, it is official government regulation that learners need to be expose to mathematics that is more meaningful to them and that they can connect to their day to day experiences, as well as to other world knowledge they encounter at a school.

On analysis, integration supports an ancillary principle of OBE, which is the need for subject material to be relevant and contextualised. By connecting ideas learners are succoured to construct relationship inherent within the mathematical field and its broader applications and thus become aware of the subject's deeper significance in everyday life.

This view of mathematics is not unique to South Africa. Similar thinking is described in and endorsed by the USA's most important curriculum document, the Principles and Standards for School Mathematics which was compiled by the NCTM (The National Council of Teachers of Mathematics) (Stols, 2004). Subsequently, there appears a form policy influencing, if not policy borrowing, between the NCTM and RNCS. As stated previously, it is important to consider the

underlying epistemology in these documents. Closer analysis reflects that that the NCTM is underpinned by the tenets of social constructivism.

Similarly, Young (2005) argues that the key ideas and debates around social constructivism and postmodernism have essentially shaped educational policy in South Africa. At the same time he stresses that OBE's emphasis on the non-school experience, the everyday life of the learner and the importance of applying knowledge, provided an alternative to the rote learning, memorisation passivity, and highly prescriptive content associated with Apartheid.

Consequently, OBE essentially was adopted, not necessarily for its educational properties (Harley & Wedekind, 2004), but because it was new and represented a 'clean break' with the old Apartheid education (Young, 2005, p, 3).

Yet, OBE is not without its critics. Jansen (1990) questions the feasibility OBE by reason of its political, rather than pedagogical overtures. From the outset Jansen's standpoint (1990, pp. 145-146) was that OBE will fail because of the lack of trained teachers, administrative burdens, complex terminology, fixation on outcomes at the expense of content, unrealistic and unsubstantiated claims relating OBE to economic growth and specific types of social relations, lack of teacher participation, instrumentalist view of learning, and lack of appropriate assessments. Concerns were also raised by Jansen (1990) over the current resource status of South African schools and the week culture of teaching and learning that dominated certain schools in the wake of Apartheid.

Mrs Naledi Pandor MP, Minister of Education, in her statement on the release of the 2008 national senior certificate examination results responded as follows to the criticism:

> The National Curriculum has been roundly criticized by many learned commentators. It will continue to be criticized largely for our failings in implementation and interpretation, and not because it is a bad curriculum. The NCS is part of our drive to improve quality, to modernize learning, and to offer new opportunities to learners in our country…As I have stated previously we intend to mount a vigorous teacher support and development programme to improve teaching and learning in all our schools. (Pandor, 30 December 2008)

In other words, the government supports their position that OBE is inherently a suitable system for transforming South African school. Challenges within the education system are ascribed to the failure of teachers to interpret and implement the curriculum appropriately. Subsequently, the education departments' focus will be on teacher training, re-training and support in order to advance educational achievement amongst learners.

Yet, Bennie and Newstead (1999) caution that curriculum innovation and its subsequent adoption by teachers require more than support and mutual adjustment during installation. Rather, it is dependent on the configuration of social, political, historical and ideological factors in the school and the surrounding community.

Apart from the drive for outcomes based education as contained in the RNCS, there are additional national policies that influence education for the Deaf. In accordance with the White Paper 6 document an inclusive education and training system is outlined. The document makes provision both for deaf learners and deaf schools (DoE, 2001). With respect to deaf learners, the document allows learners, who are deaf or hard-of-hearing and require low levels of support, to transfer and integrate into mainstream settings. Focusing on the school set-up, White Paper 6 mandates that special schools, including schools previously set apart as schools for the deaf, be converted into

resource centres. Resource centres will have two primary responsibilities. Firstly, the centres need to provide quality education to its own learner population. Secondly, the centres will be integrated into district support teams to provide specialised professional support to designated full service and other neighbourhood schools. Moreover, 'a one-curriculum-for-all' implementation strategy must be adhered in all classrooms, irrespective of the nature of the school. This means that all teachers are to plan instructions in accordance with the educational outcomes and norms listed in the RNCS.

By implication, the RNCS specifies how mathematics should be viewed and taught. In the RNCS educators are encouraged to teach mathematics to learners as 'a development of human activities that deals with patterns and problem solving, and one that assist learners to meaningful connections in an attempt to understand the world through creative and logical reasoning'. (DoE, 2003, p.9). Moreover, Curriculum 2005 and the National Curriculum Statement require that all learners learn a form of mathematics and succeed (DoE, 2003a). Moreover, the mathematics curriculum has been adapted to include a wider range of mathematical skills than was traditionally taught. Hence, mathematics, in a pure form or in a format of mathematical literacy, has been made compulsory up to Grade 12 level. This means that more learners have the opportunity to study mathematics for longer than was previously the case (Bennie, Olivier & Linchevski, 1999).

In summary, educational policy requires that OBE be implemented in South African classrooms as a manner by which to redress social inequalities created by Apartheid. OBE encourages a learner-centred pedagogy, an integrated system of knowledge and material that is meaningful and relevant to the learners. These directives implicate on mathematics teaching for Deaf learners. OBE has been criticised by various stakeholders, yet the government's position is that the challenges do not lie

within the system of OBE itself, but in the way the theory is interpreted and implemented by teachers. OBE is largely underpinned by the philosophy of constructivism.

2.2 EDUCATIONAL THEORY

In the following section constructivism as a theory of education is detailed primarily because of its link to government policy.

2.2.1 Constructivism

Constructivism is a philosophy of knowledge and learning (Jaworski, 1994). Although there are different forms of constructivism (Ernest, 1991; Jaworksi, 1994; Davis, 1996), essentially constructivism can be described 'as theory of the limits of human knowledge, according to which all we can know is necessarily a product of our own cognitions' (Watts & Bentley, 1991). Hence, central to constructivism is the role of the person as an active construer of knowledge and meaning from their experiences.

Formalization of the theory of constructivism is generally attributed to Jean Piaget (Ernst, 1991; Jaworksi, 1994), who articulated mechanisms by which knowledge is internalized by learners. Hence, the work of Jean Piaget will be discussed before continuing with Radical Constructivism.

2.2.1.1 Jean Piaget

Piaget developed the theoretical framework of genetic epistemology to explain how intelligence forms in human organisms (Piaget, 1955; Ginsburg, 1985). He likened the development of intelligence to the biological process of an organism adapting to its environment in order to survive (Ernst, 1994).

Piaget (1999, p. 8) defined the adaptation of cognitive structures as 'an equilibrium between the action of the organism on the environment and vice versa'. Equilibrium mainly occurs through the processes of assimilation and accommodation. Whereas assimilation involves the interpretation of events in terms of existing cognitive structures, accommodation refers to changing the cognitive structure itself to make sense of the environment (Campbell, 2006). In other words, assimilation means that people transform information from the environment to fit with their existing way of thinking, whereas during accommodation people adapt their way of thinking to fit new experiences (Siegler, 1995).

Two implications of Piaget's work on equilibrium are emphasized. Firstly, thought is form of organisation or equilibrium of cognitive structures (Piaget, 1999). In particular, 'human intelligence orders the world it experiences in organising its own cognitive structures' (Ernst, 1993, p.88). This means that intelligence is in part an activity of the organism in organising information effectively (Piaget, 1999). And, secondly, there must be a degree of disequilibrium or discrepancy between the organism's existing cognitive structure and some new event in the environment, for cognitive development and change in thought to occur (Ginsburg, 1985).

Piaget (1955) posited that the development of thought progressed through developmental stages representative of four primary cognitive structures namely: sensori-motor, pre-operations, concrete operations, and formal operations. The stages are sequential and hierarchical in nature, in so far as each stage signifies a more sophisticated and stable level of thought. For example, in the sensori-motor stage (0-2 years), intelligence takes the form of sensory-motor actions. Language, play and fantasy become more marked during the preoperation period (3-7 years). Piaget argued that because language had a symbolic function, this stage signified the development of representational thought. During the concrete operational stage (8-11 years) logic emerges, but depends upon concrete

referents. In the final stage of formal operations (12-15 years), thinking involves abstractions, which enables the individual to reason deductively and hypothetically.

In other words, the development of mental activity from perception to symbolic, to reasoning and formal thought, is a function of equilibrium. Equilibrium results from the successive adaptations between an organism and his environment through the functions of assimilation and accommodation (Piaget, 1999). Hence, Piaget was considered as a constructivist epistemologist in that his work speaks of the construction of knowledge through cognitive adaptation in terms of the learner's assimilation and accommodation of experiences into an action scheme (Jaworksi, 1994).

Piaget's work affects the way one thinks about learning in Deaf schools. In lieu of Piaget's theory, learning is no longer considered to be simply imposed by environmental forces i.e by association. Simply put, adopting a 'lecturing style' to 'transmit' mathematical knowledge to learners in the classroom is not considered to be effective teaching in a Piagetian model. Rather, Deaf learners must take an active role in their learning and be provided with opportunities to assimilate environmental events into their cognitive structures (Ginsburg, 1985). To encourage assimilation and accommodation, Deaf learners need to experience mathematical problems that create an appropriate level of disequilibrium. Moreover, mathematical teaching must support operative systems of knowledge. In other words, mathematical content in the classroom should not be presented as static and fixed, but learners need to work in a ways in which their knowledge of mathematics is constantly changed and transformed to meet challenges and contradictions (Campbell, 2006). Von Glasersfeld (1987) elaborated on the nature of the knowledge by proposing that the knowledge construed is not necessarily a precise reflection of reality. Rather it represents a viable match.

Two principles from the above account are emphasised.

1. Knowledge is not passively received but actively built up by a Deaf learner.

2. The function of cognition is not to discover an ontological reality. Rather, its objective is to adapt to and to organise the world as experienced by the learner.

These two principles form the bases for radical constructivism (Ernst, 1991).

2.2.1.2 Radical Constructivism

Ernst (1991) likens Radical Constructivism to an evolutionary process where the organism is seen as evolving and adapting in isolation through performing a constant generation of cognitive schemas. The generated schema that best fits the subjective and private domain of experience is adopted and retained as a guide to action. Knowledge, therefore, does not represent a picture of the real world. Radical Constructivists do not deny that a real world exists, but claim that humans cannot access the truth of the real world. Subsequently, knowledge results from an individually constructed and modified experience and provides structure and organization to experience.

Von Glasersfeld (1983) expresses this notion as follows:

> ”The world we live” can be understood also as the world of our experience, the world as we see, hear and feel it. This world does not consist of “objective facts” or “things-in-themselves”, but of such invariants and constancies as we are able to compute on the basis of our individual experience. (Von Glasersfeld, 1983, p.6)

In other words, Von Glaserfeld puts forth that knowledge is subjective conjectures that are continually used, tested and replaced. Knowledge remains viable as long as it does not clash with experience, and as long as it continues to content the organism’s expectations. Viable is derived from biology and is used to describe ‘the continued existence of species, or individual within species, in a

world of constraints' (Jaworksi, 1994, p. 18). Subsequently, viability endorses the Darwian notion of survival of the fittest, in that anything not viable is eliminated and so does not reproduce. Any knowledge that therefore does not fit further experiences will die out.

Radical constructivism is essentially a form of individual constructivism in its notion of the insulated mind learning by adapting to new experiences in the environment (Jaworski, 1991; Davis, 1996). In other words, constructivism argues that mathematical learning is something that Deaf children can only do for themselves as they interact with the world from their own conceptual states (Lerman, 1994). Furthermore, 'interaction with the world' implies that learning occurs in the context of situated reality. This means that to create knowledge and meaning in learners, mathematics must be linked to experiential contexts, and not simply be taught as an objective and decontextualised reality (Kim, 2005). In addition, since knowledge is seen as a personal understanding that develop through personal experience with the outside world rather than through the experiences of others, educators need to bear in mind that the reality of one Deaf learner in the mathematics class will be different from another Deaf learner (Nickson, 2002). This means that the educator needs to take into account that personal understandings resulting in various perspectives could emerge within the same class (Kim, 2005).

Constructivism, however, has been critiqued for its emphasis on subjective knowledge at the expense of collective knowledge. Simply put, constructivism has failed to place things in the larger socio-cultural context. The social nature of human communities necessitates that we not only learn from the environment, but also from others. In not acknowledging the issue of human interaction, a tendency towards solipsism is created (Jaworski, 1991; Davis, 1996). Solipsism refers to constructing any reality one likes (Von Glasersfeld, 1990)

Subsequently, Social Constructivism extends Radical Constructivism by suggesting a third principle which recognises that knowledge is constructed socially through negotiation and mediation with others (Jaworski, 1994). The move from Radical to Social Constructivism seems to parallel the move from Piagetian to the Vygotskian view of learning (Jaworski, 1991). It would therefore be worthwhile to consider Vygotsky's notions in more depth, before an attempt is made to expound Social Constructivism.

2.2.1.3 Lev Vygotsky

Wertsch (1988, p. 14-15) argued that Vygtosky's theoretical work comprised three core themes, viz. a reliance on a genetic or developmental model; a claim that the higher mental functions of individuals have their origin in social functions; and, a claim that higher mental functions can be understood only if we understand the tools or sign through which they are mediated. Particular emphasis will be given to the second claim i.e that social interaction plays a role in transforming elementary stimulus-response reflexes to higher, conscious cognitive functions. In this regards, Vygotsky (1978, p. 176) posited that 'human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around him". Vygotsky, therefore, did not consider intelligence innate but as a form of psychological development resulting from the cultural-historical experiences of a child interacting with an adult (Pass, 2004).

Vygotsky (1978) identified two levels through which interaction, and especially speech from and with others, becomes self-regulatory behaviour. Firstly, the child and adult would converse. Thereafter the child would internalise the conversation with the adult. Later the child would use this form of inner speech to regulate his/her own behaviour. Egocentric speech in young children is considered a transitional state from communicative speech to inner speech. Vygotsky (1978) articulates this progression from social to inner voice as follows:

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. (Vygotsky, 1978, p. 57)

Vygotsky refered to the above principle the as the genetic law of cultural development. An implication of this law is that all higher functions originate as actual relationships between individuals (Vygotsky, 1996). In other words, a cognitive function constitutes a successful transfer from the interpsychological to the intrapscyhological plane. This transfer can occur through cultural sign systems (language, writing and numbers). Yet the primarily medium is through speech (Wertsch, 1988).

Consequently, speech functions as powerful psychological tool in the construction of individual thought and consciousness (Daniels, 2005). By way of example, thinking processes are speech transferred within, and reflection is the transfer of a social argument within. Furthermore, a child's logical capacity will develop only with the increasing socialisation of the child's speech (Vygtosky, 1996).

Vygotsky's work enables teachers to understand that Deaf children whose parents do not sign, may lack early access to communication and a rich language environment (Storbeck, 2002). Subsequently, they may experience delays in cognitive functioning that could manifest as difficulties in mathematics, particularly in respect to mathematical reasoning and logic.

Vygotsky's view impacts further on teaching and learning. In line with Vygotskian thought, learning in classrooms for the Deaf should take the form of a social process that requires adult guidance and peer collaboration, and an emphasis on dialogue and language (Pass, 2004). Moreover, Vygotsky

held a positive view of teaching in his argument that the teacher can advance Deaf learners' cognitive and metacognitive development through pedagogical operations in the Zone of Proximal Development (ZPD). It is also in the ZPD the psychological tools have a mediating function. Vygotsky described psychological tools as elements that can direct thought and behaviour because of the meaning encoded in them. Of these, the most significant tool is speech. (Daniels, 2005). Yet, in the context of Deaf education sign systems rather than speech could be used to mediate communication within the ZPD (Storbeck, 202). The notion of the ZPD therefore establishes Vygotsky's position on how instruction can lead to development (Daniel, Cole & Wertsch, 2007).

Vygostsky (1978) defined the ZPD as follows:

> It is 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 adult guidance or in collaboration with more capable peers (Vygotsky, 1978, p. 174).

Simply put, the ZPD is the difference between what a learner can do without help and what he or she can do with help or in collaboration with others. A particular pedagogical ideal held by Vygotsky was the transformation of a learner's intellect in the ZPD by assisting individuals to learn scientific concepts by connecting them to spontaneous or every day concepts. If the two forms – the abstract and the concrete… the decontextualised theoretical principles of school and the real experiences from life …do not connect, then true concept development fails to take place (Daniels et al, 2007). Mature concepts thus depend on the merge of scientific and everyday versions of knowledge.

The immediate application in the context of teaching mathematics to Deaf learners is that the teacher should not attempt to teach mathematical concepts by simply providing a decontextualised

mathematical definition. Rather, mathematical concepts should be taught by connecting the properties of the concept to the every day experiences of Deaf learners. Moreover, this should be done through interaction with knowledgeable others in the context of a sign-mediated, goal-orientated activity.

However, it is not necessarily the notion of the ZPD that links Vygotsky to social constructivism. Daniels et al. (2007) argue that Vygotsky's work on the ZPD promoted a more traditional view of learning.

> Vygotsky's view of the emergence of the mind being dependant on the child's assimilation of the collective wisdom the elders suggest an extremely instruction-based, teacher-orientated view of learning… The outer limits [of the ZPD] are determined by adult instructors who lead the child through the zone. The child is depicted as absorbing antecedently existing information, rather than building concepts and constructing knowledge. (Daniels, et al. 2007, p. 62-63)

Rather, Vygotsky, and social constuctivists see similar possibilities concerning the social nature of knowledge and the social formation of the mind in so far as knowledge is mediated, collaborated, culture-bound and contingent on language and other semiotic devices. The next section discusses how the congruity between Vygotsky and social constructivist is set in symbolic interactionism, the emergence of intersubjectivity and the context of meaning.

2.2.1.4 Social Constructivism

Social constructivism considers that a person individually and subjectively constructs knowledge. However, whereas radical constructivism posits that 'the subjective construction of knowledge occurs before social mediation, social constructivism holds that social mediation occurs before the

subject's construction of knowledge' (Davis, 1996, p.188). Social constructivists lay two substantial claims to knowledge. Firstly, knowledge is not value-free in that both the knower and the knowledge are situated in a cultural context i.e. in a political, historical and social setting. Secondly, knowledge is negotiated and constructed in terms of intersubjective agreement (Jaworksi, 1991; Ernst, 1991). Simply put, people negotiate their individual accounts in order to reach some level of agreement of how the event should be interpreted.

In particular, the theory of social constructivism accounts for the possibility of knowledge being formulated through communication and agreement between individuals (Jaworksi, 1991; Ernst, 1991). Consequently, experience is shaped not only by interacting and experiencing the physical world through physical actions, but also by experiencing the social world through speech (Ernst, 1991). The theory's emphasis on speech has implications for communication. One aspect is that language can be powerfully employed to help individuals construe (Jaworski, 1991). Another is that, communication cannot be correctly described as the transfer of meanings. Rather, linguistic competence depends on achieving and sustaining a fit between the sender and receiver (Jaworski, 1994). Moreover, meaning can only be attributed by individuals, it is not inherent to any symbolic system (Ernst, 1991).

By way of summary, social constructivistism encourages teachers to help learners create and negotiate meaning through a rich language environment. An alternative view is depicted by the case below and involves a strong emphasis on the conveyance of method at the expense of dialogue.

Two weeks ago a I attended a circuit meeting where teachers from schools who achieved very high mathematical results were asked to address teachers whose schools had a low quality pass in the 2008 Matric finals. A teacher from a high achieving school described the way she taught mathematics as follows:

> I teach them how do the sum. Just like you would teach a recipe. I will teach [the procedure] again and again. Once they find the method, I tell them why. If it is the 12.5 class [the weaker class] I do not tell them why. If they ask me, "Why?", I do not tell them. I teach methods. I do not waste time talking. They don't have to figure the mathematics out. They just have to learn the method. Mathematics is a skill. You don't need to understand mathematics. You just need to identify the pattern and follow it step-by-step. Mathematics is like learning how to push the buttons on a DVD player. You can work a DVD player without understanding how it works.

Although this particular teacher produces learners who achieve A grades in their Matric finals, her viewpoint that 'talking mathematics is a waste of time' runs counter to social constructivism. Moreover 'talking mathematics' as suggested by social constructivism, can be particularly beneficial and enriching for Deaf learners. This is argued in the light that many Deaf learners experience an impoverished communication background and therefore find it difficult to use language to establish intersubjectivity (Storbeck, 2002). Hence, promoting discussions around contextual mathematical tasks may encourage learners to engage in aspect such as hypothesis testing, debating, justifying, and simply expressing a particular view to an audience. Such dialogic interaction and not only promotes conceptual and cognitive development in the light of Vygotsky's theory, but ultimately presents a form of empowerment for the Deaf learners themselves.

The concepts that knowledge is constructed and meaning attributed by individuals are representative of the one pole of a continuum. The other end signifies the existence of an ontological reality exists that can be discovered by humans. Constructivism and its contrary are found in two global

philosophies of mathematics, namely the Absolutist or Euclidean philosophy and the Fallibist or quasi-empirical philosophy (Toumasis, 1997; Ernst, 1998).

2.2.2 MATHEMATICAL EPISTEMOLOGY

The main corollaries of the Fallibist and Absolutist philosophies are detailed below. These two philosophies represent a form of theoretical polarization when juxtaposed against each other.

2.2.2.1.1 The fallibist philosophy

Fallibist or Quasi-Empiricist philosophy considers mathematical essence and meaning as the products of the human mind (Toumasis, 1997) Mathematics is largely produced through the social and rhetorical practices that occur within the mathematical community (Siegel & Borasi, 1994). Since mathematical knowledge is seen as a human construct it is argued that mathematics is historically and culturally embedded (Ernst, 1991); and it is not considered to carry absolute validity. Rather, mathematics is depicted as fallible, tentative and open to revision (Ernst, 1998). Constructivism is included in the Fallibist category.

The perspective expressed above corresponds closely to the essence of mathematics as described in the formal government definition (DoE, 2003a) viz.

> Mathematics enables creative and logical reasoning about problems in the physical and social world and in the context of Mathematics itself. It is a distinctly human activity practised by all cultures. Knowledge in the mathematical sciences is constructed through the establishment of descriptive, numerical and symbolic relationships. Mathematics is based on observing patterns; with rigorous logical

> thinking, this leads to theories of abstract relations. Mathematical problem solving enables us to understand the world and make use of that understanding in our daily lives. Mathematics is developed and contested over time through both language and symbols by social interaction and is thus open to change (DoE, 2003a, p.9).

The opposing epistemology to the one adopted by the government is the Absolutist or Euclidean philosophy (Toumasis, 1997).

2.2.2.2 The absolutist philosophy

In this epistemology mathematics is considered one of the highest and purest forms of reason (Siegel & Borasi, 1994). An absolutist philosophy is based on Plato's ideals in that mathematical knowledge is approached as a pure form of truth that transcends cultures and time. Hence, mathematical knowledge exists 'out there' and needs to be discovered (Niiniluoto, 1992). Mathematics is essentially viewed as disembodied and decontextualised. Moreover, it is depicted as a form of knowledge that is objective, universal and abstract (Ernst, 1998).

These two paradigms, due to their varied epistemological natures, underpin different views on how teaching and learning should occur in the classroom context.

2.2.2.3 Teaching approaches

Drawing from authors and researcher such as Brombacher (1997), Davis & Maher (1997), Toumasis (1997), Dossey, Giordano, McCrone & Weir (2002), Markey, Power & Booker (2003), Kim (2005) a comparison can be offered of how fallibist and absolutist philosophies can direct classroom practice and pedagogy.

a) The fallibist or quasi-empiricist pedagogy

i) Theory of learning

Due to this theory's key belief that mathematics is a product of the human mind, learners are expected to act as inquirers and insiders of the mathematical community. Through the learners' efforts and operations in solving problems, mathematical knowledge and meaning are created in the mind of the learner (Toumasis, 1997). Learners come to see knowledge as contingent upon the context of the problems, the values embedded in the context, as well as their own choices and decisions (Davis & Maher, 1997). Because of the emphasis on active inquiry, learning incorporates investigation, discovery, discussion, play, co-operative work and exploration. Errors, misconceptions and alternative conceptions play an important role in the construction of mathematical knowledge in that these create conflict (Kim, 2005). In this approach, mental conflict is considered necessary for the development of both critical and innovative thought (Davis & Maher, 1997). In addition, students are encouraged to develop meaning from interactions and discussions with other students or with their teacher (Brombacher, 1997).

ii) Theory of teaching

The teacher is responsible for creating an environment that will provoke learning. This is accomplished by choosing appropriate resources and carefully structuring these to create situations for explorations (Toumasis, 1997). Resources are selected that will capture the attention of the child; encourage continual engagement; and, will act as a vehicle for thinking rather than being an end in themselves (Dossey et al. 2002). Central to the learning experience is not whether the learners are constructing, but the nature and quality of the mental representation that is being constructed. Once identified, these constructions are elobarated on and expanded by the teacher through guiding,

questioning, discussing, clarifying and listening (Toumasis, 1997). Moreover, the teacher needs to establish a nurturing and safe classroom environment which allow learners to take risks and where all contributions are respected and valued (David & Maher, 1997). Within a fallibist framework, it is particularly pivotal that the teacher model meaningful discussions and coach learners through the difficulties they may be experiencing (Markey et al.).

b) The absolutist or euclidean pedagogy

i) Theory of learning

The absolutist philosophy emphasis the teachers role and responsibility in transmitting the appropriate knowledge and skill to the learner by lecturing or reading, which the learner then should absorb and memorise (Toumasis, 1997). Learning is seen as mainly an individual activity, which requires hard work, self-discipline and self-denial (Kim, 2005). Performance is accentuated and achieved through continual practice and drills to the extent where computational procedures are 'automatized'. Ultimately the learner's responsibility is to reproduce objective knowledge (Davis & Mahr, 1997). Hence, the learner becomes locked in a role of listening, memorising and practicing. Errors in mathematics are taken to imply that the important concepts have not been mastered (Toumasis, 1997).

ii) Theory of teaching

This approach requires the teacher to lecture in a structured manner from a standardised textbook (Kim, 2005). Knowledge is disseminated in a careful manner. Mathematics is identified as a rigid logical structure that rests on the foundation of deductive thinking (Toumasis, 1997). Subsequently, concepts, theorems, proofs, laws and procedures are correctly and clearly conveyed to learners. The rule-governed behaviour of mathematics is underscored.

The fallibist and absolutist claims support contrasting metaphors of learning (Svar, 1998 cited in Kraak & Young, 2005), viz.:

- On the one side is the fallibist belief that learning is participation and which underpins the idea of learner-centredness and 'teacher as facilitator' associated with OBE.

- And on the other side is the opposing absolutist philosophy that sees learning as acquisition and which links pedagogy to the transmission of a given body of knowledge.

These two metaphors are not just a question of improving techniques, rather, as indicated above, they influence two different teaching approaches, each with its own strengths and weaknesses. Adopting a specific claim or metaphor therefore requires the rethinking of assumptions about teaching and learning and the practical implications that follow (Kraak &Young, 2005).

d) Practical classroom implications

Cangelosi (1996) provides a critical comparative evaluation between direct instructional approach which is derived from the absolutist philosophy and the inquiry based models which draws on the fallibist approach. The problem solving mathematics curriculum as used in this dissertation can be categorised under the fallibist philosophy and inquiry instructional approach.

i) Direct instructional methods:

- tend to enhance memory-level skills to execute algorithms in self-motivated students

- are time-efficient in terms of explanations and discussion

- present an abstract procedural learning that may result in a lack of meaning-making by learners

- neglects conceptual understanding of relationships and the ability to apply mathematics to real-world situations

- creates the perception that mathematics is a 'bag of tricks' to be memorized

- have the long-term effect that learners tend to forget the algorithm as soon as they are no longer using it

ii) Inquiry instructional approaches:

- intrinsically motivate students to engage in mathematical learning and activities;

- focuses on students constructing concepts, discovering relationships for themselves and applying mathematics to solve meaningful problems.

- tends to neglect mastery of algorithmic skills

- is more time-consuming in class.

- have the long term effect that students tend to retain what they learnt over an extended period of time.

- requires teachers to be more creative, understand students as individuals, and be apt at classroom management.

Cangelosi's comparison between the direct and inquiry styles of teaching made reference to both the cognitive and affective domains of mathematical learning. The affective domain includes motivations, perceptions, attitudes and beliefs towards mathematics and mathematical learning. Studying the affective domain of mathematics is necessary considering that this research is

concerned with the orientation of Deaf learners towards problem solving mathematics. Moreover, researchers such as Skemp (1987) contests that mathematics is first and foremost a psychological undertaking and not a logical one. Similarly, Stewart (1995, p. 5) posits that in the learning of mathematics, 'the psychological is more important than the logical'. Hence, the next section will consider how beliefs play an important role in mathematical learning and achievement.

2.3 MATHEMATICAL BELIEFS

There is evidence to that suggest that students acquire their mathematical beliefs from two interrelated sources, namely current educational practices and teachers' own opinions of mathematics (De Corte, 2000). An additional source may be the input from parents (Geldenhuys, 2000). It must be considered that parents' views, however, were most likely formed during the time when they attended mathematical classes and hence, derived from their own school experiences.

It is argued that when educational practices are embedded in an absolutist epistemology it may fosters psychological barriers to mathematical learning through imparting certain negative beliefs (Siegel & Borasi, 1994; De Corte, 2000; Naidoo & Parker, 2005). Subsequently, from the aforementioned research it can be derived that absolutist teaching practices are under the scrutiny of the research community for developing incapacitating ideology in learners as part of its hidden curriculum. Absolutism is indicted for 'giving students mainly unrelated routine mathematical tasks which involve the application of learnt procedures and by stressing that every task has a unique, fixed and objectively right answer, coupled with disapproval and criticism of any failure to achieve this answer' (Ernst, 1996, par 8). It is especially the emphasis on mathematics as a decontextualised and an exact science that is subject to controversy.

2.3.1 Beliefs about the nature of mathematics

2.3.1.1 Unrelated routine mathematical tasks

Findings from research are that learners often have a negative attitude towards mathematics which includes perceiving mathematics to be dull and difficult (Grattan-Guiness, 1994; Geldenhuys, 2000; De Corte, 2000; Fuson, Kalchman & Bransford, 2005, Cangelosi, 2006;).

Grattan-Guinness (1994) expresses this common sentiment as follows:

> Mathematics quickly becomes quite a tricky subject, and beyond the natural capacities of many. Further, at school it comes over as arid and unmotivating as well as difficult and also seemingly irrelevant to normal day-to-day needs. (Grattan-Guinness, 1994, p.3)

The 'trickiness' or 'mystification' of mathematics is linked to the disembodied and decontextualised view of mathematics found in the absolutist worldview. Cangelosi (2006) states that a sense of 'trickiness' arises in learners when there is a failure to link mathematics to its historical origins; a failure to understand the language of mathematics and its symbols; the fragmentation of mathematical topics into disconnected subtopics; the failure to construct mathematical concepts and discover mathematical relations for oneself. Subsequently, strong perceptions exist that the absolutists world view of mathematics promote a public image of mathematics as 'being cold, abstract, difficult, ultra-rational; masculine, and only accessible to a few super-intelligent individuals' (Ernst, 1996, par 5).

Similarly, negative associations with mathematics are created when students' own reasoning and mathematical intuition are replaced with a set of rules and procedures (Mcleod, 1991). Routine application of procedure trains learners to respond in a particular way where a problem is automatically viewed as a "request for a computation", and not as a problem to be solved that may or may not require computation (Fuson et al. 2005). Thus, the learners' common reaction is to find the exact answer by following a procedure or rule learnt. Little time may be given to conceptualizing the nature of the problem and to estimate an answer (Fuson et al. 2005).

In other words, learners begin to focus on executing a particular skill at the expense of true meaning making. Since, learners' own attempts at developing strategies to grapple with a problem are short-circuited by the need to apply a rule, they tend not to engage in metacognitive strategies. Subsequently, the learners will generally be at a loss when the nature of the problem changes slightly, or when they have not used the taught approach for a while, or when confronting a novel problem (Fuson, et al. 2005). Alternatively, even when they can see that an answer is incorrect, they will not try and correct it. This is because they have been trained to follow a rule irrespective of whether the rule makes sense to them or not (Fuson, et al. 2005).

Likewise, when learning becomes unrelated to real life phenomena and it may undermine individuals' ability to learning with understanding (Fuson, et al. 2005). Subsequently, their perception of mathematics will tend towards a subject rife with irrelevant computations and rules.

2.3.1.2 Demand for a fixed and objectively right answer

Furthermore, when learners are taught that for each kind of mathematical situation there is one correct method, it fosters the belief that mathematics is about passively receiving a fixed body of knowledge from the teacher (De Corte, 2000). Moreover, it affects learners' beliefs about authority in mathematics in so far as the correct method and answer becomes the one approved by the authority of the teacher. Subsequently, learners develop a distrust of their own intuition (Tobias, 1994).

Moreover, such a style of teaching conveys beliefs about time and more specifically time pressure (De Corte, 2000). Learners are placed under the impressions that knowing mathematics means being able to quickly give the correct answer; and that all mathematical problems can be solved in just a few minutes (Mcleod, 1991).

When mathematics is perceived negatively in this way it starts affecting how learners define themselves in relation to mathematics.

2.3.2 Beliefs about self in relation to maths

Hence, researchers have investigated how not only beliefs about mathematics, but more specifically beliefs about self in relation to mathematics anxiety can lead to the rejection of mathematics (Geldenhuys, 2000; Thijsse, 2002).

It is recognised that many South African learners in mathematical classes, as well as non-mathematics teachers, suffer from a phobia called mathematics anxiety (Geldenhuys, 2000; Thijsse, 2002). The power of the psychological can be seen in Geldenhuys' (2000, p. 24) conclusion that

“many pupils who are quite capable of mastering mathematics are afraid of mathematics and will therefore go to great lengths to avoid it”. Part of the fear of mathematics lies in the threat that mathematics poses to an individual’s self-concept. When mathematics presents as ‘tricky’, people feel that they will be seen as dumb, stupid and clumsily should they struggle. Hence, learners try to protect their public images of themselves as bright and competent people, through various coping mechanisms. The easiest coping mechanism is the avoidance of mathematics altogether (Fullerton, 1995; Geldenhuys, 2000).

The position outlined above can be summarised as suggesting that conventional teaching tend to foster more negative beliefs pertaining to mathematics than problem solving approaches. This particular claim has been justified by the work of Schoenfeld (1988) and Boaler (1998). Hence, it argued that absolutist practices socialise learners into a psychological view of mathematics that sets them up for failure (De Corte, 2000; Geldinghuys, 2000; Naidoo & Parker, 2000). Consequently, a shift requiring a move away from absolutism towards constructivism as a psychological model for mathematics education is suggested in mainstream schools (De Corte, 2000; Naidoo & Parker, 2005), including mainstream schools with Deaf learners and residential Deaf schools (Lang & Pagliaro, 2007).

There are several findings that document the impact on and the response of learners as education shifted from a traditional way of teaching to a reformed orientation. In other words, comparative studies between learners exposed to problem solving mathematics and their peers in traditional programmes have been conducted. The picture emerging (Schoen,1993; Boaler, 1998; Riordan & Noyce, 2001; Clarke, Breed & Fraser, 2004; Kim, 2005) confers that problem solving students do as least as well, and often better, on standardized test; are more able to transfer mathematical ideas into

real world; are more confident in mathematics; value communication in mathematical learning more highly than students in conventional classes; and, developed a more positive views about the nature of mathematics than their counterparts. Whereas Boaler (1998) indicated that reform programmes are beneficial to learners from low socio-economic groups, Lubienski's (2000) analysis of data showed that reform mathematics was problematic for the low socio-economic status students. Franco, Sztajn, & Ortigão (2007) undertook a large scale investigation in Brazil to determine whether reform teaching was related to increased student achievement for all students, or whether the gains depended on students social economic status. The study indicated that reform teaching raises all students' achievement levels. Hence, the study suggests that reform mathematics has the potential to narrow the gap between high socio-economic and low socio-economic schools. Yet Franco et al (2007) posit that reform mathematics are more likely to increase inequality in education, in so far as it is often the case that schools with higher SES students provide reform teaching whereas schools with low SES students provide traditional teaching. In other words, learners who could benefit most from reform mathematics are the least likely to receive it. Moreover, Dossey et al. (2005) state that the problem solving approach is beneficial to students with learning difficulties, provided that the teacher considers outcomes that are reasonable in respect to the specific learning difficulty.

Ultimately beliefs in mathematics remain powerful because of their influence, both short and long-term, on mathematical performance. Short-term effects of incorrect beliefs are that these inhibit learning activities and approaches to problem solving in learners. In particular, misbeliefs prevent learners from careful consideration and persistence with new and challenging problems. (De Corte, 2000). Moreover, mathematics anxiety interferes with learners' conceptual thinking and memory processes (Thijsse, 2002).

The long-term effects of learners rejecting mathematics because of their own feelings of dislike and dread towards, and also because of the inability to see the current and future relevance of mathematics are two-fold. Firstly, it limits learners' career opportunities and secondly, it creates adults who cannot participate effectively in a technological society (Geldenhuys, 2000). The arguments that mathematical results can affect the economy of the country and limit career opportunities have links to the theory on human capitalism.

2.4 HUMAN CAPITALISM

Human capital refers to the skills, knowledge and health of workers (Mohr & Fourie, 1995). Education, training and experience are important determinants of human capital. Human capital, in turn, determines the quality of labour in a country. Thus, according to Becker (1993, p. xix), 'investing in human capital' describes the process of improving the quality of the labour force in a country. The crux of human capitalism is the link it posits between the improvement of individual educational attributes and its economic ramifications, in particular, its potential for furthering economic growth in countries (Becker, 1993; Young & Kraak, 2001; Chisholm, 2004). Simply put, the theory identifies that a country's potential for economic growth is related to its capacity to develop certain skills and knowledge of its population. It reflects the paradigm shift that economic growth will depend on 'human' rather than 'natural' resources (Young, 2005, p. 5).

Subsequently, human capitalism concedes that the economy of the country is at risk when there is a decrease in the number of graduates from tertiary studies in the fields involving mathematics and science (Thijsse, 2000). Becker (1993) explores how human capitalism has an affect on the economy of a country at macro-level, but also at a micro-level. He argues that 'the personal distribution of

earnings is partly determined by the distribution of, and the returns, from human capital" (Becker, 1993, p. 5). Subsequently, he assumes that individuals can maximise their well-being by accumulating human capital.

This argument is visible in mathematics. Dossey et al. (2005, p. 26) describe mathematics as the 'intellectual currency of the technological age'. Success in mathematics serves as a filter to access prestigious and powerful professions (Allen, 1998; Geldenhuys, 2000; Lubienski, 2000; Ramnarain, 2003; Van der Walle, 2007). More distinguished careers including science, medicine, engineering and computing are restricted to achievement in mathematics. Subsequently, poor performance in mathematics may affect the fiscal capacities of individuals by streaming them into careers with base personal earning profiles.

However the notion of investing in human capital is not enough. The process has to be supported and complimented by additional proviso including macro-economic progression and job creation (Kraak & Young, 2005); legislation prohibiting discrimination that is supported by positive programmes to address the general community's attitude about deafness (Win, 2007); and, the occupational expectations of the individual and significant others in his/her environment (Weisel, 1998).

The challenges of the South African economy do not nullify the benefits of human capitalism. Rather, it reinforces its value. Bhorat (2004) distinguish between two categories namely the unemployed and the unemployable. The unemployed is described as young individuals with some level form of secondary education that can be trained in useful skills. The unemployable consists of two groups, firstly, those who are older and not well-educated and secondly, younger individuals who have low levels of education - primary school or less - and who are not skilled. It is predicted that the unemployable, because of their low levels of formal education will in all likelihood never find employment in their lifetime (Bhorat, 2004). An additional aspect to consider is literacy (or the

lack thereof). Bhorat (2004, p. 51) attests that 'even within this latter cohort of workers with primary schooling or less, there exists a further sub-group whose levels of illiteracy would surely render it impossible to legitimately expect them to take up long term employment in an economy that places a premium on highly skilled job seekers'.

It is proposed that the current level of education in Deaf schools, put the Deaf population at risk of being categorised with the latter sub-grouping. Further support for the likelihood of such classification is provided by statistics which convey that approximately 70% of the Deaf population is unemployed (The Wits Centre for Deaf Studies, 2008, p. 3). Subsequently, the emphasis should be placed on developing general education in schools for the Deaf, including mathematics, as well as expanding access to vocational education and lifelong learning for the Deaf.

Hence, it can be argued from the human capitalism theory that the Deaf represent a subgroup at risk of becoming unemployable. The idea of the Deaf being a unique group in society is not new. As explained in Chapter 1, the Deaf is considered a separate cultural group in accordance with the socio-cultural view of Deafness.

2.5 THE SOCIO-CULTURAL VIEW OF DEAFNESS

The view that Deafness represents a unique linguistic and culture minority within the larger society, posits the question of membership demarcation. Baker-Shenk & Cokely (1980, p. 49-50) argue that membership to a Deaf community depends on four categories viz: audiological, linguistic, social, and political.

The audiological aspect refers to hearing loss. It deals with the physical condition of deafness. The linguistic dimension concerns being fluent in the language of the community. With reference to the Deaf community, the linguistic aspect implies being competent in Sign Language. Social refers to integration through frequent positive interaction with the members of the Deaf community. The political category involves political activism and influence in current deaf issues.

Based on the classification above, a distinction is drawn between a core and a peripheral Deaf community.

The core Deaf community consists of individuals who:

- are physical deaf or hard of hearing AND,
- use Sign Language as their first language AND,
- interact socially with the Deaf AND
- are politically aware and involve with Deaf issues

Individuals belonging to the core Deaf community base their identity on their Deafness. They feel proud of being Deaf.

On the other hand, the peripheral Deaf community consists of those who are

- hearing AND/OR;
- have sign language as an additional language AND/OR;
- interact socially with the Deaf community AND/OR

- share a political affiliation with the Deaf community

Woodward (1982) expands on membership criteria by adding the aspect of attitudinal deafness. Attitudinal deafness refers to the ability to determine for oneself whether one belongs to the Deaf community or not.

Often individual will choose membership of the Deaf community for Deaf communities provide a powerful sense of belonging. A common experienced shared by deaf people is the feeling of alienation, isolation and oppression from the hearing world. In contrast, the Deaf community enables the hearing-impaired person to find a place where they are not left out by reason of being different from the norm. Moreover, they do not have to deal with fears of miscommunication or dependency on others generally experienced in the hearing milieu.

Subsequently, Higgins (1987, p. 13) defines deaf communities as "local groups of hearing-impaired people, who based on shared experiences among each other and identification with one another, participate together in a wide variety of activities"

Moreover, Deaf communities bring about a distinguishable Deaf culture, where people are proud of being Deaf and identify strongly with being a member of the Deaf community. The identification with 'being Deaf' may become so strong that technological advances in assistive devices such as hearing aids and cochlear implants are fiercely resisted (The Star, 16 July 1997); and the birth of deaf babies are wished for and celebrated (Dolnick, 1993). Deaf culture is expressed through unique Deaf poetry, Deaf humour and Deaf art being passed on from generation to generation. Deaf culture also incorporates Deaf sport, Deaf churches and Deaf clubs.

One important aspect in the Deaf community is the focus on Sign Language. Starting with the seminary work of Stokoe (1972), followed by researchers as Petitto (1994) sign language has been established as authentic language from both a semantic and biological perspective. In other words, sign language is scientifically considered a real language on par with speaking languages.

Language and culture plays a particular important role in mathematics. Researchers such as Pepin (2002, p. 246) present an argument on how every single aspect of mathematical teaching and learning is 'culturally embedded'; whereas authors such as Cocking & Mestre (1988) describe how cultural and language affects mathematical achievement amongst learners. Even more pertinent is that Deaf learners, as a particular subculture with their own language, also have particular delays and very specific needs that should be addressed in the mathematics classroom.

2.5.1 The nature of the mathematical delays in Deaf learners

The nature of delays in the mathematical domain amongst Deaf learners include, but are not limited to, additive composition i.e. understanding that any number can be seen as the sum of other numbers (Nunes and Morena, 2002); communication about time (Nunes and Morena, 2002); word problems (Kelly, Lang and Pagliaro, 2003; Pagliaro and Ansell, 2002); low arithmetic competence (Frostad, 1999; Nunes and Morena, 1998); fractions (Bull et al. 2005:224); poor memory for digits (Nunes and Morena, 1998) and slower overall response time (Bull et al. 2005:224). Much of this research has been conducted at a primary school level, which leaves a gap at high school level within the knowledge base.

2.5.2 Risk factors that contribute to the delay

Research findings posits that hearing loss should be seen as a risk factor that contributes to mathematical difficulty, rather than the direct cause of such difficulties (Nunes & Moore, 2002). The risks associated with deafness manifest particularly as linguistic, cognitive and experiential factors.

Linguistically, Deaf students struggle with written language and have a low reading age (Johnson, Liddell and Erting, 1989:37). A particular strong correlation between language proficiency and cognitive functioning, including mathematical achievement, has been discovered. In this regard international studies show that where learners are from environments where the language of instruction and the language of the mathematical tasks are not the same as the learners' first language, mathematical achievement is generally lower (Reddy, 2003; Mestre, 1988). Such a correlation implies that 'the academic deficiency in minority students may be linguistic rather than intellectual in nature' (Mestre, 1988:215).

Moreover, Deaf learners tend not to possess good problem solving skills (Lang and Steely, 2003; Kelly et al. 2003:105). A good problem solver is described as one who can give selective and undivided attention to a problem; who can suspend closure while taking into account all relevant information; who can work with analogies and test potential solutions before affirming one's conclusions (Kelly et al. 2003:105). These characteristics were found lacking amongst Deaf students (Kelly et al. 2003). Moreover, Deaf students demonstrated little reflection and persistence when working through difficult problems (Lang and Steely, 2003; Kelly et al. 2003:105). Others described Deaf adolescents as highly dependent learners (Lang and Steely, 2003). Highly dependent learners are characterised by heavy reliance on organisation and structure within the classroom; as looking to authority figures for guidelines on what to do; and as having difficulty in developing autonomy and

self-direction. Such learners become dependent on a human support system and struggle to show initiative, self-reliance and independence (Lang and Steely, 2003:281).

Experientially, hearing loss may underlie delays in that it makes no allowance for opportunities for incidental learning. Deaf learners cannot benefit from many sources of information such as television and radio. This means that Deaf learners suffer from a form of 'information deprivation', which negatively influences their reasoning (Nunes and Morena, 2002:121). The implications for Deaf pedagogy are that these learners must be given the opportunity to learn information that is learnt informally by hearing peers. Hence, concepts that hearing children acquire implicitly through incidental learning must be explicitly and systematically taught to teach Deaf learners.

Apart from the necessity of making implicit concepts explicit in the classroom, other strategies have been researched as a way to help Deaf students improve their mathematics and to address the linguistic, cognitive and experiential barriers experienced by Deaf learners.

2.5.3 Ways to address the needs of Deaf learners in the mathematics classroom

One primary strategy is to emphasis the visual representation of course content (Nunes & Morena, 2002; Easterbrookes & Stephenson, 2006). Kelly et al. (2003) affirm the importance of visual strategies in Deaf mathematics, but argue that it is insufficient by itself to advance problem solving. Their argument is that visual strategies must be combined with deeper analytical strategies to help Deaf learners achieve strategies (Kelly et al. 2003). Hence, it is essential for principals of Deaf schools to motivate their staff to commit to ongoing training in order to be specialists in both mathematics and Deaf pedagogy.

Secondly, teachers' perceptions of Deaf learners influence the performance of learners (Kelly et al. 2003, Johnson, Liddell & Erting, 1989). Teachers who specialise in Deaf education are less positive about the capabilities of Deaf students partly because they are more familiar with the language issues of Deaf students discussed earlier. An implication of Deaf students' limited language proficiency is that since more advanced scenarios are commonly presented in written format high school teachers indicate that they provide Deaf students with simple, straightforward and familiar problems rather than with more complex and unfamiliar problems (Kelly et al. 2003). Subsequently, because of their impoverished language ability, the students are not expected to solve more cognitively demanding problems and are therefore not given the opportunity or the challenge to do so. Likewise, in primary school teachers often hold back on story sums until they feel that learners have grasped the basics (Pagliaro & Ansell, 2002). Holding back on written problems may be detrimental in that analytical cognitive skills are developed through constant practice and exposure to complex problems. Failure to do so creates a form of cognitive narrowing that only enlarges the deficit already experienced by Deaf students and leaves them unprepared for tertiary studies and/or real world situations. Consequently, Kelly, Lang, Mousley and Davis (2003, p.131) argue that pedagogic practices for Deaf students are effective when Deaf students from primary school to high school are instructed in a variety of representation strategies. The means that Deaf students, from a very early age onwards, must not only be exposed to visual representations of problems, but must be exposed to written representation as well. Moreover, Deaf learners should receive structured learning to learn how to translate such language structures, especially those that do not occur naturally in sign language e.g either, neither, nor, if x…then y, and so on (Kelly et al. 2003).

With regards to language issues, Easterbrookes and Stephenson (2006) argue that the language in textbooks must be adjusted to meet the reading ability of the learners. The fact that the verbal content of textbooks creates challenges for Deaf learners is discussed. It is suggested that the way to overcome this problem is 'through scaffolding by adding visual prompts, graphic organisers and lower level reading materials' (Easterbrookes and Stephenson, 2006, p.395). In line with their argument they cite research, which indicates that visual content together with simplified English text produced significantly higher scores than books with little visual substance and complicated English patterns. Perhaps Easterbrookes & Stephenson's insight can be combined with that of Kelly et al. by saying that Deaf learners must be exposed to complex written problem scenarios. The starting point however, could be scaffolding the text, yet the overall goal should be to get learners to a level where they can interact more confidently with more advanced written problem scenarios.

Thirdly, teachers' focus should be in maturing learners' abilities to understand the context and the network of relationships being expressed by the context. Research reveals that Deaf students generally have weaker strengths of association between concepts, and tend to process items individually while neglecting to process the relationships between items (Bull et al. 2005). It is unsure exactly what is responsible for Deaf learners' preference for individual item-processing. Item-processing has been attributed to an impoverished early communication environment, pedagogical practices, and dealing with the world primarily through a visuo-spatial mode, rather than through a dual visual and auditory mode. Moreover, reliance on interpreters results in information being processed consecutively and simultaneously. (Bull et al. 2005, p.232). Van Hiele believes that 'without the network of relations, reasoning is impossible' (Clements and Bartallas, 2005, p.54). Van de Walle (2007) lists additional benefits of relational understanding, namely that it enhances memory; that is advances the learning of new concepts and procedures; that it improves problem solving abilities, and that it helps learners to develop a positive sense of self-efficacy towards

mathematics. Hence, it is important for teachers of the Deaf to provide Deaf learners with opportunities to discover and process relationships amongst items.

Another effective practice in Deaf mathematic classrooms is that instruction must be in Sign Language by a teacher who is fluent in signing (Easterbrookes & Stephenson, 2006). With regards to the importance of teachers' ability to sign fluently, Easterbook & Stephenson (2006) emphasise that the quality of the linguistic input through which the information is conveyed is more important in the Deaf classroom than the quantity of information presented to learners. According to Mester (1988, p.216) access to information is one of the key factors in mathematical success for Deaf learners.

One theorist that considered how culture could impact on the establishment of effective higher cognitive processes, is Feuerstein and his work on the theory of mediated learning.

2.6 THE WORK OF FEUERSTEIN

The exposition in this section on Feuerstein's work has been taken from three sources, viz. Instrumental enrichment. *An intervention program for cognitive modifiability* by Feuerstein (1982); *Don't accept me as I am: Helping "retarded" people to excel* by Feuerstein, Rand & Runders (1988); and, *Mediated learning experience (MLE): Theoretical, psychosocial and learning implications* by Feuerstein, Klein & Tannenbaum's (1994).

The theory of MLE was developed between 1950 and 1963 by Reuven Feuerstein. As a psychlogist, and student of Piaget, Feuerstein was preparing children in transit camps in Morocco and southern France for immigration to Israel. In light of the preceding Holocaust, the children experienced disrupted lives, came from diverse cultural origins and displayed massive intellectual and academic

dysfuntions. While working with these children, Feuerstein noted a strong contrast between what he refered to as the culturally different and the culturally deprived children.

2.6.1 What is meant by culturally different and culturally deprived

In using the terms culturally different and culturally deprived Feuerstein (1980, p. 13) defined culture as the ‘process by which knowledge values and beliefs are transmitted from one generation to the next’. In considering the term ‘culturally deprived’, it must be stated that Feuerstein never intended for the term to convey a sense of inferiority in that one cultural group or a person from a particular cultural group is seen as less than another cultural group. Nor did he refer to the culture depriving the individual of rights and privileges. Hence, this term should not be used in the sense of attaching negative connotations to low functioning individuals (Feuerstein et al., 1994). Rather for Feuerstein cultural deprivation occurs when a group fails to transmit or mediate its culture to the next generation**.** In contrast, culturally different refers to a group whose norms differ from the dominant mainstream culture. In the context of Deaf education, where parents or caregives do not learn to sign in the early stages of the child development, the deaf child is at risk of falling into the culturally deprived category. In others words, a hearing parent who cannot sign, will find it more challenging to convey a particular quality of mediating experience to his/her child because of the communication barriers that are experienced.

Several variances exist between the culturally different and the culturally deprived individual. The main distinction, however, lies in the children’s capacity to gain from direct exposure to stimuli (Feuerstein et al, 1994). Culturally different individuals have been equipped with learning capacities through exposure to their own culture, hence they have the ability to gain from new experiences and

to be modified through direct stimuli. Subsequently, they are able to benefit from formal and informal opportunities to learn. In contrast, culturally deprived children however, gain little from new experiences. They are individuals who cannot 'benefit from direct exposure and need an intensive investment to learn what others do with ease' (Feuerstein et al., 1994, pg 5). Cultural deprivation is a state produced by the lack of mediated learning experiences (Feuerstein, 1980).

2.6.2 The theory of mediated learning experience (MLE)

A mediated learning experience describes a qualitative type of interaction between the human being and its socio-cultural environment (Feuerstein et al., 1994). In particular, it is an interaction of the organism with its environment through a human mediator. The human mediator takes the initiative to intentionally mediate the stimuli impinging on the organism. Put simply, during early childhood development there is a caring adult in the child's life who can effectively focus attention and interpret to the child the significance of objects, events, and ideas in the environment. Feuerstein's focus on mediation through an adult posits a link with Vygotsky's work and his focus on mediation within the ZPD. Both theorists require an adult to work with a child in a particular way to bring about cognitive development.

2.6.3 The importance of early mediated learning experiences

Feuerstein (1980) asserts a relationship between early mediated learning experience and later cognitive competence. He likens the relationship to the analogy of a stream. A stream not only determines the movement of its water (content) but also carves the bed (structure) along which the waters flow. Similarly, mediation gives rise to knowledge but also to cognitive structures that enable

the individual to adapt to higher and more efficient levels of functioning. In particular, human mediation develops auto-plasticity in the individual. Auto-plasticity reflects a state of internal flexibility that enableenables the individual to cope with sudden and novel changes in the environment (Feuerstein, 1980 & Feuerstein et al. 1988, 1994). Auto-plasticity forms the propensity to learn. In contrast, a lack of auto-plasticity results in diminished modifiability, rigidity and low levels of adaptability of the individual or group. If this ability fails to develop during early childhood, because of the absence of systematic learning medicated by a caring adult; it gives rise to later cognitive deficits (Feuerstein, 1980).

There are many sources that can interfere with early mediated learning experiences. The most common include economic deprivation, social and family pathology and distortions in parent-child relationships (Feuerstein, 1988). A lack of early mediated learning experiences create higher level processes that are absent, fragile or inefficient. However, a deficit in cognitive processing is not necessarily permanent or fixed. Feuerstein et al. (1988, p. viii) holds that 'except in the most severe instances of genetic and organic impairment, the human organism is open to modifiability at all ages and stages of development'. Subsequently, Feuerstein posits a very positive theory in which human beings are considered open systems, which can be cognitively modified by environmental intervention.

2.6.4 The concept of cognitive modifiability

The concept of cognitive modifiability challenges two very powerful aspects of psychology and psychiatry, viz. the concept critical period and the general hereditary view (Feuerstein et al., 1988) The critical period argues that the level of cognitive functioning becomes permanent with respect to

age. Stated differently, if stimulation were not present during the critical period, thereafter any meaningful alternations are not likely to occur through intervention. Subsequently, the earlier the intervention, the greater likelihood of success.

Similarly, the general hereditary view posits that individual functioning is determined by genetic endowment and considered static with little modifiability. Both these notions are challenged by MLE. MLE's holds that modifiability is possible in spite of forces often considered permanent, namely the age of the individual; the causes of impairment and the severity of the impairment. MLE asserts belief that modifiability is considered accessible provided that certain communication, cognitive and emotional abilities are present to enable the child to co-operate with the adult mediator (Feuerstein et al., 1988). Simply put, adolescence is not late. Deafness is not too austere.

Since Feuerstein (1980) accepts the human mind as a dynamic, flexible and elastic system whose capacity and structure change, he developed the Feuerstein Instrumental Enrichment (FIE). FIE is a strategy for cognitive redevelopment with the objective to change the cognitive structures and to provide individuals with tools for developing thinking (Feuerstein, 1980). The objective is to transform individuals into autonomous, independent thinkers, capable of initiating and elaborating ideas Subsequently, it is not concerned with what a child or adolescent has learnt, but how the child learns and solves problems. Thus, each instrument focuses on a specific cognitive deficiency and provides experience in overcoming it. It functions as a strategy for learning to learn and thus acts as a substitute for early mediated experiences (Feuerstein, 1980).

The concept that intelligence can be learnt carries several educational implications. Feuerstein argues that when human intelligence and level of functioning are considered immutable it gives rise to passive-acceptant approaches (PA). In contrast, the belief that cognition can be modified translates

into an active-modificational approach. The PA-AM difference directly influences educational procedures (Feuerstein et al. 1988).

2.6.5 The PA and AM approach to teaching

Educational curricula and teaching methods based upon the PA approach generally lack novelty and innovation. There is a tendency to remain in the realm of what the child has already acquired or what is nondemanding for him. Practices are characterised by a redundancy in curricula, concretized educational experiences, and a emphasis on 'filling the gaps'. Modest goals are set and acquired through a process of dispensing information and over learning. Such educational methods are justified through claims that the practices bolster learners' self-esteems by allowing them to experience success, instead of continual challenges, and perhaps failure and frustration (Feuerstein, et al. 1988)

Yet, the critique is that PA practices are counterproductive in that they do not prepare the learner adequately for the requirements of real life. The goal of education should be to enhancing the individual's coping capacities. Preoccupation with concrete learning experiences, instead of the continual activation of abstract thinking, may substantially reduce individuals' abilities to adapt to real life. Consequently, PA based approaches may render the student incapable of coping with a constantly changing environment and thus incapacitated in real-life situations. As was noted, the underlying philosophy of the PA approach is to change environmental conditions to suite the low level of performance of the learners. Feuerstein, however, warns that **c**omfort now means discomfort later. And that comfort, at the expense of development, is a heavy price that will later need to be paid by the child (Feuerstein et al. 1988).

In contrast, the AM approach asserts that it is the learner, rather than the material to be learnt, that must be modified. It requires an intense commitment to working under new and more demanding conditions whilst using innovate and novel approaches. Concrete apparatus are used, but as a temporary scaffold to richer and more effective levels of abstract thinking (Feuerstein et al., 1988)

2.7 CONCLUSION

By way of concluding this chapter it was noted that the intent of this research was to introduce a problem solving curriculum into a mathematics classroom for Deaf learners. For the purposes of this research problem-based integrated mathematics examples were chosen. In other words, the selection contained problems based in real-world situations that students had to explore and solve. The choice of the problem solving examples meets the specifications of governmental policy in that it is considered learner-centred, activity-based and relevant. Moreover, the selection allows for integration within and between learning areas, and between subject knowledge and the real-life experiences of the learners.

In line with social constructivism the curriculum creates opportunity for knowledge to be negotiated through dialogue and interaction amongst the Deaf learners themselves, and amongst the teacher and the learners. In addition, the curriculum fits into the fallibist paradigm. The fallibist philosophy is arguable more beneficial for Deaf learners as research findings show that it creates more positive dispositions in learners and that it improves academic results in a variety of socio-economic settings. It is important that Deaf learners' orientate positively to mathematics as they are at risk of becoming 'unemployable' should their scholastic level not be raised. It is predicted from Feuerstein's theory and the characteristics he associates with culturally deprived learners, that certain learners who appear to have such cognitive characteristics may find it challenging to orientate themselves to a new

curriculum. At the same time, it is argued that the problem solving exercises embodies many of the principles contained in Feuerstein's cognitive enrichment programme, and can therefore play an important role in empowering Deaf learners by teaching them aspects of how to cognitively work with and process information. Hence, apart from being mathematics curriculum, it also holds the potential of helping the Deaf learners 'learn to learn' and 'think about their thinking'.

In the next section a fuller description of the research design is provided.

CHAPTER 3

RESEARCH DESIGN

In this chapter the research design of this study is detailed, the different methods of data collection are discussed; and the data collection process is described.

3.1 PRIMARY AND SECONDARY RESEARCH QUESTIONS

The primary and secondary research questions pertaining to this study were noted in Chapter 1, but are re-iterated below for the sake of completeness.

3.1.1 Primary research questions

1) How do Deaf learners orientate to problem solving mathematics?

3.2.2 Secondary research questions

In order to answer the primary research question (1) the following secondary questions were formulated:

i) What are Deaf learners' orientations towards mathematics in general?

ii) Based on Deaf learners' orientation, what barriers (if any) are Deaf learners experiencing?

iii) What are the factors that contribute to certain barriers (or lack thereof) in Deaf learners?

iv) How do placing Deaf learners in a problem solving teaching environment change their orientation towards school mathematics?

To answer the primary and secondary research questions, the paradigm within which this research study is framed is now addressed:

3.2 RESEARCH DESIGN

All research is governed by a specific research philosophy. These paradigms uphold certain epistemological ideals that prescribe how research should be done and what knowledge should look like. The main paradigms within which scientific research is conducted are the *quantitative* and *qualitative* paradigms (Neuman, 2000).

3.2.1 Qualitative and Quantitative Research

3.2.1.1 Qualitative research

Qualitative research is 'a broad approach to the study of social phenomena' (Marshall & Rossman, 2006, p.2). Through investigation a complex and holistic picture of the phenomenon or event is constructed (Neuman, 2000). In order to construct this picture, qualitative research is conducted in a natural setting (Marshall & Rossman, 2006). Data can be in the form of words, pictures or objects (artefacts) (Neuman, 2000). The researcher generally adopts an inductive approach to uncover and discover themes, categories and patterns within the data that will explain the phenomenon of interest (Lee, 1999). Differing patterns emerging from the same setting enables the researcher to understand the social or human problem from multiple perspectives, yet as an interwoven whole (Maykut & Morehouse, 1994). Moreover, qualitative research contains individual interpretations of events which makes it more subjective in nature (Flick, 2006.) Since it focuses on aspects such as contextual detail and individual meaning making, qualitative data are generally more rich, time consuming, and less able to be generalized (Neuman, 2000). In qualitative research the researcher is considered the

primary data-gathering instrument and the research design generally emerges as the study unfolds (Neuman, 2000).

3.2.1.2 Quantitative research

In contrast to qualitative research, Neuman (2000) state that the aim of quantitative research is to develop generalizations that enable the researcher to predict, explain, and understand some phenomenon. The underlying assumption is that social reality, like natural phenomena, is something that can be studied objectively. Hence, the researcher should remain distant and independent of what is being researched (Neuman, 2000). The researcher seeks precise measurement and analysis of target concepts that could be replicated at a later study (Lee, 1998). Data are expressed through numbers and statistics analysis (Thomas, 2003). Quantitative data are more efficient in its ability to test hypotheses and cause-effect, but may miss the finer nuances of contextual detail (Neuman, 2000).

In lieu of the primary research question, this study aligns itself with the qualitative paradigm in that it seeks to provide a rich and detailed portrayal of the effect of a new curriculum on Deaf learners. Moreover, it aims to alert the reader to recurring patterns and themes that emerged during the transformation, but also to capture the subtleties and the subjective responses of the learners to the change in classroom circumstances. It is argued that deep descriptions of the different issues that learners deal with during their mathematical experiences may contribute to teachers' gaining more intimate knowledge which could be used to assist in higher level learning achievement. In the event of teachers encountering similar situations, it is posited that a holistic recounting of events may prevent such teachers from feeling at the mercy of the circumstances produced by a change in curriculum. Rather in depicting the situation from multiple perspectives, they may feel better able to

respond to the challenges presented by a reform curriculum. In contrast, a quantitative approach would be helpful in ascertaining the effectiveness of the programme, but may contribute little to preparing teachers and learners for the underlying classroom dynamics that may emerge during the transformation period.

In particular the action-research approach has been selected from the qualitative continuum to allow the teacher to assume the roles of both teacher and researcher at the same time (Cunningham, 2000). Kemmis (2007, p.122) describes action research as 'a process of self-education through self-reflective projects'. One assumption of action research is therefore that knowledge is generated through critical reflection on practice (McMillan & Schumacher, 2006). Carr & Kemis (1986, cited in Martin, 2007) likens the nature of the reflection to a continuous spiral of planning, acting, observing, reflecting and planning again. Through this spiral strategies emerge of how to intervene in the cultural, social and historical processes of every day life. Ultimately, transformation stems from reflection. It is through reflection that one learns about and understands the problem and later evaluates the effects of any reconstruction. Subsequently, action research presupposes a relationship of 'reflected practice and practice-orientated reflection' (Altrichter, 1993).

Deciding on a research paradigm depends on the objectives of the research projects. For the purposes of this study an autoethnographical research orientation has been deemed suitable.

3.2.2 Autoethnography

One reason for selecting an autoethnographical approach is found in Patton's (2002. p.85) definition of autoethnography as 'the study of a culture and oneself as part of the culture'. Essentially autoethnography implicates that the researcher's own every day experiences within a culture are used to gain insight into that particular culture (Moisander & Valtonen, 2006). In the specific context of

this research, the researcher's objective is to use teaching experiences in classrooms for the Deaf to gain insight into Deaf learners and pedagogical practices pertaining to schools for the Deaf. This is in line with Frakenstein and Powell's (1997) argument:

> We need to learn about how cultural practices—daily practice, language, power, and ideology—constitute people's views of mathematics and their ways of thinking mathematically. Learning about these views and ways of thinking are opportunities to deepen our mathematical, epistemological, and pedagogical knowledge. (Frakenstein & Powell, 1997, p.2)

Another reason for working within the ethnographical paradigm relates to McIlveen's (2008, p.2) definition of autoethnography as 'a qualitative method of reflexive enquiry for narrative research and practice that specifically addresses the stories of the scientist and the practitioner'. The objective of this research is also to tell the story of what happened in a particular mathematical classroom with Deaf learners through the lens of teacher reflection. As indicated in the literature review, there is a strong drive towards reform mathematics supported by several academic arguments and research findings. However, my own stance is that one has to conceptualise how curriculum change within a specific context of learning may have a strong relational effect. Such an effect occurs on multiple levels between teachers and teachers, teachers and learners, learners and learners, learners and their own selfs, parents and teachers and parents and learners. It is by engaging in reflection grounded in culture, minority voices, pedagogical theory, everyday experiences and relational events that one can begin to tie these dynamics together in an attempt to make sense of the real affect of a new way of teaching mathematics and the direction of its development.

One particular advantage of authoethnography is its ability to enhance a research situation or story by conveying 'a lived experience' (McIlveen, 2008, p.3). Such experiences help to provide rich

emotive and intimate accounts of the phenomena under investigation. Moreover, it tries to capture what the experience 'felt like in practice', with particular reference to the dilemmas and contradictions (Quicke, 2007). Hence, although a large part of this research involves the reflections of the teacher, it also desires to describe what if *felt like* for the learners to transit from one mode of mathematics to another, and their personal experiences of the barriers they encountered along the way. Providing such subjective accounts of practice assist in breaking down 'the dichotomy between subjectivity and objectivity, between action and reflection, between teaching and learning, and between knowledge and its applications' (Frakenstein & Powell, 1997, p.2). Moisander & Valtonen (2006, p.64) elaborate that when a methodology dissolves the aforementioned dichotomy it challenges 'the divide between the researcher and the researcher'; the 'ideology of detachment' and the 'insularity of academic writing' found in more conventional academic practices. Simply put, authoethnographical accounts help to bridge the gap that may exist between theory and practice in a given educational domain thereby rendering knowledge that are potentially more insightful with respect to the situation and subsequently, more meaningful to other teachers (Ellis, 2004; Moisander & Valtonen, 2006; Quicke, 2007; McIlveen, 2008).

Moreover, Dillabough (2002) posits that autoethnographical narrative allows the researcher to connect with the culture by 'peeling back multiple layers of consciousness, thoughts, feelings and beliefs' (Dillabough, 2002, p.128). Simply put, the teacher can unpack layered classroom issues in order to interact more intimately with learners. It is not enough to merely alert the reader of the intention to implement a reform curriculum substantiated by the recommendation of academic literature, and then write about the degree to which the subsequent outcome was effective or not. The very act of curriculum implementation coupled with adjustments in orientation necessitate 'a peeling back of multiple layers on multiple levels'. In getting a new curriculum to work one has to confront the history of the institution, the ideology of the Deaf culture and their beliefs about education, the

ideology of the hearing culture and their beliefs, the ideology and the beliefs of the students themselves with respect to teaching and learning, and then also the expectations of the parents (Edwards and Miller (2007). One is therefore immediately wrapped up in a conglomerate of diverse (and most often contentious) feelings, reasonings and responses. Autoethnography is powerful in illustrating such developments and to show through the researcher's reflection one possible way of making sense of the situation.

The way the story is told requires a particular genre. Patton (2002) discusses the style of writing common to autoethnographical studies. He indicates that the first person voice is used to convey personal experiences in a cultural setting. The style allows for the researcher to express feelings of vulnerability, doubts, weaknesses and uncertainties. Moreover, the writing simulates a sense of 'zooming', in so far as the researcher 'zooms out' to take into account the larger social and cultural aspects and then 'zooms in' to reflect how the inner self deals with the cultural interpretations.

Similarly Ellis (2004, p. xix) describes autoethnography as 'research, writing and method that connect the autobiographical and personal to the cultural and social. This form usually features concrete action, emotion, embodiment, self-consciousness and introspection.'

The highly personalised self-narrative genre in autoethnograpy is a form of sense-making in a culture. Dillabough (2002) states that 'we embed ourselves in stories until we find the story that makes sense, and that gives us power…'. Moreover, autoethnography illuminates the relationship between the individual and the culture by showing how the individual interacts with, resists, and shapes and is shaped by the organizational and institutional context in which s/he is situated (Marvasti, 2004). In this particular research two types of "individuals" are used to reflect the shaping process discussed here. The first section of Chapter 5 explores the shaping taking place within the teacher in response to the learners and other teachers within the institution and how it then

culminates in the consideration of a reform curriculum. The final section considers how the learners themselves 'interact, resist and are shaped' by the new curriculum. The emphasis on 'shaping' illustrates an underlying tenet of Edwards and Miller (2007, p.265) that learning is considered a practice of contextualisation and not one that simply emerges within the context. In other words, practices and learning emerge relationally and effects on how one conceptualize of mobilising learning and associated pedagogic practices. The aim of this research is not to show how particular mathematical activities or situated practice work itself out in a static context, but to depict the relational framings that support or inhibits the implementation of problem solving in a classroom for the Deaf. It is the latter that informs the selection of authoethnograpy.

The limitations of autoethnographical writings are however, that it cannot establish causal inferences. Its findings are local, and specific to particular practices. In other words, since the research design is based on a specific state of affairs, it cannot be universalised (Simons, 2000). Moreover, Patton (2002) cites Crotty (1998) that autoethnographical accounts are controversial in qualitative research, because of their strong subjectivism. An additional limitation relates to the element of bias introduced into an autoethnographical study. Firstly, the researcher's presence may bias the behaviour of those in the study (Gergen, 2009), but perhaps even more pertinent is that the ethnographer begins the study with biases and preconceived ideas about how people behave and what they think (Fetterman, 1998). Fetterman (1998, p.1) points out that even 'the choice of problem, geographical area and people to study' are in themselves biased from the outset. Whereas biases can be positive in that they help to focus the research, it is important that elements of bias remain controlled by ensuring quality checks such as making specific biases explicit, triangulation, contextualisation and non-judgmental orientation (Fetterman, 1998).

Although autoethnography entails writing about oneself as a teacher-researcher, Mosiander and Valtonen (2006, p. 64) indicate that authoethnographical writings are distinct from 'psychological or phenomenological inspired introspective traditions'. Moisander and Valtonen (2006) posit that the latter category uses introspection to reveal inner thoughts and feelings that are otherwise inaccessible. Authoethnograpy, however, uses the self to make visible cultural meanings and practices that may otherwise remain unexplored because of their 'taken-for-granted or marginalised manner' (Moisander & Valtonen, 2006, p.64). In other words, the authoethnographer has the potential to draw attention to positions that may go unnoticed in academic discourse, including acting as voice for issues that would generally remain silent. It is in particular the latter two points that led me to adopt an autoethnographical study. I posit that showing how Deaf learners orientate to a new curriculum should not be considered in isolation from the influences of the various cultures (particularly the hearing and deaf divide) and their ideologies. It is only in analysing the interaction between the cultural thought of the teachers and the learners and a new pedagogy that one can render a more meaningful interpretation of the learners' own orientation to mathematics. Moreover, it is in drawing deeply from the culture and by taking notice of various voices, and especially of the more silent ones in term of the learners, that one grows in awareness of both the overt and the hidden relationships, issues and patterns within the organisation. Within such as a framework one can more readily identify what is considered to be the real barriers within the institution to curriculum change – whether these be perceived or concrete. Taken from this perspective, Moisander & Valtonen (2006) assert that the moral, ethical and political standpoints contained in authoethnography, creates an alignment with critical theory, rather than with traditional introspection.

Likewise, McIlveen, (2008) posits that autoethnograpy is not the same as an autobiography. He argues that it differs from an autobiography in that it is more than the telling of a life. In particular, autoethnography is a form of enquiry that is embedded in theory and practice (McIlveen, 2008).

McIlveen (2008, p.3) elaborates that the enquiry may align itself with either 'constructivism-interpretivism' or 'critical-ideological' paradigms. For the purpose of this study, the autoethnographical account will be aligned with critical pedagogy.

3.2.3 Critical pedagogy

Critical pedagogy is concerned with reforming schools to achieve greater equity and excellence for culturally diverse groups and to promote a form of education that is more in line with democratic principles (Gay, 1995). Hence, critical pedagogy recognises that major problems of inequality exist within schooling. As indicated in the literature review, there exists a notable gap between the general performance of Deaf learners and their hearing peers. One of the essential components of critical pedagogy is therefore to analyse the disparities in educational opportunities and their consequences for culturally marginalised groups (Gay, 1995). In other words, the critical research paradigm is concerned explicitly with taking the sides of the oppressed or marginalised in ending societal inequality (Mertens, 2000). Giroux (1997) reiterates that 'genuine pedagogical practice demands a commitment to social transformation in solidarity with subordinate and marginalised groups'.

Although critical pedagogy recognises issues such as inequality and oppression through political, economic and ethical factors, it believes in reforming these structures by challenging the underlying values and cultural ethos. Gay (1995, p. 157) describes it as the 'pedagogy of possibility' that offers a strong sense of hope through potential change. Denzin (2003, p. 229) describes the hope in critical pedagogy as one that 'confronts and interrogates cynicism, the belief that change is not impossible or is too costly.' Hence, the imperative in critical pedagogy is therefore to design and implement educational practices that are more equilitarian and effective for culturally diverse population (Gay, 1995). As indicated in the literature review, Franco et al (2007) findings confirmed that a problem

solving curriculum has the potential as an educational tool to restore equality in mathematical performance, provided that teachers in lower achieving schools are willing to embrace the change.

Giroux (1992) attests that critical education operates on two basic assumptions in order to curb undemocratic social and cultural reproduction in schools. Firstly, it is a language of critique. Simply put, critical pedagogy questions presuppositions. It is the element of questioning contained in this assumption that aligns critical pedagogy with radical education. Giroux (1992, p.14) argues that radical education 'doesn't refer to a discipline or body of knowledge. It suggests a particular kind of practice and a particular posture of questioning of institutions and received assumptions'. Secondly, the goal of critical education is human empowerment. Giroux (1992, p.15) defines empowerment as the 'ability to think and act critically' with reference to oneself and to society for the sake of social betterment. In other words, education needs to bring people to a point where they know how to question themselves and the social structures in which they functions. Giroux (1992, p.15) contends this paradigm is also radical in nature when contrasted to more dominant education philosophies that teach people how to 'adapt to social forms rather than critically interrogate them'.

Within the framework of critique and human empowerment, teachers assume particular roles. Giroux (1992, p. 20) argues that critical pedagogy requires teachers to become 'transformative intellectuals'. Giroux (1992) elobarates that the notion of 'being a transformative individual' implicate that teachers are aware of their own theoretically perspectives and are able to translate these into skillful practices within the classroom. Moreover, teachers offer their own theories and beliefs to others in order to stimulate debate and critical enquiry. And, teachers play an active role in curriculum shaping and development. Stated differently, teachers are expected to critically consider the relationship between culture and learning and then to change the conditions under which they work. The critical paradigm contends that schools routinely perpetuate inequalities amongst marginalised groups

through underlying power relations, messages contained in the overt and hidden curricula, and through a lack of critical teaching and student empowerment (Gay, 1995). Hence, it is in combining a qualitative authoethnographical account together with critical pedagogy that one creates a space from which to make the hidden visible and the subtle more overt through reflexive practice. From within such a space one can take more meaningful measures to address inequality in mathematical performance within a school system.

In making the above considerations, the critical research paradigm requires that teachers look beyond surface reality (Parry, 2007) as 'surface reality is full of ideology, myth, distortion, and false appearances' (Neuman, 2000, p.79). In other words, teachers need to examine beyond the immediate observable experienced aspects of schooling to uncover deeper structures or unobservable mechanisms that hinder Deaf learners' from realising their potential in mathematics.

In exploring the deeper strata of a cultures and schools 'underlying power structures that may not be conscious to people yet have influence on the production of social reality' are likely to emerge (Parry, 2007, p.131). The 'deeper' social structures often represent oppressive power relations. Oppression is legitimised through ideology and maintained through political and economic power (Truman *et. al.* 2000). Subsequently, any insight or knowledge generated through research is used to engage oppressive social structures to advance the emancipation of the oppressed (Truman *et. al.* 2000).

One of the deeper underlying power structures embedded in traditional pedagogy is the 'banking approach to education' (Freire, 1994). Freire (1994) describes the banking philosophy as one in which teachers assume the role of 'depositing' knowledge into the learners. In this context, teachers 'own' education and transmit information they deem relevant to the learners, which the learners then passively receive. Since no critical thinking is required, Freire (1994) posits that the banking

approach leads to indoctrination, passivity and a submergence of the consciousness of the oppressed. Moreover, the passive acceptance of ideology facilitates the reproduction of oppressive structures in society through the mode of schooling. It is therefore a technique used by the dominant power to maintain the status quo without encountering significance resistance.

Hence, Freire (1994) argues that true transformation at school level requires that the banking approach be changed to a problem posing approach. The problem posing approach allows learners to view reality from multiple perspectives. It creates a setting for articulating and testing different ideas about society and the invidual's role in it (Nieto, 2004). In other words, the world is not seen as a static reality into which students must 'fit'. Rather, students are encouraged to see reality as a 'problem' that can be solved or transformed. As explored in the literature review [Section 2.2.2.3], the problem posing approach requires a reformulation of the traditional vertical relationship in which the teacher teaches students to a horizontal relationship where the teacher becomes a student with the student. Stated differently, students and teachers – learn from and teach one another and thus grow together. Stated differently, Freire (1994, p. 93) argues that 'authentic education is not carried on by "A" *for* "B", or "A" *about* "B", but "A" *with* "B".

In order for "A" to learn *with* "B" a specific type of discourse needs to be practiced in the classroom. Freire (1994) argues that in critical pedagogy discourse is fundamental to social transformation. Thus for Freire, the success of critical pedagogical practices depends on the ability to communicatively engage learners in educational experiences. The discourse encourages learners to recognise, name and address issues in society including asymmetrical power relations. Freire (1994) argued that problem posing education allows the true consciousness of people to emerge because it depends on communication, recognizes the relationship between people and the world and encourages inquiry. When these conditions are met, transformation is most likely to occur.

The reform mathematics introduced by this study embodies the characteristics of 'problem posing' education as detailed by Freire (1994). In the context of this research, Deaf learners are considered a linguistic minority that are marginalised and constrained by situational factors [See Section 2.5]. Ultimately, the researcher wants to make contributions to critical theory by creating a vision of possible mathematical equity between Deaf and hearing learners. In line with the philosophy of critical theory the aim of this research is to empower Deaf learners to orientate towards reform mathematics by engaging them in dialogue. The sample of learners that were selected for this study is discussed in the following section.

3.2.4 **Research sample**

The advice on active participation by minors is especially pertinent to this study because of the particular sample selected. In this design Deaf learners are considered the major stakeholders. More specifically Grade 9 learners with chronological ages ranging from 12 to 18 years have been selected as participants. All the participants are deaf and are part of a residential school for the Deaf where South African Sign Language is the medium of instruction.

The particular school where the study was conducted is situated in a well-off residential area on the outskirts of the third largest city in South Africa. Current enrolment averages at 100 children with ages ranging from 3 to 22 years old and with outliers of learners who are 18 months on the one end and 29 years old on the other side of the spectrum. The school provides an integrated preprimary, primary and high school section. It contains a cross-section of learners constituing day scholars who commute everyday, and learners who board in the residential facilities from Sunday night to Friday afternoon. In so far as possible, boarders are required to spend weekends at home in order to foster

familial relationships. Hence, the residential facilities remain closed over weekends. This particular school has relatively high school fees compared to the other Deaf schools in the province, which renders it the image of a more 'elite' environment, with a much smaller number of intakes. However, this does not mean that all the learners are from higher socio-economic backgrounds. Rather, the school hosts a programme called 'Adopt-A-Child' by which donors are afforded the opportunity to sponsor a particular individual's school fees. Subsequently, significant portions of learners fall within the lower socio-economic strata. The official language policy of the school is bilingualism constituting of Sign Language and English. The language policy, however, is not strongly enforced which results in certain teachers practicing bilingualism whilst other resort to forms of Total Communications. Even amongst the learners there are those who prefer a neat bilingual approach, whereas other learners formally request of the teacher to speak and sign at the same time. The language policy of the school, however, has been subject to much change since the formal establishment of the school 50 years ago. Initially the school started out as an exclusively white school in the Anglican tradition with a staunch oralist approach. . It then progressed through oralism (1950 – 1980), sign-supported English (1980 - 1995), American Sign Language (1990) and South African Sign Language (1995 –1999) to its current policy on bilingualism (2000 – 2008). Elements of all these different movements are still found and practiced within the teaching setup.

Not only linguistically, but also from a racial aspect the school has also undergone radical transformation over the last two decades. Since the collapse of Apartheid, the school has transformed to a multi-racial set-up of which the majority of the students are Black. The Black communities in the areas have developed different signs to the whites which in turn adds an additional element to the already diverse language practices within the school.

In accordance with governmental policy the Revised National Curriculum Statement is followed up to Grade 9. At the end of Grade 9 pupils complete the common assessment task. In Grade 10 learners commence with the Further Education and Training Curriculum. At the end of Grade 12 learners are expected to write the national Senior Certificate.

The target population for this study consists of deaf learners who are doing mathematics at a high school level. The choice to involve the Grade 9 learners in particular incorporates elements of both convenience sampling and of purposive selection. The choice of a social setting, i.e. the school where the research is to take place, was taken on the basis of convenience. Since I was already teaching in the setting, doing research locally helped to minimise travelling costs, while maximising interaction time with the learners. Additionally, the authorities and parents associated with the school were familiar with me, which meant that I could negotiate permission for research and access to the learners more readily.

As indicated above, I was already teaching mathematics at high school level within this particular institution. My initial postgraduate studies, however, took place under the college of law. In contrast to my studies, my own working history is one of training in so far as I have been involved in numerous private companies as an ICT instructor in basic computer literacy over the last 15 years. Throughout this span of my career, I was actively involved in computer training programmes for disadvantaged youth through weekend and evening classes. I started my studies in mathematics with the goal of shifting to computer science. However, instead of continuing with further modules in computer science, I moved from private training into school teaching. I taught various subject, including mathematics, at high school level at a private hearing school whilst completing my certificate in education. After relocation to another province, I decided to fulfill a longstanding personal goal to learn sign language. This particular school allowed me access as a volunteer in order

to gain exposure to South African Sign Language. I was then asked to teach the multiple handicapped special needs class for one year, before transferring to the high school section the following year. During this time I completed postgraduate studies in Deaf education through a local university and also completed several university courses in mathematics in relation to the Further Education and Training syllabus. Thus at the time of the research, I have been teaching formally in a school setup for 3 years, have completed postgraduate studies in Deaf education, and undergraduate work in mathematics. Moreover, training in Sign Language for new staff members is a compulsory aspect within the school. Hence, I have been receiving ongoing sign language tutoring once a week for two years for which I was awarded a Sign Language Level 2 certificate.

Hence, whereas the choice of school was influenced by convenience with respect to my own situation, electing the Grade 9 class from within the particular school was a purposive decision. The decision was based on the richness of diversity found in the class. The class incorporated one oral Deaf learner who has been mainstreamed until that year; four learners who have been attended the particular school since preschool and have been receiving instruction through Sign Language; one learner who attended the school, but was removed to be home-schooled for a period before returning to school; and a learner who comes from a traditionally rural Deaf school where Sign Language was also the medium of instruction.

In addition, there is a marked literacy variance in the class. Two of the learners show evidence of literacy, 3 appear to be semi-literate, while 2 appear functionally illiterate. The representation in the class allows for information to be collected across a spectrum. In the context of purposive sampling collecting data from a wider spectrum does not necessary carry with it the objective to generalise to a larger population. Rather, the motivation is to gain a deeper understanding of types (Neuman, 2000). An understanding of how ‘a type’ of Deaf learners responds to problem solving mathematics, will

help to debunk myths such as the myth of homogeneity. However, being in such a small setting protecting the privacy of the learners became a concern. Hence, the learners' identities were altered in order to ensure anonymity. Additional concerns include that the sample consisted of a very small number of learners, hence no statistically significant inferences can be made. The sample, however, is reflective of the average class size within the school with a range of between 6 – 11 learners per class. Nevertheless, based on the wide range of differences amongst the learners in terms of race, socio-economic background, family history, cultural practices, geographic backgrounds, academic proficiency levels of literacy, and previous school history it cannot be assumed that this class is a general portrayal of the larger cohort of Deaf learners within the school or in the larger community.

Moreover, active participation by minors require additional measures which will ensure that the learners understand what the project is about, and which will teach them how to ask questions and become part of the process for others to listen to their experiences and hear their voices (Hall & Hall, 2000). The next section will explore the concept of involving learners in research.

3.2.5 Engaging minors in research

Having children participate in research evaluations has up to now not been the norm. Star and Smith III (2007, p. 13) quote Corbett & Wilson saying that 'young people themselves occupy at best, a minuscule part of the literature on the process of changing and reforming education". Hence, a concern can be raised that the major stakeholders comprise a group of minors. Hall & Hall (2004) respond to this concern as follows:

> Children are increasingly being recognised as social actors able to comment on social situations, and research methods are being developed and adapted to increase the validity of data from interviews and surveys. *When the evaluation of a programme serving children is called for, children's views have to be taken into account.* (Hall, 2004, p. 124, my emphasis).

Similarly, Star and Smith III (2007) advocate that there is a void in research on how high school learners experience day to day mathematics. These authors advocate the need for high school learners to have a voice in reform mathematics. Knowing how learners make sense of their activities is useful for both pedagogy and curriculum development. These authors advocate that there is a need to examine how high school learners experience day-to-day mathematics. Moreover, high school deaf students and Gallaudet students looking back on their schooling, affirm their desire to give input into the curriculum and school policy. They propose that schools can serve deaf learners better when they start seeing them as resources, and not just consumers (Rittenhouse & Kenyon-Rittenhouse,1998). Hyde (1992) affirms that the function of curriculum negotiation with learners is predominantly an issue of appropriate design toward optimising the learning process.

> Negotiating the curriculum is not an alternative teaching strategy or a way of breaking the monotony of the second term. It involves the development of the teacher's understanding of the learning process and of how to provide conditions in which learning can best occur. It is a curriculum design that is developed by students and teachers in the classroom. (Hyde, 1992, p.53)

Nevertheless, Giroux (1992) contends that a sudden exposure to critical thinking on curricula matters may be very hard for learners. They may not have the vocabulary or the frame of reference to call into question their own experiences or to address fundamental aspects of what teaching should be. Yet Giroux (1992) continues to encourage teachers to engage learners.

> You can't deny that students have experiences and you can't deny that these experiences are relevant to the learning process even though you might say that these experiences are limited, raw, unfruitful, or whatever. Students have memories, families, religions, feelings, languages and cultures that give them a distinctive voice. We can critically engage that experience and we can move beyond it. But we can't deny it. (Giroux, 1992, p. 23)

Similarly, Hyde (1992, p.53-54) cautions that learners may react diversely to offers of curriculum negotiation. She identifies four types of learners. Firstly, there are students who will be '*thankful and amazed'* at the offer (Hyde, 1992, p.53). These are usually students who are interested in school and learning. Other students may view the offer with '*suspicion*' (Hyde, 1992, p.53). These are students who do not trust the intention of teachers, and will require ample praise and encouragement to become more enthusiastic. Some students will be '*dismayed'* at the idea, because they cannot understand how they will learn anything if someone else does not tell them what to do*(*Hyde,1992, p.54). Such students need a lot of attention and guidance to become more confident in their own judgements. They are usually students who have experienced a lot of failure and have little self-confidence. Finally, there are students who may react with '*contempt' (*Hyde,1992, p.54). These students may feel that the teacher is shirking his/her responsibility by not prescribing to the class and by allowing students to help each other. They are students who generally thrive on the competitive and prescriptive atmosphere. These learners are more judgmental in nature, resentful of helping other

students, and are most likely to express their disapproval by complaining about discipline issues in the classroom during the sessions.

Yet the essence of the research, and the particular value it ascribes to involving learners, are affirmed by Dossey, Giordano, McCrone and Weir (2002) in their advice on how high school teachers should teach mathematics.

> Learning to teach is a journey. Along the way you will encounter a number of individuals that will significantly alter your approach to teaching mathematics…Perhaps the ones that you will learn the most from are your students. Watch what they do and say as you work to get them involved in learning and using mathematics. See what works well. Examine why some methods work better than others. Reflect on your teaching and share your reflections with other teachers so that you can learn to grow better together. (Dossey, Giordano, McCrone & Weir 2002, p.590).

Hence, it was decided to maximise the experiences of Deaf learners as a resource in mathematical development.

3.3. DATA COLLECTION

Once the invitation was issued, all the learners agreed to be involved. Learners were afforded an opportunity to question the research, following which a Deaf adult interpreted the participant information form for the learners, and the minor consent form was signed. Once permission was obtained from the learners and their parents, the data collection phase began.

At the start of the data collection phase the learners were asked to complete the Students' Orientation to Mathematics (SOM) questionnaire to ascertain their general orientation towards mathematics. In addition, a group session was held to clarify the mathematical goals of each learner and to discuss the starting point of the research. In subsequent sessions focus groups were conducted fortnightly as an assessment tool for obtaining data concerning the needs and concerns of Deaf learners as they worked with problem solving mathematics. Additional insights were gained from observing the process of and experiences with problem solving mathematics during class work and these were recorded through regular evaluation tools. The objective of recording these insights was to reveal challenges and future requirements that would need to be addressed for an effective implementation of reform mathematical activities. The regular evaluation tools that were used to collect data during this study, and their levels or reliability and validity, are detailed in the following section.

3.3.1 Data collection techniques

As indicated before, at the onset of their studies, students within the sample were surveyed. A survey is useful in quantitative research studies to collect information from participants in an objective way (Neuman, 2000, p. 34). During the survey, primary information relevant to the research question was gathered from the students. The survey involved administering the SOM questionnaire to the Grade 9 students

3.3.1.1 Structured questionnaire

The SOM questionnaire was developed locally for South African learners (Maree, Prinsloo & Claassen, 2006). It measures five fields, namely study attitude (SA), mathematics anxiety (MA), study habits (SH), problem solving behaviour (PSB) and study milieu (SM) pertaining to mathematics.

The Manual for the SOM questionnaire describes each of the aforementioned fields as follows (from Maree, Prinsloo & Claassen, 2006):

a) Study attitude

Study attitude has bearing on feelings and attitudes that are consistent and affect pupils' motivation and interest in mathematics. The category includes pupils' mathematical world view as it relates to self, to the nature of mathematics and the nature of learning mathematics. Hence, various factors including the enjoyment of the subject, self-confidence and the usefulness of mathematics are taken into account. Pupils' study attitude can be regarded as the driving force behind their study habits.

b) Mathematics anxiety

This category measures feelings of panic, anxiety and concern that may manifest in mathematics. Emotional liability undermines learners' self-confidence and may inhibit their risk-taking attitude and delay their cognitive functioning.

c) Study habits

This field depicts the extent to which learners display consistent and effective study methods and habits. It measures the learners' willingness to gain insight into mathematics, learn theorems, rules

and definitions properly and carry out assignments in a focused manner. Moreover, it considers whether learners keep homework up to date, keep up in mathematics and avoid wasting time in class.

d) Problem solving behaviour in mathematics

Cognitive and meta-cognitive learning strategies in mathematics are considered. These include planning, self-monitoring, self-evaluation, self-regulation and decision making during the process of problem solving. Moreover, it extents into using strategies such as searching for patterns and relations, estimating and approximating answers, trying alternative methods and considering the overall structure of mathematics.

e) Study milieu

The study milieu considers three sub-sections, namely the social, the physical and the experienced milieu. The social milieu considers the background and home environment of the individual. Often restrictive circumstances at home can produce non-stimulating learning and study environment. The physical milieu is concerned with the learners' ability to see and hear well. The experience milieu takes into account the language background of learners. Often second-language learners may be at a disadvantage in understanding the specific language of mathematics, which may undermine their performance and inhibit mathematics achievement.

The table below records the reliability measures of the questionnaire.

FACTOR	DESCRIPTION	RANGE OF RELIABILITY COEFFICIENTS
Study attitude	Attitude and beliefs related to mathematics	0.728-0.800
Mathematics anxiety	Extent to which anxiety is experienced while doing mathematics	0.739-0.790
Study habits	Display of acquired, yet consistent and effective study methods in mathematics	0.786-0.790
Problem solving behaviour	Cognitive and meta-cognitive learning strategies in mathematics	0.661-0.785
Study environment	Extent to which learning and study environment is restrictive	0.713-0.765

Table 3.3 Dimensions of the SOM and reported reliabilities for Grade 9-11 Learners (Eiselen, 2006)

The criterion validity of the questionnaire was tested in three separate studies (Eiselen, 2006) with absolute values of these correlations ranging from between 0.1 to 0.4.

Hence, the advantages of the SOM questionnaire are that is that it has been developed for South African learners, and that it possesses strong indicators of reliability and validity.

A disadvantage of the SOM questionnaire, however, is that it is susceptible to social desirability bias. Participants want to look, and it is easy for them to choose an answer on the questionnaire that will make them look good (Kelvin, 2007).

Considering the advantages and disadvantages of the questionnaire, the SOM was deemed appropriate for the measurement of the affective and behavioral domains pertaining to the current study. After contacting the original developer of the SOM (Maree, 2004-2005), the researcher was granted permission to use the SOM for the purposes of the intended study. The Student Orientation towards Mathematics (SOM) questionnaire was used to assess learners' orientation towards mathematics both before intervention and immediately thereafter. This intervention served as a type of baseline assessment, and also as a source of validation. Adaptations were required to accommodate the needs of Deaf learners. One such an adaptation was asking a Deaf adult or suitable interpreter to sign the questionnaire in class. This intervention is necessitated by low literacy levels common amongst Deaf learners (The Wits Centre for Deaf Studies, 2008).

3.3.1.2 Observation

Nine weeks were spent in the classroom implementing problem solving mathematics among Grade 9 Deaf learners. I would observe the lessons myself three times a week whilst teaching. Each lesson was 40 minutes in length, with a double lesson taking place mid-week. Observations were made throughout the teaching and learning process. During this time comprehensive field notes were taken and broad questions asked about the orientation of the learners towards problem solving mathematics. Although a semi-structured observation schedule [see Addendum F] was used to assist the observation, attention was directed towards how the learners engaged with the problems, particular dispositions they were expressing and specific problems they encountered. The interaction between the learners was also noted. This situation provided first hand experience of the issues that developed when a reform curriculum is introduced. As was noted in Section 3.2.2 the teacher who is fulfilling the dual role of researcher carries with her an element of bias from the outset. In other

words, as teacher one has preconceived concepts about the learners and their work, which affects how and what one observes. As a control measure against this type of bias, another teacher acted as co-researcher by coming in to observe and give feedback from an outsider perspective in the form of a written report. This particular teacher was trained in Deaf education and also involved with her own research project through the university. Although hearing, due to her attained qualifications in the field of Deaf education, her proficiency in Sign Language and her familiarity with the process of research she was deemed a suitable to act as a measure of quality control and triangulation during the observation process.

3.3.1.3 Qualitative interviews

Four semi-structured focused group interviews were conducted fortnightly to reveal diversity, clarify contradictions, and amplify certain issues and to make amendments. In doing so, the focus group interviews acted as a source of validation (Mouton, 2006). The purpose of the focus group was to act as a vehicle to bring forth the issues the group considered most prominent at that particular time. In other words, the focus groups were designed to sensitively 'listen to the 'voices' of the Deaf' in order to develop intervention that represents the experiences of those with the least power (Hall & Hall, 2004). All seven of the learners participated in the focus group session, except for one session where a particular learner left school earlier during the day due to familial arrangements. Each session lasted 45 minutes. The sessions were facilitated in Sign Language by the teacher who was described in Section 3.3.1.2 as the one who acted as observer of the class during the week. Questions from the semi-structured interview schedule [Addendum A] were mostly used during the group sessions, but opportunity was provided for any party to raise additional points of discussions or questions. Permission was obtained from the learners and their parents/guardians to videotape the sessions.

Thereafter the video sessions were transcribed with the help of a Deaf adult to ensure that what the learners communicated were interpreted clearly and correctly. A particular bias of the focus group session is that my own presence as a researcher/teacher could constrain the learners from expressing their true feelings or perceptions of the new programme.

In order to curb the potential bias created through the presence of the teacher/researcher during the focus group sessions, individual interviews were conducted at the end of the data collection stage. Each Deaf learner was interviewed in private by a Deaf adult through the medium of Sign Language. The Deaf adult was asked to sign a form to indicate that she would keep the content of the interviews confidential. The interviews lasted between 15 and 45 minutes depending on the learners' own need and style of expression. The focus was in particular on these learners' personal salient experiences of problem solving mathematics and was directed by the questions in Addendum [B]. The personal interviews were also videotaped and transcribed. The rationale behind the observations, focused group sessions and individual interview sessions was to investigate issues such as self-motivation; daily study habits; underlying feelings of boredom; learners' perceptions of the outcomes of participation in the programme; learners' perception of methodology of the worksheets and of self-learning; underlying feelings towards mathematics; any perceived anxiety towards mathematics and mathematics tests; aspects the learner identifies as having changed because of participation in the programme; any changes in how learners feel about mathematics because of participation in the programme; the level of interest and belief in ability to pursue a career involving the sciences and mathematics (adapted from Tjisse, 2002).

The reliability and the validity of observation and interviews differ in nature from that of the SOM questionnaire. This is because the SOM questionnaire is a quantitative research instrument, where as observation, focused group sessions and personal interviews are generally associated with qualitative research. In quantitative research, reliability means dependability (Neuman, 2000); consistency of measure over time and across settings (Marczyk, DeMatteo & Festinger, 2005); or producing stable, consistent scores that are not strongly influenced by chance/random error (Kelvin, 2007). Hence, the reliability of the SOM questionnaire is portrayed in terms of a range of reliability coefficients over time.

On the other hand, Neuman (2000) explains that definitions of reliability are applied differently in qualitative practice. The setting and dynamics of qualitative research call for the differences in application. More specifically, qualitative research often takes place in a natural milieu where processes are not stable over time. Rather, continual changes are experienced particularly in the interactions and the relationships between the researcher and researched. This does not mean that qualitative research is erratic in its approach. It does mean, however, that consistency is achieved through using a variety of techniques (e.g. interviews, observation, document students) to record observation, rather than through the test-retest method (Neuman, 2000). Consequently, reliability in this study will be achieved by triangulation of method. Flick (2006) argues that triangulation can take the form of combining several qualitative methods, or of combining qualitative and quantitative methods. It is conceived that the different methods complement one another and in doing so compensate for the weakness of a single method (Flick, 2006).

Similarly, Neuman (2000) points out that in qualitative research validity is closely associated with truthfulness. Truthfulness is secured through authenticity. Authenticity means ‘giving a fair, honest and balanced account of social life from the view point of someone who lives it everyday’ (Neuman,

2000, p.171). In other words, there must be a strong degree to which the social world described by the researcher matches the world of its members. More specifically, the researcher must provide an insider perspective by being true and candid about the experiences of those being studied.

McIlveen (2008) applies the principles of validity in qualitative research to authoethnography. He posits that autoethnographic narrative analysis should meet two particular conditions when reporting experiences. Firstly, the rendering of the author's experiences must be faithful and comprehensive. In other words, the writing should reflect fairness, authenticity and meaningfulness. Secondly, the writing should show how the author was transformed through reflection and self-explication. McIlveen (2008, p.4) refers to the latter as 'educative authenticity and catalytic authenticity'.

As noted in Section 3.2.2 an ethnographer is faced with the issue of subjectivity, which could exacerbate the risk of not providing a truthful account of the experiences. Measures were taken within the study to work with a colleague as a form of member check. Moreover, the findings of the research were presented to the staff during which opportunities were created for engagement, evaluation and validation of data. Special care was also taken to consult with Deaf teachers and adults within the school to secure a more balanced interpretation of events from a Deaf perspective.

Together with meaningful reflexivity, transformation and authenticity, there are additional criteria that may be taken into account when judging authoethnographic narratives. Quicke (2007) cites Richardson (1995) in this regard. Richardson (1995) requires that the accounts make a substantive contribution to understanding life as a teacher within the Deaf set-up. Moreover, the stories need to succeed aesthetically. Simply put, they must contain a sense of complexity that prevents boredom, generates new questions and evoke in the reader a sense of having lived the experience.

An alternative form of validity is convergent validity (Neuman, 2000). This is obtained when the findings of multiple measures converge. In other words, when similar findings are yielded through the various data collection instruments, including the observations, interviews and structured questionnaires.

In addition to reliability and validity, the ethical issues pertaining to qualitative measures must also be considered. Ethics cover a broad range of concerns. Some ethical considerations particularly relevant to this study are outlined in the next section.

3.4 ETHICS

During the study sensitivity was shown to common research ethics to prevent irresponsible behaviour on the part of the researcher and to protect participants from physical, psychological and legal harm. The learners were not inconvenienced, as they participated in the research during formal mathematics class. Moreover, the content of the mathematics corresponded with the Grade 9 mathematical learning outcomes specified by the Department. Informed consent was obtained in writing from the participants' parents or guardians. Subsequently, only learners whose parents or guardians provided written consent for their children's information to be used were involved.

The ethical integrity of this study was maintained by conducting the study in collaboration with the Department of Deaf Studies at the Wits. All research findings were reported with full disclosure of the research methodology and the limitations of research. Moreover, the privacy of the Grade 9 learners and the anonymity and confidentiality of their records were secured.

One particular aspect that needs to be addressed is the ethical issues that arise when a teacher simultaneously fulfills the role of researcher.

3.4.1 Teacher/Researcher conflict

In the present educational climate, teachers are expected to be active as a teacher and as a researcher simultaneously (Johnson, 1993; Wilson, 1995; Kincheloe, 2003; Nolen & Vander Putten, 2003). This means that 'teachers are themselves involved as researchers, or collaborators in the research process, in their own teaching situations" (Nixon, 1987, p.21). Subsequently, conflict may arise between traditional and action-orientated approaches in terms of the role of the researcher as a neutral outsider or an active insider working as an agent of change (Wilson, 1995; Wong, 1995; Kincheloe, 2003).

Several advantages have been cited in the consideration of a teacher as a researcher. It is generally argued that when teachers begin to study their work themselves rather than only having their work being studied by others, teachers' practice and professional development will be enhanced in several (Johnson, 1993; Wilson, 1995; Kincheloe, 2003; Nolen & Vander Putten, 2003). Examples include that research encourages scepticism in that teachers have the opportunity to question 'common sense' and 'taken-for-granted' assumption that may enjoy widespread credence (Nixon, 1987). In addition, because teachers are allowed to implement new ideas and reliably assess their effectiveness, their research will most likely inform practice in a more meaningful and lasting manner as it relies on a logic-in -use rather than abstract generalisations (Nolen & Vander Putten, 2007). By way of summary, it is argued that the teacher-researcher role will cultivate teachers' capacities as a self-direct professionals by encouraging teachers to build reflective practices and

make confident instructional decisions, based on proven techniques (Johnson,1993; Kincheloe, 2003; Nolen & Vander Putten, 2007).

On the other hand, the possibility of tension or conflict developing when a person has to fulfil the role of researcher/teacher within the complex classroom environment need to be assessed from an ethical and a logistical aspect (Wong, 1995). In doing so, a number of methodological issues need to be address.

Firstly, the research paradigm that is adopted must allow scope for the teacher to be active as an insider. For the purpose of this study an autoethnographical approach has been deemed suitable to allow the teacher to work with the learners in order to bring about change.

Secondly, in the teacher as researcher model the accountability issue needs to be addressed. It is suggested that the teachers/researchers subject their own practices to critical scrutiny by colleagues (Nixon, 1987). Subsequently, to alleviate some of the role conflict in this particular study, the art teacher will become the researcher during mathematics lessons, and the mathematics teacher will become the researcher during art lessons. In such events, one particular source of tension is that teachers fear being exposed in a negative light (incompetent, etc.) by their colleagues. Hence, to protect teachers from being gossiped about by fellow colleagues and from any other misuse of information, ethical procedures need to be maintained. Of particular relevance is the principle of confidentiality, and the principle of participants having control over their own data following a democratic evaluation (Nixon, 1987). This means that participants have control over what is given and released to outsiders.

Thirdly, there is the issue of validity. In order to ensure validity, the teacher-researcher must be able to trace generalisation made in the research study to clear records.

Fourthly, general principles related to research such as three ethical principles: respect for persons, beneficence, and justice must be applied to the research setting. Other ethical principles involve informed consent, voluntary participation, risk and benefits being clearly communicated to the participants before hand. Nolen and Vander Putten (2007) suggest that a board should be established to oversee such situation in teacher practice. However, for the purposes of this research the Wits School of Education will oversee that such procedures are in place.

SUMMARY

This study assumes a qualitative framework in the form of action research to produce an autoethnographic account situated in critical pedagogy. Such a framework was deemed suitable considering that the research is focused on Deaf learners who are considered a culturally diverse minority; and when taking into account that inequality in mathematics education exists between the Deaf as minority group and the hearing as a majority. Hence, the long term objective of this research is to advance equity in education by studying how Deaf learners respond to reform mathematics. Moreover, this study made use of critical pedagogy's notion of problem posing as a way to empower Deaf learners to achieve and transform their situation. More specifically, the idea of problem-posing is inherent with the reform mathematics curriculum. At the same time the study tried to achieve authentic education reform by facilitating constant dialogue between the learners and the researcher/teacher. Subsequently, Deaf learners were given a voice with regards to the changes

implemented into their classroom. Special ethical safeguards were provided to protect the learners as minors and to accommodate the role of teacher as researcher.

The following section details the analysis of the data collected in this study using the methods described in this chapter.

CHAPTER 4

DATA ANALYSIS

This chapter will consider the data that were collected using the instruments and methodology discussed in Chapter 3. Responses to the research questions from the learners, parents and teachers are analysed and interpreted.

The data were collected together with a fellow researcher and though both our studies address different questions, we use the same data set. This particular study was set up to examine how Deaf learners orientate to problem solving mathematics. For this information to be interpreted meaningfully, the researcher needed additional information with regards to Deaf learners.

Firstly, the researcher was interested in the behaviour of Deaf learners in mathematics classes. In other words, it was necessary to know how Deaf learners orientate to mathematics in general. Gaining understanding into this aspect enables the researcher to become aware of similarities and differences between the learners' general orientation to mathematics and their orientation when a problem solving curriculum is introduced. Stated differently, more meaningful comparisons and conclusions can be made when the researcher is aware of what is happening in other mathematics classes within the school. Since the school size is very small it contains only one Grade 9 class. The Grade 8 class was not used in the study since the teacher/researcher was also this teacher for this particular class. The Grade 10 and higher classes could not be interviewed as these form part of the FET phase which follows the NCS and not the RNCS. To gain insight into mathematical performance within the school the primary school teachers were interviewed. In this particular school, the primary section no longer has subject specialists. They adhere to a more general teaching approach where each educator is assigned a particular grade. The educator is then responsible for

teaching all eight learning areas to his/her class. Hence all the primary school teachers provide some level of mathematical education to Deaf learners and could therefore contribute to the discussion on Deaf learners and their response to mathematics in the classroom. Altogether 6 primary school teachers were interviewed.

There are several reasons for interviewing primary school teachers as well as high school teachers. The Senior Phase in the South African setup covers Grades 7 to 9. Subsequently there is a formal extension from the primary school into the high school. Yet, a more significant aspect relating to this study is that four of the Deaf learners in the Grade 9 class "grew up" within the school system. Several primary school teachers therefore taught these particular learners and thus have a rich history and a familiarity with them. Discussions with these teachers are useful in constructing a more intimate profile of the learners and their backgrounds, in line with the aims of qualitative research to provide a complex and holistic picture of the phenomenon under investigation. Ultimately, poor mathematical performance appears to be a problem experienced throughout the school. Consequently, obtaining data from as many sources as possible offers one a much broader framework from which to gauge where barriers to mathematical learning start and how they developed as learners progress in their schooling career. It must also be borne in mind that within this particular school setup there is no sharp distinction between primary and high school sections as normally be the case in other schools. What is experienced in the high school is often echoed in the primary school section and vice versa.

Secondly, the researcher needed to know whether the particular attitudes, values and behaviour displayed by the Grade 9 learners were unique and limited to the mathematics class, or whether similar responses and attitudes were noticed in other subjects in which these learners participated. Should the behaviour be unique to the mathematics class, it implicates that the researcher should

more deeply explore the factors within the mathematical environment. However, should the behaviour be resembled in other subject areas as well, a much broader interpretation may be required. Subsequently, five high school teachers who taught the Grade 9 class in that year, were interviewed to ascertain whether corresponding teacher observations and experiences occurred in other learning areas.

In the next section the characteristics of the teachers who were interviewed and their responses, are detailed. Thereafter the input from the learners and the parents will be provided.

4.1 CATEGORISING RESULTS FROM TEACHERS

As was noted in the previous section eleven teachers were interviewed. The sample consisted of 6 primary school teachers and 5 high school teachers. All were working at the time in this particular school for the Deaf. A semi-structured interview was conducted with each teacher to ascertain aspects such as teaching practice, barriers to learning within the school system, use of problem solving, and further more (A more detailed list of the questions is provided under Addendum C). The interviews were conducted by myself and the aforementioned colleague who also acted as an interpreter for the Deaf staff members. The answers to the interview questions were written down and returned to the various staff members to verify their accuracy. The demographics of the teachers are detailed below.

4.1.1 Demographics of teachers' interviewed

Table 4.1 shows the demographics of the teachers used in this study.

Table 4.1

Sex	Females (10); Males (1)
Race	Caucasian (9); Indian (1); Black (1)
*** Fluency in Sign Language**	Low Level Proficiency (1); Moderate Level Proficiency (3); High Level of Proficiency (7)
Experience in Deaf Education	Range of 2 – 33 years

* The fluency in Sign Language was not formally assessed, but was based on self-reported data.

An additional factor to consider in the context of a Deaf school is membership to the Deaf community.

4.1.2 Membership to the Deaf community

Four of the teachers belong to the core Deaf community according to the criteria of Baker-Shenk & Cokely (1980), Woodward (1982), Higgens (1987) and Thornton & Ramphele (1988) as discussed in Chapter 2. Of the four, one teacher is hard of hearing and two are profoundly Deaf. In addition to these teachers sharing the physical experience of hearing loss, they have adopted Sign Language as their first language, affiliate strongly with the Deaf community and pride themselves on their Deaf identity.

Six of the teachers can be categorised as being members of the peripheral Deaf community. They are hearing, but are part of the Deaf community through the teaching services they deliver. One teacher has a Deaf daughter. The others have no immediate Deaf family members.

One hearing teacher belongs to neither the core nor the peripheral category in that he denies the existence of Deaf culture. An analysis of his response indicates that he identifies with the medical model. This is seen in his description of deafness as a handicap and his rejection of the view that deaf people comprise a socio-linguistic minority in society.

Teacher B: Deafness is not a culture. It is a handicap. By saying that there is a Deaf culture, it gives them a false sense of importance. Culture is not only language - in this case signing by a group of people. Culture interfaces at many different levels. Like history. History doesn't exist in Deafness. Yes, I understand that they share hardships and SASL…Language does help us to transcend – braille is the same. But braille does not transform blindness into a culture. Culture is not their main reason for existence.

In the following section the primary school teachers' responses were coded according to the most common themes that emerged during the interviews.

4.1.3 Teachers' experiences of teaching mathematics in a classroom of Deaf learners

The primary school teachers used in this research indicated that they could not complete the syllabus due to a specific range of barriers that they experience. The barriers mentioned during the interviews are outlined in the following paragraphs. The teachers from Grade 1 to Grade 6 were interviewed with regards to mathematical issues in their classrooms. Unfortunately, the Grade 7 teacher was unavailable during this time period due to her writing examinations.

a) Barriers to learning experienced in classrooms for Deaf learners

All the teachers of mathematics indicated that they were not able to complete the mathematical syllabus or reach the mathematical outcomes specified within the RNCS. The reasons given by the teachers for not being able to attain these outcomes include several themes that span systemic barriers, barriers within the learners themselves, and barriers inherent in the teachers.

Systemic barriers related to a lack of financial and educational resources; inadequate staffing provision, homogenous power relations found between teachers and management, the manner in which learners were grouped together in classes within the school system, insufficient time allocated to mathematics in the time table, lack of homework supervision, and little continuity or cohesion experienced between the foundation phase and the intermediate phase. Inadequate staffing referred to the lack of multi-professional teams comprised of psychologists, social workers, audiologists, speech therapists and occupational therapists within the school setup. It also included the lack of sufficient teacher assistants within the classroom. Moreover, certain staff felt that the element of dynamic leadership was missing within the higher levels of the school. With respect to class groupings, the school setup reflects mixed ability groupings, rather than learners being streamed according to 'weak' and 'strong' academic functioning. Teachers indicated that the mixed ability groups slowed their teaching down, which in turn prevented them from meeting governmental outcomes. In addition, certain teachers indicated that the Deaf learners seem have inadequate homework supervision both at home and in the hostel.

Teacher B: I am not able to get through the curriculum. The learners work slower because of the different levels. There is also only one person per class. We try to get the weak ones up. Assistants help. I want assistants in the intermediate phase. We are told that it is the teachers' fault that they are not developing. But others

dictate to us. We know what works, but we are not allowed to do what we know works. Another problem is the resources. The books are outdated and old. The children are not motivated to read. There is no money spent on new resources. The budget gets used up by the foundation phase. It is not spread evenly. Also the intermediate phase does not work the same way as the foundation phase. We need a bridge between the foundation phase and the intermediate phase.

Apart from the hearing loss, additional barriers within the learners were referenced. These barriers include that several learners may be affected with multiple disabilities; that the majority of the learners lack a strong foundation in core mathematical concepts; and that low literacy levels in learners impeded mathematical progress. However, it is debatable whether the 'lack in basics' and 'low literacy' should be attributed to the learners, the teachers, the parents or to larger societal forms such as a lack of early intervention.

Teacher S: The biggest problem is understanding literature in mathematics, for example word problems. It says that there are 7 apples. Mom bought 4 more. How many apples are there? They have no idea. Their reading skills are weak. They cannot read with understanding.

Lastly, barriers within the teachers themselves related to poor qualifications, inadequate signing capabilities, low expectations of the learners, and not providing learners adequate speech therapy during class time.

Teacher H: Also the teachers don't understand how to teach. Maths needs to be perceptual. It cannot be copied out of text books. There is no proper signing in class either. Signing is vital.

From the aforementioned factors, the two most frequent concerns were the learners' low literacy levels and the teachers' own curriculum initiatives being bound by the bureaucratic setup within the school.

The teachers try to compensate for these barriers through implementing specific pedagogical strategies in their classroom.

b) Teaching strategies adopted in mathematical classrooms for the Deaf

Teachers primarily implemented a 'back to basics' approach. Their objective was to reteach the foundational mathematical concepts to 'fill in the gaps' and re-establish a core number sense in the learners. They approached this aim through constant repetition of previously learned concepts. One teacher however, stated that she moved away from repetition, as she believes it makes the learners lazy. The teachers described the higher cognitive processes of the Deaf learners in their classrooms as 'very very weak'. The higher processing functions that the teachers were asked to comment on included problem solving, transfer, abstract thinking and reasoning. One exception in this regard was a hard-of-hearing student who described the learners' ability to recall as moderate and not as weak. Since the teachers perceived Deaf learners to struggle with these formal operations, they emphasised concrete learning experiences and practical every day tasks in their classrooms. Moreover, they only taught and formulated questions in one particular way. Certain teachers indicated that they taught visually using a variety of materials such as the computer and the interactive whiteboard. At the

times the teachers adopted a one-on-one teaching approach to manage the wide range of academic ability within the same class.

The above teachings strategies were implemented as a strategy in response to certain characteristics which were visible in mathematics classes and that seemed common to Deaf learners within this particular school These characteristics are detailed in the following sections.

c) The general orientation of Deaf learners to mathematics

Teachers described their Deaf learners as generally passive. Their passiveness is more pronounced when they are bored, tired or when there is reading involved. They rely on their fingers to compute, are comfortable at a concrete level of mathematics and particularly enjoy games and activities. The teachers are unsure of the extent to which the activities during games carry over into mathematical learning. Not only is the transfer from games to mathematics uncertain but the learners seem to find it difficult to interlink across learning areas, and to cross-link from classwork to homework, computation to application and, classroom mathematical operations to real life scenarios. The learners were described as highly teacher-dependent and with a tendency to rote learn. The teachers expressed the latter two elements in terms of 'being spoonfed'…'do not think for themselves'…'only regurgitate what is taught'…'parrot learners'. In addition, one primary school teacher both discussed a completely visual problem solving approach where material was presented visually and interactively. It is interesting that she did not report a notable improvement in the learners' performance. It was commented that "Visual is not enough. They need more". Furthermore, the Deaf staff was more positive with regards to the recall abilities of Deaf learners, but the overall impression was that their recall is inconstant, and thus largely ineffective.

With specific reference to problem solving mathematics, teachers constructed a general profile of learners who do not have the literacy to read the problem or the instructions on their own. The text containing the problem must therefore be signed to them. Once the text has been signed to them learners still experience difficulty in visualising or drawing the situation reflected in the problem. There appears to exist a lack in both cognitive and metacognitive skills, which prevents the learners from solving simple problems independently. Apart from the absence of planning an approach, there is also little perseverance evident amongst the learners.

The above descriptions call for the questions as to why such characteristics appear to be common in the Deaf learners of this particular school.

d) Reasons for Deaf learners general orientation to mathematics

The reasons given by the primary school teachers corresponded so closely to those provided by the Grade 9 subject teachers who commented on the Grade 9's behaviour, values and attitudes in their classes, that it was decided to combine these in a later section, rather than to repeat the information.

In the next section, therefore, it will be established how the teachers who taught the Grade 9 learners subjects other than mathematics, described them. It was explained previously that this information is necessary in order to determine whether the Grade 9 learners' response to problem solving mathematics presented an isolated and unique occurrence limited to the mathematical classes, or whether the learners presented similarly in other learning areas.

4.1.4 Teachers' perception of the general orientation of the Grade 9 class in subjects other than mathematics

The following section concerns general patterns of behaviour of the Grade 9 learners in subjects other than mathematics. Hence, five high school teachers who present subject material to the Grade 9 class were interviewed. The interviews were coded according to the frequency of the themes that emerged. The general patterns or themes that emerged from these interviews are detailed below.

a) *Group dynamics*

The teachers describe the group dynamics observed in the Grade 9 class in terms of three dimensions. Firstly, teachers acknowledged a constant vying which creates strong undercurrents that affected the learners' focus in class as well as their functioning in groups. The vying seems to surround three interrelated dynamics, viz. a vying for positions of power or leadership; a vying for friendship; and, a vying for attention from one another. The root of the rivalry was attributed to jealousy.

Secondly, a strong peer pressure exists. Teachers describe the influence of peer pressure by commenting on different facets. These included class members being 'easily swayed into silliness' by peers; deciding as a group not to complete homework for the next day; individuals conforming to the low level of the group, rather than to 'stand out as a big head' by working at a higher level; and, providing a sense of cohesion and support.

Hence, peer pressure powerfully impacts the class in terms of general behaviour, commitment to homework, individuals' levels of academic performance and achievement; and group solidarity. The quality of the solidarity or cohesion is defined as follows:

Teacher B: They have a rather distorted and fierce loyalty amongst each other. There is no rationale behind their loyalty. They don't weigh right and wrong. It's about support and cohesion. That is what is most important.

Thirdly, a prevailing need or habit to socialise with one another while the lesson is in progress was reported. Although it can be argued that socialisation in the class is normal teenage behaviour, the teachers found the interactions of this class particularly disruptive to the point of preventing meaningful teaching from taking place.

Teacher D. There is a lot of chatting and interaction with each other. They fight for leadership. This makes it extremely difficult for the teacher to teach. They can only focus on you for 2 to 3 minutes. It is more noticeable in this class. This class has really been bad. It has been 2 years of hell. [The teacher had this particularly class in Grade 8 and in Grade 9, hence the reference to two years].

b) *General disposition towards teachers and school work*

The disposition of the group was primarily described in negative terms. The teachers described the situation in terms of learners 'not assigning to school its rightful place'; 'not valuing education'; ' not being serious' about education; and 'not seeing the point'.

Learners were perceived as having a low view of teachers. Their attitude towards the staff was articulated as rebellious, frustrated, disrespectful and insolent.

Their work ethos was depicted as poor. Learners were described as unmotivated and lazy.

c) *Problem solving behaviour*

Interestingly, there was a marked difference between the hearing and the Deaf teachers' perspective on the problem solving abilities of Deaf learners. The Deaf teachers were generally more positive in their appraisal, indicating that Deaf learners had average to good problem solving provided that the problem was presented through visual, and not written communication. In contrast, the hearing teachers described the problem solving skills of Deaf learners as weak. They described the Grade 9 class' skills as 'very very low'; 'at foundation phase level'; 'no ability to think on their own'; and 'they can't seem to know how to even approach the task'.

Moreover, the Grade 9 teachers recognised a passiveness amongst Deaf learners with regards to academic tasks and independent thought. This is coupled with a tendency to give up easily. Learners will simply shrug their shoulders and sign "I don't know", rather than enter into the process of problem solving issue. Two teachers expressed their unwillingness to engage as follows:

Teacher T: Generally, people who want to learn accept that they don't necessary understand something right away as they should, so they keep going. But with the Deaf, they adopt the attitude, "If I do not understand right now, I am not willing to unravel it. Give me the answer and I will give it back". They are generally passive. They want someone to find out and give them the answer.

Teacher B: They expect the teacher to do the job. INPUT!! INPUT!! But nothing ever comes from them.

In addition, all five teachers indicated that the higher levels of thought – abstract thinking, logic and reasoning – were very weak.

It was described in various ways:

Teacher B: Their level of cognition compared to hearing children is frightening.

Teacher D: Their thinking is simple, naïve, concrete and low functioning. They function at a different level to hearing children. They are about 8 or 9 years behind. I would say they compare to a hearing child at Grade 1 or 2 level. They are very comfortable in the concrete level. They don't want to move away from the concrete to the abstract.

Teacher T: Their level of thought is very immature. Sometimes I just have to resort to reasoning like I would with a 3 or 4 year old…They are not at a reasoning level yet. They are low functioning... They do not see logical progression.

Teacher P. They have no basics in thinking or reasoning.

Teacher S: Abstract thinking is the worst.

With respect to recall, both the hearing and the Deaf teachers noted that the Grade 9 class had the ability to remember, but that it was dependant on certain aspects including their ability to understand the language; specific settings and specific materials. In other words, Deaf learners could recall if the work was presented through visual communication and not English. Moreover, they could remember in life settings, but not in academic settings. And lastly, they could recall simple straightforward material, but not necessarily the formal scientific concepts required in schooling.

Possible causes for specific types of behaviour need to be taken into account. The next section considers the teachers' perceptions for the behaviour listed above, in particular for the low level of formal operations.

4.1.5 Barriers identified by teachers to explain learners' orientation

The staff provided a complex cluster of reasons for the behaviour recorded in the previous section. These reasons have been categorised. It is important however, that these categories are not viewed in isolation. It has to be recognised that there is a dynamic interplay amongst all the factors detailed below:

a) Communication

In the context of deafness, communication issues arise within the home environment and within the school context. Both need to be considered.

i) Communication at home

When parents are not able to sign fluently, deafness interrupts normal interaction patterns at home, in that the child cannot access the family's mother tongue naturally. Subsequently, communication difficulties arise. All the family members that were interviewed made an attempt to learn Sign Language [See Section 4.3.1 for details regarding the parental interviews]. Yet, they all expressed difficulty in conveying more detailed concepts to their children. Hence, communication affects the quality and quantity of input parents offers their children.

There are additional factors to consider with respect to parental contribution. Teachers argued that not all parents have a strong educational background. Furthermore, the situation of educational support is confounded by the wide variety of languages and dialects present in South Africa. A large number of learners interact through Sign Language at school, read and write English, and then go home to an Afrikaans or Zulu family. All the teachers argued that language barriers experienced at home ultimately impacts literacy, general knowledge and cognition at school level.

ii) Linguistic policies at school

As was detailed in Section 3.2.4, the school has adopted numerous language policies since its inception 50 years ago. Undercurrents continue to exist between more extreme proponents of oralism and fervent supporters of sign language. Both parties introduce linguistic programmes in line with their own epistemologies and as a subtle form of political power play. Subsequently, there is a constant flux in procedure relative to which party holds the greater authority at the time.

One teacher elaborated on the difficulties that emerge with regards to these programmes and the political overtures that accompany their implementation. Her general argument was that programmes introduced into the school were generally not effective in the long run because of the following three aspects. Firstly, no attempt is made to do research in order to establish their actual educational value. Secondly, often programmes are not in circuit long enough to gauge their impact on learners over time. And thirdly, these programmes are enforced on staff. There is little discussion to secure 'buy-in' at grassroots levels. The teacher stated that unnegotiated implementation fosters tensions in staff relations.

Moreover, aspects of communication and language were used to explain the difference in opinion between the hearing and Deaf staff on the problem solving skills of Deaf learners. Interviews with

Deaf staff members were conducted through an interpreter. Moreover, the content voiced over by the interpreter was written down and returned to interviewee to check for accuracy. The Deaf teachers felt that the learners presented with poor problem solving skills because of the language barriers they experience in the classroom. The quote below is from a Deaf staff member commenting on problem solving amongst Deaf learners.

Teacher S. [Their problem solving is] Average. Very poor when children have to read. But they can problem-solve. For example, they can solve riddles when it is done through SASL because it is visual communication. Literacy prevents problem solving when problems are presented in writing. Also reading. Because they are exposed to two languages at the same time, it prevents clarity. “Pidgin” is the real problem.

Apart from the literacy element, Deaf staff also felt that way certain teachers taught contributed to the learners’ poor problem solving performance.

Teacher P. They [the Deaf learners] have problem solving skills but they are spoonfed by teachers in the primary school. They [the teachers] are not patient. They do not let the child think for himself. They give answers to quickly in a parrot fashion. They are not patient. They are too much in a hurry. They should not give the answer. They should try other ways first. But they are spoonfed. Learners are trained to give back what is given in class. They do not really understand the question. An example is when I ask the children “Who is going to the shop?” They answer WATER or HUNGRY. I say “no!” “Who is a person!” Concepts are not understood because of the language barrier.

In contrast, the hearing teachers based their classification of Deaf learners being poor problem-solvers on the lack of higher-order cognitive skills such analysis, synthesis and hypothesis testing. One teacher distinguished between social problem solving skills such completing household chores, and academic skills. The conclusion put forth was that the Deaf learners could problem-solve in certain practical settings, but that problem solving skills in an academic setting were lacking.

Similar lines of thought were notices when the teachers were asked to explain the learners' low levels of formal operations. The Deaf teachers attributed the low cognitive functioning of learners to the hearing teachers' reluctance to adopt the socio-cultural model in their classroom. Hearing teachers are allegedly contravening this model in several regards:

- low level of signing proficiency
- unwillingness to adapt their personal teaching practices to be more in line with "the Deaf way"
- filling teaching positions that should rather be assigned to Deaf adults who can simultaneously act as appropriate role models for the Deaf learners
- strong emphasis on speech
- promoting and using signed-supported English

The hearing teachers' perceived disregard of the socio-cultural model is attributed to their lack of qualifications in Deaf issues. Consider the following quote from a deaf staff to explain the low level of cognitive function in this particular school.

Teacher S. In primary school language development starts late. Teachers are not qualified in Deaf education. It is better with [name of staff member] working in the

> preschool now. She is Deaf. Both the hearing and Deaf teachers at the school have poor qualification in Deaf issues. The primary school is not trained for Deaf. They worked at a hearing school before. They then move to a Deaf school. The Deaf need to be taught in a different way – the Deaf way. Teachers do not adapt to the Deaf way. They just continue as before. The problem is therefore poorly qualified teachers in the primary school. When they come to high school it is too late. The root problem is that the children do not know how to move between Sign Language and English. SASL needs to be established as their first language. Thereafter they need to learn English as a second and SEPARATE language. They need to understand that SASL and English are separate. Then they need to learn how to translate between them. Signed English confuses them. It does not clearly separate between the two languages. Signed English should be left out. Separation of the two languages will aid the building and development of cognitive thinking. So the first issue is a language barrier. There is also not enough exposure to the social model. Teachers follow a pathological view instead of a sociological/linguistic mode. They worry about sound, lipreading and not about education.

In contrast, the hearing teachers attribute the prevailing situation to lack on other fronts:

- parental input from home, including discipline
- ineffective school disciplinary policy;
- a school board that is disengaged from classroom issues
- low levels of language and literacy;

- inability to gain from incidental learning experiences;

- low intellectual ability inherent in certain learners;

- and learners 'being more than Deaf'. The phrase 'being more than describe children who are deaf with additional disabilities including intellectual impairment and other barriers to learning not as yet formally diagnosed.

Subsequently, a marked difference between the two groups is the Deaf's faith in Deaf culture and Sign Language to 'save' Deaf learners. Yet in spite of their difference, both parties put significant emphasis on the need for early exposure to language to curb developmental delays; and the need to stream learners i.e. to group learners according to their academic ability. All teachers commented on the difficulty of managing disparate levels of such extremes in academic functioning within the same lesson slot.

The above section detailed the teachers' perceptions of how Deaf learners orientate themselves towards mathematics in this school; as well as how the Grade 9 learners respond in classes other than mathematics. The teachers also provided reasons as to why the learners may be performin in this particular way. In the next sections, the learners own views and their reasons will be detailed. The first instrument used to capture the views of the Grade 9 learners with regards to their own mathematical orientation was the SOM questionnaire.

4.2 CATEGORISING RESULTS FROM THE GRADE 9 LEARNERS

The following section contains the responses of the Grade 9 learners themselves obtained during the research.

4.2.1 Study Orientation Questionnaire in mathematics (SOM)

The SOM questionnaire was detailed in Chapter 3. For the sake of completeness, it is repeated that the SOM questionnaire was developed locally for South African learners (Maree, Prinsloo & Claassen, 2006). It measures five fields, namely study attitude (SA), mathematics anxiety (MA), study habits (SH), problem solving behaviour (PSB) and study milieu (SM) pertaining to mathematics. The SOM Manual (Maree, Prinsloo & Claassen, 2006:11) offers the following broad guideline for interpreting the profile of the learner based on these five fields.

A:	70 – 100 %	:	Clearly positive study orientation
B:	40 – 69 %	:	Neutral, but can contribute to positive or negative study orientation
C:	0 –39 %	:	Clearly negative study orientation

4.2.1.1 The SOM results as a pretest

The learners were asked to complete the SOM questionnaire one week before the study commenced. The SOM questionnaire functioned as a pretest and a type of baseline assessment. The objective was find out how the learners rated in themselves with respect to their study attitude, mathematical anxiety, study habits, problem solving behaviour and their study milieu before introducing problem-solving mathematics into the classroom.

Table 4.2 SOM scores of Grade 9 learners before intervention

Field	Learners (n = 7)							Number of learners per category (Percentile Rank)		
	A	B	C	D	E	F	G	0 –39 %	40 –69 %	70 –100 %
Study attitude	28	18	7	20	43	28	18	6	1	
Mathematics anxiety	70	70	50	92	30	65	20	2	2	3
Study habits	50	20	30	19	45	25	5	5	2	
Problem solving	55	8	13	5	43	20	5	5	2	
Study milieu	68	68	53	78	60	60	4	1	5	1

As recorded in Table 4.2, before intervention the scores revealed that six out of seven of the learners have negative study attitudes and 1 learner had a neutral attitude. Five out of seven learners had negative study habits and problem solving skills towards mathematics, whereas two of the learners held a neutral disposition in this regard. Moreover, two out of seven learners may be suffering from mathematical anxiety, whereas three of the learners recorded a strong sense of confidence in their own ability to do mathematics. Furthermore, the majority of the learners (five out of seven) appear to have neutral feelings toward their study environment, one learner is particularly positive in this respect and only one learner finds his/her study milieu at the time unsuitable. There thus seems to be a tendency between the learners description of their study attitude and habits and problem solving abilities, and the picture portrayed by the teachers in term of the learners' orientation being primarily negative.

After obtaining these results through a pre-test, a problem solving curriculum was introduced into the class for eight weeks, where after the test was administered again as a form of post-test.

4.2.1.2 The SOM results as a post-test

After eight weeks of exposure to problem solving mathematics, the same learners were retested. Following intervention, the students showed the following orientation towards mathematics.

Table 4.3 SOM Scores of Grade 9 learners after intervention

Field	**Learners (n = 7)**							**Number of learners per category (Percentile Rank)**		
	A	B	C	D	E	F	G	0 –39 %	40 –69 %	70 –100 %
Study Attitude	40	28	15	12	20	35	18	6	1	
Mathematics Anxiety	38	75	70	83	35	55	45	2	2	3
Study Habits	60	30	35	6	30	35	7	6	1	
Problem solving	73	28	30	12	10	25	10	6		1
Study Milieu	35	60	65	68	25	35	7	4	3	

The overall results between the pre- and post-test remained largely unchanged. In other words, six out of seven of the learners maintained negative orientation towards study attitude, study habits and problem solving. Yet, within this negative orientation several small positive changes can be noted. Four of the seven learners displayed a more positive worldview of mathematics. In other words, the relevance of mathematics in the real world has become more apparent. A slight increase in attitude towards study habits were noted in five of the learners. Moreover, with the exception of one learner,

the other six learners reported more positive problem solving behaviour. At the same time the scores seem to reflect an increase in mathematical anxiety.

It is interesting to note that the five of the learners were less satisfied with their study environment after the study than before. Some of the reasons for the learners' dissatisfaction with their study environment were clarified during the focus group sessions. During these sessions, the boarders expressed that they find it particularly difficult to study in the hostel as their friends wanted to socialise with them during the time they set aside for homework.

Learner E. I find it difficult to study at school, because of socialising. I find it difficult to concentrate with my friends around.

Additional aspects were also explored in more depth during the focus group sessions and personal interviews.

4.2.2 The focus group session and personal interviews

The purpose of the focus group session and personal interviews were to give the learners 'a voice'. The objective was hear how they make meaning of their mathematical situation and the reasons they attribute to their specific orientation. Both the focus groups and personal interviews followed the SOM questionnaire's categories meaning that the learners' study attitude, levels of mathematical anxiety, study attitudes and response to problem solving were the topics of discussion. Generally the learners' responses were similar during the focus group sessions and the individual interviews. Hence, it was decided to collate the information except for instances were significant differences in response were noted. In such instances, the information is presented separately.

The learners' responses during these sessions correlated closely to data in the SOM questionnaire and to what the teachers were saying about the learners in the class. Firstly, learners were asked to describe their study attitude and study habits. All the learners described mathematics as hard. They responded that they enjoyed mathematics that was very familiar to them, that they found easy, and that involved games and activities. But they disliked and gave up on mathematics that they perceived to be hard.

The learner who indicated that she may be experiencing mathematical anxiety described mathematics as follows:

Learner G: It [Mathematics] is difficult. Some [questions] are difficult and hard – like a rock. Sometimes I struggle and struggle. I forget all the time. I forget a lot of things about area and other things.

Except for two learners, the study pattern in the other five learners was strongly negative.

Learner E I want to say something about myself. When I go home, I take files home with me to study. I never take my maths file. I am not interested in the maths file.

Learner C: I do not study at all during the week. Only during the weekends. That is all.

Yet, a theme that emerged during the focus group sessions that was not so evident during the personal interviews was the learners need for support when they study. It seems that the learners depend on someone to help them understand their homework. If that someone is not present at the time, they tend to leave homework unattended. During one particular interview five of the respondents made reference to their support structure when they do homework, referring to 'sharing

homework with their siblings', 'studying with their Mom', 'having the support of the house father' or the support 'of hearing friends'.

Learner D: I do not really study at home. I study in the hostel at night. [The housefather] is there to teach me. I understand better through [the house father]. I do not study at home at all. Only at school.

Learner B: I study with my mom. I don't look at the time. I only do it [study] over the weekends. I understand some times with my mom.

However, the learners did not seem to attribute their difficulties in mathematics to poor study habits. Rather, the learners felt that their mathematical difficulties that they experienced were rooted in the teacher and in the English language. With regards to the teachers learners expressed that the teacher would revert to Signed Supported English, rather than pure Sign Language structure. The learners commented that they did not always understand what the teacher was trying to convey. Moreover, the weakest learner continually expressed the desire for more one-on-one teaching and she felt disrespected when the teacher could not provide this during class time. The most prominent theme, however, was the learners' desire for clear examples that could easily be followed.

Learner A: I do not understand what to do because there are not enough examples given to me. If you give me more examples, I will understand clearly….I would prefer that one example is explained to me before giving me more homework.

Learner H: If [the teacher] shows me how to do the first question, then I will be able to copy the example and do the rest by myself.

Learner E: [The teacher] must make it clearer on the board. …It depends on [the teacher] to explain in detail. This is my opinion on the class and myself. If you had to explain in more detail and deeper and make the subject motivating for me, then I will feel more motivated.

As indicated previously, despite the lack of clear examples provided by the teacher, learners also indicated that experienced language barriers pertaining to English.

Learner A: But when we come across a question it is difficult to understand the question because it changes all the time. I do not understand the question.

Learner G: I understand, but I do not understand the sentences. Some questions on the paper are not easy. They confuse me. I am confused with question sentences.

In addition to the above, problem solving mathematics often assume that learners work in groups to solve a particular problem. Subsequently, the learners' attitude towards group work was ascertained. With the exception of two learners, the other five learners indicated that they preferred group work when the work was more 'difficult'. They seem to value the support that is found in working in a group on challenging tasks. Yet, at the same time the learners acknowledge that they struggled with the way others treated them.

Learner E: I prefer to work in a group. If I work on my own I have no motivation. I will just make excuses. If I work with the group they help me and explain to me. They force me to make an effort. Sometimes I do not like to work in the group because they criticise me.

Leaner F. I like to work both – in a group or individually. If the work is hard, I like to work in a group. If the work is easy, I prefer to work on my own. I prefer the group because of the discussions and helping each other.

The one learner, who indicated that she preferred to work alone, stated that she could concentrate better when she worked on her own.

Learner A: I prefer to work alone because in the group they get distracted, and start discussing other things and start socialising. I prefer to be on my own because I can then concentrate.

The other learner wanted to work alone because of he experienced the group dynamics negatively.

Learner D: I prefer to work alone. Because in the groups they do not want to listen or help. That is why I prefer to work alone.

As indicated by the excerpt above, a particular problem experienced in during mathematics lessons were the continual socialising amongst learners while the lesson was in progress. The learners indicated that they socialised because they did not understand the mathematics itself, that they became bored with 'long and detailed' explanations and that there was too much repetition – being 'taught the same work over and over again'. Furthermore, they would talk when they did not understand the teacher's sign language or when they were feeling tired.

By way of summary, the learners held a negative orientation towards mathematics. This was evident in their description of their feelings towards the subject, but also in how much time they spend on the subject. The learners felt that the difficulties they were experiencing in mathematics were related to the way the teacher taught the subject and also to the level of English of the problem solving text.

The majority of the learners enjoyed working in groups to solve problems, but some learners found the underlying group dynamics distracting.

In the following section, the parents' were interviewed with regards to the learners' orientation in mathematics.

4.3 CATEGORISING RESULTS FROM THE GRADE 9'S PARENTS

The following section contains the responses of the parents of the Grade 9 class obtained during the research.

4.3.1 Parental Interviews

During the eight weeks of intervention arrangements were made to conduct semi-structured interviews with the parents either at their homes, telephonically or at a pre-arranged venue. A colleague who was also conducting research but from an art perspective accompanied me to secure a member check with regards to the data that was obtained. It became clear during the interviews that the majority of the parents 'just needed to talk to someone' about their Deaf child. Hence, they were very appreciative of the visit or the phone call. This study collated data from the interviews that were relevant to the child's study attitude and study habits. A list of questions that were asked is found in Addendum E. Allowance was made for any questions or issues that the parents themselves wanted to pursue during the interview time.

The parents were generally vague with regards to the actual time spent on homework. No real set routines were reported. When prompted to be more specific, most parents whose children were boarders indicated that the learners spend about 2 hours on their homework over the weekend. Only one parent whose child is a day scholar gave a clear and definite answer of 1.5 to 2 hours of study

daily during the week. It is interesting that this is also the child who performs best in mathematics. All parents indicated that in general a lower level of supervision is exercised at home. The general trend indicated is that homework is left to the discretion of the learner. Parents remind children of their homework, but they do not seem to enforce homework time nor check up on the quality of homework produced.

Mother A: She is happy to study. She is diligent. I am not sure if she is really studying. Maybe she is on her cell phone.

Mother D: Maybe he sits and you think he is doing his homework and studying but he could be thinking of something else. I don't know.

Moreover, only two parents reported the learners modified their study habits during the school examination period.

Mother D: The exam is the same as normal homework time. But during exam and test time she studies in the taxi or while waiting for the taxi.

Mohter A. It [revision] fluctuates. She will start doing revision closer to exams. About 2 weeks before exams, she will start bringing files home.

The parents indicated that the learners would approach them for assistance when they are not managing with the work i.e when they are 'stuck'. It is generally the mother figure in the house i.e. the mother or grandmother, who tries to assist with homework. Only one referred to siblings assisting and one mentioned that the father was involved in explaining mathematics as the mother was unfamiliar with the subject.

The main difficulties experienced with doing homework at home included language and communication barriers. (Although the elements surrounding Sign Language proceed far deeper than simply being a 'communication barrier', these elements are explored and expounded on in the parallel research being conducted at this specific school and which was mentioned at the start of this chapter). The learners struggled to interpret the English text, and the parents did not know how to sign the concepts to them to help them understand. A second prominent difficulty was that the parents were not familiar with the subject material, especially with mathematics, and therefore they were unable to assist their children.

Parent D: If he writes x and that I don't know. I especially struggle to help him with maths. I sometimes watch the man on television and try to follow what he teaches. You know the x and the y. But I don't understand it, so I am not able to help him in maths. The type of maths they have now - I don't know that maths.

Mother E: She used to ask about maths. I do not understand maths. I do not know how to help. I don't know anything about maths. Other subjects like natural science, I can still read the English and help her with some of the activities like filling in the missing word.

In addition, emotive barriers such as learners' dislike of subjects and difficulty in adapting to having failed a grade the year before were reported.

During the interviews parents were asked how they thought their child understood and felt about mathematics at school.

At large, the parents were aware that the learners were struggling in mathematics at school.

Parent F: She likes maths; but I don't think she can.

Parent B: She struggles with mathematics and tends to put it off.

Parent E: She likes maths. But when she works on her own she cannot understand step-by-step.

Parent D: The teacher goes to fast. I told him to ask the teacher, maybe after school. But I know N always wants to play.

Yet, the parents did not appear primarily concerned about the learners' low levels of achievement in mathematics. Instead they were more worried about the learners' struggle with literacy. I gained the impression that their argument was that if the learners' literacy would improve, their mathematics would fall into place as well.

Parent B: The problem is a mixture of concepts and English instruction. My husband spends a lot of time with her explaining problem solving examples. He takes an example of problem solving and then explains to her what it means, because she does not understand the written English.

Parent D: English is the problem. He is not running away because he does not like maths. His English is poor. Even when he SMS's me, I can only understand the English because I know that Sign Language is the opposite way round. If I did not know that, I would not be able to understand his SMS. He follows the Sign Language way and not English. If he can't understand English how will he understand other subjects?

Hence, it appears that the parents are aware of the learners' current position in mathematics. They ascribe it mainly to poor literacy. Moreover, parents are largely unable to assist their children in mathematics because of they are not familiar with the content of the subject; and they find it difficult to sign detailed elements to their children.

4.4 SUMMARY

The teachers of mathematics indicated that Deaf children within the school tend to lag behind their hearing peers in mathematics. This is attributed to specific barriers within the system, within the teachers and within the learners themselves. Moreover, the general pattern of negative orientation appears more widespread than the subject of mathematics. Educators from other learning areas experience similar challenges with learners from the Grade 9 class. All staff largely attributes the difficulties experienced to complex and interrelated issues surrounding communication inherent in rearing a deaf child. However, the Deaf staff feel that the difficulties are exasperated when teachers within the school do not adhere to the socio-cultural paradigm of Deafness in their pedagogy, whereas the hearing staff tend to draw on the medical model in their explanations of the current low academic functioning. Moreover, the learners' own responses were in correlation with the overall profile presented by the teachers. The learners reported very low levels of study attitude, study habits and problem solving skills. These were attributed by the learners to manner of the teacher and to difficulties experienced in understanding English. The parents seemed aware of the learners' current position in mathematics and were in agreement with the learners and teachers that literacy was one of the major contributing factors.

In the next section, these findings will be discussed and evaluated in more depth.

CHAPTER 5

DISCUSSION OF FINDINGS

'"Initially I thought, I will teach, and they will learn". Gradually and painfully, I began to recognise that my assumptions were wrong. In fact, much of the teaching methodology that I have learned previously just didn't seem to work' (Wink, 2005, p. 14).

In essence this is a scientific enquiry. Yet, throughout this work, research and reflective practice are closely interconnected. It is therefore also an attempt to chart honestly and critically my conceptions and conjectures as they developed and complexified. Hence, included in the dissertation is an autoethnographical account that reveals my own grapple and appropriation of theory as I, a *new hearing* teacher, taught mathematics in a school for the Deaf rife with contradictions, multiple realities and change. Moreover, my exploration involved a personal striving to rationalize classroom issues not only with contemporary theoretical perspectives but also with current Deaf thought encountered within the institution.

In lieu of the above, the findings are discussed in two sections. In the first division, pronounced pedagogical experiences that put me on path to a problem solving philosophy are described, whilst the second section is devoted to the research question and its corollaries i.e. how Deaf learners orientate themselves to problem solving mathematics. The pedagogical experiences in the first section do not form part of this particular research in a stricter delineated sense. They do however, provide a background against which the current research findings can be interpreted more meaningfully. Moreover, they form part of critical pedagogy and hence part of research in a broader significance. Wink (2005, p.3) describes critical pedagogy as the ability to read and write your world' by being able 'to name, to reflect critically, and to act' on the situations you encounter.

Through this engagement a complex and evolving process of learning, relearning and unlearning is set in motion that decides the actions one takes in the real world when necessary (Wink, 2005).

SECTION A

Giroux (1997, p.36) argues that critical pedagogy 'provide educators with an opportunity to examine, dismantle, anlayze, bracket, de-and reconstruct pedagogical practices'. In the following section, my own experiences and enactment of Giroux's statement are detailed in the form of successive critical pedagogical experiences. These critical pedagogical experiences also support Hill and Boxley (2009, p.48) notion that 'theory can provide the analytical and conceptual apparatus for thinking about practice in schools and classrooms, within the formal and within the hidden curriculum, while practice can provide the opportunity for the testing and assimilation of theory'. In other words, the experiences recorded below take on the form of testing popular theory and conceptions in respect to Deaf education found within this particular school.

5.1 Critical pedagogical experiences in a mathematics classroom for Deaf learners

My own path into critical pedagogy started when I was teaching the Grade 10 class at a local residential school for the Deaf. According to Kilpatrick, Swafford and Swindell (2001) the instructional goal in a mathematics classroom should be that of "mathematical proficiency". Mathematical proficiency is a much broader outcome than mastery of procedures in that is consists of five intertwining strands:

1. *Conceptual understanding*—comprehension of mathematical concepts, operations, and relations

2. *Procedural fluency*—skill in carrying out procedures flexibly, accurately, efficiently, and appropriately

3. *Strategic competence*—ability to formulate, represent, and solve mathematical problems

4. *Adaptive reasoning*—capacity for logical thought, reflection, explanation, and justification

5. *Productive disposition*—habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy

In using the above strands as a baseline measure of assessment, I could express that I was perplexed at the learners' *lack of mathematical proficiency*. Yet what I really felt at the time, resonates in the words of another teacher captured by Brombacher (1997) during his research on how mathematical teachers adapt to policy, and subsequent curriculum change:

> I got so frustrated. I mean, the reason I became a high school teacher -. I didn't want to teach fractions; I didn't want to teach, you now, stuff like that. They come into ninth grade, and they don't know decimals, and they don't know rounding off. They don't know how to enter a division into a calculator. You have to start to look and say, "All right, you have been teaching this kid from elementary school. You have been teaching them for 10 years how to multiply, how to divide, how to find a percent – move on!" You know if you look at a mathematician they are not arithmetic… (Brombacher, 1997, p.53)

Although the quote above does not entirely carry academic veneer, I felt drawn to it in my attempt to explicate the basis of my experience. In comparison to my own reaction at the time, several similarities can be noted.

Firstly, I too was deeply disconcerted. Aspects of procedural fluency and conceptual understandings that should be in place by Grade 10 were unfamiliar to the learners. Secondly, the lack necessitated a design down approach in terms of teaching and assessment standards. Stated differently, the class needed to revisit general education and training phase outcomes, instead of continuing with the further education and training phase curriculum. This created enormous time pressure. Thirdly, the learners showed an awareness of arithmetic (although all calculations were carried out on the calculator), but not of mathematics in its fuller domain. And lastly, I likewise transferred the responsibility and the blame to my predecessors. Detailed above was the background to my first significant pedagogical experience in Deaf education

5.1.1 Lack of mathematical proficiency in Deaf learners

My first critical pedagogical experience (bearing in mind Wink's concession that such an experience should be named, reflected upon and acted on) can be summarised as follows:

In naming the experience, I resorted to the phrase 'severe lack of mathematical proficiency in Deaf learners'. While reflecting on the situation, I located the root cause of the deficiency in the perceived inadequacy of the staff's pedagogy. I subsequently confronted my colleagues on the issue. Their reply was, "We taught the work. The evidence is the learners' profiles. Go and have a look". I mused over their response for a time, before dismissing it. In acting, I deliberated to teach in a more systematic and thorough manner than was previously administered.

Critical pedagogy ‘questions not only the knowledge, but also the method of delivery’ (Wink, 2003, p.32). The next question was therefore to analyze how a systematic and thorough method of mathematical delivery presents in practice. I advanced with the traditional or absolutist way of teaching mathematics because of its familiarity from my own schooling and educational experiences. Moreover, it was practiced by the other mathematical teachers at the particular school where I taught; as well as by teachers from the neighbouring schools with whom we interacted. Naidoo & Parker (2005) affirm that the absolutist philosophy of mathematics is a popular image of mathematics, which is promoted by teachers who have been socialised into a specific educational identity.

In spite of several months of working on an intense traditional mathematical programme no substantive evidence of progress emerged. Rather, the situation appeared to have worsened. The learners were struggling to grasp the concepts. On average work had to be retaught three to five times over dispersing intervals before the learners began to show mere awareness of the concepts. This created conditions of redundancy and overlearning. At the same time learners resented the intensity of the programme that called for mathematical workshops after hours, including Saturdays and holidays. This forced me to take my second step into critical pedagogy.

5.1.2 ‘Most unpopular teacher’

My second experience can be named “Most unpopular teacher“. Because of the effort demanded, I was unpopular with the class; and, in spite of the effort demanded, I was failing to close the gaps in mathematical proficiency. My reflection on the matter yielded little closure. Since I perceived my own conduct and pedagogy to be in close conformity to the absolutist/traditional ‘manual’, I acted by seeking the opinion of my Deaf colleagues. The Deaf actively promoted the ‘Deaf way’ as the solution to the challenge of low performance amongst Deaf high school learners. This propelled me into my third critical pedagogical experience named ‘the Deaf way’.

5.1.3 The Deaf way

This event necessitated that I reflect on the Deaf and their ways. I understood the Deaf way to comprise two key aspects, namely visual learning and Sign Language. Already in 1912 a Deaf man named George Veditz described Deaf people as 'the first, last, and for all time, the people of the eye' (Padden & Humphries, 2005, p.2). In doing so, he argued that Deaf people's lives revolved around the central core of 'seeing'. In other words, Deaf people are guided by the visual and show preference for practices associated with seeing.

The emphasis on the visual invites further considerations. Firstly, it suggests the possibility that Deaf learners experience a form of sensory compensation. Research on the aspect that Deaf learners may develop more acute visual sensations than a hearing person in order to accommodate the loss of one sense, remains under the examination of the scientific community (Emmorey, Kosslyn & Bellugi, 1993; Finney & Dobkins, 2001). A deeper discussion detailing the various pieces of research on the matter is documented in Marschark (2003). After considering findings from this field, Marschark (2003) concludes that deaf individuals show an advantage relative to hearing peers in several domains of visual processing. The difference, however, is considered a function of experience in sign language. Hence, similar benefits were found in hearing people who use sign language. Subsequently, it appears that apart from increased attention to the visual periphery, there is not sufficient evidence to conclude that deaf learners possess a form of sensory compensation.

Secondly, Deaf learners are assigned the status of being predominantly 'right brain learners'. The dichotomy of the left and right brain is a popular theory that posits that the left hemisphere of the brain is specialized for language, mathematics, detailed analysis, logical thought, temporal and sequential analysis and serial processing of sensory information. The right brain, however, is specialised for emotional expression, intuition, the recognition of faces, artistic achievement, musical

aptitudes, visual-spatial analysis and parallel processing of sensory information (Efron, 1990). These generalisations paved the way for the notion that there are left and right hemisphere cognitive styles or personality types. The interpretation of this theory places the Deaf in the latter category i.e. the non-verbal visual side and may subsequently possess a resulting superior non-verbal intelligence. Efron (1990) cautions one against this type of interpretation. He argues that the left-right brain dichotomy predisposes people to believe that a specific cognitive function is performed in a specific cerebral area, which is specialised for that function. This view however is refutable in lieu of evidence from brain imaging revealing that forms of cognition requires an anatomically extensive system involving *both* hemispheres (Efron, 1990). Efron (1990) substantiates his view by differentiating between *support* and *specialisation*. There are areas in the brain that support specific functions such as language. Support functions are localised. Specialisation in language however, comprises a complex network of support functions linking and spanning interspersed areas of the brain.

Taking the above into account, the critical pedagogical experience that followed was an attempt at integrating the Deaf way into my own pedagogy, with special focus on the visual experience. This birthed a re-learning experience. Wink (2005) describes relearning is a shift in methodology. She indicates that 'relearning can be uncomfortable at first, but eventually, it becomes doable' (Wink 2005, p. 67).

I set out to learn from the Deaf how they taught. I informally interviewed them on their methods; sat in on their classes to observe their pedagogical style; and, invited them to teach sections of mathematics that I have taught previously. This created openings for critical comparisons between my own manner and the "Deaf way".

Based on these experiences a variety of changes in accordance with the "Deaf way" were implemented in my classroom over the subsequent months. I started teaching in colour. For example, x would be red and y would be blue. I imported workbooks and software that portrayed common mathematical concepts through interactive and animated imagery. I constantly reflected on what it truly meant to teach mathematics visually.

Although each of these tools has merit in enriching and supplementing teaching methodology, there was still no substantial change in mathematical proficiency. On the other hand, a large proportion of the learners had difficulty interacting with the concepts when portrayed through imagery, instead of through procedures limited to numbers. In aftermath, I deliberated that their response may be due to the abstract nature of the concept being conveyed by the image, rather than the imagery itself.

Yet of the product of this experience has been an acknowledgement of Marsharck & Hauser's (2008) recognition that Deaf learners may possess different perceptual strategies compared to hearing children. New developments in this field stem from the notion that an abstract structure is an image structure (Wheatley, 1997). Subsequently, research is advocating the use of imagery through the "mind's eye" rather than through the human eye. Visual reasoning through metaphors, metonymies, anologies and images has been investigated with hearing children (English, 1997). It was found that children who used imagery in their reasoning were more successful in solving non-routine problems than those who approached the task procedurally (Wheatley, 1997). Similarly, it has been analysed how being able to evoke a mental representation can assist mathematical learning and problem solving in Deaf learners (Lang & Pagliaro, 2007).

I returned to my Deaf colleagues.

In discussions that followed, my Deaf colleagues continually re-emphasised the importance of fluency in signing and the hindrance of signed supported English in the cognitive development of learners. Subsequently I considered the role of Sign Language in Deaf education.

5.1.4 Sign Language

The argument expressed in research is that teachers of the Deaf who can sign fluently, better facilitate the construction of knowledge by Deaf learners in several ways. A visual language provides access to the curriculum content (Akach & Aarons, 1999); affects Deaf learners' recall (Lang & Pagliaro, 2007); and, impacts on Deaf learners overall motivation to learn (Lang, Dowaliby & Anderson, 1004).

The following critical pedagogical experience was therefore named "Fluency in Sign Language". I reflected that I would be unable to increase my own sign language ability effectively in a limited time space, in spite of regularly attending numerous sign language courses and socialising with the learners during tea-time at school. Subsequently, I approached a Deaf adult who is fluent in Sign Language and who previously taught mathematics to high school learners at the school. This particular person was recommended to me by past pupils for helping them understand mathematics. The Deaf adult played the role of assistant teacher while I observed. There was an immediate bond between the Deaf adult and the learners. Communication flowed rapidly and little time was wasted trying to obtain clarity on the learners' questions. However, I still observed the same occurrences that I have been questioning right from the start of my teaching. The Deaf adult taught a section on exponents. The learners acknowledged their understanding of the content and later completed the activities successfully. Once the Deaf adult had ascertained that the learners were familiar and confident with the topic, he progressed to a new section of mathematics. Two weeks later he asked the learners a question based on something in the previous section of exponents. The learners did not

respond. When he prompted them again, they denied 'having ever seen the material' or the particular type of question before. The Deaf adult rationalised that their lack of recognition was directly related to them not 'practicing everyday'.

A similar incident presented itself a month later. My Deaf colleague of mathematics took up a more lucrative position in industry. I was asked to set his exam papers. Because I constantly discussed mathematics with him, I was aware of the progress he was making in his class. He assured me that the learners understood the curriculum and were capable of meeting its mathematical demands. In setting the exam, I used the learners' practice books. I only included straightforward questions that the learners successfully completed. Yet, all the learners achieved a very low mathematics result in this examination. In other words, they were unable to carry out procedures, which they effectively completed a month or two before.

At the same time, staff had to be repositioned within the school to accommodate the loss of this particular staff member. Subsequently, mid-year I inherited a class taught by a hearing teacher. The learners' books contained extensive and repeated practice of mathematical concepts. However, when asked to refer back to these, with the exception of one learner, there was no recollection. The learners signed that they did not know, that they were confused and they subsequently requested that the work be retaught.

In comparing these situations, several similarities emerge. Firstly, all my contemporaries (the Deaf adult, the Deaf teacher of mathematics, and the hearing teacher of mathematics) were fluent signers. Two of them were Deaf with a strong Deaf identity that rendered them insiders of the 'Deaf way'. I was the exception, in that my signing was not on par with the others. All followed a traditional absolutist philosophy, which meant that they taught mathematics in a decontextualised context; devoid of all but basic mathematics language; and, providing clear step-by-step examples of

algorithms that learners have to practice for homework. Yet, all experienced similar results. Learners could manage the work, but as soon as a new topic was introduced previous topics were simply forgotten as though never experienced or practiced before. Consequently, when an exam is set that calls for the integration of previous work, it is consistently marked by low performance. On the other hand, with class tests that covered the work just taught, performance is reasonable. Since the learners indicate that they cannot remember the work, key concepts are continually being retaught resulting in a repetitive teaching cycle whereby learners are exposed to the same materials 'over and over again'. This is the problem I encountered when I first started working with the Grade 10 class. Hence, despite several attempts at intervention the initial problem still remained.

In naming this particular pedagogical experience, I again resorted to the phrase 'severe lack of mathematical proficiency'.

5.1.5 Lack of mathematical proficiency in Deaf learners (2)

While first reflecting on the situation, I then located the root cause of the deficiency in the perceived inadequacy of the teaching of my colleagues. I now realised that my colleagues most probably did teach the work. Trying to make sense of the situation, I no longer agreed with the Deaf staff that Sign Language in itself was enough to circumvent or gain advantage over the academic challenges. I pondered on the claim that the problem in mathematics is not the lack of ability of students, but the teaching method (Sousa, 2008). In a sense, I was forced to agree, because it was evident that generally the learners could do the work *at the time. They were not however, able to connect the work to new areas or to retain the work once new topics or a lapse in time had been introduced.* This led me to question the 'method of teaching'.

> Problem posing brings interactive participation and critical inquiry into the existing curriculum and expands it to reflect the curriculum of the students' lives. The learning is not just grounded in the prepared syllabus, the established, prescribed curriculum. Problem posing opens the door to asking questions and seeking answers, not only of the visible curriculum, *but also of the hidden curriculum.* (Wink, 2005, p.51, my emphasis)

As indicated previously, we all used an absolutist/traditional method. In line with the aforementioned quote, I began to question the hidden curriculum contained in traditional teaching. Was it possible that its decontextualised and defragmented manner of presentation prevented Deaf learners from making connections between mathematical topics? Was the lack of connection in turn aiding the deficit in memory recall? This type of thinking was being echoed and explored by the work of Lang & Pagliaro (2007). Lang & Pagliaro (2007, p. 450) emphasise that an absolutist approach should not be followed with deaf learners i.e. 'mathematics should not be taught to deaf students as a discrete series of computational skills'. Rather, it is more beneficial for deaf students to follow a teaching approach that allows them to make connections between new mathematical concepts and prior knowledge as they solve problems; and one that emphasises reasoning based on the understanding of the content.

Having previously delved into systematic teaching, integration of the Deaf way into pedagogy, and observing the influence of fluent signing, I was now left with the method of problem-based conceptual mathematics.

5.1.6 Problem-based mathematics

The action that I foresaw was to implement this kind of teaching into my classroom. I immediately felt a sense of tension at the prospect. This 'angst' stemmed from my many reservations.

Firstly, there was the issue of literacy. An absolutist approach has a limited range of commands e.g.

- *Simply.*
- *Expand.*
- *Find the product.*

In contrast, a conceptual approach has rich language structure surrounding the problem. Consider the following example.

> Edna leaves the trailhead at dawn to hike 12 kilometres toward the lake, where her friend Maria is camping. At the same time, Maria starts her hike towards the trialhead. Edna is walking uphill so she averages only 1.5 km/h, while Maria averages 2.5 km/h walking downhill. When and where will they meet? (Murdock, Kamischke & Kamischke, 2002, p.308)

The generally low literacy levels of Deaf people underpinned my concerns surrounding the linguistics of the conceptual approach. The Wits Centre for Deaf Studies (2008) cites statistical data that 'approximately 66% of Deaf people are functionally illiterate and on the average general knowledge levels equal that of an 8 year old hearing child'. Current research (Stone, 1988; Pagliaro & Ansell, 2002; Kelly, Lang, Mousley & Davis, 2003) indicates that my concerns are both acknowledged but at the same time challenged.

Teachers of the Deaf in both primary school (Pagliaro & Ansel, 2002) and in high school settings (Kelly, Lang, Mousley & Davis, 2003) tend to withhold written mathematical problems from the learners. This is largely because teachers feel that educationally, the impact of deafness is greatest in the area of language development (Markey et al. 2003). Stone (1988) affirms that because Deaf learners have language problems, teachers try to simplify the classroom situation by eliminating written language. Stone (1988), however, supports the exposure of Deaf learners to mathematical language and cautions as follows:

> Elimination of written and spoken language hardly enriches the context of instruction for students who have language problems, although in the short run this may ease the task of the teacher. It is human nature to try and make a complex situation more simple, but finally the reduction of language in situations where communication is difficult as it may be with Deaf students does not result in greater learning… To increase opportunities for incidental or unplanned learning for Deaf students greater exposure to the language of the classroom and the language of mathematics is necessary. Rather than eliminate, we need to elaborate language for these students. More, not less, communication is required for intention to be recognised, for convention to be broadly defined and for understanding to occur. (Stone, 1988, p. 63)

Generally, however, educators lower their educational expectations because they perceive deaf children as 'slow and unable to learn' (Simms & Thuman, 2007). Subsequently, they are relegated a watered down mathematical curriculum. A limited curriculum supports the corollary that mastery of basic computation is all Deaf learners need. Markey et al (2003) express this as follows:

> Because of the difficulties many students who are deaf or hard of hearing experience with literacy, and because the same students are generally able to do simple computation, it is commonly believed that such students achieve acceptable levels of mastery in mathematics. However, the reality is that they have long struggled with mathematics in the broader sense because it involves much more than memorisation and formula. (Markey et al. 2003, p. 252)

The emerging argument is therefore that the academic and social development of Deaf learners must be advanced, by exposing Deaf learners to rich instructional experiences that incorporate 'mathematics in the broader sense'. It is based on the premise that students will develop an improved understanding of mathematical language through using it and seeing it (Markey et al. 2003). Moreover, because of the suggested link between language development and thinking processes (Vygotsky, 1978), it is proposed that withholding language from learners, can facilitate a form of cognitive narrowing, that leaves Deaf learners unprepared for tertiary studies and/or real world situations.

Secondly, I was concerned about the nature of mathematics. As stated previously, I was familiar with an absolutist approach. It was hard for me to envisage teaching mathematics in an alternative way. The theoretical aspect of shifting from a curriculum dominated by memorization of isolated facts and procedures and proficiency with paper-and-pencil skills to conceptual understandings, multiple representations and connections, mathematical modelling and mathematical problem solving appeared stimulating. I had little idea of how this should translate into practice, nor was I fully convinced of its effectiveness. Was I dealing with a utopian vision – or with a practical reality?

Thirdly, I consulted textbooks for examples of problem solving. Brombacher (1997) states teachers often do not experience standards first hand, but through textbooks and curriculum materials. He

argues that this is not always ideal as textbook publishers respond swiftly to changes on the market. Often their response takes the form of patchwork modification rather than embodying the true nature of the standard. He offers the example that instructions such as 'think' and 'predict' will be added to 'dress up' previous exercises as authentic problem solving. It was particularly difficult to source materials on the South African market since Brombacher's predictions about the nature of textbooks were reflected in many editions.

What I did realise however, was that if I choose to change to a new teaching approach, the process of unlearning was inevitable. Wink (2005, p.67) describes unlearning as a painful process – one that involves a complete re-examination of philosophy, beliefs and assumptions and ultimately, a 'jump across the great paradigm'. In other words, whereas relearning comprises a shift in methodology; unlearning involves a shift in philosophy, beliefs and assumptions.

My last reservation concerned the time frame. We were nearing the end of the year. This meant that the Grade 10 class would be progressing to Grade 11. I felt that Grade 11 was too pivotal to introduce a new programme of which the effectiveness was still unchartered in South African Deaf waters. The Grade 10 class was already behind in the government syllabus, therefore I did not want to expose them to the risk of widening the deficit gap, should the programme prove ineffective. Subsequently, a critical pedagogical experience named "Implementing problem solving followed".

5.1.7 Implementing problem solving

In this experience, I resolved to implement a problem solving approach. Subsequently, the Grade 8 learners were introduced to a fractal design. It was an inductive teaching investigation that guided the learners through several activities to a certain conclusion. I piloted the learners through the first two levels of pattern formation as a measure of putting them at ease; and, as a way to model to them how

to interact with the given requirements. Thereafter I expected the learners to continue with the subsequent steps in a relatively independent manner. For the remainder of the lesson, the learners made no noticeable attempt to continue with the exercise. They would not look at the paper nor try to follow the instructions. They simply pinned their gaze to a spot on the floor in front of them and relieved it with cursory glances to one another. The same behaviour continued into the second day. I kept encouraging them to return to the text and attempt to make sense of it. They played with their pencils, socialised with each other more openly than the day before, but silently refused to progress with regards to the mathematics problem. On the third day the situation reached a climax. The leader of the group approached in a very angry manner. She argued that "You did not give us the answer. Therefore, we cannot give the answer back. You must first tell us how to get the answer."

Her response gave me a measure of understanding into the situation. The three days resembled a dialectic standoff with the learners wanting me to provide solutions whereas I wanted them to engage their own reasoning and find possible alternatives themselves using the materials provided. The origin of the tension nested between the opposing thoughts and beliefs that surfaced in the class with the learners saying "Just tell me what it means", and my feeling of "Just discover what it means".

After this experience, I was uncertain as to how to continue. I decided to go back to absolutism and traditional mathematics largely because of the perceived unproductivity with respect to problem solving.

5.1.8 The return to absolutism

Brombacher (1997) indicates that oscillation between traditional and reform practices tends to occur at the onset of incorporating a new philosophy into the classroom. He describes a process of dissatisfaction on the part of the teacher that is largely induced by the students' reaction to traditional

mathematics. Thereafter follows a period during which teachers question aspects of their practice and embark on a search for solutions. Yet, teachers tend to return to earlier practice. This is because they find it difficult to incorporate the remedies while having to teach the curriculum. Brombacher (1997) argues that without a vision of what the alternate classroom might look like, teachers cannot maintain the changes they are attempting. Change will ultimately be constrained by the educator's' views of mathematics and mathematics education.

Nevertheless, I was determined to win the dialect war by 'getting the Grade 8 learners to think for themselves'. Problem solving extensions were therefore introduced on a fortnightly basis. Unaware to me at the time, I was moving through the stages along the pathway from teacher-centred to student-centred practice as identified by Goldsmith and Sunther (1997) cited in Artzt and Armour (2002). According to Goldsmith and Sunter, the initial stage of the transition is characterised by traditional instruction with special emphasis on clear transmission. Subsequent stages involve more focus on building students' understanding and less on acquisition. It stems from the belief that students should take greater responsibility for learning. The advanced stage adopts instruction in line with the reform movement and is motivated by the belief that learners can construct deep and interconnected mathematical understanding.

My final stage took the form of a formal research project which is detailed in the following section.

SECTION B

This section discusses the current research findings with respect to the primary and secondary research questions outlined in Chapter 3. This section is divided into three sub-sections. Firstly, Deaf learners' orientation to mathematics in general will be considered. The information was gained from the mathematics teachers at the particular school. Barriers to the learners' progress will also be

highlighted. Secondly, the Grade 9 learners' orientation to a problem solving mathematics will be discussed from a researcher/teacher perspective. Thirdly, the learners' own experiences of a problem solving curriculum will be detailed in the final section.

5.2.1 Teachers perception of the general orientation of Deaf learners to mathematics

There are several patterns that emerge from the interviews conducted with the teachers.

The first consideration is the general level of performance in mathematics in a classroom of Deaf learners compared to that of a mainstream setting. Although not based on formal testing, a predominant perspective of the teachers are that in an average class size of 6 to 9 learners, approximately 1 or 2 of the learners could manage with a mainstream curriculum at a mainstream pace. The others were described as lagging behind with a gap ranging between 3 and 4 years. Subsequently, the teachers' evaluations tend to correspond to international findings (Nunes & Morena, 1998; Traxler, 2000; Nunes & Morena, 2002; Zarfati, Nunes and Bryant, 2004; Bull *et al.* 2005, p.223) that suggest delays of about three years in Deaf mathematics compared to hearing youth. Outliers of five to six years have also been noted in certain classes with specific individuals.

Furthermore, all the teachers indicated that they were not able to work in accordance with government regulations. In other words, they could not reach the outcomes, nor cover the necessary concepts as listed in the Revised National Curriculum Statement. The most frequently stated reasons were related to low literacy levels; low level of formal operations attained by the learners; mixed ability groupings incorporating learners who are 'more than just Deaf'; foundational mathematical concepts not being in place; and, their own professionalism being dominated and curtailed by existing authority structures. These reasons are elaborated on below.

5.2.1.1 Common barriers experienced in Deaf mathematics.

a) Low levels of literacy

Consistently low literacy levels remain an area of concern in schools for the Deaf. Discussions on how to improve literacy inevitably culminate in aspects of the oral/signing dispute. This dissertation does not wish to undermine the importance of this centuries old debate with formidable historical proponents such as Abbè Charles Michel D'lEpeè (1712-1789), Abbè Roch Ambroise Sicard (1742-1822) and Edward Miner Gallaudet (1837 – 1917) advocating Sign Language as the first language of the Deaf; and their rivals in the like Samuel Heinicke and Alexander Graham Bell (1847 – 1922) who promoted speech practices as the way to educate a deaf child (Winefield, 1987). Nor does it wish to be ignorant of the contemporary developments and neo-schools of thought emerging from these administrations (Nover, 1998). Yet it is argued that the enormity of the scope of this disputation and its impact on Deaf classroom practices, fall outside the confines of this work. Nevertheless, editors such as Cocking & Mestre (1998) have collated the linguistic and cultural influences of learning mathematics from a second-language perspective. It is generally found that first language learners outperform second language learners. Second language learners have particular difficulties in word-related problems. On the other hand, one question that emerged in this research with respect to literacy is the degree to which lack of literacy influences Deaf learners' general attitude towards school, with particular emphasis on commitment to homework.

b) Weak formal operations

Formal operations include higher cognitive functions involved in problem solving, abstract thought, logic and transfer. Teachers noted that the learners were 'very very weak' in these areas. Both hearing and Deaf teachers explained the deficit by establishing a relationship between the delayed

development of the learners and their caregiving histories. In other words, the teachers maintain that Deaf learners do not reach age-appropriate developmental outcomes because normal transactions between the child and the stimulation and nurture provided by the caregiver in the child's development, are interrupted through the communication barriers inherent to deafness.

Simply put, it was attested that the learners' cognitive skills were atypical because of lack of early language experiences. The exact nature of the relationship between language proficiency and thinking processes has been at the root of several broader philosophical and psychological discourses (Piaget 1955, Vygotsky, 1978). These debates significantly impact deafness by reason of the strong recognition in Deaf education that inadequate early language development may carry serious cognitive repercussions (Marschack, 1992; Akamatsu, 1998; Mayberry, 2003). A general argument found in Deaf education is that the deficits experienced in the classroom are not necessarily the result of a lack of hearing, but the lack of language. Such views rest on a strong Vygotskian element of reasoning, which is also reflected in the considerations of teachers interviewed for this particular study.

As explained in the literature review, Vygotsky posited that social interaction plays a role in the development of higher cognitive functions. Stated differently, as social beings our minds and our identities develop relationally. Firstly, through culture children acquire much of the content of their thinking, that is, their knowledge. Secondly the surrounding culture provides a child with the processes or means of their thinking, what Vygotskians call the tools of intellectual adaptation. And thirdly, lower biological elements transform into qualitatively different higher functions such as memory, reasoning and logic through mediation. Consequently, cognition is the product of socialisation. Consistent with the concept is the argument that deaf children experiences greater social deprivation and thus manifested greater developmental disturbances. In essence, the ability to

make sense of our experiences and thus render it meaningful is both enabled and constrained by language (Davis, 1996).

Deaf learners, however, are more prone to social deprivation because of their inability to access the language of the family in a natural way. This stems from the finding that 90% of deaf babies are born to hearing parents (Dolnick, 1993). It is common that parents and family members want the Deaf child to be 'just like them'. Hence, many hearing parents tend to use a spoken language, rather than adapt to signing. Subsequently, the deaf child is cut off from the dialogical relationship between the individual and collective knowledge. Since, the child's access of the social plane is limited, it impacts on the transfer to the psychological plane. The result is that a deficit in higher cognitive functions to regulate behaviour, particularly problem solving situations, develops. Current research appears to support the aforementioned argument. Kritzer's (2007) research found that relatively high mathematical ability in young deaf children are associated with early identification of hearing loss, at least one deaf parents, and fluent exposure to sign language in the home. Her work particularly emphasis how higher quality mediation techniques, supplemented with language-rich learning opportunities within the home environment translate into more 'mathematical success'. In contrast, children that have less access to language and high quality learning opportunities at home tend to display relatively low mathematical ability.

Without denying the explicit importance of language in learning and development, Marschark (1992) cautions not to oversimplify the relation between language and cognitive development. He posits that the relationships may not necessarily be representative of a straight-forward direct type of correlation, but more probable one that is confounded by yet undiscovered sub-factors.

In addition to the emphasis on language and cognition, teachers made other comments that suggest that Deaf learners experience difficulty within the school setting to transit from other-regulation to self-regulation through the Zone of Proximal Development.

Teacher B: I will act the lesson for the class. I will put it altogether for them. Step-by-step. I will then explain it to them on a one-on-one basis. Suddenly, a learner will ask me a way out question on an isolated issue that has nothing to do with what I have been trying to explain.

The above quote describes a child responding in a manner that has nothing to do with the task, as the adult perceives it. Wertsch (1979) posits that a learner will transit through four levels from other-regulation to self-regulation in order to attain independent problem solving abilities. The behaviour expressed in the quote typifies the first level the child has a very limited definition of the situation and subsequently fails to interpret the adult's statements in terms of the task situation.

There is evidence that some of the learners progressed to the third level in Wretch's hierarchy. At the third level the child is able to follow nonexplicit directives and has begun to take over some of the responsibility for regulating his/her own activity. Stated differently, the transition from other-regulation to self-regulation has begun but it still takes place on the interpsychological plane (Wertsch, 1979).

Teacher B: My biggest frustration in Deaf education is that you have to think of everything all the time. You cannot just simply give an instruction. You must specify the START, the MIDDLE, the END, the TOP, the BOTTOM. But there is one Grade 11 boy who seems to be able to work out some of the task for himself. It is really only the Grade 11s.

What is confounding, however, is that there is little evidence to suggest that Deaf learners at this school successfully move into the fourth level. The fourth level signifies the final shift from the interpsychological to the intrapscyhological. Simply put, the child can carry out the task without any assistance from an adult (Wertsch, 1979). The question therefore is why there is so little evidence of internalisation and subsequent self-regulation occurring within the Deaf child in the school setting? Closure in terms of moving from the interpsychological to the intrapsychological plane through the ZPD is largely delayed, and it is debatable as to whether it happens in the majority of learners at this particular school.

c) Mixed-ability groupings

Large individual differences were identified amongst the Deaf learners grouped together in particular classes. These differences may be attributed to several factors including family background, language and, multiple disabilities. With respect to the latter, Bruce, DiNatale and Ford (2008, p.368) state that 'according to even the most conservative estimates, at least a quarter of deaf children have additional disabilities'. In such cases, deafness and the additional disability or disabilities interact with each other, compounding the effect. One particular effect is the ability to attain the necessary educational outcomes in the specified time frame.

Both hearing and Deaf mentioned the multiple levels of ability in one class being a factor that influenced suitable progression through the curriculum. Linchevski & Kutscher (1998) conducted research on mixed-ability and same-ability grouping in mathematics in hearing classes. They concluded that placing students in mixed ability groups was not detrimental to their achievements when compared to similar-ability-level classes. On the contrary, the average and weaker students in mixed-ability settings showed significant gains, whereas the loss in achievement of the stronger students was negligible. Subsequently, when streaming according to same-ability groups take place,

the stronger students' do not gain much from the arrangement, however the weaker students are disadvantaged.

The research above considered low, moderate and high ability groupings. One aspect that needs to be taken into account in Deaf education is that the groupings are often extreme. Marshack & Hauser (2008) state that already at preschool level large individual differences exist amongst Deaf individuals. Unless attenuated, these gaps tend to grow larger as learners progress through formal schooling. The following teacher's comment renders support that very large gaps indeed exist by the time learners reach middle to late adolescence.

Researcher: Describe the levels of the learners in the Grade 9 class.

Teacher T: H is at a Grade 7 or 8 level … Grade 9 in some instances. A is conceptually on a Grade 8 or 9 level. She has a limited vocabulary for a Grade 9 learner. There are many words she does not know. This limits her compression. She is conceptually on par with hearing Grade 9's, but her lack of comprehension hampers her. G has a big vocabulary. She can recognise words, but does not comprehend them. She is like a parrot, with no understanding or insight of the written word. She is functioning at a Grade 7 or 8 level. She is weakish. C and F are at a Grade 5 level. And with B it is hard to tell. She is a dreamer. She seldom engages. D and E are at a foundational level. Remember, D was a premature baby. He couldn't yet write his name in Grade 4.

The range extends from foundation phase to Grade 9. This covers the entire GET curriculum in one class with a 'low' group at a foundational phase level, the 'moderate' group at an intermediate phase level and the high group at a senior phase level. Interviews with other teachers show that the levels

are not unique to the Grade 9 class, but occur in most classes. The implications of the varied levels are that Deaf learners tend to benefit less from standardised school settings than hearing children (Marshack & Hauser, 2008), and will thus require teachers who have ample experience with multilevel instruction (Bruce, DiNatale & Ford, 2008). It is recommended, however, that further research is conducted to monitor how such strong outliers in mixed groupings and in similar groupings affect the performance of weaker and stronger learners.

d) Lack of professional freedom

All the primary school teachers indicated that they were not free to give expression to their own professionalism. Rather, they felt subjected to literacy and numeracy programmes, timetables, report-writing and other aspects that they did not agree with. The teachers articulated that their own ideas would more effectively address the needs they perceived amongst the learners

Teacher I: I do not have freedom. I must follow a structure, otherwise I get into trouble. I do not necessarily agree with the structures. It works for some children, but not for others.

Teacher R: I did things that were good for the children in terms of literacy and numeracy. But I was forced to give it up and teach Leonardo da Vinci. So the teachers are not listened to. They have no freedom. You must fight for it.

It emerged from the interviews that the primary school teachers felt bound by bureaucracy within the school itself. In other words, they felt that they had little control over decisions to influence strategy and make the curriculum more appropriate for their learners. Carl (1995) argues strongly that meaningful curriculum renewal is only possible through active teacher involvement.

> As teachers are the implementers of the syllabus, they may identify deficiencies and defects for example, the relevancy of contexts, the practical feasibility thereof, the degree of difficulty, the realization of the objectives within the specific time schedules, unclear formulation and the realism of syllabus content. It is therefore essential that there should be greater teacher input so that teachers will be curriculum developers. (Carl, 1995, p. 250)

Wink (2005) encourages teachers who are experiencing homogeneous power relations to find a way to renegotiate their power within the constraints of their work context. Likewise, when the principal was interviewed on this matter, she expressed that the teachers themselves needed to mediate a way through which they can exercise their professional freedom. The teachers' however, desired the moral support of the principal in order to create an organisational climate within the primary school where change is considered lawful.

Taken into account the constraint teachers felt within the system, and that learners' performances are substandard relative to government outcomes in lieu of the elements outlined above, teachers try to combat the situation by adopting specific pedagogical strategies. The most common strategies reported by the teachers interviewed are discussed in the next section.

5.2.2 Teaching strategies employed in mathematics

Teachers attempt to re-establish foundational concepts by 'going back to the basics'. Their intervention is based on 'filling the gaps' and 'establishing a core number sense' in the learners. The perceived lack of abstract thought in learners is accommodated by focusing on concrete learning activities and practical every day tasks. Teachers resort to continuous repetition of previous learning activities and examples to address the elements of poor recall and transfer they experience. Since the

learners are seen to lack metacognitive abilities, questions are always asked in one set way or from one standard angle. Furthermore, learners are encouraged to focus on the task at hand by engaging them in games and activities and visual learning. And lastly, often the wide range of abilities in the same class is dealt with by teaching 'one-on-one'. Teachers do incorporate activities geared at engaging learners in the richer, more abstract nature of mathematics. However, they describe their attempts as largely unproductive.

The teachers' adaptive strategies illustrate two aspects.

Firstly, they downgrade from attempting a normal standard government curriculum to working within a reduced and simplified framework. It could thus be argued that Feuerstein's passive-acceptance approach (Feuerstein, 1980) is adopted in Deaf education. This occurs in mathematics as indicated by the teachers of mathematics, but also in other subjects as indicated by the Grade 9 teachers interviewed with respect to the further learning areas. As explained in the literature review, the passive-acceptance approach concentrates on changing environmental conditions to suite the low level of performance of the learners. The passive-acceptance approach is contrasted to the active-modification approach where an intense commitment is made to modify the learner, rather than the material to be learnt.

A similar interpretation in which to explain the teachers' strategies is provided by Moores' (1996, in Marshack, 2003, p. 465) three historical stages of cognitive investigation amongst Deaf learners. Moores identified the first stage as 'deaf as inferior'; the second stage as 'deaf as concrete' and the third stage as 'deaf as intellectually normal'. From the teachers' responses it can argued that the school is functioning in the second stage where deaf learners are seen as concrete. Marshack (2003) cautions that this does not mean that Deaf learners are considered as incapable of abstract thought. Rather, in this stage 'educators continue to struggle with deaf children's academic difficulties and

their tendencies to behave in apparently concrete ways in various problem solving, academic, and social situations' (Marshack, 2003, p. 465). In other words, educators observe that older Deaf children function in the classroom in a similar manner to younger pre-operational or concrete-operational children according to Piaget's stages and adapt their teaching accordingly.

Secondly, Simms & Thumann's (2007) claim of presenting Deaf learners with a 'watered down' and 'relegated' curriculum appear substantiated. However, the reasons differ. At this particular school, the teachers started with a high view of Deaf learners and concerted attempts to teach mainstream curriculum in visual and innovative ways. Yet, despite their efforts the Deaf learners were generally not able continue the trend. Several factors, including the aspects discussed above such as poor recall, inability to transfer and lack of motivation to learn, hinder progress and necessitate teachers to lower their expectation and to offer a reduced curriculum. In other words, it is valid to say that low expectations exist in this particular school for the Deaf. Consider the following comment by a teacher:

Teacher U: After working with Deaf I no longer agree that the 'Deaf can do anything, but hear.

These expectation, however, seem to originate with the Deaf learners' inability to perform at the expected standard, rather than being inherent within the teachers after exposure to audism in society and through specific university courses. In other words, teachers state that they change their expectations of Deaf learners once they experience that Deaf learners cannot keep up with the curriculum as specified by government regulations. The general results from the study is thus that teachers initially set out to adjust the curriculum and their teaching instruction in several ways (scaffolding of language, strong emphasis on role play, visual learning, frequent repetition). However, to a large extent these still do not present a panacea for the difficulties Deaf learners have

with mathematics or any other subject. Hence, there comes a particular point where primary blame is transferred onto the students.

Teacher I: I followed the curriculum at the start of the year, but the children were not with me. They were very weak.

Teacher B: The curriculum is way too fast for them if you teach it at its normal pace with its normal requirements. They couldn't to the practical tasks. I explained it to them. We did it in school. But when they had to do it on their own it was beyond them. They tried, but it was hopeless.

From my own perspective I was particularly interested in the learners' recall and in their apparent passive approach to problem solving. It was the inability of the learners to recall information previously taught that forced me into a cycle of redundancy and overlearning. It was the consideration that the learners' meta-cognitive skills may be insufficient for a complex problem solving curriculum that trapped me in vacillating between traditional and reform mathematics. Therefore, I would like to present my personal pursuit to rationalise these two particular aspects of Deaf education.

5.2.3 Aspects of recall and problem solving

a) Recall

I firmly hypothesised that the disparity in Deaf performance in mathematics during my teaching substantially correlates to the learners' perceived inability to recall. Although the Deaf staff is moderately positive about the abilities of the Deaf to recall, there are clear indications from the interviews concerned, that recall may warrant further academic inspection.

The following extracts from these interviews demonstrate that recall component creates its own challenges in the classroom.

Teacher O: I will repeat the lesson a thousand times. They still forget. I was teaching Sign Language in the high school from 2002 to 2004. It was a terrible experience… Their lack of memory scares me.

Teacher K: Some can't recall at all… They learn how to count in 2's. When they are tested the next day or within the week, they don't know. It is lost within a week.

Teacher D: It depends on what they have learnt. Like historical facts. There is very little recall. When I do the work and then test them 3 days later, there is no recall at all.

Recall can be related to several factors. There is the claim that when mathematics is taught using the transmission model, the procedures are only remembered as long as they represent knowledge-in-use (Cangelosi, 1996*).* In other words, when the algorithms are no longer practiced, the learners tend to forget the procedure. These excerpts, however, suggest that the recall challenge appears wider than mathematics. During the research it has surfaced as a concern across all subjects and all grades. Many of the teachers reported using teaching strategies other than the transmission style. Moreover, similar to my earlier critical pedagogical experiences, it surfaced amongst both hearing and Deaf staff i.e. staff who have sign language as their first language and those who do not. And yet there are also anomalies.

Teacher B. Their recall is odd. When that Brazil girl was here they recalled fine. They had a brain. They responded like a normal class. They put their hands up to answer questions. I was totally shocked. They behaved like normal children. C especially. Now in the exams she can't remember. I think they don't study.

Another teacher hinted at something very similar during an informal discussion.

Teacher T. It is so strange. I know that deep inside of them they know. If you had to put a loaded gun to their head and say, "This is your last chance. Give it to me or die!", I tell you now, they will be able to come up with the answer.

I found it particularly hard to make sense of the situation. Initially, my own thoughts on the matter converged with the teacher's comment that too little time is spent on homework. As indicated in the data analysis the Grade 9 learners who are also boarders acknowledge that they do no homework whatsoever in the hostel at night. Both the house father and the house mother confirmed the lack of time spent on homework. Aside from the hostel, the learners are assigned one hour for homework in the hall under the supervision of a teacher. Yet the supervisors in the hall expressed that the general performance is erratic. Neither is the opportunity for studying fully realised at home. The parents indicated that the learners spend occasionally around 2 hours on homework over the weekend. The homework, however, is not moderated and neither is the time enforced.

The following excerpt was recorded in the Grade 9 class following a particular poor performance in a control test.

Researcher: How much time did you spend learning for this test?

F: One and a half hours with my sisters.

H & A: The same – one and a half hours.

Researcher: R, what topics did you cover during that time.

H: SILENT.

F: Area

H: Area

F: And triangles

H: Triangles

Researcher: F could you perhaps give H an opportunity to speak for herself.

Researcher: H what topics did you cover?

H: SILENT. SHRUGHS HER SHOULDERS AND AVOIDS EYE CONTACT.

Researcher: [addressing the rest of the class individually] How much time did you spent learning for the test?

A: I studied area and triangles.

D: Nothing

C: Nothing.

G: I paged through my book for about 15 min.

E: SILENT

B: A little

Researcher: What topics did you cover?

B: SILENT.

Except for the one learner, little evidence of real studying can be gathered from the learners' comments above, despite the matter that this was an important term test. The homework situation is certainly an issue for concern and it does have the potential to impact recall. Simply put, if one never studies for a subject, how will one answer questions related to the content or increase memory, understanding and abstract thought.

This then raised the question as to why Deaf learners were reluctant to do homework. Several factors may contribute to poor academic preparation, including the Deaf learners' conceptual and content knowledge, comprehension and learning strategies (Marshack & Hauser, 2008); fewer demands placed on them and/or the learners being less invested in academic success (Marschack, 1998). In this particular school there was generally little sense of academic pressure compared to hearing schools in the area, which may help to explain the learners disinterest in homework, and which may also be explained by Marschark (1998) latter comment that often fewer academic demands are place on Deaf learners. Personally I attributed the lack of commitment to homework to the learners' low levels of literacy. It is difficult to specify the exact level of Deaf literacy in the high school. The HOD of the high school explained that an attempt was made previously to establish this data using a standardised English reading assessment formalised for such purposes. The lowest entry of the interpretation of the scores was that of a 6 year old. Exceptionally few learners had sufficient scores to fit into this category. Stated differently, the majority of the learners' scores could not be assessed as they were too low to fall within the range of given interpretation. Subsequently, all that could be concluded from the procedure was that the majority of learners in high school had a reading age below that of a 6 year old.

My predictions with regards to the impact of literacy on homework were shared by another Deaf staff member.

Teacher P: The learners are frustrated. They hate to work. They can't understand anything. I can identify with that. I went to UNISA five years after school. It was hard. The level of reading and vocabulary was high. I was frustrated and tearful. I couldn't understand. I couldn't picture it.

In other words, the learners have difficulty picturing what they are reading. This limits their understanding. Thus, any learning activity is devoid of real meaning. A person's disposition to learn is inextricably bound to his/her ability to create meaning. Hence the lack of meaning may feed into the negative epistemological attitude commented on by teachers.

Researcher. What is your biggest problem?

Teacher D: Their general behaviour, attitude and lack of interest are the biggest problems. They are not here to learn.

Teacher B: I do not expect them to do homework any more. There were times when I gave them homework. They just didn't do it. I gave them lines as punishment.

The situation in the school is not reflective of teachers who are not concerned. Rather, it speaks of teachers who have tried all the punishments methods made available by the school including, writing lines, detention, parental meetings and positive reinforcement. Yet, despite these efforts the learners show little interest in scholastic achievement. Over time the teachers tend to resign themselves to the reality of dealing with learners who do not seem to value education.

By way of summary, my reasoning was that the learners cannot read with meaning. Therefore school carries little significance. Moreover, illiteracy curbs attempts at homework. Punishment is ineffective

as the root cause is not dealt with – the root cause being the learners; ability to make sense of the text they are meant to process. Ultimately, lack of effort and time on homework exasperates poor recall.

Yet, the argument is not necessarily as straightforward and simple as given above. Further investigation reveals that even in situations where homework is consistently enforced by the parents, and where parents work intensely with children to establish meaning through sign language, recall remains a problem. A mom, who is also a staff member at the school, expressed her daughter's performance as follows:

Mom K: Yes, she also has a recall problem. You show her a problem today, tomorrow she forgot about it. All of them seem to battle with recall. It must be more than just a lack of learning. I will show her at school. I will do it again at home. Half way through she will get stuck again. Tomorrow she will ask me again.

Another aspect closely related to recall is that of transfer.

Teacher I: For example, I teach subtraction in various ways – in money and measurement. I have to reteach subtraction in each of these sections. There is no spontaneous linking. I don't know why.

It was, however, in reading the work of Feuerstein that deeper insight into the situation at school relative to attitude, transfer and recall emerged. Feuerstein et al. (1994) make reference to the cognitive deficits experienced by the culturally deprived child.

> And yet, there are masses of individuals who are totally unaffected by direct exposure to stimuli, i.e. they are unmodified in their responses and their behaviour. In some extreme cases, even task related behaviours are continued rigidly in the same way *as if the previous experience has been wiped out as soon as it occurred, and the perceived object or event is experienced as new, never seen, never heard, never registered.* In these cases the "perceived" stays as a totally isolated episode, *neither related to the previous experience nor to the one that follows*". (Feuerstein et al., 1994, p. 10-11, my emphasis)

In other words, Feuerstein et al. (1994) explain that it is common in culturally deprived individuals to react to content previously taught by saying that they have never seen the material. Moreover, once learners start learning new content, they will simply forget work that they previously mastered. Feuerstein (1980) explains that on the level of memory, there occurs a loss of fragments of previously acquired information, as soon as the individual changes the focus of his/her attention. The learners are therefore unable to retain those elements that they were able to recall at first, once they succeed in remembering material they are currently exposed to.

The learners' impoverished states of recall are ascribed to their passive attitude towards themselves as the mediums through which cognitive processes operate. Simply put, culturally deprived individuals believe that they exercise no volitional control over cognitive process, including the act of remembering (Feuerstein, 1980). Remembering is not conceived as an active process of reconstruction of the experienced reality. Rather it is considered as something over which they have limited control. In other words, remembering happens to them, and not by them. Thus, memory is considered to be either there or not. There is no belief in their own capacities to recall memories at will or to make it happen by generating information beyond what emerges spontaneously and

immediately (Feuerstein, 1980). Hence, they will remember certain dimensions quickly and spontaneously by virtue of their greater immediacy or saliency, or through increased vigilance. Yet, they are inclined to renounce other information of greater relevance and importance because it is not easily accessible should it requires specific directed effort. Consequently, their perception of possessing an extrinsic locus of control to information results in a narrow and restricted mental field (Feuerstein, 1980).

In addition, Feuerstein's (1980) work can also be used to explain the anomalies described previously where one teacher commented that the learners 'suddenly started functioning as normal children' and another 'that they will give you the answer if you hold a loaded gun to their head'. Feuerstein (1980) explains that under certain conditions, adequate recall functioning may appear in culturally deprived learners. This is because the cognitive functions are not necessarily totally missing from the repertoire of the individual. Rather they are weak and vulnerable. The conditions of adequate functioning are dependent on the elicitation of a strong need in the individual. Perhaps in this particular instance the need was to create a positive impression on a foreign girl visiting the classroom. Subsequently, manifestations of adequate functioning are rare and infrequent because of the lack of the requisite need. Without a need it takes too much effort to mobilise these functions, which render their use uneconomical. Hence, it is to be understood that the ability to recall will not appear regularly and predictably in the individual (Feuerstein, 1980).

In addition, Feuerstein (1980) states that such learners will not be able to transfer information i.e. make connections between related areas of work. Culturally deprived individuals experience an episodic grasp or reality, where each object or event is experienced in isolation without any attempt to relate or link it to previous or anticipated experiences. An episodic grasp of reality implies a lack of comparative behaviour.

Moreover, Feuerstein (1980) work can also be used to explain why Deaf learners tend not to value schooling in their tendency to dismiss the importance of homework and habits such as learning for a test.

> The culturally deprived individual is the one who, either not having been exposed or not having been able to benefit from his exposure to mediated learning experiences, is devoid of learning tools, habits, dispositions, and propensities to learn. (Feuersteien et al., 1994, p. 5)

Feuerstein argued that often culturally deprived individuals will have a complete lack of interest in academic studies; and, that they will experience no arousal of curiosity within such a setting.

At the beginning of this section it was noted that apart from recall, I was also particularly interested in the aspect of how Deaf learners' adjust to problem solving in an academic setting. Hence, the next section moves away from recall, transfer and interest in academics to explore how Deaf learners' in the school were found to manage problem solving activities.

b) Problem solving

Problem solving generally requires higher order cognitive functions such as abstract thought and logic. Teachers, however, indicated that the learners had a strong reliance upon the concrete, associated with a lack of readiness to use representational mechanism to actively manipulate information. Several reasons were attributed.

Certain teachers attributed the lack of representational thought to a lack of knowledge.

> Teacher B. It [abstract thinking] is very weak across the grades. You need knowledge in order to abstract from it.

Others mention the learners' apparent limited intellectual capacity.

Teacher D. Yes, the work level is too high. I brought it down. Because of their lack of intellectual ability. Reading problems. They are not very bright. Lack of general knowledge and no language.

Feuerstein (1980) acknowledges these teachers' responses by affirming that often a child's failure to perform in the classroom is attributed either to a lack of knowledge; or, to a level of intelligence which precludes the child from understanding the principles. He argues that it is often overlooked that the deficiency may reside not in the specific content of the child's thought processes, but in the underlying functions, which make cognitive operations possible. In other words, the low level of scholastic achievement and low level of general cognitive adaptation during adolescence are a product of the lack of, or inefficient use of, functions that are a prerequisite to adequate thinking (Feuerstein, 1980).

The teachers' perceptions' of the profile of a Deaf learner to problem solving were discussed in detail in the previous paragraphs of this chapter. The next section will evaluate the degree to which the Grade 9 class' orientation to problem solving in mathematics corresponds with the broader and more general description gathered from the interviews. The Grade 9 class' orientation will first be considered from a researchers' perspective, and thereafter presented from interpretations of their own experiences.

5.2.4 Deaf' learners' orientation to a problem solving mathematics curriculum

Maree, Prinsloo & Claassen (2006) state that developing effective problem solving processes in learners requires a specific classroom set-up. They elaborate on the specifications as follows:

> These learning strategies flourish in a learning environment that gives preference to problem-centred solution approach and the co-operative attempting of Mathematics problems, and where socialising (social interaction) in the Mathematics class is realised adequately. Pupils should participate actively in acquiring the language of Mathematics and enculturation should occur in the classroom so that certain ways of expression, terms and/or explanations become acceptable in the classroom concerned, i.e. become a part of the classroom culture. In other words, where pupils gain the insight that is formative to discuss relevant concepts with friends and teachers, explain them to friends, parents and other persons, and where pupils have enough insight to search for possibilities of applying Mathematics in real life'. (Maree, Prinsloo & Claassen, 2006, p. 6)

From the quote above three aspects were selected for the purposes of this study. These include problem-centred mathematics (divided in problem solving though application and problem solving as the basis for learning), co-operative groupings, and mathematical communication. The Grade 9 class's orientation to each of these categories will now be discussed below.

In terms of communication, and group work dynamics there appeared to be little observable difference between the two approaches i.e. the problem solving activities requiring application of previously acquired concepts and the problem solving activities requiring the constructing of new

mathematical knowledge. The following provides a more detailed account of how the learners' orientated themselves in terms of these two categories.

a) Group work

Although seated in groups, very few learners worked together on a task. They spontaneously assumed the traditional classroom role where they learn in the presence of others, but not with others. Moreover, the setting was generally used as forums for social talk while the teacher was with another group. They had particularly difficulty in adjusting to personalities whilst working on problems together. Statements such as "I don't want to work with this person" or "I can't work with this person" were often re-iterated.

b) Mathematical communication

Murray, Oliver and Human (1998) state that communication serves distinct purposes in a problem-centred classroom. Shared mathematics knowledge creates a consensual domain. As learners express their thinking, it promotes a form of examination and reflection that may reveal insufficiencies, contradictions, or irrelevancies. Through negotiation within this domain viable conceptual strategies may be advanced and redundant thought constrained. Moreover, learners' self-confidence may be raised as they actively participate in the negotiation and institutionalisation of mathematical knowledge.

Learners found communicating mathematics particularly difficult. Mathematics communication was mostly restricted to pointing out errors, copying answers without any explanations or thought, and requests to borrow stationary such as rubbers or tippex. Subsequently, many learners did not participate in their any meaning-making of their own, but simply 'shared' in the answer that 'was going around'.

When each group was asked to present its ideas two extremes were noted. On the one hand, certain students seem to enjoy the attention they gained from being the speaker for the group, and would meandered on, but without much focus. During these sessions, there was no visible building toward student-to-student talk. Rather, interactions were directed toward the teacher in spite of encouragement to divert attention and eye-contact back to the audience. On the other hand, others just refused to communicate by signing that they did not know. By way of summary, there was little middle ground where students debated and wrestling with ideas and problems, to reach some common solution based on a mathematical argument. The poor mathematical dialogue may be attributed to Deaf learners' lack of familiarity with and previous exposure to justifying and arguing a point (Markley et al. 2003); or to a lack of "inner speech" (Wertsch, 1979; Schoenfeld, 1987).

Nevertheless, there were two aspects of their rhetorical practices that particularly confounded me. The first occurred when learners were asked to explain their findings to the group. A common response to this request was for learners to simply write the answer on the board and sit down with any dialogue or explanation. The second was that while the presenters were signing or 'writing on the board', the others in the class would passively await their turn. One chief aspect was that learners appeared to accept the explanations offered without any question or interjection even when the person's expositions made little sense or were totally unrelated to the problem. Feuerstein (1980) explains the first scenario with reference to egocentric communication modalities and, the latter with respect to a diminished need for logic.

Feuerstein (1980) posits that egocentric communication becomes apparent when there is a necessity to provide evidence for claims and arguments. Egocentric communicational refers to impairment of communication because of the way an individual regards his partner. Culturally deprived individuals may fail to differentiate between themselves and others. Simply put, they do not see others as

different to them. Subsequently, the individual will not make the communication explicit by providing evidence necessary for the listener to comprehend the situation. Rather, the individual will limit communication in terms of detail, precision and argumentation. This is because the individual feels that his responses are well known to the others and it is therefore futile to communicate. Subsequently, responses are limited to the necessary minimum.

Furthermore, Feuerstein (1980) argues that culturally deprived individuals generally adopt an attitude of acceptance. They are not disturbed by illogical relationships or by direct deviation from instruction; nor do they respond to incompatible or incomplete particulars. The lack of cognitive dissonance should not be attributed to low intelligence or an inability to demonstrate logic, but again to a faulty need system. Simply put, culturally deprived individuals experience little need for logical evidence, hence logical standpoints are not deemed essential. Deaf learners who possess a low need for logic, poses a unique challenge for problem solving mathematics. Siegel and Borasi (1994, p. 210) states that 'inquiry classrooms emphasize the full complexity of knowledge production and expect students to see the doubt arising from ambiguity, anomalies, and contradiction as a motivating force leading to the formation of questions, hunches and further explorations'. In other words, it is the need for logic that acts as a stimulus in problem solving. Without a need for logic, learners will not naturally enter into the processes of problem solving.

c) General disposition to problem solving by application

As was noted previously, learners were firstly exposed to problem solving activities that were rich in language and required of them to apply mathematical knowledge to which learners were previously exposed. Students were exposed to these principles during formal teaching sessions where the primary mode of instruction included participation in mathematical investigations using either physical objects or technology. The objective of these investigations was to extract primary

mathematical principles, which were then summarised, and clarified by the teacher at the end of the session. Thereafter learners were expected to apply these principles to set problems. Examples of these types of activities are found in Addendum H. They can be described as a bridge between traditional decontextualised exercises and fully integrated modeling. During this phase of the research, several phenomena emerged that are very similar to the profile constructed during the teachers' interviews. Generally there was a passiveness when confronted with these types of problems. Kelly & Mousley (2001) confirm that Deaf learners have a negative, disengaged approach to problem solving tasks presented in writing. Moreover, during investigations learners depicted a sense of being disinterested and bored, combined with uncertainty and a lack of confidence to proceed. Subsequently, they waited for and relied on being coached by the teacher. Their own attempts resembled a scattershot approach, rather than careful choices of core concepts. Often learners would simply repeat the previous day's example without considering that, although the principles remained the same, the content and the context of the question have changed. Moreover, weaker learners would set aside the given problem and create problem scenarios of their own which they then set out to answer.

In addition, the learners' perceived the power of mathematics to lie only in exactness and not in processing information. Simply put, the learners were very concerned with 'getting to the right answer' and did not seem to attach much value to the processes of problem solving or mathematical dialogue. Moreover, if they did not have immediate access to the answer, they would show frustration and a tendency to give up without considering further plausible solutions. During a particular instance a learner and her partner were notably detached from the problem and from each other. When I asked why they where not in discussion, the learner replied by saying, "I can't discuss it, because I don't know the answer". This need for 'having the answer' was further evident in their constant request for affirmation by asking "Is this right?" In other words, the learners were hesitant

to creatively venture towards a solution on their own. Moreover, there was a reluctance to rethink or discuss their solution.

What was interesting to note was the distinct difference between the learners who had previous exposed to similar problem solving application activities through my earlier critical pedagogical experiences, and those that were not. Four learners were in my Grade 8 class the previous year. I will refer to them as Group A. Group B consisted of the other four learners who were all new to the class and had very limited previous exposure to problem solving mathematics.

Group A settled into problem solving mathematics by application more readily than Group B. When the task was presented to them in writing, they made an effort to read the text and engage the task at hand, asking for assistance and affirmation as they continued. They were also more willing to spontaneously assist one another.

In contrast, Group B did not initiate any interaction with the problem at all. They choose to openly avoid the encounter. They were passive in that they would not consider the text given to them; neither would they participate with the other member(s) in their team or group. They almost immediately withdrew from any activity associated with the mathematics. Thereafter they would sit quietly for a time while watching the other pupils. Follow on from this they would start behaving disruptively. Their behaviour assumed various forms including throwing paper balls at fellow students; pinching their team mate; starting a social conversation; scribbling on paper; or drawing a fellow peer into a verbal fight.

Moreover, Group B students had particular difficulty relating to the nature of the curricular problems in relation to more computation-orientated work. Subsequently, a strong recurring theme during the focus group sessions was the learners' solicitation for a more directive teacher role spearheaded by

Group B. They insisted that they were better with mathematics when they were given step-by-step instructions and similar examples to follow. In other words, they wanted the teacher to transmit mathematical content, demonstrate procedures for solving problems, and explain the process through solving sample problems. Hence, they argued that they could not do the work, as the teacher did teach according to these specifications. They wanted their workload reduced to duplication and a display of ready-made knowledge as is found in more traditional settings. When this was refused, group B went through a very angry phase. During this phase they frequently expressed their desire for a Deaf teacher or teacher assistant who could sign more fluently. Interestingly enough, their behaviour corresponded strongly to Group A's initial behaviour during my critical pedagogical experience named "Implementing Problem solving".

Comparing the two group's behaviour over time, it appears that these Deaf learners go through emotional stages in adapting to the requirement of applying previously acquired knowledge to context-rich problems. These stages are marked by intense passivity, followed by reluctant and superficial involvement which then climax in an anger period. The anger is often expressed by demanding a Deaf teacher. Thereafter, the learners appear to become more settled and independent in their approach. It is difficult to estimate the time period as it differs from individual to individual. Yet, in both groups the entire cycle seem to span at least 6 to 8 months.

McLeod (1988) recognises that many students have rather intense affective reactions to mathematical problem solving which appear to be quite different from the usual conceptions of attitude. However, I have not yet found literature to describe any stages of affective adjustment to problem solving mathematics. Perhaps the lack of information can be interpreted in light of McLeod's (1991) concern that apart from mathematics anxiety, emotional factors in problem solving remains an underrepresented theme in general mathematical research. Subsequently, he argues that curriculum

changes towards problem solving mathematics do not seem ready for the emotional characteristics of problem-solvers.

On the other hand, Marschark (1998) describes that Deaf learners demand for examples, and their agitation when these are not offered, should not be considered unusual. He argues that this attitude should not necessarily be associated with their deafness. Rather, it is reflective of the kind of educational experiences the child has had thus far, in particularly experiences that are specific and concrete in nature; or alternatively, resultant of poor communication at home and at school. A similar need for examples have been found in hearing classes amongst African-American students (Solomon, 2006) and lower white socio-economic groups (Lubienski, 2000). In contrast, learners form middle to upper white socio-economic groups did not express the same need. Lubienski (2000), like Marschark, argued that it is an issue of communication at home. In lower socio-economic groups the tendency is to communicate with children in a more directive and authoritarian manner i.e. "You do this exactly like I did it or like I told you". However, in middle to higher socio-economic groups parents tend to reason more with their children in respect to particular views and actions.

An equivalent argument originates with Cangelosi 's (2006) view that producing an algorithm or procedure in a decontextualised context is mostly memory based. Memory is a low-level cognitive work, where as problem solving requires complex intellectual synergy (Feuerstein, 1980; Erickson, 2006). Following on from this, Feuerstein argues that culturally deprived individuals are more comfortable with elementary processes such as identification, recognition, association and reproduction. Although his reasoning is rich in detail, a superficial synopsis is that a lack of early mediated experiences diminishes the brain's auto-plasticity which renders the brain more rigid. Subsequently, the learners resist activities that require more purposeful, intentional and intensive cognitive orientation.

When the learners were asked to voice their experiences during the focus group sessions, the learners indicated that they had difficulty in determining what to do with these specific problems. They attributed their difficulties to the general sentence structures and vocabulary used, as well as the lack of specific directions in how to solve the problems. On closer analysis, the problem seemed to lie with mathematical hermeneutics rather than with English comprehension. Even when the questions were signed to them, they had difficulty in interpreting and finding ways of fitting the words and symbols to any experience. Moreover, they described this particular type of teaching as "boring". Because Group B experienced such strong emotions towards this type of mathematics, a different module was introduced at this stage. In this approach problem solving was used as the basis for learning mathematics. See Appendix I for an example. This particular module followed an integrated modeling approach. Interestingly enough, when learners engaged with these modeling activities different attitudes were noted.

During the focus group interview following the introduction of problem solving as a basis for learning, all the learners indicated that they enjoyed this specific unit of problem solving and that they preferred modeling to the problem solving-through-application approach. The reason they gave was that this type of teaching approach was 'clearer' to them. This was particularly interesting to me as I felt that the second approach involved much more complex than the first. It was also interesting to note that during this period the learners did not become 'agitated over the need for the teacher to provide them with more explicit examples', nor did they voice difficulties with understanding the language. During one particular lesson, the same learner who refused to engage with the mathematics in the previous approach, approach me at the end of the lesson and asked if he could continue mathematics for the following two lessons. Normally, he would move on to the English class, but that particular day the English teacher was absent. Hence, he requested to stay and continue with his mathematical class!

This then raises the question as to why mathematics presented in a 'problem solving-as-the-basis-for-learning' was perceived as being 'clearer' and more appealing to the learners than 'problem solving-requiring-application'? The learners themselves could not elaborate on this aspect when prompted to do so. Several suggestions can be put forth.

Donovan & Bransford (2005) attest that real-world contexts are particularly helpful in building conceptual bridges between students' informal experiences and new formal mathematics they may be learning. However, in comparing the two approaches, both types of problem solving activities contain strong emphases on real-life experiences. Yet, it appears from the learners' comments that there was something in the second type of approach which was more effective in promoting a positive orientation of Deaf learners towards mathematics. The question one is left with is whether this particular type of approach provide a stronger conceptual ladder than the other approaches, and one that helps Deaf students move in a more connected way from where they are into a more mathematically orientated realm? If so, what are the elements within the curriculum that may contribute to these developments? Perhaps the answer lies in Jones, Valdez, Nowakowski and Rasmussen (1994) analysis of engaged learning.

What is seen in the example of the learner asking for an extension of his mathematics lesson, is a learner who is energised by this type of approach and who are beginning to set his/her own learning goals. Jones, Valdez, Nowakowski, and Rasmussen (1994) describe this type of behaviour as 'indicators of engaged learning'. According to Jones et al (1994) one of the key aspects of engaged learning is that the learner begins to take responsibility for his own learning. Their argument is also that engaged learning will occur when mathematics becomes meaningful to the learner. Ultimately, meaningful learning will shift learners from being mere knowledge consumers to becoming strategic and reflective knowledge producers. Engaged learning tasks need to be challenging, authentic, and

multidisciplinary. Such tasks are typically complex and involve sustained amounts of time. They are authentic in that they correspond to the tasks in the home and workplaces of today and tomorrow and that they draw on collaborative learning.

At the same time the findings from the SOM Questionnaire suggests an increase in mathematical anxiety. It is not clear how to interpret these findings. Firstly, mathematical anxiety is an expression of mathematical confidence. The pre-test showed very high ratings in terms of mathematical anxiety. High rankings in the SOM questionnaire mean that the learners were generally very positive and confident in their ability with little fear for the subject. The question raised is whether these very high scores were realistic at the start in consideration of the learners' poor mathematical record. To put it more directly, can a learner who is achieving 17% in mathematics realistically self-report a 80% level of self-efficacy? Solomon (2006) spoke about a similar 'contradiction' among low performing African-American students from low socio-economic backgrounds who related their own mathematical competence and confidence very highly. Alternatively, has the mathematical research increased anxiety? And then which factors contributed to it? Was it perhaps related to being involved in research, or aspects concerning the researcher, the nature of the mathematics where learners had to apply their knowledge, or the nature of the mathematics where learners experienced using problems as the basis of their learning? These questions cannot be answered within this study and will need further investigation.

Another element that emerged is whether the learners enjoyed modeling as the basis for learning and orientated more positively to it, not so much for its mathematical properties and possibilities, but rather because of the particular type of activities contained in it.

Learner E: The third and fourth term is much better. I do not enjoy algebra. The other things I enjoyed because there were activities involved.

Learner A: I understand things clearer when I do an activity outside, than sitting in the class working. When I do an activity outside, I enjoy it more and it is clearer for me.

Learner D: I do not understand maths. Maths is boring. Sitting down and watching is boring. Going outside and doing something is more enjoyable.

(The activity the learners refer to above is going outside to measure their own shadows and that of selected trees and then returning to the classroom to consider how knowing their own length and the length of their shadow could assist one in using the tree's shadow to determine the length of the tree.)

Although both modules contained activities, on face value it seemed that the problem solving-application-approach focused more on a theoretic curiosity on rational relations between things, whereas this particular module contained problems that were grounded in sensational curiosity i.e., things that move, living things, human actions and accounts of human action. However, a much deeper professional analysis of both curricula are required to substantiate these deductions and to begin to understand why the learners felt more attracted to the one approach than to the other. Notwithstanding, the implementation of games and activities into Deaf classrooms carry certain affective cognitive, and linguistic benefits (Markey et al. 2003). In the affective domain, it may help to motivate children and generate an interest in the mathematics. Cognitively, it can assist Deaf children to generalise to more abstract and higher level mathematical ideas. Linguistically, learners may be presented with opportunities to see mathematical language and use it to negotiate meaning as they interact with the activities and with each other.

Nevertheless, there is concern that it is easy for students to get caught up in the activities without exploring or internalising the mathematics behind these activities (Brombacher, 1997; Huntley,

Rasmussen, Villarubi, Sangtong & Fey, 2000). In other words, the learners may only experience the activity instead of actively looking for mathematical patterns or meanings. Hence, teachers must take heed to help students abstract and articulate the underlying mathematical ideas embedded in problem solving scenarios, even to the point where learners will be able to deal with similar algebraic problems free of context cues. Several suggestions are put forth as to how learners may be encouraged to abstract general mathematical principles from contextualised activities. One way in which the learners may be assisted is through encouragement and opportunity to articulate any principles or patterns that were noted during the activity and share these insights with other learners/groups. During such discussions the principles discovered by the learners could be made explicit, highlighted and further honed by the teacher. Additionally, the teacher could introduce a variety of different learning contexts in which the same principle must be applied from within different settings and from different angles. Alternatively, learners may be asked to construct their own mathematical problem in which the relevant principle features.

While it was found that the learners preferred the problem solving approach as the basis for learning because of the activities and that it was 'clearer' to them, what was still notable absent in both curricula were any outward signs that characterise problem solving sessions. Schoenfeld (1987) explains that during problem solving one can observe the roles individuals assume as the work on the problem.

> At different times, he functions as an idea generator, a systematic planner, a critic, a "progress monitor", and advocate first for one particular point of view ("Maybe I should do it this way…") and then for another, and so on. …You see him function in his problem solving as a "society of the mind" – putting forth multiple perspectives, weighing them against each other, and selecting among them. When this works well,

> it is highly productive. The idea generator suggests many interesting avenues for him to try as he works, while the critic and monitor can keep him from going off on wild goose chases.' (Schoenfeld, 1987, p. 210)

Although it is difficult to monitor the inner most thoughts of the individual, there was little outward evidence of the learners assuming any of these roles. Stated differently, learners appeared to lack the individual and social procedures to monitor and improve the nature and quality of their constructions. This evokes the question as to why learners are responding in this manner. Is it primarily unfamiliarity with problem solving in that learners yet have to internalise the social values and norms of an inquiry based problem approach? Is it a lack of strong metacognitive strategies?

By way of summary, the learners expressed that they have negative study attitudes and habits towards mathematics. Moreover, they lack problem solving skills and mathematical hermeneutics which hampers their engagement with the problem solving scenarios. Although, they find it difficult to deal with the open-ended nature of the problems, they particularly enjoy the activities surrounding these problems. In essence, they feel that the activities help them to understand mathematics better.

5.3 CONCLUSION

From the interviews conducted it was noted that teachers, parents and learners concurred that Deaf learners are struggling with mathematics. Hence, the learners have a predominantly negative general orientation to mathematics. What the study did reveal however, is that the learners' orientation to mathematics is not fixed. Both the difference noted between Group A and Group B, and the slight increase in the study attitude, habit and problem solving behaviour seem to confirm De Corte's (2000) view that learners can develop a propensity for problem solving mathematics. However, it

was not followed up whether this change did translate into other classes and whether it was noted at home. It is therefore a limitation of the research that will require further investigation.

In a sense this chapter raised more questions than it provided answers.

Is the learners' negative orientation related to the hidden philosophy embodied in the absolutist approach to teaching mathematics? Yet, it is the teachers' perceptions that similar orientations seem to be visible in other learning areas where teaching sessions are more in line with constructivism.

Can the current situation be ascribed to the lack of systematic studying and work habits of the learners themselves? And then why are the learners not studying? Is it because Deaf learners lack the literacy to make studying meaningful? Do Deaf learners require a stronger support structure, which makes them 'feel that they understand the work', and which is not currently being provided by the school setup or the parents? Or is it simply a lack of academic pressure characteristic within the Deaf school?

Moreover, are the learners' difficulties in responding to a problem solving approach a result of their history of being taught in a passive-acceptance manner, which stems from the school being in Moore's stage of 'Deaf learners as concrete'? Alternatively, is what is seen in class the profile of a culturally deprived individual as depicted in the work of Feuerstein?

These questions open up the dissertation to further critical pedagogical possibilities, some of which are alluded to in the recommendations of the next chapter.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This study explored how Deaf learners orientate to problem solving mathematics. As noted, the theme itself was deemed necessary in the light that few Deaf educators implement authentic problem solving mathematics curricula into their classrooms. Moreover, the problem solving examples were carefully selected to ensure that they meet the criteria of OBE, and are in line with a social contructivist and fallibist philosophy. During later analysis it was also discovered that the problems chosen incorporated many of the principles of cognitive mediation as suggested by the work of Feuerstein.

The following conclusions were drawn from the study:

Before the study was conducted it was important to ascertain how Deaf learners within the particular school orientated towards mathematics. Firstly, the learners self-reported a negative attitude towards mathematics. This was done through a structured questionnaire that was interpreted to the Grade 9 learners in a school for the Deaf by a Deaf adult. Their response showed that a negative orientation towards mathematics, poor study habits, and a low appreciation of mathematics as subject and its relevance in the world. Moreover, the learners also reported very low problem solving skills. The learners' orientation, however, appeared more widespread than the mathematics class in that similar responses were noted during interviews with these learners' teachers from other learning areas. The learners' responses were clarified through focus group sessions and personal interviews.

Secondly, the teachers were interviewed to ascertain the general orientation of the learners towards mathematics in this particular school for the Deaf. The teachers provided a profile of Deaf learners stating that, with the exception of one or two learners in the class, the majority struggle to grasp mathematical concepts at grade level. Moreover, Deaf learners are described by their teachers as passive problem-solvers, dependent on the teachers, possessing low levels of literacy which makes it difficult for them to interpret and derive meaning from the problem independently, and as learners who perform poorly in mathematical tasks that require one to draw on formal operations and metacognitive skills. When parents were interviewed they appeared to be aware of the learners' position towards mathematics.

The barriers that were seen to contribute to this profile spanned several themes. The teachers identified systemic barriers, barriers within the learners and barriers within the teachers. Particular emphasis was given to the learners' perception of what barriers they themselves identified. The learners felt that the barriers lay with their teacher who did not sign properly nor gave clear problem solving examples that they could copy. Moreover, the learners expressed that their comprehension of the English text prevented them from understanding the questions raised in mathematics. The parents agreed with the learners that English and low literacy levels were the main barriers experienced by Deaf learners in mathematics.

Interesting enough, mathematical anxiety did not emerge as a dominant factor in Deaf learners. The majority of the learners depicted high levels of confidence in their ability to do mathematics, despite achieving consistently low academic results in this area.

From a theoretical perspective possible causes of these barriers relate to the learners' general lack of access to language at an early age as found in the work of Vygotsky; experiencing a lack of cognitive mediating experiences when younger and being exposed to a passive-acceptance approach to

teaching as covered by Feuerstein; and being taught in accordance with an absolutist philosophy of mathematics that may foster negative beliefs towards the subject.

Once the problem solving curriculum was introduced, many of the learners experienced certain psychological and pedagogical difficulties that made it difficult for them to optimally access the approach. The learners found it difficult to manage the interpersonal dynamics and on-task behaviour required in group work. Moreover, their ability to communicate mathematics was restricted. In addition, learners needed time to adjust to the generative element of problem solving mathematics. Learners expressed that they were more comfortable with the reproductive aspect of traditional mathematics than with problem solving that 'provides no examples for them to copy'.

Yet at the end of the research learners' reported slightly more positive orientations towards mathematics as well as a moderate increase in problem solving skills. Learners particularly enjoyed certain elements embedded in the problem solving curricula, one of these being the activities. Moreover, learners indicated that they preferred to be taught according to a specific module of problem solving rather than being taught traditionally. The module the learners preferred contained problems that were grounded in sensational curiosity i.e. in material things, things that move, living things, human actions and accounts of human action rather than in a theoretic curiosity focused on rational relations between things.

The findings seem to suggest that it is possible through exposure to increase Deaf learners' propensity for problem solving mathematics. However, as noted earlier the research design does not allow for generalisation of the findings to other Deaf learners.

6.2 RECOMMENDATIONS

The following section details some recommendations in respect to government policy, curriculum development, teacher training and instruction that emerged from this study:

1. Governmental policy already supports a problem solving approach to mathematics. The difficulties lie in implementation when considering the work schedule at NCS level. More specifically, the amount of content that needs to be covered every term can only realistically be achieved through a transmission model. A problem solving approach is too time-consuming in the classroom to allow for all the mathematical topics to be taught within the allocated timeframe. Hence, should one follow a problem solving approach it is unlikely that the learners will be adequately prepared in terms of content to write the government examination papers that are distributed every term. Consequently, government needs to investigate how their theoretical stance on problem solving can be practically realised in South African mathematical classrooms, especially in classrooms where learners are experiencing additional barriers that all ready hamper them from working at the same pace as other learners.

2. Deaf education is largely impacted by two theories namely that of Vygotsky and Feuerstein. Both these theories presuppose the role of a human mediator in bringing about cognitive development. The human mediator is essentially the teacher in the classroom. Hence, teachers in Deaf education need to be trained or re-trained in how to engage in a specific quality of human mediation with Deaf learners. More specifically, teachers need to know how to mediate in a way that secures cognitive development, rather than merely covering learning area content. In other words, teachers of the Deaf must be socialised into a vision of teaching for cognitive change and thereafter be equipped and with strategies and practical

examples of how to enable learners to process information effectively. Some of these principles can be derived from Feuerstein's work. It may therefore be necessary to introduce Feuerstein's cognitive programme into the classroom, or alternatively, to introduce the principles contained in the programme into the various learning areas and teaching programmes offered by the school. Subsequently, the need in Deaf education is for teachers who do not only focus on what the child has learnt, but also on how the child learns and solves problems.

In addition, this study opens up avenues for additional research:

- The present study needs to be generalised to include a larger and more representative sample of Deaf learners.

- The reasons for the lack of mathematical dialogue in Deaf learners need to be investigated, with particular emphasis on providing strategies or techniques to promote discussion among students who are deaf or hard of hearing. Discussion in social constructivist classroom remains pivotal in establishing and generating mathematical knowledge. A lack of mathematical communication therefore hampers the learning process.

- The role of affect in problem solving needs to be investigated. This study has brought to light that Deaf learners show strong emotional reactions to certain elements of problem solving. It has also been noted that Deaf learners are quick to give up once they experience feelings of frustration. It is important that the essence of Deaf learners emotional experiences be understood in order to assist them through the cycle. This could be a form of empowering Deaf learners so that they can adapt more readily to problem solving situations, not only at school but in everyday living as

well. Such awareness could also be of practical help to teachers in how to orientate Deaf learners to problem solving more quickly and more positively.

- More research is required on image supported reasoning compared to image-independent reasoning. Certain of the problem solving activities utulise metaphors and analogies to teach mathematical concepts. The effectiveness of such an approach, compared to the more 'pure' presentation of mathematical concepts needs to be investigated in Deaf learners through additional research.

- Closely linked to the aforementioned aspect, is the need for the intellectual transfer from games and activities to mathematical understanding to be assessed and monitored. Although activities are associated with enjoyment, the value of activities is dependent on their ability to produce a certain quality of transfer from the activities to the subject content. The 'when' and the 'how' of the transfer need to be understood for 'fun' activities to have deeper educational relevance at high school level.

Through this study, problem solving mathematics emerged as a valuable tool to empower learners to process information, and also to use the skills and dialogue practiced in class in confronting more effectively the problems they experience in their own realm of living.

BIBLIOGRAPHY

Adamo-Villani, N; Doublestein, J; Martin, Z. (July 2005). Sign Language for K-8 Mathematics by 3D interactive animation. *Journal of Educational Technology Systems*. 33(3),241-257

Adler, J., Pournara, C. & Graven , M. (2000). Integration within and across mathematics. *Pythagoras*. 53, 2-13

Akamatsu, C.T. (1998). Thinking with and without language: What is necessary and sufficient for school-based learning. In Weisel, A.(Ed) *Issues unresolved: new perspectives on language and deaf education.* Washington, DC.Gallaudet University Press.

Akach, P. & Aarons, D. February 1999. UNESCO Discussion Document: Inclusion and the Deaf child in South African Education: Executive Summary

Allen, T.E. (1998, May/June). Mathematics. Successful transition requires curriculum reform*. Perspectives in Education and Deafness.* (16)5

Altrichter, H. (1993). The concept of quality in action research. Giving practitioners a voice in educational research. In Schratz, M. *Qualitative voices in educational research.* London:Taylor & Francis

Artzt, A.F. & Armour, T. 2002. *Becoming a reflective mathematics teacher. A guide for observation and self assessment*. London:Lawrence Erlbaum Associates

Ausubel, D. Novak, J. & Hanesian, H. (1978). *Educational Psychology. A cognitive view*. 2nd edition. Chicago:Holt, Rynard and Waiston

Baker-Shenk, C. And Cokely, B. (1980). American Sign Language: a teachers' resource text on grammar and culture. In Storbeck, C. & Jurgens, J. SPED4001. *Sign Language for Education, Theory and Practice 1*. Course Reader. Johannesburg, University of the Witwatersrand, School of Education.

Becker. G.S. (1993). *Human capital: A theoretical and empirical Analysis, with special reference to education.* Chicago: University of Chicago Press

Bennie, K., Olivier, A., & Linchevski, L. (1999). Everyone can learn mathematics: Addressing the fundamental assumptions and goals of Curriculum 2005. Paper presented at the 5th Annual Congress of the Association for Mathematics Education of South Africa (AMESA), Port Elizabeth, 5-9 July 1999. Retrieved 28 January 2009 from: http://academic.sun.ac.za/mathed/MALATI/Files/Equity991.pdf

Bennie, K. and Newstead, K. (1999). Obstacles to implementing a new curriculum. In M.J. Smit & A.S. Jordaan (Eds.), Proceedings of the National Subject Didactics Symposium (pp. 150-157). Stellenbosch: University of Stellenbosch. Retrieved 2 February 2009 from: http://academic.sun.ac.za/mathed/MALATI/ConferencePapers.htm.

Bhorat, H. (2004). The development challenge in post-apartheid South African education. In Chisholm, L (Ed). *Changing class. Education and social Change in post-apartheid South Africa*. Cape Town: Human Sciences Resource Press

Boaler, J. (1998). Open and closed Mathematics. *Students experiences and understanding. Journal for Research in Mathematics Education*. 29, 41-52

Bowie, L. (2000, August). A learning theory approach to students' errors in a calculus Course. *Pythagoras.* 52:33 – 46.

Bringuier, J.C. (1989). *Conversations with Piaget.* Chicago:The University of Chicago Press

Bottge, B.A , Heinrichs, M. Chan, S.Y. & Serlin, R.C. (2001, September/October). Anchoring adolescents' understanding of Math concepts in rich problem solving environments. *Remedial and Special Education*. 22(5), 299- 314

Brombacher, A.A. (1997). High school Mathematics teachers' – Transition to a standards-based curriculum. *Unpublished Masters.* Athens, Georgia

Bruce, S., DiNatale, P., Ford, J. (2008). Meeting the needs of deaf and hard-of-hearing students with additional disabilities through professional teacher development. *American Annals of the Deaf.* 153(4), 368 - 375

Bull, R., Marschark, M., Blatto-Vallee, G. (2005). Examining number representation in deaf students. [Electronic Version]. *Learning and Individual Differences* 15:223–236

Campbell, R.L. (2006, March). *Jean Piaget's genetic epistemology: Appreciation and critique.* Retrieved on 7 December 2008 from http://hubcap.clemson.edu/~campber/piaget.html.

Cangelosi, J.S. (1996). *Teaching Mathematics in secondary and middle school. An interactive approach*. Englewood Cliffs:Merrill/Prentice Hall

Carl, A.C. (1995). *Teacher empowerment through curriculum development. Theory into practice.* Cape Town:Juta

Chauke, E. & Venkatakrishnan, H. (2006). The effect of contextualising a problem on learners' approaches to algebraic equations. *Learn. Teach. Math*. 4, 33-36

Chen, K. Spring 2006. Math in motion: Origami Math for students who are deaf and hard of hearing. *Journal of Deaf Studies and Deaf Education.* (11)2, 262 – 266

Chisholm, L (Ed). (2004). *Changing class. Education and social Change in post-apartheid South Africa*. Cape Town: Human Sciences Resource Press

Clarke, A. (2000). *Evaluation research. An introduction to principles, methods and practice*. London: Sage Publishers.

Clarke, D., Breed, M., & Fraser, S. (2004) The consequences of problem-based Mathematics curriculum. *The Mathematics Educator* 14(2), 7 - 16

Cocking, R. & Mestre, J.S. 1988. *Linguistic and cultural influences on learning Mathematics.* New Jersey:Lawrence Erlbaum Associates

Cunningham, D. (2000). Asking and answering questions about practice. In Martin-Kiep, G.O. *Becoming a better teacher.* VA, United States of America: Association for Supervision and Curriculum Development

Daniels, H. (2005). *An introduction to Vygotsky*. New York: Routledge/Taylor & Francis:

Daniels, H., Cole, M. Wertsch, J. 2007. *The Cambridge companion to Vygotsky*. New York: Cambridge University Press

Davis, B. (1996). *Teaching Mathematics. Towards a sound alternative*. New York: Taylor & Francis

Davis, R.B. & Maher, C.A. (1997). How students think. The role of representation. In English, L.D. (Ed.) *Mathematical reasoning: Analogies, images and metaphors*. Hillsdale, New York: Lawrence Erlbaum Associates.

De Corte, E. (2000, August). New perspectives for research and practice in mathematics education. *Pythagoras.* 52, 33 – 46.

Denzin, N. K. (2003). *Performance ethnography. Critical pedagogy and the politics of culture.* California: Sage

Department of Education. (2001, May 31). *Education White Paper 6. Special needs education. Building an inclusive education and training system*. Pretoria:Department of Education

Department of Education. (2003a). *National Curriculum Statement Grades 10-12 (General) Mathematics.* Pretoria: Department of Education

Department of Education (2003b). Strategic Plan 2003-2005. The DoE Statement of policy and commitment by the Minister of Education. Pretoria: Department of Education. Retrieved on 12 February 2008 from http://education.pwv.gov.za

Department of Education. (2003c). NQF and Curriculum 2005 Policy. Retrieved on 12 February 2008 from www.saqa.org.za/html/nqf/does/curricul2005.html

Dolnick, E. (1993). Deafness as a culture. In Storbeck, C. 2007. *SPED4001. Sign Language for Education. Theory and Practice 1.* (Course Reader, p. 29 – 38). Johannesburg: University of the Witwatersrand, School of Education

Dillabough. J.A. (2002, Summer). The "hidden injuries" of critical pedagogy. *Curriculum Inquiry*. 32(2), 203-214

Donovan, S.M. & Bransford, J.D. (2005). *How students learn. Mathematics in the classroom*. National Academy Press. Retrieved on 4 November 2008 from: http://www.nap.edu/catalog/11101.html.

Dossey, J.A., McCrone, S., Giordano, F.R. & Weir, M.D. (2002). *Mathematics methods and modelling for today's Mathematics classroom. A contemporary approach to teaching Grade 7 – 12.* California:Brooks/Cole

Easterbrook, S.R. & Stephenson, B. (2006). An Examination of Twenty Literacy, Science, and Mathematics Practices Used to Educate Students Who Are Deaf or Hard of Hearing. *American Annals of the Dea*f. 151(4), 385-397

Emmorey, K., Kosslyn, S.M. & Belugi, U. (1993). Visual imagery and visual-spatial language: Enhanced imagery abilities in deaf and hearing ASL signers. *Cognition*. 46, 139 - 181

English, L.D. (Ed). *Mathematical reasoning: Analogies, images and metaphors.* Hillsdale, New York: Lawrence Erlbaum Associates.

Efron, R. (1990). *The decline and fall of hemispheric specialisation*. Hillsdale, New York:Lawrence Erlbaum Associates

Eiselen, R.J. (2006). Predicting achievement in mathematics at tertiary level. *Unpublished doctoral thesis*. Johannesburg:University of Johannesburg

Ellis, C. (2004). *The ethnographic 1: A methodological novel about autoethnography.* Oxford:Rowman Altamira

Erickson, H.L. (2006). The Thinking Classroom. In. Erickson, H.L. & Tomlison, C.A. (2006). Concept-based Curriculum and Instruction for the Thinking Classroom. California:Corwin Press

Ernst, P. (1991). *The philosophy of Mathematics education. Studies in Mathematics education.* London:Falmer Press

Ernst, P. (1993). Constructivism, the psychology of learning and the nature of mathematics: Some critical issues. *Science and Education.* 2, 87- 93

Ernst, P. (1994). *Constructing Mathematical knowledge: Epistemology and mathematical education*. London:The Falmer Press

Ernst, P. (1996). The nature of Mathematics and teaching. In *Philosophy of Mathematics Education Newsletter 9*. Retrieved on 15 June 2008 from: http://people.exeter.ac.uk/PErnest/pome/pompart7.htm

Ernst, P. (1998). Social constructivism as a philosophy of Mathematics. Albany:State University of New York

Erting, C., Johnson, R. & Smith, D. (Eds). (1994). *The Deaf way. Perspectives from the international conference on Deaf culture.* United States of America:Gallaudet University Press:

Fetterman, D.M. (1998). Ethnography. California: Sage Publications

Feuerstein, R. (1982). *Instrumental enrichment. An intervention program for cognitive modifiability.* (2nd edition). Baltimore:University Park Press

Feuerstein, R., Rand, Y. & Rynders, J.E. (1988). *Don't accept me as I am: Helping "retarded" people to excel*. New York:Plenum Press

Feuerstein, R., Klein, P.S., Tannenbaum, A.J. (1994). *Mediated learning experience (MLE): Theoretical, psychosocial and learning implications*. Tel Aviv: Freud Publishing House Ltd.

Finney, E.F. & Dobkins, K.R. (2001). Visual contrast sensitivity in deaf versus hearing populations: exploring the perceptual consequences of auditory deprivation and experience with a visual language. Cognitive Brain Research. 11(1), 171-183

Flick, U. (2006). *An introduction to qualitative research. (*3rd edition). California:Sage Publications

Frakenstein, M. & Powell, A. 1997. *Paulo Freire's contribution to an epistemology of Ethnomathematics*. Retrieved on 5 January 2009 from http://andromeda.rutgers.edu/~powellab/docs/proceedings/paulofriere_epis.pdf

Franco, C., Sztajn, P., Ortigão, M. I. R. (2007). Does reform teaching raise all students' math scores? An analysis of the role that the socioeconomic status of students plays in closing the achievement gap. *Journal for Research in Mathematics Education.* 38(4), 393-419.

Freire, P. (1994). *Pedagogy of the oppressed.* (2nd edition). New York:Routledge

Fuson, K.C., Kalchman, M., & Bransford, J.D. (2005). Mathematical Understanding: An Introduction. In Donovan, S.M. & Bransford, J.D.*How students learn. Mathematics in the classroom*. National Academy Press. Retrieved on 4 November 2008 from: http://www.nap.edu/catalog/11101.html**.**

Fullerton, O. (1995). Who wants to feel stupid all of the time? In Rogers, P & Kaiser, G. (Editors) *Equity in Mathematics education. Influences of feminism and culture.* London:The Falmer Press

Gay, G. (1995). In Sleeter, C.E. & McLaren. (Eds). *Multicultural education, critical pedagogy, and the politics of difference.* Albany: SUNY Press

Geldenhuys, J.L. (2000, August). Mathematics Anxiety. *Pythagoras.* (52), 24 – 29.

Gergen, K. (2009). An invitation to social construction. London:Sage Publication

Gertz, G. (2008). Dysconscious Audism. A Theoretical Perspective. In Dirksen, H & Bauman, L. (Eds). *Open your eyes. Deaf studies talking*. United States of America:University of Minnesota

Ginsburg, H.P. (1985). Piaget and education. In McDonald, C. 2005. *Teaching and Learning.* (Course Reader, pp. 39-54). Johannesburg: University of the Witwatersrand, School of Education

Giroux, H.A. (1992). The Hope of Radical Education. In Wheeler, K. & Mitchell, C. (Eds). *What schools can do*. Albany: New York University Press

Giroux, H.A. (1997). *Critical pedagogy and predatory culture.* London and New York:Routledge

Grattan-Guiness, I. (Ed). (1994). *Companion encyclopaedia of the history and philosophy of the Mathematical sciences. Volume 1*. Baltimore and London: The John Hopkins University

Hall, I. & Hall, D. (2004). *Evaluation and social Research. Introducing small-scale practice*. China: Palgrave Macmillan.

Harley & Wedekind. (2004). Political change, curriculum change and social formation, 1990-2002. In Chisholm, L (Ed). *Changing class. Education and social change in post-apartheid South Africa.* Cape Town:Human Sciences Research Council Press

Harton, B. (1953, May). Suggestions for Mathematics**.** *Peabody Journal of Education.* 30(6), 349-350

Higgins, P.C. (1987). The Deaf Community. In Storbeck, C. (2007). *SPED4001. Sign Language for Education, Theory and Practice 1.* (Course reader, p. 11 – 28). Johannesburg: University of the Witwatersrand, School of Education

Huntley, M.A., Rasumussen, C.L., Villarubi, R.S., Sangtong, J., & Fey, J.T. (2000). Effects of Standards-based mathematics education: A study of the Core-Plus Mathematics algebra and functions strand. *Journal for Research in Mathematics Education.* 31, 328-361

Hyde, S. (1992). Negotiating Mathematics. In Boomer, G., Lester, N., Onore, C. & Cook, J. (Eds). *Negotiating the curriculum. Educating for the 21st century.* London:The Falmer Press

Jansen, J. (1999). Why Outcomes-Based Education will Fail. In Jansen, J & Christie, P. (Eds). *Changing curriculum studies on outcomes-based education in South Africa*. Cape Town:Creda Communication.

Jaworski, B. (1994). *Investigating Mathematics teaching. A constructivist enquiry.* London and New York: RoutledgeFalmer

Johnson, B. (1993, March). Teacher as Researcher. *ERIC Digest ED355205.* Retrieved on 5 May 2008 from http://www.ed-gov/databases/ERIC_Digests/ed355205.html

Kelly, R. & Mousley, K. (2001). Solving word problems: More than reading issues for deaf Students. *American Annals of the Deaf.* 146, 253-264

Kelly, R; Lang, H., Mousley, K. & Davis, S. (April 2003). Deaf college students' comprehension of relational language in arithmetic compare problems. *Journal of Deaf Studies and Deaf Education* (8)2, 120-134

Kelly, R., Lang, H., & Pagliaro, C. (Apr 2003). Mathematics word problem solving for deaf students: A survey of practices in Grades 6 - 12. *Journal of Deaf Studies and Deaf Education.* (8)2, 104 - 117

Kelvin, L. (2007). Measuring and manipulating variables. Reliability and validity. In Mitchell. M.L. & Jolley, J.M. *Research design explained*. 6th edition. Belmont, CA: Thomson Wadsworth

Kemmis, S. (2007). Exploring the Relevance of critical theory for action research: Emancipatory Action Research in the Footsteps of Jurgens Habermas. In Reason, P. & Bradbury, H. (Eds). *Handbook of Action Research.* California: Sage Publications

Kilpatrick, J., Swafford, J., Findell, B., Kincheloe, J.L. 2001. Adding it Up. National Academies Press. Retrieved 25 March 2008 from: http://www.nap.edu/catalog/9822.html

Kim, J.S. (2005). The effects of a constructivist teaching approach on student academic achievement, self-concept, and learning strategies. *Asia Pacific Education Review*. 6(1), 7 - 19

Kincheloe, J.L. 2003. Teachers as Researchers: Qualitative Inquiry as a Path to Empowerment. London:Routledge

Kraak, A. & Young, M (Eds). (2005). *Education in retrospect. Policy and implementation since 1990*. Pretoria:Human Sciences Research Council

Kritzer, K. (2007). Factors Associated with Mathematical Ability in Young Deaf Children: Building Foundations, from Networks to Numbers. *Unpublished doctorate thesis*: University of Pittsburgh

Lang H.G., Dowaliby F.J., Anderson, H.P. (1994). Critical teaching incidents. Recollections of deaf college students. *American Annals of the Deaf.* 139(2), 119-127

Lang, H., Steely, D. (2003). Web-based science instruction for deaf students: What research says to the teacher. *Instructional Science* 31, 277–298

Lang, H. & Pagliaro, C. (2007). Factors predicting recall of Mathematics terms by deaf students: Implications for teaching. *Journal of Deaf Studies and Deaf Education.* 12(4), 449 – 460.

Lee, T.W. (1998). *Using qualitative methods in organisational research.* California:Sage Publications.

Lerman, S. (1994) Articulating theories of Mathematics learning. In Ernest, P. (Ed). *Constructing Mathematical knowledge: Epistemology and Mathematics education. Studies in Mathematics education. Series 4*. London:The Falmer Press

Lewis, H. (2007). *Deaf liberation theology*. Great Brittain:.MPG Books

Linchevski, L., & Kutscher, B. (1998). Tell me with whom you're learning, and I'll tell you how much you have learned: Mixed-ability versus same-ability grouping in mathematics. *Journal for Research in Mathematics Education.* 29, 533-554

Lubienski, S.T. 2000. Problem solving as a means toward mathematics for all: An exploratory look through a class lens. *Journal for Research in Mathematics Education.* 31, 454-482

Maree, J.G., Prinsloo, W.B.J. & Claassen, N.C.W. (2006). *Manual for the study orientation questionnaire in Maths (SOM*). (2nd edition). Pretoria:Human Sciences Research Council

Marschark M. (1992). Origins and Interactions in the Social, Cognitive Development and Language Development of Deaf Children. In Marschark, M. & Clark, D. (Eds). *Psychological perspectives on deafness.* New Jersey:Lawrence Erlbaum Associates

Marschark, M. (1998). *Raising and educating a deaf child.* United States of America:Oxford University Press

Marschark, M. (2003). Cognitive functioning in deaf Adults and children. In Marschark, M. & Spencer, P.E. *Oxford handbook of deaf studies, language, and education*: New

Marschark, M. & Hauser, P.C. (Eds). (2008). *Deaf cognition: Foundations and outcomes. New York*:Oxford University Press US

Marczyk, G., DeMatteo, D. & Festinger, D. (2005). *Essentials of research design and methodology.* New Jersey: John Wiley & Sons. York:Oxford University Press

Markey, C., Power, D. & Booker, G. (2003). Using structured games to teach early fraction concepts to students who are deaf or hard of hearing. *American Annals of the Deaf.* 148(3), 251 – 257

Marshall, C. & Rossman, G.B. (2006). *Designing Qualitative Research.(* 4th edition). California:Sage Publications

Martin, A. (2007). Large group processes as action research. In Reason, P. & Bradbury, H. (Eds). *Handbook of Action Research.* California: Sage Publications

Marvasti, A. (2004). *Qualitative research in Sociology*. Sage Publications:California

Mayberry, R.I. (2003). Cognitive development in Deaf children: The interface of language and perception in neuropsychology. In Segalowitz, S.J., Boller, F. & Rapin, I. (Eds). *Handbook of neuropsychology*. *Volume 8. Part II*. (2nd edition). Amsterdam:Health Sciences:

Maykut, P.S. & Morehouse, R.E. (1994). *Beginning qualitative research: A philosophical and practical guide*. Great Britain:Burgess Science Press:

McIlveen, P. (2008). Autoethnography as a method for reflexive research and practice in vocational psychology. *Australian Journal of Career Development, 17*(2), 13-20.

McLeod, D.B. (1988). Affective issues in Mathematical problem solving: Some theoretical considerations. *Journal for Research in Mathematics Education.* Vol 19 (2),134-131

McLeod, D.B. (1991).Research on learning and instruction in Mathematics. The role of affect. In Fennema, E. Carpenter, T.P. & Lamon, S.J. (Eds). *Integrating research on teaching and learning mathematics.* Albany:State University of New York Press.

McMillan, J.H. & Schumacher, S. (2006). *Research in education. A conceptual introduction.* (6th ed). New York:Longman

Mertens, D. Deaf and hard of hearing people in court: using an emancipatory perspective to determine their needs. In Truman, C., Mertens, M., & Humphries, B. (Eds). (2000). *Research and inequality.* London and New York:Routledge:

Mohr, P. & Fourie, L. (1995). *Economics for South African students*. Pretoria:Van Schaick Publishers

Moisander, J. & Valtonen, A. (2006). *Qualitative marketing research: A cultural approach.* London:Sage Publications

Mouton, J. (2006). *How to succeed in your Master's & Doctoral studies. A South African guide and resource Book*. Pretoria: Van Schaik.

Muller, J. (2005). Progressivism redux. Ethos, policy, pathos. An international perspective. In Kraak, A. & Young, M (Eds). *Education in retrospect. Policy and implementation since 1990.* Pretoria:Human Sciences Research Council

Murdock, J., Kamischke, E. & Kamischke, E. (2002). *Discovering Algebra. An investigative approach*. United States of America:Key Curriculum Press

Murray, H., Olivier, A. & Human, P. (1998). Learning through problem solving. In A. Olivier & K. Newstead (Eds.), Proceedings of the Twenty-second International Conference for the Psychology of Mathematics Education. 1, p. 169-185. Stellenbosch: South Africa. Retrieved on 12 February 2009 from http://academic.sun.ac.za/mathed/MALATI/ConferencePapers.htm

Naidoo, D. & Parker, D. (2005). The implications of mathematics teachers' identities and official mathematics discourses for democratic access to mathematics. *Perspectives in Education*. 23(11), 53-67

Neuman, W.L. (2000). *Social research methods. Qualitative and quantitative approaches*. (4th edition). Boston:Allyn And Bacon

Nickson, M. 2002. Social and critical mathematical education: underlying considerations. In Haggarty, L. (Ed). *Teaching mathematics in secondary schools. A reader*. London:RoutledgeFalmer

Nieto, S. (2001). Critical pedagogy, empowerment and eearning. In Soler, J. & Collins, J. (Eds). *Developing pedagogy: Researching practice.* California:Sage Publications

Niiniloto, L. (1992). Reality, truth and confirmation in Mathematics – Reflections on the Quasi-Empiricist Programme. In Echeverría, J., Ibarra, A., & Mormann, T. *The space of Mathematics: Philosophical, epistemological, and historical explorations*. Berlin/New York:De Gruyter

Nixon, J. Winter, (1987). The potential and practice of action research: Part 1. *Peabody Journal of Education.* 64(2), 20-32

Nolen, A.L. & Vander Putten, J. Action research in education. Addressing gaps in ethical principles and practices. Educational Researcher. 36(7), 401-407

Nover, S.M. (1998). *Year one 1998 – 1999. Critical pedagogy in Deaf education: Bilingual methodology and staff development.* Retrieved on 15 January 2008 from. www.starschools.org

Nunes, T. & Moreno, C. (1998, Jan). The signed algorithm and its bugs. *Educational Studies In Mathematics*. 35(1), 85-92

Nunes, T. and Moreno, C. (2002). An Intervention Program for Promoting Deaf Pupils' Achievement in Mathematics. *Journal of Deaf Studies and Deaf Education*. 7(2),120-133

Nunes, T. & Moreno, C. (2007, June) An intervention program for promoting deaf pupils' achievement in Mathematics. *Journal of Deaf Studies and Deaf Education. (*7)2,120 - 133

Padden, C. & Humphries, T.L. (2005). *Inside Deaf culture.* United States of America: Harvard University Press

Pagliaro, C. & Ansell, E. June 2002. Story problems in the deaf education classroom: Frequency and mode of presentation. *Journal of Deaf Studies and Deaf Education*. (7)2, 107-118

Pagliaro, C.M. & Kritzer, K.L. (2005, Summer). Discrete mathematics in deaf education: A survey of teachers' knowledge and use. American Annals of the Deaf. 150 (3), 251 – 260.

Pandor. N. (2008, December 30). *Statement by Mrs Naledi Pandor MP, Minister of*

Education, on the release of the 2008 national senior certificate examination results. Retrieved on 14 January 2009 http://www.education.gov.za/dynamic/dynamic.aspx?pageid=306&id=8276

Parry, K. (2008). Viewing the Leadership Narrative through Alternate Lenses: An Autoethnographic Investigation. *Management Revue*. 19(1 –2), 127 - 147

Patton, M.Q. (2002). Qualitative research and evaluation methods. (3rd edition). California: Sage Publications

Pass, S. (2004). *Parallels paths to constructivism. Jean Piaget and Lev Vygotsky*. United States of America: Lawrence Erlbaum Associates

Patton, M.Q. (2002). Qualitative research and evaluation methods. (3rd edition). California. Sage Publications

Pepin, B. 2002. Different cultures, different meanings and different teaching. In Haggarty, L. (Ed). *Teaching mathematics in secondary schools. A reader*. London:RoutledgeFalmer

Petitto, L.A. (1994). Are Signed Languages 'Real' Languages. In Storbeck, C. 2007. *SPED4001. Sign Language for Education. Theory and Practice 1.* (Course reader, pp. 1 - 9). Johannesburg: University of the Witwatersrand, School of Education

Piaget, J. (1955). Development and learning. Paper presented to the International Center of Genetic Epistemology, Geneva. In McDonald, C. (2005). *Teaching and Learning.* University of the Witwatersrand:Johannesburg, School of Education

Piaget. J. (1999). *The psychology of intelligence.* Routledge:London

Principles & Standards in School Mathematics. NCTM website. Retrieved on 10 February 2009 from www.nctm.org/standards

Quicke, J. (2007). Inclusion and psychological intervention in schools: A critical Autoethnography. The Netherlands: Springer

Quinn, M. (2002). Qualitative Research and Evaluation Methods. 3rd edition. Sage Publications:California

Quicke, J. (2007). Inclusion and psychological pntervention in schools: A critical

autoethnography. Netherlands: Springer

Ramnarain, U. (2003, April). A strategies-based problem solving approach in the development of mathematical thinking. *Pythagoras* (57), 32-35

Rittenhouse, B. & Kenyon-Rittenhouse, P. (1998). The teaching and extra-teaching characteristics of beginning teachers of deaf students as perceived by teacher education, master teachers, school administrators and college-bound Deaf high schoolers. In Weisel, A. (Ed.). *Insights into deaf education. Current theory and practice*. Tel Aviv:University. Academic

Riordan , J. E. & Noyce, P. E. (2001, July).The impact of Two Standards-Based Mathematics Curricula on Student Achievement in Massachusetts. *Journal for Research in Mathematics.* 32(4), 368 - 398

Schoen, H. L. (1993). Report to the National Science Foundation on the impact of the Interactive Mathematics Project. Madison, WI: Wisconsin Center for Education Research. Retrieved on 14 November 2008 from: http://jwilson.coe.uga.edu/EMT669/Student.Folders/Frietag.Mark/Homepage/Welcome/IMPreport.html.

Schoenfeld, A.H. (1982, Jan). Measures of problem solving performance and of problem solving instruction. *Journal for Research in Mathematics Educatio.* 13(1), 31-49

Schoenfeld, A.H (Ed). (1987). *Cognitive science and Mathematics education*. California: Lawrence Erlaum Associates

Schoenfeld, A.H. (1988). When good teaching keads to bad results: The disasters of ``well-taught" Mathematics courses. *Educational Psychologist*. 23(1), 145-166.

Siegler, R.S. (1995). Reading and developmental processes. In McDonald, C. 2005. Teaching and Learning.(Course Reader, pp. 37-38). University of the Witwatersrand:Johannesburg, School of Education

Siegel , M & Borasi, R. (1994). Demystifying Mathematics education through inquiry. In Sierpinski, A. *Understanding in Mathematics*. London: Falmer Press

Simeonsson, R.J. (2006). In Field, M.J,; Jette, A.M.; Martin, L. (Eds). 2006. *Workshop on*

disability in America: A new summary and background papers. National Academies. Retrieved on 8 October 2008 from http://www.nap.edu/catalog/11579.html

Simms, L. & Thumann, H. (2007, Summer). In search of a new, linguistically and culturally sensitive paradigm in deaf education. *American Annals of the Deaf.* 152(3), 302-311

Skemp, R. (1987). *The psychology of learning Mathematics*. United States of America: Lawrence Erlbaum Associates.

Solomon, J. (2006). Exploring culture and pedagogy in mathematics class through student interviews. In, Zoest, L.R. (Ed). *Teachers engaged in research. Inquiry into mathematics classrooms, Grades 9 – 12*. Greenwich:Information Age Publishing

Sousa, D.A. (2008). *How the brain learns Mathematics*. California:Corwin Press

Star, J.P. & Smith III, J.R. (2007, Jan). Expanding the notion of impact of K-12 standards-based mathematics and reform calculus programs. *Journal for Research in Mathematics Education*. 38(1), 3-34.

Stewart, I. (1995). *Concepts of modern Mathematics*. New York: Dover Publications

Stokoe, W. (1972). Semiotics and human sign languages. New York: Walter du Gruyter

Stols, G. (2004). *Geometry. Study Guide 1 for FDEME5-N/MSE218-3/MPE218-J*. Pretoria: University of South Africa:

Stone, J. 1988. Intention and convention in Mathematics instruction: Reflections on the learning of Deaf students. In Cocky, R. & Mestre, P. (eds). Linguistic and cultural influences on learning Mathematics. Hillsdale, New Jersey:Lawrence Erlbaum Associates

Storbeck, C.2002. SPED 4001. *Psychology of Deaf eduation*. Course Reader. Johannesburg: University of the Witwatersrand, School of Education

The Star. (1997, June 16). Science triumphs, but group fights ‘for right to be deaf’. In

Storbeck, C. (2007). SPED 4001. Sign Language for Education. Theory and Practice1. (Course Reader, pp. 39 – 41). Johannesburg: University of the Witwatersrand, School of Education

The Wits Centre for Deaf Studies. (2008*). Celebrating 10 years of Excellence in Deaf Education. (1998 – 2008).* University of the Witwatersrand: Johannesburg

Thijsse, L.J. (2002). The effects of a structured teaching method on Mathematics anxiety and achievement of Grade 9 learners. *Unpublished Masters.* Pretoria: University of South Africa

Thomas, R.M. (2003). Blending qualitative & quantitative research methods in theses and dissertations. California:Corwin Press

Thornton, R. & Ramphele, M. (1988). The quest for community. In Storbeck, C. & Jurgens, J. SPED4001. *Sign Language for Education, Theory and Practice 1*. Course Reader. Johannesburg, University of the Witwatersrand, School of Education.

Tobias, S. (1994). *Overcoming Maths anxiety*. New York: WW Norton & Company

Toumasis, C. (1997).The NCTM Standards and the philosophy of Mathematics. *Studies in Philosophy and Education.* 16, 317–330

Truman, C., Mertens, M., & Humphries, B. (Eds). (2000). *Research and inequality*. London and New York: Routledge. ISBN 1-857-28962-5

Van de Walle, J. (2007). *Elementary and middle sSchool Mathematics. Teaching developmentally.* (6th edition). Boston: Pearson

Von Glasersfeld, E. (1983) *Learning as constructive activity*. Proceedings of the 5th Annual Meeting of the North American Group of PME. Retrieved on 14 October 2008 from: www.scribd.com/doc/6827185/von-Glaserfeld-Learning-as-constructive-activity

Von Glasersfeld, E. (1987). *Learning as a constructive activity.* In McDonald, C. 2005. Teaching and Learning. (Course Reader, pp. 1-16) University of the Witwatersrand:Johannesburg, School of Education

Von Glasersfeld, E. (1990). An exposition of Constructivism. Why some like it radical? In Davis, R.B., Maher, C.A. & Noddy, N. *Constructivist views on teaching and learning.* United States of America: National Council of Teachers of Mathematics:

Vygotsky, L.S. (1978). Interaction between learning and development. In McDonald, C. 2005. Teaching and Learning.(Course Reader, pp. 171-180). University of the Witwatersrand:Johannesburg, School of Education

Vygotsky, L.S. (1996). Genesis of the higher mental functions. In McDonald, C. 2005. *Teaching and Learning.* (Course Reader, pp. 123-132) University of the Witwatersrand:Johannesburg, School of Education

Watts, W. & Bentley, D. (1991). Constructivism in the curriculum: Can we close the gap between the strong theoretical version and the weak version of theory-in-practice. In McDonald, C. 2005. Teaching and Learning.(Course Reader, pp. 17-28) University of the Witwatersrand:Johannesburg, School of Education)

Weisel , A.(Ed). (1998). *Issues unresolved: New perspectives on language and deaf education*. Washington, DC:Gallaudet University Press.

Wertsch, J.V. (1979). From social interaction to higher psychological processes. In MacDonald, C. 2005. *Teaching and Learning.* (Course Reader, pp. 181-204) University of the Witwatersrand: Johannesburg, School of Education

Wertsch, J.V. (1988). *Vygotsky and the social formation of the mind.* United States of America: Harvard University Press

Wheatly, G.H. (1997). Reasoning with Images in Mathematical Activity. In English, L.D. (Ed). *Mathematical reasoning: Analogies, images and metaphors.* Hillsdale, New York: Lawrence Erlbaum Associates.

Wilson, S. (1995, Nov). Not tension but intention: A response to Wong's analysis of the researcher/teacher. Educational Researcher. 24(8), pp. 19-22

Win, S. (2007). Employment outcomes for people in Australia who are congenitally deaf: Has Anything changed? *American Annals of the Deaf.* 152 (4), 382 – 390

Winefield , R. (1987). *Never the twain shall meet: Bell, Gallaudet, and the communications debate.* United States of America:Gallaudet University Press

Wink, J. (2005). *Critical pedagogy. Notes from the real world*. Boston:Pearson

Wong, E.D. (1995, April). Challenges confronting the researcher/teacher: Conflicts of purpose and conduct. *Educational Researcher.* 24(3), 22-28

Woodward, J. (1982). How you gonna get go heaven if you can't talk with Jesus: Depathologizing deafness. In Storbeck, C. 2007. *SPED4001. Sign Language for Education. Theory and Practice 1.* (Course Reader, 41-51). Johannesburg: University of the Witwatersrand, School of Education

Young, M. (2005). Education reform in South Africa (1990 – 2000). An international perspective. In Kraak, A. & Young, M (Eds). *Education in retrospect. Policy and implementation since 1990*. Pretoria: Human Sciences Research Council

Zarfaty, Y., Nunes, T., Bryant, P. (2004, Summer). The performance of young deaf children in spatial and temporal number tasks. *Journal of Deaf Studies and Deaf Education*. 9(3), 315 - 326

United Nations Convention on the Rights of People with Disabilities. (2006). Retrieved on 17 December 2008 from http://www.un.org/disabilities/default.asp?navid=12&pid=150

Addendum A

LEARNER INTERVIEW SCHEDULE (Focus group sessions)

The following questions are simply a guide. They do not represent a fixed interview schedule. The idea is to work with the learners and their responses.

1. How do you feel about maths in general?

2. When did you start feeling this way?

3. Did anything happen to make you feel this way towards maths?

4. Has there been any time in your life when your feelings towards maths changed? Could you talk about what happened at that time?

5. How do you study for maths?

6. How did you feel about the activities in class this week? Which ones were helpful? Which ones were hard to understand?

7. What changes would you like to see in the class to improve your maths?

8. Were there any particular problems (in mathematics, or with the relations during group work) that you would like us to look at before next week?

Addendum B

B: LEARNER'S INTERVIEW SCHEDULE (Personal Interviews)

1. Which mathematics lessons did you find the most beneficial? Why?

2. Which mathematics lessons did you find the least beneficial. Why?

3. How do you prefer being taught mathematics? Why?

4. Do you prefer working on your own or in a group? And why?

5. How much time do you spend on your maths homework?

6. How did you feel about maths before problem solving was introduced?

7. How do you feel about maths after this research project?

8. What changes did you notice within your own way of thinking and doing mathematics during the course of the problem solving programme (if any)?

Addendum C

SEMI-STRUCTURED INTERVIEW SCHEDULE WITH PRIMARY SCHOOL TEACHERS AT LOCAL DEAF SCHOOL

The aim of the questions is to establish the opinion of the teachers of the Deaf at the local school with regards to Deaf learners' performance in mathematics.

1. Comment on the general level of mathematics at which your Deaf learners are functioning.

2. In your opinion, what (if any) factors are hindering your Deaf learners from progressing in mathematics? (What do you perceive as barriers in classrooms of the Deaf with respect to mathematics?)

3. What do you feel is necessary in classrooms for the Deaf to enhance the performance of Deaf learners in mathematics?

4. How much general knowledge would you say your Deaf learners have of the concepts before they are exposed to them in mathematics?

5. Comment on your Deaf learners' ability to recognise, and manipulate abstract concepts?

6. Comment on the written language level of the Deaf learners in your class?

7. To what extent are your Deaf learners able to comprehend abstract mathematical words without repeated input?

8. Would you feel that these Deaf learners are capable of language, rich real-life simulated mathematics? Give reasons for your view?

9. Describe the way you generally teach a mathematics lesson in your class.

Addendum D

SEMI-STRUCTURED INTERVIEW SCHEDULE WITH GRADE 9 SUBJECT TEACHERS AT LOCAL DEAF SCHOOL

The purpose of this interview was to gauge the general behaviour and level of academic and cognitive function of the Grade 9 class outside of mathematics.

1. Describe the general behaviour and dynamics of the Grade 9 class during your lessons.
2. Describe their level of recall.
3. Describe the work ethos of the Grade 9 learners.
4. What factors do you feel are contributing to their work ethic?
5. Describe the homework habits of the Grade 9 class.
6. What factors do you feel are contributing to their homework habits?
7. Describe the problem solving capacity of the Grade 9 class?
8. What factors to you feel are contributing to their current level of problem solving?
9. Describe the level of abstract thinking within the class?
10. What factors do you feel are contributing to their level of abstract thinking?
11. Describe the learners' level of literacy?
12. What factors do you feel are contributing to the learners' current level of literacy?
13. Comment on the learners' ability to link information.
14. What are your biggest frustrations as a teacher of this particular class?
15. Are you able to complete the prescribed government curriculum? Why or Why not?
16. What changes do you feel is necessary to be implemented in Deaf education at this particular school?

Addendum E

PARENTS' INTERVIEW SCHEDULE (Semi-Structured)

1. a. What are the ways you use to communicate with your child at home?

   b. How do you sign complex subject matter to your child?

3. a. How many hours does your child spend with homework every day?

   b. What is your child's attitude towards homework?

   c. How does your child study?

   d. How much time is spent daily revising work other than the normal homework?

   e. What are some of the main difficulties or frustrations your child experiences when doing homework/studying?

   f. What are some of the main difficulties or frustrations you experience in helping your child study/do homework?

4. Have you noticed any change in your child's attitude and behaviour towards mathematics during the time of the research? Explain.

5. What are some of the difficulties your child is personally experiencing at school that could be influencing his/her academic progress?

(These questions were adapted to parents whose children stay in the hostel during the week by asking what happens over the weekend, rather than what happens daily)

Addendum F

SEMI-STRUCTURED OBSERVATION SCHEDULE

1. What are the learners' levels of self-motivation?
2. What are the daily study and homework habits?
3. Learners' levels of participation in the activities/discussions/questions
4. Any underlying feelings towards mathematics (anxiety, boredom, enthusiasm, level of interest)
5. Suggestions/comments made by the learners
6. Learners' response to the work schedule (correctness, particular difficulties, layout, level of perceived understanding)
7. Group dynamics (behaviour in groups, acceptance of each other, willingness to work together)
8. The level of interest and belief in ability to pursue a career involving the sciences and mathematics
9. Learners personal views of the relevance of mathematics to the world and to their own lives
10. Learners' perception of the methodology of the worksheets and activities
11. Performance in mathematical tests
12. Aspects learners identify as having changed because of participation in the programme

Addendum G

EXTRACT FROM THE STUDENT ORIENTATION TO MATHEMATICS (SOM) QUESTIONNAIRE

Since this questionnaire is copyrighted, only an extract is given.

R - RARELY	S - SOMETIMES	F - FREQUENTLY	G - GENERALLY	A - ALMOST ALWAYS

1. I enjoy solving Maths problems.
2. While answering tests or exams in Maths, I panic.
3. I catch up lost work in Maths.
4. I explain Maths to my friends, parents or other persons.
5. My teacher uses words that I do not know and that confuse me.
6. I believe that I can do well in Maths.

Addendum H

EXAMPLE OF THE FIRST TYPE OF PROBLEM SOLVING EXERCISES

TO WHICH LEARNERS WERE EXPOSED.

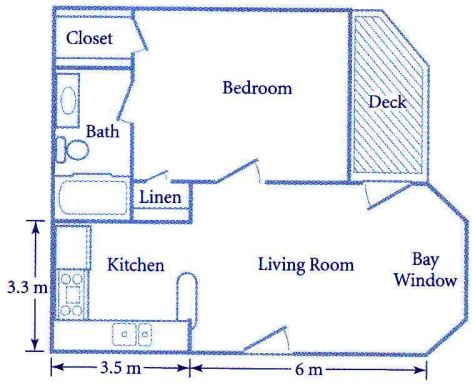
Addendum 1 – An example of a MR-RL mathematics activity

(adapted from Murdock, Kamischke & Kamischke, 2002)

Investigation

Floor Plans

This scale drawing shows the floor plan of a flat. We will use it to investigate how rate and direct



variation apply to scale drawings.

Step 1 Use a centimetre ruler. Measure the three lengths given on the floor plan.

Step 2 Make a table with a column for actual length in meters and with a column for scale drawing measurement in centimeters i.e.

Actual (m)	Scale Drawing (cm)

Step 3 Complete the table for the three lengths in Step 1.

Step 4 Compare each pair of measurement in a ratio:

$$\frac{\text{Actual measurement in meters}}{\text{Scale drawing measurement in centimeters}}$$

Use your calculator to convert each ratio to a decimal.

Explain your findings.

Step 5 State the scale for the drawing and explain how you got it. Then write the scale as a ratio.

Step 6 Measure the length and width of the bedroom in centimeters on the scale drawing. Use the scale you wrote in Step 5 to calculate the dimensions of the actual bedroom.

Step 7 The manager of the flat wants a small model of this apartment to show people. She wants the 6m wall of the flat to be 10cm in the model.

Write an explanation that she can use to convert from the scale drawing to the model.

Step 8 On a clean sheet of paper, draw an accurate floor plan for the model of the apartment. Think carefully of how to find the length of each wall and the angles where the walls meet.

Step 9 Compare your floor plan to the scale drawing in the book. Describe how they are alike or different.

Step 10 (For enrichment) Transfer your perspective drawing to the computer using CAD.

Addendum I

EXAMPLE OF THE MODELING EXERCISES USED IN THE RESEARCH

(Taken from Fendel, D., Resek, D., Alpher, L., and Fraser, S. (2000). *Interactive Mathematics Programme. Shadows*. California: Key Curriculum Press)

Homework 19 To Measure a Tree

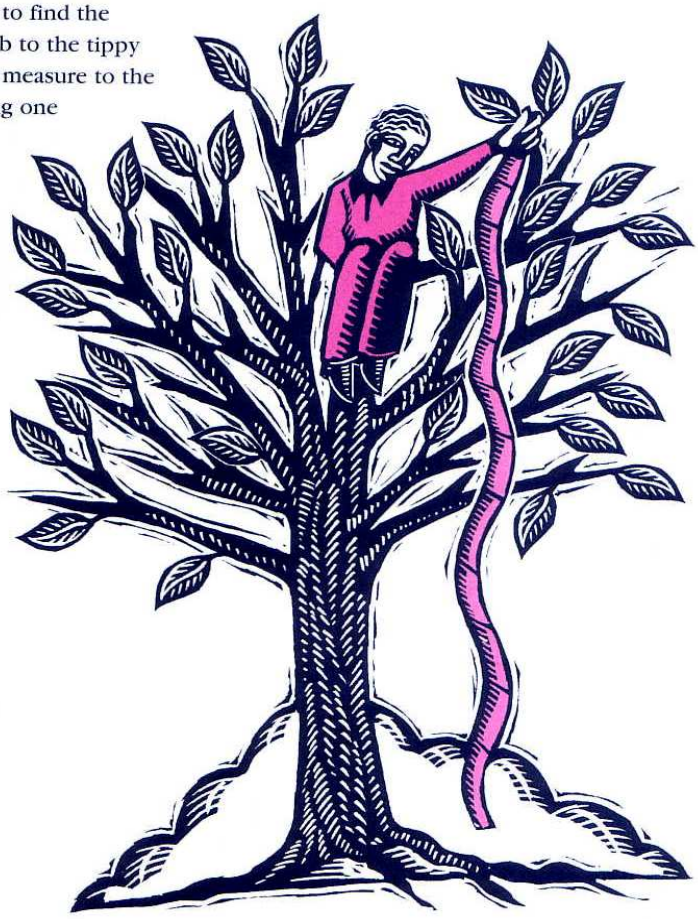
This unit started with a problem about finding the length of a shadow. But other measurement ideas have come up as well.

You've seen how to measure the height of an object using a mirror. Now you will look at measuring the height of a tree.

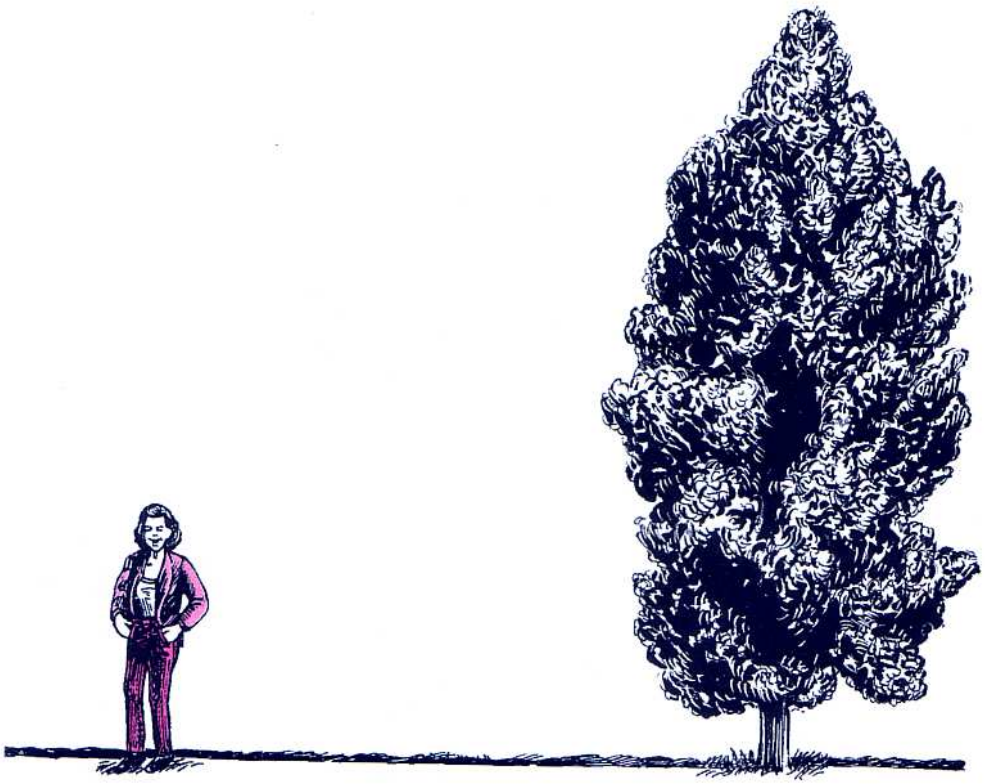
One straightforward way to find the height of a tree is to climb to the tippy top and drop a long tape measure to the ground (while still holding one end) and have a friend on the ground read off how tall the tree is.

Although straightforward, that method has many potential difficulties (and dangers).

Fortunately, there's a less hazardous method—one that uses similar triangles.



Continued on next page



Your task in this assignment is to use your knowledge of similar triangles to invent a method for measuring a tree. Use the illustration above for ideas.

Write down what you'd have to know and how you'd use that information to figure out how high the tree is.

Identify clearly what similar triangles there are in the situation, and explain how they would fit into your method.