Using Art to develop Mathematical concepts in Deaf learners

an investigation

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DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the degree of Master of Education (M Ed) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signed

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Desiree S. Seekola

September 2010

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Abstract

The current poor mathematical results in Grade 9 at a school for the Deaf in South Africa are a cause for concern. Consequently, various endeavours of teaching mathematics in the hope of elevating the grades have followed. This research focuses on using art to teach mathematical concepts prior to the mathematics lesson. Review of the literature reveals visual and pedagogic similarities inherent in both art and mathematics. The visual nature of art aligns itself directly to Deaf learners who access information visually. It therefore seems a logical application to explore art as a gateway to educating Deaf learners into mathematical concepts/literacy. Following on from the input received through research, this dissertation makes a case for the potential art has to expound world knowledge, elevate the confidence and personal self esteem in the Deaf learner and so augur mathematical literacy. The research is designed around individual case studies and an art intervention program. Through the intervention learners managed to take implicit knowledge acquired through activities and make the knowledge explicit. Art was found to encourage theory building through the conscious construction and exploration of analogies between art and the real world.

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To my parents

CHAPTER ONE

1.1 Introduction

The mathematic results at the school were cause for concern as it has taken a downward plunge year on year decline which has had a negative impact on the attitude of learners towards mathematics (Naidoo & Parker, 2000). The poor results leads to learners becoming increasingly uninspired and lack perseverance towards mathematics. However, with mathematics being a compulsory subject at high school level, the DoE, the need to see its relevance in real life was not happening as envisaged (DoE, 2005). In view of this context at the research school, it was hypothesised that art would be a realistic device to use in the quest for attitude changes, improved results and in realising the ultimate goal: for learners to be able to apply themselves to forming a link between mathematical theory and practice (Isbell & Raines, 2007). Research reveals that art has been used to foreshadow a learners' scope of world knowledge and psychology. Therefore applied to mathematics, it was deemed an apt tool and feasible strategy to enhance mathematical progress at school [1](Bart, 2007). The aim of this research is consequently to investigate the potential function that both practical and history of art can play in fulfilling mathematics curriculum requirements.

From the outset of this project it is evident that I am a practitioner at this school for the deaf where the research was conducted. My experiences here as a result, led to certain assumptions that informed the consequent research project. As the grade 9 learners' art teacher, and equally as an involved researcher the following arrangements were made to secure validity. I engaged the services of the mathematics teacher, who was also a teacher/researcher working jointly and yet independently on this research. The role of the mathematics teacher in my study was to objectively observe and record the students' responses during the art lessons. (Aside from the research, the mathematics teacher like other subject teachers at this school frequented my art classroom curious to observe the development of the learners' practical works of art. Therefore it was not unusual for the learners to experience the presence of another teacher in the classroom other than myself.)

[1] Personal Interview: August 2007

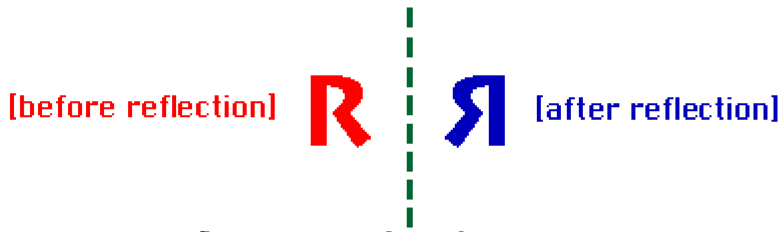
This was to support my own observational focus on learners' attitudes and academic progress.

1.2 Background

The need for computer skilled work has increased since post World War II from 25 per cent to 75 per cent. Today the need is close to 90 per cent (Spady, 1995 cited in Macdonald, 2001). Pressure for an information-literate, technologically competent skills workforce growth is being felt at all levels of society and is proving a challenge to the education system (Macdonald, 2001) including schools for the deaf. Of these skills literacy may be one of the biggest challenges that face teachers, parents and other caregivers in the lives of the deaf child. The booming technological age and the introduction of the Further Education and Training(FET) syllabus at schools compels deaf learners to keep pace with their peers in mainstream education. Although a welcome challenge for deaf students, understanding the many new concepts they are faced with, within given contexts has proved to be a strain. The practical challenge I was faced with arose as an opportunity to test the premise that art can be used as a gateway to conceptual comprehension and as a result subject content. This was an exploration worthy of endeavour.

1.3 Problem Identification

I was teaching a class certain aspects of art: symmetry and reflection with particular reference to Islamic patterns. Islamic patterns are based on the concept of reflection as may be seen in Figure 1. To reflect an object means to produce its mirror image. Every reflection has a mirror line. For example a reflection of an "R" is a backwards "R". Reflecting an object creates a balance, *symmetry*. Islamic Art used this system of reflection to create patterns which then decorated mosques.



Reflection as used in Islamic pattern

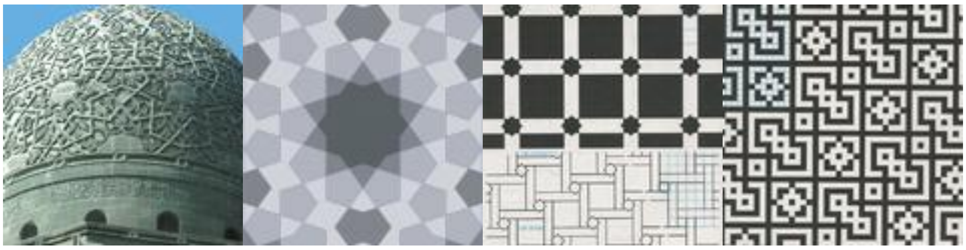


Figure1: Reflection

At about the same time the mathematics teacher was teaching the reflection of graphs across the Cartesian plane. Within a few weeks the learners remarked to their parents and their mathematics and I, their art teacher that they were confused about whether they were learning mathematics or art. They would also regularly comment and give examples of symmetry and reflection they noticed in school and at home wholly animated by their findings. Such observations were relevant in revealing a spontaneous link the learners were making between mathematics, art and the real world. The findings are pertinent to *learning outcome one and two* in the Department of Education National Curriculum Statement (NCS) 10-12 Mathematics (General). It points learners to "explore real-life….mathematical number patterns…and…provides learners with powerful tools for understanding their world" (DoE, 2005: 21). It also became evident that through these specific art examples on Islamic patterns, learners seemed to understand the mathematical concepts by means of the visual data base that art provided (Skemp, 1986). The mathematics teacher, familiar with the mathematics NCS, began pointing out to me the association learners were making as a result of the art intervention. Further prominent observations in the mathematics classroom according to the mathematics teacher were the enthusiastic responses from previously docile learners. These included elevated levels of confidence at attempts to answer questions.

Prior to the art intervention learners were afraid to get their answers wrong and had to be coaxed to attempt an answer. It was as a result of these positive responses that the mathematics teacher and I pondered on ways in which to create a visual data base in the form of a prototype to model each mathematical concept. We researched the 'maths-art' link for this purpose through an on-line investigation of an assortment of educational institutions including deaf, hearing, secondary and tertiary.

1.4 Significance of the study and rationale

It was discovered that using art to teach mathematics is not a new phenomenon but is exercised at schools and at universities globally producing a myriad of benefits, ranging from changed attitudes in learners to excellent results [2](Bart, 2007). Bart (2007) investigated the poor mathematical results of first year students. Thereafter, proactively, a way forward was devised to improve these results. After her research was complete, a group of students with improved results, enthusiastic towards mathematics emerged. This study replicates Bart's method with changes in three areas: firstly, the learners at the current school are at secondary level where as Bart's students are at a tertiary institute. Secondly, the student's in Bart's research participated from a first world country and the learners in this research, a third world country. Thirdly, Bart's students were hearing. The learners in this study are deaf. However, similar to their South African counterparts, Bart's students experienced a transformation in the form of a domino effect of an enthused succession of attitude and behaviour changes in the learners. Bart's dissertation and step by step workshop on how these successes through introducing her learners to art may be seen online.

Henceforth, these psychological changes acted as a trigger for perceptibly improved results in mathematics. Heartened by such encouraging grades, a sense of self determination was activated in each student. Having thus accepted ownership of their improved marks a group of self-assured students emerged. Parents at home were subjected to optimistic conversations about mathematics which they had never experienced before and the natural science and English teachers observed and reported their positive attitudes, increasing confidence and self-esteem. For the mathematics teacher, the class tests evidenced these findings.

This cycle of change happened within a period of one month and provoked my pursuit of the interdisciplinary use of art as a launch pad to create visual mathematics at schools for the deaf.

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[2] Personal Interview: August 2007

Prior to this rapid, radical transformation in the class where the pilot study was conducted, the observed lack of interest in mathematics among deaf learners in this class and at the school in general, had been cause for concern for both the management team and staff. Their blatant refusal, in the form of bad attitudes, to learn classroom mathematics culminated in poor results. A key reason for initiating this research is the pattern of poor mathematic performance being experienced at the school by learners from their primary level onwards. Naidoo & Parker (2000) corroborate the adverse effect negative attitudes have on Mathematics performance. Yet it is these same learners who produce surprisingly good results in art. Firstly according to research and from my own personal experience as art teacher, learners come into the art class enthusiastically (Isbell & Raines, 2007). They then sit and wait for information about the next task eagerly. Research by Isbell & Raines (2007) confirms that from their focussed expressions learners enjoy the process of working with the paint, clay and other media and experience satisfaction when the task is completed. I deliberated ways in which art could be used to create a visual mathematical model to facilitate mathematical comprehension. The sequence of the art lessons would make a strong foundation; I hypothesised, for the start of a mathematics lesson.

From the start of the art lesson to the end students are engaged in the process of acquiring four outcomes; that of conceptualising, making, management and presentation and culture studies. During the conceptualising period, learners ‘research from a variety of sources, work within time and resource constraints, and develop both personal imagery and a personal visual vocabulary’ (NCS, 10-12 Visual Arts, 2003, p 12). I wondered about the possibilities of the mathematics teacher teaching mathematics in a visual way, by using paints and constructing projects. Such a possibility becomes more feasible in light of the following consideration that ‘deaf learners are predominantly visual learners’ (Cotton, 1991). Art, in turn, is a visual language and therefore creates a direct correspondence to the visual needs of deaf learners. Moreover, art can be used as a tool for ciphering information from other subjects. According to Clark, (1973) cited in Forseth (1998, p 22) this is possible as ‘art education supports an interdisciplinary use of art as a medium for coding information from other subjects’. Although this scheme of the interdisciplinary use of art is theoretically sound, it would be impractical and impossible in the current situation at my school for three reasons. The first is that in order to teach visual mathematics the mathematics teacher must also be skilled in teaching art or the art teacher, a skilled mathematician. This was not the case and thus presented a drawback to the hypothesis. The second problem encountered is time constraints enforced by curriculum requirements. The third challenge which both the teachers faced, and which seems a contradiction is that lessons were being taught through the natural language of the learners, that of sign. Although a seemingly faultless pedagogy may be predicted in light of this perfectly viable communication strategy, this study is underpinned by a multitude of barriers that language presents to each learner differently. The premise for this apparent paradox, points to late detection of deafness, little or no parental support in dealing with a deaf baby and therefore lack of communication skills on the part of the parent. Art therefore plays a pivotal role in bridging the language barrier as may be seen in the exemplars of art lessons in this study and in 2.2.3: constructing a mental image of a concept.

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It is for this reason that the mathematics teacher and I decided to graft our abilities towards mutual intent. The intent was to develop mathematical concepts using art. The research was guided by the following critical questions.

1.5 Critical questions

1.5.1 What are the main causes of poor mathematical results among deaf learners?

1.5.2 What is the quality of mathematical concepts deaf learners currently possess?

1.5.3 How can a comprehensive concept be constructed and modelled in deaf learners?

1.5.4 What are the factors which inhibit or advance the development of a prototype in deaf learners?

1.6 The definition of key concepts

The key concepts used in the study will now be discussed.

Art: In the context of this research art is used in an educational setting to mean the area of learning that is based upon the visual, tangible practical art such as drawing, painting, sculpture, art appreciation the history of art and design in jewellery, pottery, weaving, fabrics.

Constructive education as in OBE: It advocates that knowledge can be generated by the student engaging in the subject matter whilst the educator acts as a facilitator of knowledge (Spady, 1998, as cited in Macdonald, 2001).

Deaf/deaf: "deaf" usually takes on a generic audiological definition in its reference to the condition of having some degree of hearing loss (Stewart, 1994). The term "Deaf" is taking a foothold in our consciousness. Most of us will define a Deaf person as being someone with a hearing loss who is also part of a culture that uses a sign language. Events and entities associated with the Deaf population are similarly named which give us such terminology as Deaf community, Deaf culture, Deaf folklore, Deaf sports, and Deaf way. However, a person may have a hearing loss, use SASL and not be Deaf. Must a deaf student be Deaf? Many may answer "yes". But such a narrow stance does little justice to improving our understanding of the diversity within the deaf population. There are many deaf people who are fluent in SASL but have little to do with the Deaf community as well as those deaf people who never sign. They are comfortable in their interactions with people who are not deaf and who speak. It is the thoughts and actions of Deaf people that provide the definition of what it means to be "Deaf." The identities deaf people choose are shaped by the social context in which they interact.

Ultimately then, two definitions to the word deaf have come into existence: a cultural and clinical definition. These are identified by a capital 'D' as in the case of culturally Deaf and a small letter 'd' in the context of non-specific deaf (Steward, 1994).

Mathematics: This research refers to mathematics as a subject taught at schools. Mathematics is the body of knowledge centred on such concepts as quantity, structure, space, and change. Mathematics is the science of pattern. Through the use of abstraction and logical reasoning, mathematics evolved from counting, calculation, measurement, and the systematic study of the shapes and motions of physical objects.

Outcomes Based Education (OBE): Outcomes-based education has been the basis for South African education. Its goal: that all learners acquire maximum education according to their ability. No prescribed texts were prearranged. Instead educators were encouraged to use as wide a range of resources as possible including the internet. OBE encouraged a learner centred and activities-based curriculum (DoE, National Curriculum Statement, Visual Arts, 2003, p 2). Many schools struggled to change from traditional methods of teaching and implement OBE since its introduction in 1997 for a number of reasons. Educators' cries to scrap OBE echo today in the echelons of the DoE.

Prototype: Used in the context of this research, a prototype is a general internal image or a common average of the concept. An active prototype consists of three separate mental systems viz. the recognition system, in which stored representation of the concept is held; the semantic system, in which the general knowledge one possesses about the concept is located, and lastly a system from which the written forms of words (the names) are retrieved. Example: If we choose a well-known concept, red; and imagine that we are explaining the concept to a man, blind from birth, who has been given sight by a corneal graft. The meaning of the word is the concept associated with that word, so our task is to enable the person to form the concept red and associate it with the word 'red'. Intuitively, we would point to various objects and say 'This is a red diary, this is a red tie, and this is a red jumper…' We would arrange for him to have, close together in time, a collection of experiences from which we hope he will abstract the common property-red. The same process of abstraction could take place in silence, but it would probably be slower' (Skemp, 1998:23-24) and the word 'red' would be attached in Sign Language. The words prototype and model will be interchanged within this text.

Traditional education: In essence traditional education evolves around the teacher as authority and the students as passive learners. The curriculum assessment systems are treated as ends in themselves and everybody is assessed and measured by the same standard (Spady, 1998, as cited in Macdonald, 2001)

Transformative Education: This term is coined from The Constitution of the Republic of South Africa (Act 108 of 1996 cited in DoE, NCS Visual Arts, 2003: 1) and in this thesis refers to the transformation of the education system to reflect the changes that are taking place in our society and to strengthen the values and practices of our new democracy. The higher education system is being transformed to redress past inequalities, to serve a new social order, to meet pressing national needs and to respond to new realities and opportunities. Transformative education during this period of change refers specifically to methods in teaching. The new system envisions a drastic change in teaching methods from the traditional approach to a learner centred constructive approach in order to overcome the fragmentation, inequality and inefficiency of the past, and create a learning society which releases the creative and intellectual energies of all our people towards meeting the goals of reconstruction and development (DoE, NCS Visual Arts, 2003: 2)

1.6 Explanation of codes

The codes used during direct quotation of interviews are explained below by an example.

Teacher Interviews: T represents teacher, the initial next to it, the name of the teacher and the numbers that follow, the actual numbers as taken from the raw data. *Example TC 22 should be interpreted as Teacher Cayla extracted from line 22 of this teacher's interview.*

Codes beginning with the letter S represent Student, FG represents Focus Group and P represents Parent.

1.7 Progression of the study

Chapter 1 provides a broad introduction to the current state of mathematics at schools for the deaf, and the rationale that art may be used as a way to advance mathematics among deaf students in South Africa..

Chapter 2 deals with theories that framed the research and a review of relevant literature.

Chapter 3 is a description of the methodology that was used in carrying 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 case studies and emergent themes are outlined in each case.

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

Chapter 6 gives a conclusion and recommendations on the role of art in the mathematics classroom.

CHAPTER TWO

Theoretical Framework and Review of Literature

For the inhabitants of a built environment, the very obviousness of certain patterns can make them invisible. We don't realize that we are surrounded by the shapes of Euclid – circles, rectangles and triangles, etc. (Eglash & Odumosu, 2005,p.1)

2.1 Introduction

In light of the premise that deaf students struggle to understand mathematical concepts due to inadequate access to language ((Pagliaro& Kritzer, 2007; Simms & Thumann, 2007; Easterbrooks, Stephenson, Mertens, 2006; Ray, 2001), and the hypothesis that the subject art, aside from its well known aesthetic and therapeutic functions, can also be used as a tool to building concepts, the cognitive benefits of art will first be explicated.

The question may arise as to whether art is an undemanding discipline suitable only to amuse and divert the mind but not suited to cultivate thinking. Research does not answer this question directly. What it does suggest is that the each domain of the brain makes different demands on thinking and that art is placed in the cognitive landscape where the power to formulate interpretations becomes dominant (Efland, 2002). On the other hand, art in education is not given the prominence in line with its cognitive function that it deserves.

The theoretical framework to the topic highlighting cognition in art will be followed by a review of related literature.

2.2 Theoretical Framework

As far back as 1939, it was believed that teachers of art should attempt to relate art instruction to such fields as history, geography and social studies to name but a few (Efland,2002). However the school experience at the time favoured subject matter divided by boundaries. Current arguments however, are stated in terms of cognitive benefits which are likely to arise when subject matter is made meaningful by pointing out its inter-relationships. More often than not a work of art draws its knowledge from differing domains. As a result, artworks can lie at the core of integrated conception of general education including mathematics (Efland, 2002).

Furthermore, art might serve as an integrating vehicle within the curriculum since the interpretation of art works requires that it be situated in its social and cultural context (Efland, 2002) It is for this reason that the framework, from which mathematical concepts are hypothesised to develop in this research, lies in creating a visual prototype of commonly used mathematical words and with reference to the learners environment during the art period at school. It is put forward that possessing a visible model (Lang & Pagliaro, 2007) of certain mathematical concepts can help bridge gaps and assist the deaf child in his/her mathematical learning. Given that reference to mathematical terminologies will be used during art lessons, the art period thus simultaneously serves to expand understandings of words such as symmetry, rotation or reflection. How these concepts and their associated meanings will be modelled to the learners is discussed below. However, the educators view of the learner and the learners' response to the educator further contributes to conceptual insight.

It is important to this study that the perspectives of deafness are elucidated as it has become clear that one can adopt either of two opposing perspectives when interacting with the Deaf learner. While these perspectives have been given different names or labels by different authors and researchers, we will refer to the differing perspectives as the "pathological model" and the "cultural model." It is essential to understand which of these perspectives one might hold for each result in vastly different ways of dealing with and treating the Deaf Community.

Indeed, the first perspective, at least in some of its extreme manifestations, would seek to deny the very existence of the Deaf Community.

2.2.1 Socio-cultural vs the medical model of deafness

The pathological view of deafness has also been called the clinical-pathological view or the medical model. Essentially this view accepts the behaviours and values of people who can hear as "standard" or "the norm" and then focuses on how Deaf people deviate from that norm. This is the perspective that has been traditionally held by a majority of non-deaf professionals who interact with the Deaf Community only on a professional basis. In a sense this is the "*outsider's*" view - a view that focuses on how Deaf people are different from non-deaf people and a view that generally perceives those differences negatively. It is also a view that deaf people have something wrong with them, something that can and must be "fixed."

Those who hold a pathological view might define the Deaf Community as: a group of people whose hearing loss interferes with the normal reception of speech; a group of people who have learning and psychological problems due to their hearing loss and their perceived communication difficulties; a group of people who are not "normal" because they cannot hear. It should be fairly easy to see that this view, the "pathological" one, results in paternalistic and oppressive behaviours and attitudes towards Deaf people. Recently this way of dealing with Deaf people, of treating them as incapable of self-determination, has been called "audism" to emphasize the fact that this view shares much with other paternalistic perspectives such as racism, sexism, and anti-Semitism. The "pathological" view stands in sharp contrast to the view based on linguistic and sociological research findings which is the cultural view.

The cultural view recognizes that there is a complex set of factors that must be considered when examining the Deaf Community. Indeed, it is this very fact that makes defining the Deaf Community a complex task.

Those who hold a cultural view might define the Deaf Community as: a group of persons who share a common means of communication (sign language) that provides the basis for group cohesion and identity; a group of persons who share a common language (SASL) and a common culture; those whose primary means of relating to the world is visual and who share a language that is visually received and gesturally produced.

Understanding the view of deafness one holds is crucial for it will, in large measure, determine ones relationship to and with the Deaf Community. One’s attitude towards the community's language and its culture determines ones perspective towards deaf pedagogy. One may either maintain a medical/pathological or cultural view of the deaf child.

2.2.2 Modelling mathematical concepts

With regards to the model which I aspire to create in order to develop mathematical concepts, the term prototype is used. A prototype is a cognitive representation of mathematical concepts. The value of possessing an expanded and more coherent prototype should not be underestimated. Ausubel et al. (1978, p 167) argue that having representational functioning in the form of an acquired stable cognitive structure is "*also* in its own right the most significant *independent* variable influencing the learner's capacity for acquiring more new knowledge in the same field". His emphasis in this regard is very strong and also links with Vygotsky's Zone of Proximal development which will be discussed later on in this study:

> If we had to reduce all of educational psychology to just one principle, we would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly (Ausubel et al. 1978, p 163).

The prototypes in this research will evolve around particular mathematical concepts and will consist of generating a web of many different visual images that connect to that particular concept. The vastness of this semantic dimension of the word depends on the richness of its stored meaning. Said differently, and applied to mathematics, the embryonic stage of understanding a mathematic concept will be unfolded during the art period as meanings are explained in a variety of real life settings. The question that emerges foregrounds how one would then account for this type of conceptual development in research?

For an educator to accurately assess students' understanding of a concept it would be ideal to identify what is going on inwardly, i.e. inside their minds. Since this is not possible the outward indications of conceptual understanding need to be considered (Harlen & Osborne, 1985, cited in Macdonald, 2001). Therefore, indicators of children generating novel conceptual structures may be by them *relating* new ideas (their own or others) to earlier experiences and ideas recalled from memory, and also by *questioning* original ideas (their own and others) and testing them against additional experiences (Harlen & Osborne, 1985, cited in Macdonald, 2001). Moreover, for the student to experience concept development finding similarities among objects must be encouraged. This in place, a further strategy needs consideration before a concept is created in the minds of deaf learners.

Given that the students at this school are deaf, and learn by way of Sign Language, conceptual development for them must include not only recognising and learning to finger spell the written English word and the associations attached to it but also incorporating knowledge of a sign for the concept each time a word is used. The next section details how these characteristics are applied within this study.

2.2.3 Constructing a mental category of a concept

As was indicated by Skemp's work, we build concepts through mediation in words.

The observations in the pilot class revealed that having seen and in some instances come into contact with the concept in its every day form, facilitated the speed and ability with which the learners were able to manipulate the concepts on an abstract plane. Below is a diagrammatic explanation of how this is envisioned to have happened. In this manner, I integrate each of the specified mathematical concepts into the prescribed art syllabus. Overlapping the subject content is essentially one of the tenants of OBE; that of integration (DoE NCS General,Visual Arts :6) After a period of guidance, when students have acquired the knack of collapsing specifics into concepts by this means extracting the attributes, they will in essence be defining a concept on the own.

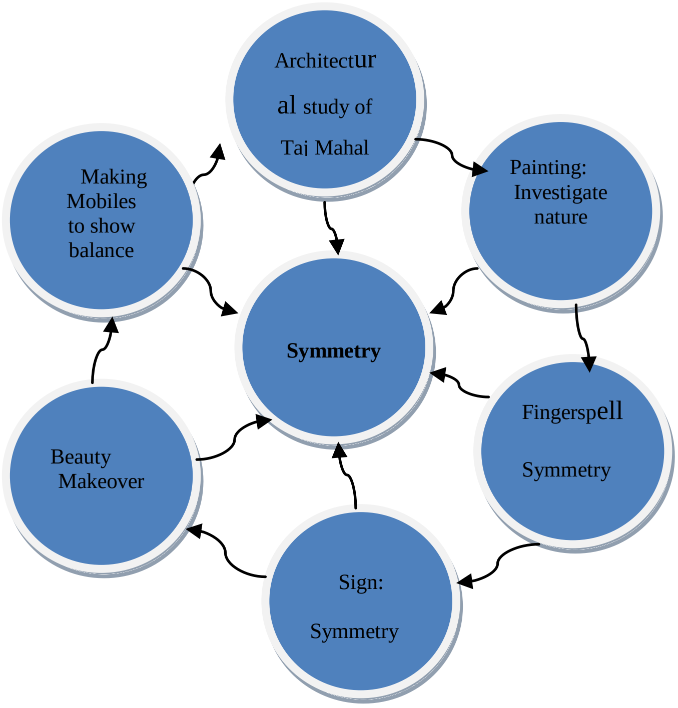


Figure 2: Developing a model of the word "symmetry"

The following example serves to elucidate how learners can learn mathematics with the use of a visual prototype. It also explains why the art had to be done in the art room and could not have been done in the mathematics classroom by the mathematics teachers. A theory supporting this plan is that mathematical understandings of concepts are not easily understood by the lay person (Livio, 2006). Therefore in the case of facilitating deaf learners understanding, art is used to soften the setback. Moreover, time constraints did not allow the mathematics teacher to complete the syllabus and execute an art lesson during the time allocated for mathematics. This would have firstly been construed as wasted time. Secondly, it would not be part of the mathematics curriculum and thirdly, the mathematics teacher would also have had to be familiar with art practical and history subject content.

Let me tell you what we do in the classroom. Learners are given a background to introduce symmetry: “Symmetry, as wide or as narrow as you may define its meaning, is one idea by which man through the ages has tried to comprehend and create order, beauty, and perfection” Hermann Wey (2008). From the mathematical background of symmetry we understand symmetry to refer to an object that is preserved by a transformation (Bart & Clair, 2008). Its more familiar English vindication makes reference to balance, equilibrium and proportion. Initially, as the baseline discussion will show, students are given exercises in creating patterns from rotational symmetry, reflectional symmetry and transformational symmetry. Much symmetry is found in folk art. Therefore as a historic point of reference, learners may be shown creations of these symmetrical patterns. Discussions thereafter evolve around how symmetry differs. I have chosen one lesson to explicate this phenomenon.

An example of an art lesson on reflectional symmetry:

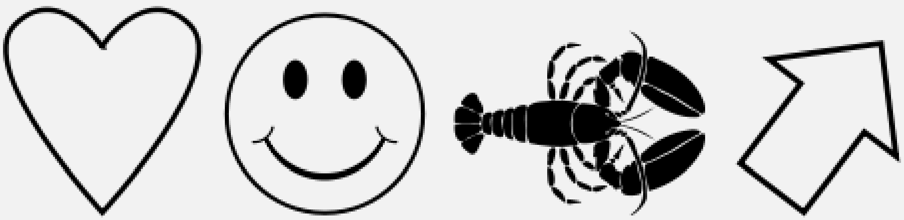
Baseline discussion

If one side of the image is the mirror image of the other side, then we say the figure has reflectional symmetry. Sometimes we would say that the image has a mirror line. Here we have some images from real life that have such mirror lines. In the first picture is a piece of a Persian rug. Here again you can see that the left side is an exact mirror image of the right hand side. The bug right next to it also has a vertical mirror line, and the left side is a mirror image of the right side. The image of the ducks shows that the mirror line can also run in other directions. In the duck picture the mirror line runs from left to right.

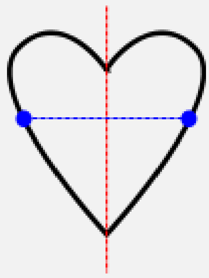
		
A rug	A Beetle	Ducks

To make the idea of symmetry a bit more precise, we would say that if points of a figure are equally positioned about a line, then the figure has **reflection symmetry**. Note that **mirror symmetry** is just another word for reflection symmetry. You can use either one of these terms. The line is known by several different names. Sometimes it's called the **reflection line**, others may call it the **mirror line**, or the **axis of symmetry**. The important part to remember is that this line separates the figure into two parts, one of which is a mirror image of the other part.

Here are several more examples of this mirror symmetry:

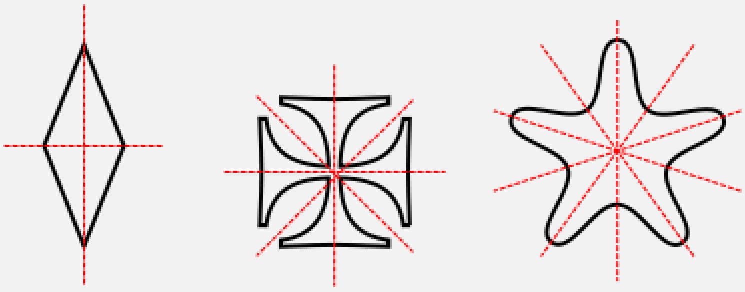


The heart and smiley each have a vertical mirror line, and the lobster has a horizontal mirror line. The arrow has a mirror line at an angle. If you draw the mirror line though any one of these figures, you will notice that for every point on one side of the line there is a corresponding point on the other side of the line. If you connect any two corresponding points with a segment, that segment will be perpendicular to the axis of symmetry and bisected by it (cut into two equal length segments):



Mirror or reflection symmetry is the most common type of symmetry found in nature, occurring in almost all animals and many plants. Scientists have shown that our brain is rather good at recognizing this type of symmetry. In fact, people are especially good at detecting mirror symmetry when the mirror line is oriented vertically (up-down). Remember that your eyes are hard wired to do this well when the axis is vertical, and so it will be a big help to turn the images (or your head) as you look for symmetries. Try this with the picture of the ducks for instance: turn your head to the right and the look at the picture again. Do you notice the mirror line even more?

Some objects or images can have more than one mirror line. Here are some examples, with the mirror lines shown as dotted red lines:



Pay special attention to the diagonal mirror lines in the cross. These are easy to miss, and do show up quite often.

Practical Task

Students are then asked to create their own symmetrical patterns based on either an example from nature (such as a butterfly, flower, leaf, fruit or reflections in water etc.) or a symbol. Compositions may take the form of a wall paper pattern or landscape painting.

This is just one example of creating an understanding of the concepts reflection and rotation as it is done in the art class. When learners proceed to the mathematics class they would already have a wealth of knowledge of the concepts. The mathematics teacher may therefore teach mathematics instead of delving into a lesson illuminating a concept first before teaching mathematics. It is therefore hypothesised that learners will learn mathematics more effectively as a result of this baseline knowledge.

The literature review continues to throw light on the overlying factors associating mathematics and art that makes learning mathematical concepts through art a viable option.

Success at constructing concepts implies the ability to apply this process and abstract words in other subject areas including mathematics. For example: an *even number* is an integer that is a multiple of 2. Thus the attributes of the concept *even number* are (a) integer and (b) multiple of 2. Students should thus recognise that any specific that meets these two attributes is an even number. Furthermore, using art to teach mathematics in this manner encompasses one of the critical outcomes of OBE to 'collect, analyse, organise and critically evaluate information' (DoE: Design 2003, p2) which points to the quintessence of developing a concept.

To facilitate a more stable conceptual structure in deaf learners this study is inclusive of literature relating to the establishment and maintenance of more powerful cognitive connections through subject integration, social integration and cognitive integration.

2.2.5 Subject integration

The subject integration perspective based on the theory by John Dewey (1993) cited in Isbell & Raines (2007) is followed through in the current education curriculum as set out in the Revised National Curriculum Statement (RNCS). Dewey's viewpoint is especially apt for deaf learners in developing concepts as integrating subjects serve to link one notion with the next across the curriculum.

It was Dewey (1993) in Isbell & Raines (2007) who argued that a student must connect new knowledge with previous experiences to develop clear understanding of the new concepts. This notion is hypothesised in this study as a way forward to developing concepts among deaf learners. Constructivism is based on John Dewey's work and shaped by the efforts of Piaget (1976) and Vygotsky (1978) cited in Isbell & Raines (2007). A more detailed exposition of Dewey and his educational philosophy is detailed below.

Dewey (1933) cited in Isbell & Raines (2007) contends that learning takes place by doing i.e. the student must be actively involved in the learning process. The OBE curriculum encourages and spirals around such practice. Individuals construct their own meaning as they reflect on their interactions with their environment. The pilot study in Section 1.3 adds more depth to this particular perspective since the class was taught concepts during the art class. These were concepts which the mathematics teacher wanted them to understand before she taught the mathematics. During this process of developing an understanding of concepts, the students indulged in selecting their own materials and creating works of art in a relaxed environment almost unaware of their growing knowledge.

The epistemology of constructivism argues that learners generate knowledge and meaning from their experiences. A major theme in the theoretical framework of Bruner (1977) is that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Constructivism as a paradigm or worldview posits that learning is an active, constructive process. The learner is an information constructor. People actively construct or create their own subjective representations of objective reality. New information is linked to prior knowledge (von Glaserfeld, 2002). It departs from the premise that knowledge is in every persons mind and that a person constructs or builds new knowledge based on life's experiences (von Glaserfeld, 2002).

Vygotsky's (1978) theory is one of the foundations of constructivism. It asserts three major themes:

1. Social interaction plays a fundamental role in the process of cognitive development. In contrast to Jean Piaget's understanding of child development (in which development necessarily precedes learning), Vygotsky felt social learning precedes development. He states: "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).” (Vygotsky, 1978).

2. The facilitator or mediator refers to anyone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The mediator is normally thought of as being a teacher, coach, or older adult, but the mediator could also be peers, a younger person, or even computers.

On the other hand, Piaget saw knowledge developing in stages. How our thinking is organised and structured is key to Piaget’s philosophy. The manner in which individuals interact and react depends on their own set of internal cognitive structures that they have erected over the years (Piaget, 2003). A central component of Piaget's developmental theory of learning and thinking is participation of the learner. Knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner. The learner must be active; he is not a vessel to be filled with facts. He emphasized that children cannot learn something until maturation gives them certain prerequisites. The ability to learn any cognitive content is always related to their stage of intellectual development. Children who are at a certain stage cannot be taught the concepts of a higher stage (Piaget, 2003). The theories of both Vygotsky and Piaget have implications for constructivism.

The implications of Dewey’s theory of constructivism for education is that learners are encouraged to follow their personal interests, make choices and combine materials in their own way (Isbell & Raines, 2007). As they interact with their environment, they develop schema (a mental representation or visual plan) to organize their experiences (Isbell & Raines, 2007). The Dewey ideal is that learners can communicate effectively using visual, symbolic and/or language skills in various modes and, in keeping with the DoE Design syllabus, demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation (DoE: Design 2003, p2). Unpacking the visual implications of this theory may have a positive impact on deaf learners, and will be used in the art intervention programme, since one of the ways information is acquired is through their sense of sight. A hands-on, visual approach allows the deaf learner to engage in activities which serve to reinforce integration of acquired knowledge and new concepts developed from old ones in the different learning areas. This particular method of using art to introduce mathematical concepts to deaf learners is innovative and contrary to "the continued use of a traditional mathematics curriculum that is both outdated and inappropriate for preparing deaf and hard of hearing students for today's world" (Pagliaro & Kritzer, 2005, p 259).

Typical classroom mathematics today involves a presentation of a multitude of theories of mathematical learning. One of the main factors for this is that mathematics education is heavily influenced by cultural, social and political forces. Towards the end of 1980 there was a switch to mathematical learning as a social product (English & Sriraman, 2005). Social constructivism which draws on the works of Vygotsky has been the dominant research paradigm ever since. On the other hand, cognitive theories have emphasised the mental structures that constitute and underlie mathematical thinking and the extent of which the curricula should capture the essence of school mathematics. If our theoretical view is that children learn through practicing to produce the correct response to a given stimulus then they should be given more practice. If on the other hand we believe that they should learn by making sense of the world then we should provide them with stimulus in the appropriate environment. Any attempt to hasten the child by learning using rote methods may persuade the child that mathematics is meaningless (Orton, 2004). The South African education system by the implementation of OBE has attempted to steer clear of the rote learning theory.

The original intention of OBE to facilitate meaningful integration forms a bridge which links the social and cognitive perspective of this learner-centred and learner-paced constructivist philosophy Spady (2007). It was based on four principals by Spady (2007).

> First, each of them had clear, tangible performance criteria that defined what it meant to be competent, proficient, qualified, and/or professional – often at clearly distinguishable levels of demonstrable expertise. Second, these criteria were used to define/shape three key things: 1) the credential or license the learner received for successfully demonstrating the established criteria, 2) the precise nature of the performance assessment that would be conducted so that the learner could demonstrate what had been learned, and 3) the design of the instructional experiences that would directly and eventually assist the learner in demonstrating

> the defining performance criteria successfully. Third, “success” occurred WHEN, and WHENEVER, the learner could demonstrate ALL of the defining performance criteria in a “live”/authentic performance. Learners were not penalized for making mistakes while learning and they were allowed multiple opportunities to develop and demonstrate their eventual/required/highest level of performance. Fourth, in most cases learners could proceed at a pace that suited their particular rate of learning – meaning that neither instruction, assessment, nor credentials were defined by, or limited to, specific calendar dates or specific blocks of time.

OBE was positioned so central in the South African education curriculum that it became synonymous with C2005[3]. The new curriculum supports subject integration across as many learning areas as possible thus requiring major changes in education. School subjects were replaced in the OBE system by abandoning the previous separate subject content and instead 8 learning areas with new and alternative assessment structures were encouraged. These learning areas were formed by grouping subjects. For example, History, Geography and General Science were at one time separate subjects, however these three are now a component of one learning area called Natural Science. Art is now more specifically Art and Culture. Drama, Music and Art were separate subjects are now included in the art and culture syllabus. At grassroots level, however, many schools struggled to put Spady’s (2007) principles into practice. Spady’s said: “I quickly came to realize that the four distinctive features combined to form a “paradigm”of learning and credentialing that was just about the opposite of how the education systems” operate. In the OBE, successful outcome performance is the clear/fixed/pre determined/known/constant factor in the equation, and time is the flexible/variable/adaptable factor. In formal education, however, exactly the opposite pattern exists: time is the clear/fixed/pre-determined/known/constant factor, and learning success is the flexible/variable/ adaptable factor”.

Despite very real implementation difficulties, OBE may be especially beneficial to the deaf leaner as it allows opportunities to develop a broader understanding of concepts by

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[3] C2005 stands for the curriculum planned for South African education.

allowing education within school to overlap. Such intersection of knowledge allows learners to broaden what they learn in the classroom to real world settings making school life an educational experience that may continue at home. These encounters create pathways to real life. Supporters of OBE believe that "there is no reason why all schools can't emulate" this system of education (Spady, 1998, as cited in Macdonald, 2001, p83) rather than to continue with the more insulated characteristics of traditional teaching. It is posited that in the past school subjects were compartmentalised and that such a boxed type of education facilitated further fragmenting of concepts (Efland, 2002) which in turn impeded the progress of conceptual development in deaf learners. Conversely, research shows that the current broader curriculum refers to the cognitive benefits of art.

The use of art in contemporary education in Africa is evident in the Africa meets Africa project: Making a Living through the Mathematics of Zulu Design. The project includes a work book and a video with instructions on a step by step guide to Zulu beadwork. It clearly demonstrates how art and mathematics are linked conceptually. Learners use Smut's (2006) ideas to develop beadwork skills from the Zulu cultural heritage and in doing so work with mathematical ideas prescribed by the Revised National Curriculum Statement (Smut, 2006).

Apart from content integration, one also needs to consider social integration within the deaf context.

2.2.6 Social integration

The social integration perspective is based on the theories of Lev Vygotsky (1978) cited in Isbell & Raines (2007), who advocates a social constructivist view to education inherent in the South African OBE system. Vygotsky's notion regarding concept formation is based on his idea that mediation is used to guide the student's thought processes (Dixon-Krauss, 1996, cited in Storbeck, 2003).The abstract thought processes can be traced to the start of the of the interaction between mother and child who acts as the child's first mediator of knowledge to the world around him.

Although we think of language as in words, the mediation of meaning of these words takes place between the mother and child when interaction is still at the preverbal stage. The mother makes the child aware of a certain scope of reality through various modes of communication, through kinaesthetic, through body language, through the redundancy and frequency of the stimuli mediated (Feuerstein, Klein & Tannenbaum, 1994). Accordingly the child's wish to throw objects is given a significant meaning when the mother bends down and picks up the thrown toy repeatedly. The expression of joy on the child's face is evidence of the preferred play (Feuerstein, Klein & Tannenbaum, 1994). Consequently language is happening between all of these explained non-verbal interactions between mother and child. An analogy may be drawn between the child's expression of joy and the words 'thank you'. The mother's response to the joy stimulates a thought process which may be hypothesised as an association made between the throwing picking action: baby throws, mother picks. In time *thank you* will become words learnt and then a symbol to mean gratitude and may accompany the expression of joy. 'A definition of a concept is only possible if one knows, to some extent, the thing that is to be defined' (van Hiele, 2009, p1). For instance if a child is exposed to apples, pears, oranges and bananas, he can over a period of time deduce that these are all fruit by regular reference to these objects through experiencing it (Ausubel, 1978 cited in Macdonald, 2001). In this way the mother has acted as a guide, a facilitator of the child's understanding of the concept fruit.

Mediating the deaf learner's thinking is facilitated best by means of the teacher signing or using whatever means it takes to provide the learner access to understanding a word. In forming concepts, Vygotsky explains that mediation is the *word* which later becomes the symbol. To a deaf child, the visual word written on the classroom board must first have meaning in itself before it is processed to take on its abstract form. Therefore mediation involves a facilitator analysing a word in different contexts until the learner is able to use it with understanding. It is for this reason that the teacher as a mediator is constantly aware of the vital role he plays in extending the deaf child's world knowledge. For in the case of deaf education how the word is transmitted may make a difference to how the deaf learner understands it. If concepts are mediated within contexts as is advocated in OBE, students will learn more by the mediation of the word than through individual isolated experiences (Dixon-Krauss, 1996, cited in Storbeck, 2003). Concepts are also often developed by repeated use through verbal interaction. Therefore in-class group discussions around a particular topic are encouraged as learners communicate information in a language they can all understand (Secada, 1996 cited in English, 2008). Furthermore, learners are more comfortable clarifying misunderstandings they may have with their peers (Secada, 1996 cited in English, 2008) than with a teacher who struggles to understand their signs.

Apart from the linguistic emphasis in the socio-cultural approach a further application of Vygotsky's theory which also marks a pivotal feature in OBE is the emphasis on collaboration amongst students. Learners are encouraged to relate to their peers during group discussions as a means of generating new knowledge. Not only is interactive dialogue amongst peers encouraged but active partnerships between teachers and students are also deemed crucial.

Constructive socialising among each other is an important tool especially among deaf students in so far as it can reinforce and clarify information that students sometimes miss from having a hearing teacher not fluent in Sign Language. This is unfortunately the case in many schools for the deaf in the country. Not only can one identify communication barriers between teachers and learners, but different cultural groups of deaf learners have a different signing vocabulary at this school thus hindering learner- to- learner interaction. Furthermore the teachers at this school also have various modes of communication that they are comfortable with other than SASL. Each student in this class also has a different communication preference developed from the previous school attended together with the type of communication they are exposed to at home. Of the 7 students in the class being investigated the communication preferred is South African Sign Language and Total Communication. English and Zulu is the language of speech used. One student only uses speech but is slowly developing a Sign Language vocabulary this year. It is for this reason that social integration is advocated in order to address such communication issues. To this end, Secada's (1996 cited in English, 2008), reiteration of Vygotsky's notion on 'revoicing' and its effects on students in a multilingual classroom is applicable. Revoicing occurs when a teacher facilitates a lesson in such a way that every appropriate answer or comment is repeated by another student in a way that is clearly understood by other learners in the class. For example the learner might use words or phrases acceptable and more clearly comprehended by his peers. I conjecture a type of *signed 'revoicing'* (my own term) among the students in this class as although each student owns varied modes of communication as was noted; they share a unique understanding of each other's language. This is so because they also share a common culture and identity, setting them apart from the hearing teacher. A hearing teacher may sign in a way he thinks best. A peer signs in a way he knows for sure is understood by the class. This is evident from the confident manner of signing apparent during classroom discourse. Repeating what the teacher says reinforces an understanding for the signer and an appreciation of the subject content by the peer/s. Furthermore, by using *signed revoicing* the stronger students can intervene in the learning process of the weaker ones thereby successfully assisting them to reach a higher level of understanding. This corroborates with the Vygotskian view of directing educators and peers to their social role in facilitating higher level thought processes through interaction in the *zone of proximal development (ZPD)* (Isbell & Raines, 2007). My interest in Vygotsky's theory of ZPD lies in the value of my art intervention programme which is the crux of this research. My hypothesis is that in the process of creating a visual mathematical model the art intervention programme acts as a stepping stone to the next level of understanding mathematical concepts and therefore may be used as a device within the zone of proximal development.

The zone of proximal development originates from the work of Vygotsky (1978) and implies that the guidance of a teacher plays a pivotal role in assisting students to problem solve. The teacher or facilitator coerces the learner to make progress by acting as a sign post in the development of individual functions of the child (Wertch, 1980, as cited in Macdonald, 2001, p 252). In other words, the development of a child does not lie solely within the child's mind, but is advanced in the zone of proximal development as he/she is guided along by more capable adults who prove to be 'mediators of learning' (DoE: Design, 2003, p3). It is hypothesised that this theory coupled with OBE's hands-on-activity approach in the art intervention program will serve to guide deaf learners to higher level thinking and subsequently to acquiring new concepts.

Vygotsky's work on collaboration proposes that such guided interaction with more knowledgeable peers and facilitators is essential for learners to maximize their own potential (Isbell & Raines, 2007). Taken further, knowledgeable deaf peers obviously erudite signers, may facilitate the interactive process with greater proficiency. More relevant to this research, using peers, the art intervention within the zone of proximal development may act as a visual buttress in the educational life of the deaf learner. Vygotsky's mediation during learning is advanced by Feuerstein in his theory of mediated learning experience (MLE) The theory of MLE was developed between 1950 and 1963 by Reuven Feuerstein. MLE describes the interaction between a human being and the environment through a mediator (Segal, Chipman, Glaser, 1985; Presseisen & Kozulin, 1992). For example, if a learner were studying the circulatory system then the mediator should first link what the learner knows perhaps the plumbing system of the kitchen sink, to the new knowledge to help facilitate a clear understanding of this knowledge (Segal et al, 1985). In educating deaf learners the mediator (Teacher) may make use of such bridging strategies and thereby help the learner to manage his own process of learning and ultimately facilitate knowledge acquisition and understanding (Segal et al, 1985; Presseisen & Kozulin, 1992). A learner who is able to make use of bridging strategies on his own, i.e. without the assistance of a mediator, will fare well as an independent worker in a job situation. This is the eventual goal of education: that learners find a comfortable niche in the working world.

The effect of mediation on the development of mathematical concepts affects the level of understanding mathematics and ultimately the future of the learners as many jobs require some form of mathematical skill.

2.2.7 The impact of conceptual development on job opportunities and its effect on the future of deaf adults

Vague impressions of concepts may even extend into adult deaf life and ultimately impact them being the recipients of higher paid jobs as these are often afforded to members of society having creative thinking and problem solving strategies. Unfortunately most deaf adults in South Africa, about 70%, are unemployed (Parkin, 2008) and those who do work often end up 'in low-level jobs such as cleaners, packers, drivers, etc' (Parkin, 2008), due to a lack of pursuit in academic tertiary education. For the deaf adults who may want to engage in tertiary education; academic conceptual understanding is a decisive barrier. A deaf adult, who has little understanding of concepts, will struggle to pursue tertiary education. Therefore, much earlier on in the adult's life, it is the task of his teachers and other role players in the life of the deaf student such as caregivers, to provide access to conceptual acuity and in due course the same level of information as their hearing peers. According to the literature reviewed, it seems that the challenge of acquiring the English language through understanding concepts and its relation to mathematics and the real world begins in the primary years of a child's life and that means it begins at home.

2.2.8 Cognitive integration

Feuerstein and Vygotsky take a sociological approach to the development of intelligence and cognition.(Presseisen & Kozulin,1992) Although their theories are closely related to the theories of Piaget, the uniqueness of their research lies in the concept of the mediation. Feuerstein has been influenced by Vygotsky's inference of learning through social integration (Presseisen & Kozulin, 1992). The focus of this research is on forming such networks visually through art. Art is normally seen as a fun subject, a time to relax, unwind and create pretty pictures. However this dissertation makes a case for art as an effective tool in the MLE of a Deaf learner. Art is regarded as a visual universal language, and thus one that could surpass certain limitations of verbal communication. Therefore given that the students are deaf, they often depict signs of a language deficiency that can be traced further back to barriers in communication from birth to the current age (Watkins, 2004). Unless the communication is between other people who can sign, deaf learners are left with a want for communication which impacts their lives from the family at home into every facet of adult life. If adults in the Deaf child's life do not find ways of introducing concepts to Deaf learners the implications to all areas of their lives may be affected. Apart from the social-emotional dimensions, insight into cause and effect is obstructed and the logical sequence applicable to other components of life may become stagnated. This may include linking familiar concepts to draw logical conclusions in children. For example Peter, a grade 11 learner understood that a cow is an animal and that this animal is also seen on milk cartons. Yet he had no understanding as to why the cow was the chosen animal to go onto a milk carton. One day he asked why? The following conversation ensued.

Teacher: 'Where do we get milk from?

Peter answered: 'From the shop.'

Teacher: 'Where does the shop get it from?'

Peter said: 'Maybe from a factory.'

Teacher: 'What else does this factory make?'

Peter said: 'It only makes milk.'

Teacher: 'So there are milk factories that manufacture the milk?'

Peter said: 'Yes. Now why is the cow on the carton?'

When the process was explained he was surprised that he was really drinking milk from the cow. He now has a better understanding when cow's milk is poured over his breakfast cereal each morning. Peter's limited exposure to communication blurred clarity over this issue until it happened by chance when he was 20 years old. He learned generally at a young age by incidental learning.

Another student, Jim, lived with his father who owned a leather shoe shop. Jim's father would buy the animal hides cut them into the different shoe sizes and then stitch the shoes. He had many workers specialising in the various stages of the shoe making process. Jim watched them intently from the time he was 4 years old. He was now 19 and in the grade 12 art class. He could tell me about every stage of this process in great detail and even made a pair of shoes for himself. One day I asked him to bring along some leather off-cuts for his art project. As we talked I asked him what leather was used for and where his father got it from. I expected him to give me a name of an animal or place. But he looked baffled. 'Where did leather come from?' It was obviously not something he had thought about. From his perplexed expression I suspected he did not know the answer. When I asked if he knew what leather was as opposed to plastic or other material, he assured me it came from trees. He took me to a tree outside the classroom and pointed to the bark peeling of. He acknowledged the "leather" and explained again the preparation process before making the shoes. We ventured into a discussion about animal hides and the real leather-making process before it reached his father's shop. It took several pictures, photographs from encyclopaedias and the high school head of department's opinion to convince him. It was not easy to digest that we actually wore animal skins on our feet that way. His parents did not think it necessary to explain what he did not see. Therefore he developed his own connections in life based on what was visible to him. It is within this space that art can be utilised effectively as a tool to elevate the confidence, competence and social status of deaf learners.

By way of summary and in consideration of the potential role of art in the MLE of a deaf learner, this research postulates that art could provide an *ocular* MLE serving to knit together the other principles in this study. Using this theoretical framework as the backbone to my research, it is advocated that art can be used as a bridge to subject, social and cognitive integration among Deaf learners with specific reference to concept formation.

2.3 The Literature Review

The literature review is guided by the following critical questions: What are the main causes of poor mathematical results among deaf learners? What is the quality of mathematical concepts deaf learners currently possess? How can a comprehensive concept be constructed and modelled in deaf learners? What are the factors which inhibit or advance the development of a prototype in deaf learners? This section also addresses issues related to the government's policy on education, educating the deaf child with particular reference to conceptual development and reasons for the feasibility and coalition between mathematics and art.

The first part relates to the barriers which Deaf learners may be experiencing in mathematics. The question that emerges foregrounds a consideration of possible variables that correlate with and accompany a decline in results. Although this section will primarily concern itself with mathematical attainment amongst deaf learners, it must be brought to the reader attention's that mainstream education in South Africa is not exempt from similar challenges. Researching the current state of South African education revealed 2007 as a stressful and disturbing year in so far as most students were struggling with mathematical concepts (Mohlala, 2008). Moreover, during this period mathematical achievement became an issue of national public concern and one which encouraged stakeholders to seek solutions to advancing mathematical standards. Several predominant areas in mainstream education seem to be at the forefront of low performance viz. barriers to learning (Pagliaro& Kritzer, 2007; Easterbrooks & Stephenson, 2006; Simms & Thumann, 2007; Ray, 2001), reduced recall (Lang & Pagliaro, 2007), poor teacher qualification (Jansen, 2001; Mohlala, 2007), low expectations (Simms & Thumann, 2007) and a difficult and undifferentiated curriculum(Mohlala, 2008; Jansen, 2001). It will be demonstrated how many of these factors translate into deaf education. However, this research would argue that there are intensifying elements within deaf schools of which the high ratio of teachers who remain unqualified in deaf education are prominent (Parkin, 2009[4]). Some of these elements will be examined below and serve to shed light on the need to raise mathematical standards at schools for the deaf. Before analysing potential causes of mediocre mathematical grades among deaf

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[4] Parkin,I. Director of Education,DEAFSA : Personal Interview on 5 September 2009

learners locally in further depth, it could be asked what necessitates improving the mathematical norm of deaf children.

2.3.1 Why it is necessary to raise the mathematical standard among deaf children

Some of the theories that impact school mathematics reform are of macroscopic nature and will be examined below.

Martin (2003) supports the urgency in terms of broader educational change. Statistics reveal global knowledge developing at an alarming rate. For example:

> from the year 1750 to 1900, a period of 150 years, knowledge doubled once. Fifty years later, from 1900 to 1950, knowledge doubled again. Ten years later from 1950 to 1960 knowledge doubles again. From 1960 to the present times knowledge doubles about every 5 years. By the year 2020 knowledge will double every 73 days (Martin, 2003[5]).

The data above exposes us to the technological revolution we live in. ‘As the century closed, the world became smaller. The public rapidly gained access to new and dramatically faster communication technologies’ (Shapiro & Varian, 1999; Kurweil, 2001, p1) and little is constant. Because of the express production of knowledge each day, access to information for the deaf learner has become the fulcrum to educational parity. Moreover, as was explained in the section under government policy, growing knowledge and as a result technology, is affecting the direction and intensity of school transformation (Macdonald, 2001).Forecasting the educational impact of the technological boom, the DOE has placed mathematics in the spotlight of school reform by making it a compulsory school subject. For this reason there has been much interest surrounding OBE as a potential instrument of transformation in education. Those who advocate OBE have deemed it an appropriate and exciting tool in light of the “major changes taking place in our economy and society” (Macdonald, 2001, p 82).

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5 Dr. David Martin, 23 September 2003 at a lecture presented to B.Ed students at University of Witwaterand Education Campus.

‘Every day brings new technological advances to which the old business models no longer seem to apply’ (Shapiro & Varian, 1999, p2). Part of adjusting to the information age extends beyond having access to this information, to the role of producing new knowledge or applying existing knowledge in innovative ways. Using the infrastructure of the emerging electricity and telephone networks at the time for example, the industrialists transformed the economy, just as today’s entrepreneurs are drawing on computer and communications infrastructure to transform the world once again (Shapiro & Varian, 1999). With the introduction of electricity for example, the process of manually sanding wooden furniture is replaced by the electric sand-belt. Understanding the dynamics of how this instrument safely works is an educational experience in itself. Other examples of the rapid advancement in technology may be found in our system of communication (Shapiro & Varian, 1999; Kurweil, 2001).One hundred years ago for example, cellular communication was unheard of.

However in the past few years this instrument has become synonymous with words such as information technology, video calling and infrared mega-pixels and bytes to name but a few (Shapiro & Varian, 1999). Can a teacher of the deaf child imagine signing the word “byte” to his class and getting on with the lesson expecting the learner to fully comprehend its meaning? In the context of deaf education a teacher will have to sign the word conceptually correct as opposed to following English phonetics. With each subject comes the introduction of a new set of subject vocabulary that must be understood in order to be used appropriately. For a person unfamiliar with rugby, a loose scrum means nothing (Huntley, 1998). In computer language the words bytes, megabytes, floppy disk, display monitor or screen are common terms used (Huntley, 1998). A concerted effort must be made to communicate these concepts to the deaf child. The child will only then be able to make meaning of these concepts within the context. It can be argued if a hearing child at a mainstream school will understand most concepts. However, this is not a comparative study between deaf and hearing but one which focuses on educating the deaf child through the medium of Sign Language at this particular school. What is most important to education in our developing world is that firstly, the technologically related job opportunities are greater and secondly require a level of mathematical literacy (Shane & Tabler, 1981). The argument is supported by Meece, Eccles & Wigfield (1998, p 62) who reiterate that: ‘A strong background in mathematics is critical for many career and job opportunities in today's increasingly technological society’. Therefore the value of assisting the deaf child raise conceptual acuity of the new emerging vocabulary in our everyday life is linked directly to needs of the competitive world our learners will soon find themselves in.

In an effort to keep our learners on par with the fast moving society, we as educators need to keep abreast of our times to successfully mediate this rapidly changing information and prepare ourselves to teach the learner where to look for themselves. In this way, whilst mediating temporarily teachers are also developing independent learners. If the deaf child under our care is not formally introduced to the new technological advances, life will whiz by leaving him baffled by the change.

2.3.2 Helping the deaf child adjust to the knowledge age

The urgency not to allow the deaf learner to lag behind in this age of new knowledge is directed by the deaf child's scenario from birth. From the time a deaf baby is born, he totally depends on adults in his environment for information of its surroundings. Deaf children in contrast to their hearing peers are up against barriers to incidental knowledge because of their inability to voluntarily access sound. Therefore they are unable to "pick up concepts and vocabulary incidentally" (Ray, 2001, p2).

The implications for the deaf child living in the information age is that the deaf child will have to creatively find ways of applying the new found information by visual means (Ray, 2001). Teachers, parents and other caregivers in the life of the deaf child should be on alert of the child's barriers to access communication and information. In this research it is posited that one particular measure of preparation is creating a visual prototype or model of concepts.

The process of constructing a prototype involves creating a set of connections around a concept (Skemp, 1998). The course of action is not once off but repeated in various contexts as ideas are networked (Skemp, 1998). The actual method of creating a visual model has been detailed earlier in the theoretical framework of this research (Skemp, 1998). Following on from this route, a prototype is necessary in creating a web of connecting ideas. It is argued that by creating deeper levels of interconnections learners may be more prepared cognitively to deal with the technological revolution demands to shift away from the consumption of knowledge to the production of knowledge. The lack of research with deaf students is surprising in this area (Magne, 2003, p19) in light of the view that in the past it sufficed to unquestioningly consume knowledge as compared to today where there is greater emphasis on generating new knowledge ((Shapiro & Varian,1999; Cain& Oakhill, 2007). Apart from assisting a deaf child to access and produce knowledge to a greater extent through the use of a prototype, it is put forward that a prototype could also function as a cognitive tool or structure from which to advance mathematical attainment. International comparisons reveal South Africa is not alone is her pursuit of mathematical excellence in spite of results being indicative of rather significant setbacks (Zarfati, Nunes & Bryant, 2004; Magne,2003).

2.3.3 Poor mathematic results

Research findings from schools for the deaf in England show that there is a delay in mathematics of 3.4 years amongst 16 and 17 year old Deaf youth (Zarfati, Nunes and Bryant, 2004). One of the reasons for this may be traced to barriers to language, mentioned earlier on in the study, which deaf babies experience from birth. Another deterrent to deaf learners' progress may be the change in the mathematics curriculum which calls for all students in South Africa to write the FET examination. This is a school exit requirement which means that by the time a deaf student reaches grade twelve, he must be familiar with similar content information to mainstreams learners if he wishes to acquire an accredited exit qualification certificate. The competency of South African Deaf youth has not yet been confirmed through published research. However local observation suggests that the learners from our particular school lack necessary mathematical competency and skill required by the FET mathematics curriculum.

Before one is in a position to intervene, consideration must be given to elements that may correlate or cause setbacks in mathematical performance. This study revealed fourteen causes of poor mathematical results at the school were the research was conducted.

2.3.4 Causes of poor mathematical results among deaf learners locally

From an exposition of literature various themes have emerged to account for poor mathematical results among deaf learners. Some of these will be expounded and explored in more depth for the purposes of this study. Matters associated with poor mathematical results in this study include:

1. Barriers to language
2. Challenges educators face in putting the transformational theories into practice
3. The paradigm shift in eduction associated with the new transformation
4. Difficulties associating classroom practice mathematics to real-world encounters of mathematics
5. Questioning the attainability of the National Curriculum Statement
6. Cultural background of the students and its effect on poor mathematical results
7. Poorly qualified teachers
8. Teacher's low expectations of the deaf learner
9. Poor recall
10. Anxiety
11. Students' negative attitude towards mathematics
12. Students negative attitudes towards the mathematics teacher

One of the first matters to open itself up to investigation is the possible results of miscommunication of concepts due to the inaccessibility of sound and or as a result of a barrier to language.

a) Barriers to language

Barriers to language in this study refer in particular to three ways the child at this school struggles to acquire language. The first is as a result of the deaf child's inability to access sound and therefore the incapability to access the language of the hearing community that the child grows up in. The second is the hearing community's inability to communicate with the child in the child's first language of sign. The third is the parents' lack of knowledge and or funds in dealing with finding alternate means to provide access to language such as seeking speech therapy, attending to sound amplification via an audiologist in the form of hearing aids or cochlear implants and placing the deaf child in an appropriate school at an early age.

Once again, the language barriers faced by deaf people are not limited to South Africa. It is a global challenge which has interestingly been dealt with differently within each country. However, dissimilar to the position taken by the South African government is the outlook by the Norwegian government after the 1977 reform in Deaf education. Unlike the South African stance of still not recognising SASL as an official language, the Norwegian policy proactively tried to diminish communication barriers by adopting guidelines that officially supported the use of Sign Language in education and by endorsing the Deaf community as a separate but equal linguistic group (Pritchard, 2005). The educational guidelines implemented by The Norwegian Ministry of Education…

> defined deaf pupils in 1997 as (those) who use Sign Language in communication with their social environment and to gather information. Functionally bilingual pupils can belong to this group. By using Norwegian Sign Language (NSL), one is defined as Deaf. The Ministry did not use a medical definition, but a linguistic one. The National Curriculum, implemented in 1997 is called L97. L97 for Deaf pupils is based on the principle that each child be given the opportunity to develop to their full potential in an environment which respects the child's language (NSL) and culture (Deaf culture). At the same time as the child develops a positive, confident Deaf identity, he/she should be helped to develop the skills and knowledge necessary to participate in the hearing world. Bilingualism in NSL and Norwegian is one of the main educational goals for Deaf pupils (Pritchard , 2005).

A much greater level of reform is still needed relating to linguistic policies and recognition of Sign Language on a national level. On the educational front spearheaded by governmental regulations other changes have occurred that have contributed to poor mathematic performance. The Department of Education's intentions for change are noble and evidence of this may be seen in the introduction of C2005 and the RNCS. However some of the changes have directly or indirectly had a negative impact on the deaf learner.

b) Challenges educators face in putting the new transformational theories into practice

The post apartheid government of South Africa has committed itself to achieving transformation in education by adopting policies and measures such as C2005 and RNCS to redress equity and enhance democracy and participatory decision making at all levels (DoE, 2005, p 12). The significant refashioning of education over the last decade has thus seen several developments towards achieving social justice and has been documented by the Department of Education. These include better qualified teachers, proactive school nutrition programs, gender equality amongst learners, and expansion of childhood development initiatives and the addressing of backlogs in infrastructure (DoE, 2005, p12). However, in putting the theories of curricula change into practice, educators have experienced many challenges. According to Jansen, teachers claim that the educational policies of the government "have a logic different from its practice and that pursuing a perfect match is both a waste of implementation time and a misdirection of intellectual energies" (Jansen, 2001, p1).

Old Curriculum(before 2006)	**New FET Curriculum** (First implemented in2006)
Standard 8,9 & 10	Grade 10,11,12
Compulsory subjects:	*Compulsory subjects:*
English & Afrikaans	English, One other official S.A. language Mathematics and Life Orientation
A choice of four of the following:	*A choice of three of the following:*
Mathematics, Physical Science Biology History, Geography, Accounting, Music, Art, Drama,	Physical Science, Life Sciences, Economics, Accounting, Consumer Studies, Hotel Keeping, Tourism, Agriculture, French, Visual Arts, Design, Drama, Music and many more
Total of six subjects	**Total of seven subjects**

Table 1: Compulsory subjects before 2006 and subjects in the new FET phase

Subsequently, the transformation process has not been without disparagement. Of particular interest to this research is how policy and its implementation can limit aspects of social transformation, and more specifically, reparation in Deaf education. The setbacks and contradictions resulted from factors, which have affected the type of policies developed to transform the education sector.

The emphasis of this dissertation will be on two specific policies and their implementation viz. the mandate that mathematics is compulsory in the Further Education and Training (FET) phase (DoE, 2005, p 19; Jansen, 2002, p 3); and the requirement that all learners are to write the same national exam at the end of Grade 12 (DoE, 2005, p 14). These amendments required by the policies are positive in that Deaf learners have the opportunity to learn challenging curricula alongside their hearing peers. However, at the same time these have the potential to create setbacks in education when implemented into Deaf classrooms of Learners with Special Education Needs (LSEN) schools. The forecast that the implementation of these two policies will create challenges at grassroots level i.e. amongst Deaf learners in the classroom is made in the light of the current poor performances with regards to mathematical achievements in Deaf education. Mohlala (2008) blamed a change from the traditional system of teaching mathematics to the current FET system as a cause of stress for both teachers and learners.

c) The paradigm shift in the transformation of education

As was noted before, the government's master plan to aid in transformation including curriculum reform is embodied in Curriculum C2005. C2005 advocates a paradigm shift in education by calling for a move away from a rote model of learning and teaching, to a learner centred, enterprise with a view to revolutionary form of integrated knowledge (DoE, 2005). In addition its aim is for education to prepare learners to meet the following outcomes:

- identify and solve problems and make decisions using critical and creative thinking;
- work effectively with others as members of a team, group, organisation or community;
- organize and manage themselves and their activities responsibly and effectively;
- collect, analyse, organize and critically evaluate information;
- communicate effectively using visual, symbolic and or language skills in various models; use science and technology effectively and critically showing responsibility toward the environment and the health of others; and

- demonstrate and understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation (DoE, 2003, p 2).

The outcomes that underpin all curricula require learners to go beyond recall; recognition and reproduction to critically evaluate analyze, synthesize, produce and apply knowledge (DoE, 2003). Moreover, students are encouraged to develop a positive self image. These premises and strategies of OBE create the supportive, learning environment for Inclusive Education, into which Deaf education is incorporated. Through the new system of education Deaf students and students with other disabilities have the prospect to learn exciting curricula together with their peers (Bottge, Heinrich & Hung, 2002).

Despite the good intentions depicted within policies such as C2005, the main argument in this section is strong evidence suggesting that C2005 as an educational venture is working counter to its social reform aims (Chisholm, 2004). C2005 is charged for widening and not narrowing the gap between formally historically disadvantaged and advantaged schools, and between mainstream and special schools (Chisholm, 2004). Hence, C2005 is seen as ironically producing inequalities in social class. Such inequalities could lead to include greater divisions between Deaf and hearing learners. These claims run counter to the original intention of Government to produce equity in education through C2005 (DoE, 2003). Moreover, when considering the poor mathematical achievement of Deaf learners, a need for change becomes more apparent (Bottge, Heinrich & Hung, 2002). Recognising the shortfalls in C2005 the Revised National Curriculum Framework (RNCS) was subsequently introduced and desires to bring change by emphasizing a learner-centred, activity–based approach to the teaching of mathematics based on the premise that all students can learn (DoE, 2003).

d) Difficulties associating classroom mathematics to real-world encounters of mathematics.

Included amongst its varied features the RNCS identifies learning areas, which include inter-related knowledge and skills, on the basis of which learning outcomes and assessment standards are set. Integration across learning areas can be regarded as one of the strategic qualities of the RNCS. It is explained that the "the integration of knowledge and skills across subjects and terrains of practice is crucial for achieving applied competence as defined in the National Qualifications Framework. (DoE, 2003).Over and above integrating knowledge within a subject the RNCS advocates integration across the different subjects and integration between subjects and real life. Adler, Pournara & Graven (2000) elaborate on how the learning area of Mathematical Literacy, Mathematics and Mathematical Science (MLMMS) has 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, 2003) 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 and to other world knowledge they encounter at a school. MLMMS's is trying to meet this objective through integration across other learning areas and with real life; and, through a deliberate effort to shift from mathematical abstraction to mathematical meaning (Adler, Pournara & Graven, 2000). The RNCS translates into the NCS at FET level

e) Questioning the attainability of the National Curriculum Statement

Many of the principles contained in the RNCS occupy a similar pedagogical space and prominence in the NCS document. However, not all are in support of strategy contained in the NCS. Consequently, there are parties such as the Concerned Maths Educators, based in the Western Cape, who are calling for the new system of mathematics to be discontinued. Around the same time, a coalition of Western Cape-based mathematics teachers was formed (Mohlala, 2008). In light of the inadequately prepared mathematics teachers, they have appealed to the national department of education to suspend the format of the mathematics curriculum from grade 10 to 12 (Mohlala, 2008). The group, currently circulating a petition to mathematics teachers countrywide, intend gaining support with a view to assist the student (Mohlala, 2008). This call was supported by Jansen (2008) who said: "Once again here we have an instance where good curriculum ideas run ahead of implementation realities in the case of mathematical education". Mohlala, a reporter for *The Teacher*, revealed that the extent of the implementation challenge produced a broken will to learn amongst the learners themselves (Mohlala, 2008). According to these mathematic experts, the previous mathematics curriculum included higher and standard grade mathematics. This enabled learners to make choices according to their capabilities. The new mathematics curriculum, mathematic literacy and pure mathematics, although allowing learners access to a wider range of university degrees, is more difficult than the previous higher grade syllabus (Mohlala, 2008). Deaf learners too are exposed to this seemingly unattainable curriculum but experience a further disadvantage to their hearing peers in understanding mathematic concepts. Their mathematics education lies in hands of educators unqualified in mathematics education and unqualified in deaf education

The aforementioned learning environment anticipated by the RNCS and NCS guidelines and its teething problems are placing demands on teachers in their approach to mathematics. In view of these demands, special educators are reconsidering their approach in helping students with disabilities meet the new standards (Bottge *et. al*. 2002).

f) Cultural background of the students and its effect on poor mathematical results

The high school's cultural distribution of students is as follows:

Grade	Indian	White	Black	Coloured
Home Language	English	English	Zulu	English
12	1	2		
11	2	1	3	1
10	1	3	2	
9a	3		3	1
9b			5	
8			5	
Total	8	6	18	2

Table 2: Cultural division in the high school

Table 2 reveals that the Black population of students at this school comprises of a larger proportion compared to the other cultural groups. Among the black population the dominant home language is Zulu. The Zulu's prescribed pattern of interaction between adult and child provide us with an example of how culture may lead to mathematical delays among deaf learners. In Zulu culture, adults command authority and children listen respectfully, according to “Zulu mothers involved in dyad studies in the department of psychology at the University of Natal” (Macdonald, 2001, p 330). Zulu culture relies on adults passing down knowledge to children orally. In other words the rules of behaviour, morals and values are unwritten but ingrained in the lives of children through verbal instruction. Consequently children look to these adults as their guides who sign-post their lives as they reach adulthood. Adult authority is not questioned. Since most of this school’s student population come from Zulu homes, this research also observed the influence of ethnicity on learning not only in the mathematics classroom but in general. Surprisingly, however, it has been observed that this passive, disempowered learning style is also indicative of the students at this school who come from other cultural groups.

Macdonald (2001, p 330), notes that

> In cultures with an oral tradition, the transmission of knowledge is vertical and anti-dialogical. Therefore the child from such a culture will develop the notion that knowledge will be given to him from those “above”, with relatively little discussion or questioning on his part.

The above extract raises questions related to similarities between Zulu culture and the deaf child. Are deaf children also becoming passive learners because knowledge is transferred to them via an unwritten system of signs? Or do deaf children become passive learners because of a traditional[6] system of education still practiced in the primary school? A correlation of Macdonald’s extract may be drawn among deaf children since they too grow up looking solely to adults for information to be given to them. Even as they mature deaf learners and many adults are still dependant on interpreters to pass down information to them in their respective communities. Could this humanly dependant way of life affect the culture of learning from primary through to high school? There is a similar observable occurrence at

[6] In the traditional system, education engages a one way pedagogy, where the teacher remains in a position to disseminate knowledge and the learners receive and do as instructed.

this school among the population of deaf students here who continue the tradition in the classroom by looking to teacher, as the provider of information.

An additional aspect which directly influences pedagogical beliefs and learning styles relate to the qualifications of the teachers themselves.

g) Poorly qualified mathematics teachers

Statistics reveal that “more than half of South Africa’s mathematics teachers are unqualified” (Mohlala, 2008, p 2). Subsequently, another reason why mathematical results may remain low is poorly or unqualified teachers of mathematics. Simply put, there are insufficient teachers who have enough depth of subject-matter knowledge. Teachers in deaf educations are faced with similar challenges. Could the poor service delivery in mathematics be due then to poorly qualified mathematics teachers or to these ‘complex conditions’, teachers find themselves working under? One further consideration relevant to this study is that many teachers at schools for the deaf are also not qualified in deaf education. Research by Bottge, Heinrichs, Mehta & Hung (2002) reveals that when teachers of the deaf are not qualified to teach the deaf student they believe that students are unable to engage in higher level mathematical processes because of their deafness. As a result they make little attempt to motivate the learners and maintain low expectations of them (Bottge, Heinrichs, Mehta & Hung, 2002,). Observations by Director of DeafSA (an NGO lobbying for Deaf issues in South Africa), maintain contrary views to Bottge *et.al.*

> I have observed many, many teachers who have trained specifically in Deaf Ed and in some cases have come to the conclusion that this does not necessarily solve the problems. On the other hand, I have observed many, many teachers who have NOT trained in Deaf Ed and who are absolutely excellent. It really, depends on the individual teacher (Parkin, 2009).

South Africa holds the belief that poorly qualified teachers of the deaf do not necessarily impact a low standard on deaf education. In spite of the fact that many teachers of the deaf in South Africa are hearing. As a result of Parkin’s (2009) visits to the schools for the deaf in the country, she maintains the view that educating the deaf learner ‘depends on the individual teacher’ and not necessarily on qualification or on whether the teachers themselves are deaf or hearing. According to Simms & Thuman (2007)

> hearing teachers of the deaf in America still hang on to the pathological view of educating the deaf child. Research is conducted “on” the deaf child and that to be effective and long lasting, change must be initiated by a grassroots movement within the Deaf community.

Studies by Lang & Pagliaro (2007) uncover further associations between poorly qualified teachers and poor mathematical results.

> The responses of the certified mathematics teachers in several studies support the notion that preparation and certification in mathematics makes a difference in instruction, particularly in the kinds of word problem solving challenges provided to deaf students. It was found that regardless of instructional setting, deaf students are not being sufficiently engaged in cognitively challenging word problem situations (Lang & Pagliaro, 2007).

Taking cognisance of the minister’s statement, and lining it up with research which affirms that if there is a challenge teachers’ face, one is led to question possible underlying sources of the challenge. I posited that outcomes are much more likely to be found in the way we teach and what we expect from deaf students, than in the students themselves in so far as teachers in their attempt to understand the deaf child, have developed low expectation towards the deaf learners’ ability (Simms & Thuman, 2007).

h) Low expectations

Teachers internalise, over a period of time, that the deaf child cannot learn (Simms & Thuman, 2007 p 302; Marchark, Lang & Albertini, 2002, in Marschark, 2005, p 7). When teachers have low expectations of their students they fail to adequately motivate them. With reference to mathematics in particular, it is for this reason that "low motivation is probably one explanation… why some students, even with good computation skills, do not solve problems" (Bottge, Heinrichs, Mehta & Hung, 2002, p 187). Maintaining this mentality is detrimental to students' progress. (Bottge, 2001, p 255) charges:

> with a few exceptions teachers tend to deprive students of meaningful or motivating context for learning or using skills that are taught; postpone more challenging and interesting work for too long, in some cases forever; and underestimate what disadvantaged students are capable of doing. The search to discover effective ways to improve students problem-solving skills may have been delayed by the beliefs that many educators pass on to their students that maths is a set of rules that require memorization.

Simms & Thuman (2007) concur but add that low teacher expectation and as a result low motivation is due to an audistic mentality hearing teachers have of deaf children.

> The history of deaf education suggests that audism (placing a higher value on hearing and oral/aural education; Lane, 1992) continues to significantly affect deaf people. Specifically, audism affects teacher preparation and teaching practices by impeding student achievement through low expectations (Simms & Thuman 2007).

Furthermore, some teachers, due to being untrained in deaf education, believe that Sign Language is not a real language and therefore deaf children grow up with only concrete thought incapable of abstract thought (Burger, 2007) hence convincing themselves that high level mathematics cannot be taught.

i) Further barriers to learning

A consequence of low teacher expectations is unsatisfactory learning experiences resulting in scarce conceptual development. Inadequate development of concepts affects students' ability to integrate new knowledge structures with prior ones. According to Ausubel (1978) cited in Macdonald (2001) the association of prior knowledge to new knowledge is a simple process only in rote learning. In meaningful learning however, the process is more complicated and is linked to the application of cognitive structure. Simply put, without adequate cognitive connections being constructed, knowledge to a deaf student may become an arrangement of meaningless letters which form words they are told they must understand. Thus understood in this manner, knowledge can only be remembered by the process of rote learning. In the absence of sequential understanding poor recall emanates.

j) Recall

The constructivist perspective in learning mathematics and problem solving emphasizes the importance of both short-term (working) memory and long-term (semantic) memory….Semantic memory, is used to activate concepts during mathematical problem solving and to make a representation of these problems (Lang & Pagliaro, 2007).

It is for this reason that forming a visual model of the mathematical concepts will significantly impact recall as high imagery terms are recalled significantly better than low imagery terms. Research by Lang & Pagliaro (2007) brings to light the impact of concept formation, and problem solving and the relationship this may have with teacher preparation and teacher signing and recall. Imagery on the mind acts as a 'mental blackboard' (Lang & Pagliaro, 2007), that can aid the learner in problem solving activities. It was found that images can help make abstract mathematics concrete in ways that assist both deaf and hearing students with problem solving.

Further, it has been discovered that when teachers know their content well they are able to find effective ways to convey the knowledge so that learners fully understand and are therefore more likely to recall (Lang & Pagliaro, 2007).

As a result of poor recall it has been hypothesised that mathematics may be particularly vulnerable to the adverse effects of anxiety because of features like precision, logic and the emphasis on the ability to problem-solve. (Skemp,1986).

k) Anxiety

It is of interest to this research to throw light on the origins of this mathematical fear in the hope of intercepting and curtailing it at its roots. According to literature available, mathematics special needs students display complex behaviour profiles (Magne, 2003; Meece, Eccles, Wigfield, 1990). One of these may manifest as fear. Further, children bring inherent definitions to the class room situation in the particular emotional developmental stage they are at. Consequently they offer their own motive for being unfocussed by their extrinsic actions manifested as inappropriate behaviour (Macdonald, 2001). How the mathematical knowledge is acquired, often already at primary school level, can lead to mathematical anxiety (Meece, Eccles, Wigfield, 1990). Fear of mathematics can be further exacerbated at secondary school in so far as it relates to internal biological changes. Research has shown that, students' reports of uneasiness, worry, and anxiety related to mathematics increase during the early adolescent years because of hormonal changes (Brush, 1985; Meece, 1981; Wigfield & Meece, 1988 cited in Meece, 1990, p 61). This is a phase all teenagers experience in so far as there is no difference among deaf, hearing and hard of hearing identity groups (Storbeck, 2003). One manifestation of this phase is an attempt by adolescents to exert a certain amount of false authority when confronted or when placed in challenging situations. Learning mathematics is seen as an active and constructive activity that is accessible (Piaget, 1970), rather than the passive acceptance of ready-made knowledge which they do not understand; fear dissipates. Affirming that mathematics anxiety is existent in many first year university students, Bart & Clair (2008), assent to Piaget’s theory by way of their solution to this fear. She uses for example, exercises creating patterns from tessellations or symmetry among other art activities, “as her motivating tool and a recurring theme in a course developed to teach mathematics more specifically isometries and even non-euclidean geometries” (Bart & Clair, 2008, personal interview). Whilst fear significantly and negatively impacts attitudes in the mathematics classroom; in a relaxed atmosphere students are directed by high levels of confidence as they engage in exciting art projects.

l) Negative attitudes towards mathematics

The argument from research is that when learners have pessimistic attitudes towards maths, it culminates in poor results (Naidoo & Parker, 2000). Research supporting this argument affirms that higher mental processes such as problem-solving and divergent thinking which are required for mathematics are negatively influenced by mathematics anxiety and as a result start a degenerative decline in overall mathematical performance (Jones, 1986; Skemp, 1986; Newstead, 1998; Naidoo & Parker, 2000). Moreover, a number of our learners openly express a negative attitude towards mathematics as a school subject (Skemp, 1986). "Mathematics may be particularly susceptible to the adverse effects of anxiety because of features like precision, logic and the emphasis on the ability to problem-solve" (Richardson & Woolfolk, 1980 cited in Newstead, 1998, p 53). Investigations in child development uncover that 'the foundations of attitudes are formed early' (Suinn et al.cited in Newstead, 2007, p 49), and as a result, it may be that a fear and a negative attitude toward mathematics has its roots in the primary school of a child's life (Newstead, 2007). A negative sentiment towards mathematics is not a new observation in the research field. Courant (1953) as cited in Grattan-Guiness (1994, p1) attributes such a disposition to the place of mathematics in life and society, and especially in education.

> After an unbroken tradition of many centuries, mathematics has ceased to be generally considered as an integral part of our culture in our era of mass education. The isolation of research scientists, the pitiful scarcity of inspiring teachers, the host of dull and empty commercial textbooks and the general educational trend away from intellectual discipline have contributed to the anti-mathematical fashion in education.

Seen against the DoE's claim that mathematics is essential to a variety of career paths and to personal, social, scientific and economic development (DoE, 2005, p 21) poor mathematical achievement and attitudes become an issue of concern (DoE, 2002, p 8). Consequently, measures have to be taken to help Deaf learners adjust more effectively to FET demands and in particular to the continuation of mathematics throughout their FET career (Naidoo & Parker, 2000). So set are students in their negative attitudes towards mathematics, this study observed the impact this attitude had on their relationship towards mathematic educators.

m) Negative attitudes towards mathematics teachers

Markey, Power & Booker (2003) explain why students may have developed negative attitudes towards teachers or the subjects. In the context of deaf education, elements of negativity may be directly linked to the manner in which communication is managed within the classroom.

> When signed or spoken communication occurred, the students had to choose where to focus their attention: the signer/speaker or the materials being discussed. This is cognitively challenging task, as they had to make the semantic connection between two things separated in time and space. Furthermore, when students wanted to contribute to the discussion or make a comment, they were only understood by those who were watching if the message was signed or those who could hear if they spoke without signing. These were not ideal conditions for spontaneous sharing of information. To minimize the effects of this situation, certain factors must come into play. First, there must be awareness of student needs by the teacher, who can then modify his or her communication style by giving students time to shift attention from communicator to referent. Second, students themselves have a role to play by similarly modifying their communication style for their peers and by taking responsibility for watching appropriately when important matters are being discussed (Markey *et al.*2003, p 255).

In the absence of the awareness of the need for these time delays as the lesson progresses the student may feel like a stranger to the mathematics lesson as both the content and procedures remain foreign to him. Research confirms that the students' situation is further aggravated by that fact that those "who cannot participate in [classroom mathematical] practices are no longer members of the classroom community from a mathematical point of view" (Bottge, Heinrich, Chan & Serlin, 2001, p 10). Hence, learners' inability to participate may drive them to feel like outsiders to the mathematics lesson.

Taking all of these factors into consideration, the need for various positive systems to improve thought and memory in relation to conceptual development becomes important for possible mathematical advancement. Based on research, I hypothesised art as a possible link to intercept mathematical underachievement (Lang & Pagliaro, 2007). Further investigation into the subject art, within the context of deaf pedagogy suggests that art and mathematics may be a viable union. The hypothesis that such a joint venture can effect change is worthy of research due to the low mathematics performance among deaf learners within the school.

2.3.5 Proposed solution using art

Following on from this, the objective of this research is to prepare the Grade 9s for FET mathematics through the medium of art. Bart & Clair, 2008, mathematical researchers among mainstream undergraduate students from the U.S.A. experienced similar circumstance with her first year mathematics students. They too came with negative attitudes towards mathematics, the outcome of which was poor results. Subsequently, their research led them into developing an on-line course using art to teach mathematics. They enthusiastically converse their successes using art to teach mathematics. In line with this investigation studies by Bart & Clair (2008) show that art has successfully bridged barriers to mathematics. Explorations are intended to introduce material in a way that motivates and prepares the student for the more rigorous approach in mathematics. Familiar with the art of Picasso, M.C.Escher and Mondrian, to name but a few, they have compiled on-line and tertiary level courses on how students can use art to learn mathematics.

Hickman & Huckstep (2003) do not accede with Bart’s views on the positive impact of art on mathematics. They criticize the commonalties drawn between mathematics and art considering the relationship between the two subjects superficial and the connections drawn weak and arbitrarily. Their argument is that these connections are easily dissolved through a more rational and deliberate consideration of the meaning of words such as creativity and intuition. Aslaksen (2001) affirms this sentiment adding that depending on how the written words ‘mathematics’ and ‘art’ are positioned a certain perspective is created which may be confusing and merely positioned to the user, for example, mathematical art, mathematics in art, art in mathematics, art of mathematics or mathematics and art. Having taken cognizance of the varying application of the topics, art and mathematics; as used in this research has been elucidated in the *key words.*

Attentive to the link between art and mathematics, Bart & Clair (2007) engage students at the level of college algebra and geometry in an art environment. Her course involves students experiencing hands-on art activities and exploring art history. Instructions are designed to encourage students to investigate and then indulge in creating their own works of art, and simultaneously through these means to lay a solid foundation for subsequent mathematics lessons (Bart & Clair, 2008). Much of the theory and practical aspects of her course particularly converges on Escher's art. The reason for this is that the 20th century Dutch artist Maurits Cornelis Escher was a master printmaker, whose works were heavily infused with ideas from mathematics. Their course became popular because of the increase in the mathematics pass rate among the learners (Bart & Clair, 2007). Because students have concrete examples to work with they are able to quickly get a grasp of the mathematical concepts and understand them fully (Bart & Clair, 2007). It may be inferred that these learners developed in their minds a concrete network of various aspects of abstract mathematics through hands-on art activities and created for themselves a visual prototype of the abstract mathematical concepts. Consequently the concepts were more clearly understood A further advantage was a positive change in the learner's attitude towards mathematics (Bart, 2007). Using art as a motivating tool and recurring theme, isometries and non-euclidean geometries can be learnt through rosette patterns and tessellations even by students who have very little mathematical background. These topics may be difficult to motivate and teach doing just abstract mathematics.

It is of interest to this research to explore the rationalization of Bart's positive findings in the hope of adapting and then implementing such a study at this school. In must be borne in mind that this will be a three way adaptation since it will be tested in a different country, South Africa; at a secondary school not a university and it will be tested on deaf students not hearing. During the course of reviewing the literature two issues surfaced. One, that the merits of this paradigm have surprisingly, not been assessed on deaf learners in South Africa was revealed as it has been in the U.S.A. (Bart & Clair, 2008; Serra, 2003) and secondly, literature elucidated the similarities between art and mathematics since antiquity. The second issue clearly explaining the similarities between art and mathematics is unravelled below.

2.3.6 Similarities between art and mathematics

It is of significance to this research that the similarities between art and mathematics be motivated as this defends the premise that likelihood of a correlation between art and mathematics is relevant. Said differently, the correspondence between art and mathematics is appropriately significant as opposed to the relationship between any two other subjects.

On face value the respective domains of art and mathematics may be considered diametrically opposed in that they manifest in right brain/left brain incongruence (Morgan, 1998); an emotional-rational stand-of; and, a free-spirited creative enterprise intruding on a limiting rule bound environment (Farsi & Freiberger, 1998). Yet proponents of this convergence (Serra, 2003; Morgan, 2008; 1994) mention several important commonalties.

Locally, research by Gerdes (1999) provides evidence for the diversity of the people of South Africa to prove that it often manifests in imagining, creating and exploring forms and shapes in cultural and social contexts. Within this context, his findings reveal that examples of geometrical thinking abound. He analyses geometric ideas inherent in crafts, and explores possibilities for their educational use. Using examples of African ornaments, he demonstrates how learners can be led to find the Pythagorean Theorem and proofs of it. He further illustrates how these mathematical ideas can be explained in mathematical teaching.

Exploring the inclusion of symmetry in Swazi grass mats, research by Patel (2001) supports Gerdes (1999) theory that “an artisan who imitates a known production technique is, generally, doing some mathematics” (Patel, 2001, pg1). Patel’s research in essence, elucidates the presence of symmetry in these Swazi mats as she explores the concept of fractals, the geometry of similar shapes repeated on ever-shrinking scales. Therefore in this way art may be used to develop mathematical concepts among learners.

Smuts(2006), Africa meets Africa project points to similarities art and mathematics have in terms of their problem solving values and conceptual knowledge among other areas.

Cultural expression and mathematical problem solving help us to make sense of the world. One of the RNCS tells us that problem solving seldom exists in isolation, because the world is made up of related systems. The lessons in the Africa meets Africa project serve to make clear the similarities between art and mathematics and the benefits of teaching this integration in the classroom within the RNCS. The lessons have been designed by Smuts and van Heerden (2006). The key activity in these lessons unpacks the cultural background and heritage of the Zulu basket weavers and bead makers. In Kwa Zulu-Natal for example many generations before we had mass produced containers, the Zulu people made storage vessels for milk, water and beer out of clay, grass and palm leaves. When introduced in the classroom, learners explore the idea that when they weave regular patterns, they are doing geometry with their hands! Five NCS linked mathematics worksheets on polygons, tessellations and four types of symmetry show that understanding mathematics can be much easier if we relate it to the things around us. Learners explore the principles of Geometry and mathematical symmetries by looking carefully at beadwork and baskets from the Zulu heritage. During the art introductory lesson learners are exposed to the elements and principles of design and shapes commonly used in Zulu designs such as triangles, polygons and diamonds. Later on this introductory lesson links their understanding of design to mathematical concepts of geometry and symmetry. For example the basket by Reuben Ndwandwe in Appendix 12 is perfectly symmetrical. No modern technology is used. He counts as he works to create each triangular pattern on the basket and the shape of the basket. Appendix 12 shows a break down of a worksheet linking the working relationship between mathematics and art. Further examples showing the understanding and application of concepts like tessellation, reflection, rotation and many types of symmetry may be found on the Africa meets Africa website.

According to Eglash (2008) the use of geometry in mathematical thinking may be associated to almost all aspects of African culture from hairstyles to architecture. His ideas concur with Patel's research on fractals and symmetry. Eglash has documented the use of fractal geometry- in African thinking. The complicated designs and surprisingly complex mathematical processes involved in their creation may force researchers and historians to rethink their assumptions about traditional African mathematics and may provide a new tool for African mathematical pedagogy.

Similarities between mathematics and art are not only confined to South Africa but have seen a convergence over the centuries even internationally. The examples below serve to trace the history of modern international artists whose works demonstrate similarities between art and mathematics.

a) The Golden Ratio

In architecture, the mathematical problems architects of the Parthenon were faced with were many. A temple of this magnitude is sure to appear distorted from afar and from various angles yet the Greeks wanted to give the impression of a perfectly proportioned building with no distortion (Taylor, 1999). As a result of natural distortion of its size for example, the columns will look narrower in the middle. The vertical sides of the facade will seem to cave in. In painting, the chosen example for this study is 'The Baptism of Christ' (Taylor, 1999). The mathematical problem posed here is how to successfully fit in all the figures, elements and symbols, onto this semi-circular-rectangular shape without it appearing crowded, keeping Christ as the focal point and creating depth at the same time. In crafts, African bead work is faced with a mathematical problem of maintaining the symmetry of the design whilst at the same time creating patterns of colour within.

What is common for the beauty of a sculpture, painting or architecture? It is the Golden Ratio (Livio, 2008). This proportion is also called: golden section, golden ratio, golden number, divine proportion and golden mean. The Golden Ratio also shows up in nature as the *golden spiral* (evident in natural objects ranging from sea shells to pine cones). The next section in this study explains the Golden Ratio in more detail (Livio, 2008).

> To the ancient Greeks, it was not numbers themselves that were important as the Egyptians and Babylonians believed, but the relationship between the numbers. These relationships were known as *ratios* and *proportions.* Through experimentation and the careful analysis and proof of findings, the ancient Greeks had already proven connections between math and nature, math and music, math and conceptual judgement. For example, a comparison of two things (mother:father, water:air, dog:cat) that we learn as babies is the most basic process of intelligence and the elementary basis for *conceptual judgment*, or how we figure things out. This comparison of two different things or ideas or quantities is a *ratio* or a measure of difference expressed in the formula *a: b* or *a* is to *b*. A *proportion* is more complex because it is the relationship equivalency between two ratios, or *one element is to the second element as the second element is to the third* (Andrew, 1996, p 2).

Moreover, the Golden Ratio (or "Golden Section") is based on Fibonacci Numbers, where every number in the sequence (after the second) is the sum of the previous 2 numbers:

1, 1, 2, 3, 5, 8, 13, 21, ...The Fibonnaci Numbers lead to the Golden Ratio:
$\Phi = 1.618\ 033\ ...$

The Golden Ratio is the ratio between two dimensions of a plane figure or the divisions of a line such that *the smaller is to the larger as the larger is to the sum of the two,* represented by the ratio 1:1.618 or roughly 3 to 5 (Andrew, 1996; Taylor, 1999). The ancient Greeks considered this to be the perfect proportion and the *golden rectangle* features prominently in ancient architecture, especially the Parthenon.

Pythagorus was especially interested in the Golden Ratio. The golden ratio is further explained in figure 3 below (Wasler, 2001).

```
  A               M            B
/-----------------/------------/
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Figure 3: A diagram representing the golden ratio

The line AB is divided at point M so that the ratio of the two parts, the smaller MB to the larger AM is the same as the ratio of the larger part AM to the whole AB (Wasler, 2001).

We have seen that this gives two ratios, AM: AB which is also BM: AM and is 0.618... which we call phi (beginning with a small p). The other ratio is AB: AM = AM: MB = 1/phi= 1.618... or Phi, *note the capital P* (Taylor, 1999, Wasler, 2001, Livio, 2008) **.**

The golden ratio is inherent in many works of art. It seems that without it, we would be robbed of aesthetics in life itself. It is for this reason that mathematics can effortlessly be integrated in the art lesson to expound works of art analytically. Examples of exactly how these ratios function and exist in works of art will be documented below.

b) An example of the golden ratio as seen in the human head

Pythagorus proved that the Golden Ratio was the basis for the proportions of the human figure. An example of a human face illustrates this in figure 6. The head forms a golden rectangle with the eyes at its midpoint. The mouth and nose are each placed at golden sections of the distance between the eyes and the bottom of the chin. Phi defines the dimensions of the human profile. Even when viewed from the side, the human head illustrates the Golden Proportion (Taylor, 1999, Wasler, 2001, Livio, 2008).

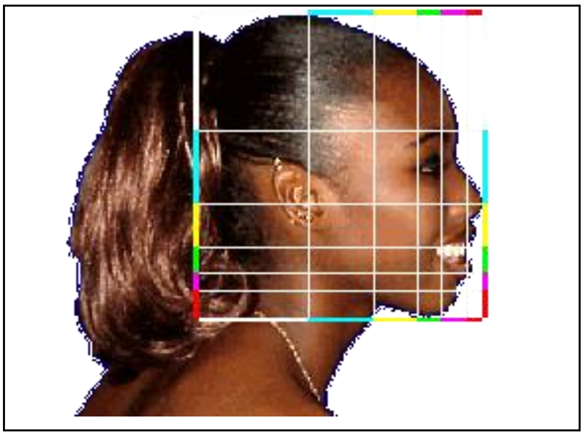


Figure 4: The golden ratio and the human face

The *mask* of the human face below (figure 5) is based on the Golden Ratio in Figure 5. The proportions of the length of the nose, the position of the eyes and the length of the chin, all conform to the relationships found in the Golden Ratio. When the mask is placed over the photograph of model, Jessica Simpson, we see there is a good fit (that is, the proportions of her face fit the geometrically "nice" proportions of the mask, based on the Golden Ratio). Her beauty is mathematical (Taylor, 1999, Wasler, 2001, Livio, 2008) !

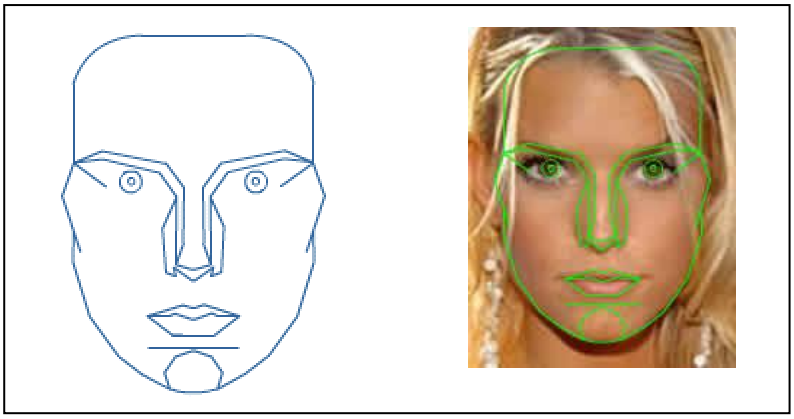


Figure 5: A photograph of a perfectly proportioned face

The example of creating a symmetrical face was used in this study with the grade 9 learners when students had to learn the word ‘symmetry’. Learners engaged in a beauty makeover session with their peers from other classes revealing symmetry among other art related exercises. For ethical reasons their own photographs will not be displayed.

The concept symmetry had to be understood during the mathematics lessons of the Cartesian plane. The concept of mathematical symmetry is much too difficult for the lay person to understand (Livio, 2006). However, art softens it in a crowd-pleasing way. Therefore the mathematics lessons were taught after the concept symmetry was developed in the art class. As can be seen from the examples in figure 4 and 5, the proportions culminating in symmetry is associated with aesthetics.

Similar proportions are taken further into various disciplines of art as will be elucidated below.

c) An example of the Golden Ratio as seen in the Parthenon

Situated in Greece it has been inspired by Greek mathematician Pythagorus. The dimensions of the Parthenon (figure 6) and its aesthetic appeal, was achieved through utilizing the mathematical principles of the Golden Ratio (figure 3). Due to the presence of optical illusions, the Parthenon has what are known as “optical refinements” built into its structure. It must be stressed that these illusions are physiological and psychological in nature.

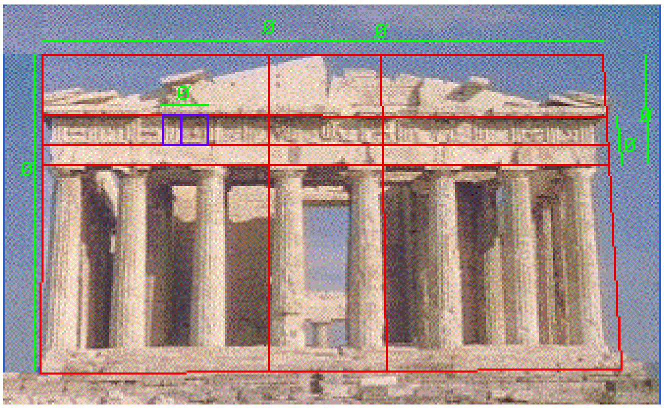
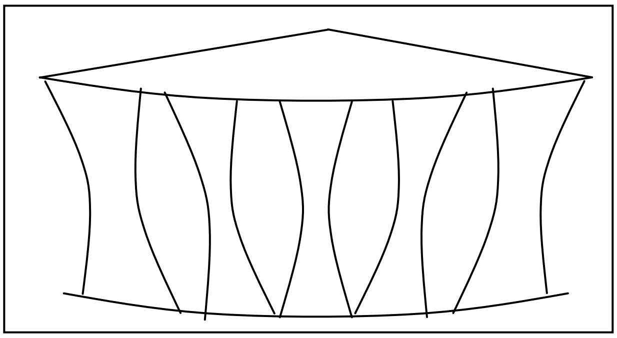


Figure 6: The Parthenon as it stands today

To the unaided eye, columns tend to look narrower in the middle than at the top or bottom. Each of the columns in the Parthenon was built with a slight bulge in the middle, to make them appear “straight”. Columns tend to “contract” near the top, and hence the base of each column was built a little thicker. Columns further away from the centre appear thicker. To counteract this effect, the columns in the centre were built a little thinner. Furthermore, the spacing between the columns appears smaller towards the centre. Therefore, they were spaced wider apart accordingly. Horizontal lines appear to “dip” in the middle, and hence the centre portion of the floor was slightly raised. Furthermore, the columns were slanted inwards so that they would meet if they were extended one mile into the sky. The triangular outline of the roof makes the top part of each column appear to slant outwards (Andrew, 1996, (Taylor, 1999, Wasler, 2001, Livio, 2008).

The illustrations below shed light on what the Parthenon would look like without the optical consideration in figure 7 compared to the way it looks today after the modification, figure 8.

Figure 7 *Figure 8*



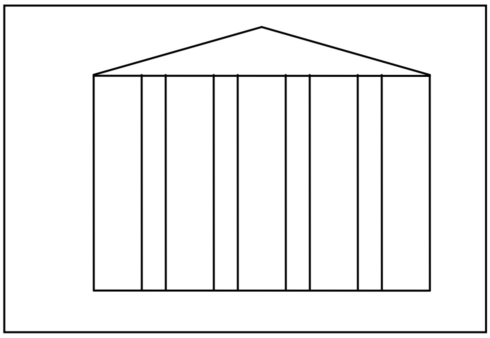


Figure 7:The Parthenon without optical Consideration (left) *Figure 8: The Parthenon today after modification (right)*

The Parthenon is an example which illustrates that some of the finest examples of mathematics in history are found in architecture. In designing buildings architects need to be aware of principles of mathematics to be able to construct building that stand the test of time. Therefore an architect must be able to use the instruments of a mathematician in all underlying architecture (Viljoen, 2009[7]) correcting angles, considering weight of the people it will hold and the weight of materials used in its construction, the height in proportion to each other and the effects of the weather on the angles of constructions with a goal to secure a study structure. Architecture is in fact real-life mathematics.

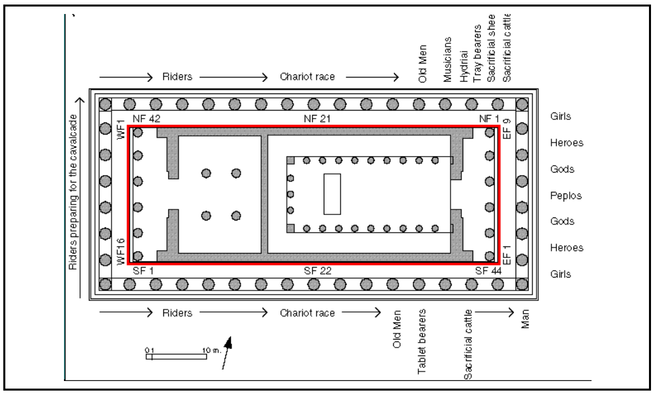


Figure 9: Floor plan of the Parthenon

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[7] Viljoen A. One of the architects at BKS for the Moses Mabidha Soccer Stadium in Durban. Personal interview in June 2009.

Besides its optical considerations, the floor plan of the Parthenon bears striking similarities to figure 5 in that its dimensions lie in the basic principles of the golden ratio.

From dissecting the Parthenon it may be concluded that mathematics is the core of its construction and that the ancient Greek architects who calculated the measurements that would be used in the used in this building therefore used mathematics to come up with their designs.

Figure 12: Le Corbusier's church at Ronchamp in 1955

Other works of art based on sound mathematical concepts include the Taj Mahal in India (Figure 1), admired for its symmetrical grandeur (Serra,2003). The Egyptian Pyramids at Gizeh (figure13), and Le Corbusier's church at Ronchamp , figure 12 (Gardner, 1980) are all popular examples of the interrelated effects of mass and space, both mathematics concepts, to produce effects of great complexity and splendor.

Some argue that indeed there is no association between art and mathematics (Aslaksen, 2001) and that mathematical associations in art are mere coincidences. Those assuming this stance must also make decisions as to whether the pyramids for example are designed with certain numerical ratios in mind or numerical 'coincidences'. Let us look at just one presumed coincidence involving the golden number. The golden number is $(1 + \sqrt{5})/2 = 1.618033989$ and an angle based on this will have size arc sec (1.618033989) = 51° 50'. Now the sides of the Great Pyramid rise at an angle of 51° 52'. Is this a coincidence?

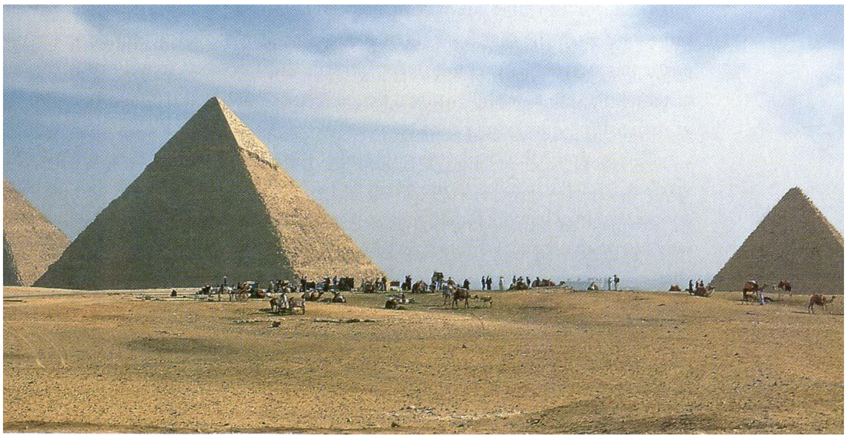

Figure 13 –The Great Pyramids of Gizer

It presumes less effort to work these calculations out mathematically than to mystify a coincidental existence.

d) An example of the golden ratio as seen in sculpture: the statue of David

The statue of David by Michelangelo depicts the human body abounding with examples of the golden ratio (figure 15). Pythagoras' discoveries of the proportions of the human figure had a tremendous effect on Greek art and on later developments in art such as in the Renaissance period (Taylor, 1999). Leonardo da Vinci's drawings of the human body emphasised its proportion.

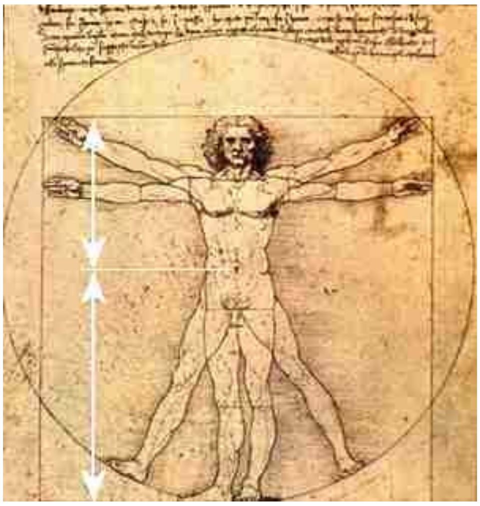

Figure 14: The Virtruvian Man by scientist and artist Leonardo da Vinci

Scientists believe that we perceive proportional bodies to be healthier. We may deduce from this that the proportions used to construct ‘David’ by Michelangelo were created perfectly in order to give the appearance of a strong, healthy young man ready for battle. The ratio of the following distances is the Golden Ratio: (foot to navel): (navel to head). If the educator focuses on these mathematical issues inherent in art work then students’ may learn concepts of ratio and proportion from these art theory lessons.

Figure 15- Sculpture of David by Michelangelo

The great creations of the Greek sculptors are considered as the standards of human beauty and the samples of a harmonic body (Taylor, 1999). The principle of the golden proportion is used in Greek sculptures from Archaic to Classic time where it developed into the reverse ‘S’ curve during later periods called contra-posture. An example of contra-posture, is Afrodita's sculpture created by Agesander. It is considered to be the masterpiece of woman's beauty and was based on a system of realistic proportions (Figure 17). Many years later, the ‘David’ (Figure 15) by Michelangelo was developed on the same principles of contra-posture (Gardner,1980). The Golden Section, also known as Phi, is manifested in the structure of the human body. If the length of the hand has the value of 1, for instance, then the combined length of hand forearm has the approximate value of Phi. Similarly the proportion of upper arm to hand forearm is in the same ratio of 1: Phi .

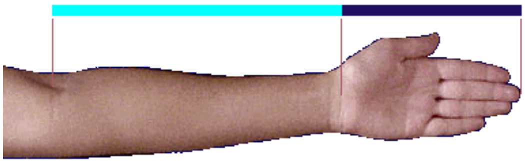

Figure 16: Ratio of palm:hand as used in the 'David'.

Figure 17: Afrodita's sculpture created by Agesander

e) An example of the golden ratio and other mathematical principles as seen in painting

The Golden Proportion, *phi*, has been observed to evoke emotion or aesthetic feelings within us. The ancient Egyptians used it in the construction of the great pyramids and in the design of hieroglyphs found on tomb walls. At another time, thousands of miles away, the ancients of Mexico embraced *phi* while building the Sun Pyramid at Teotihuacan. The Greeks studied *phi* closely through their mathematics and used it in their architecture. The Parthenon at Athens is a classic example of the use of the Golden Rectangle. Plato in his Timaeus considered it the most binding of all mathematical relations and makes it the key to the physics of the cosmos. During the Renaissance, *phi* served as the "hermetic" structure on which great masterpieces were composed. Renowned artists such as Michelangelo, Raphael, and Leonardo da Vinci made use of it for they knew of its appealing qualities. Evidence suggests that classical music composed by Mozart, Beethoven, and Bach embraces *phi* Gardner (1980).

Whilst architecture and sculpture exists in three dimensional spaces, mathematical skills are also evident in painting which is two dimensional in nature. For example, the illusion of spatial depth in Leonardo Da Vinci's painting: The Last Supper is based on several mathematical principles. To further illustrate the underlying mathematical principles inherent in a work of art before it is executed, I have chosen Baptism of Christ by Pierro della Franscesca 1415/20-1492 (figure 18).

We are accustomed to people specializing in just one aspect of art, however, Pierro della Franscesca as well as being an artist was an outstanding mathematician (Taylor, 1999). His profound mathematical knowledge is not immediately obvious in his art. In admiring the Baptism of Christ in the example on the left, one is drawn to its aesthetic beauty without analyzing why the painting is beautiful. One observes a still poised scene. The calm mood creates a sense of excitement at the possibility of movement. The three angles will sing, the motionless dove must flap its wings soon to maintain its hovering, and the water trickling from the bowl held over Christ's head will wet him in a fraction of a second. The distinctive shapes of the square and semi-circular shapes of the painting seem to add to this mood of spiritual calm (Taylor, 1999). On seeing incomplete shapes, the viewer instinctively completes them mentally.

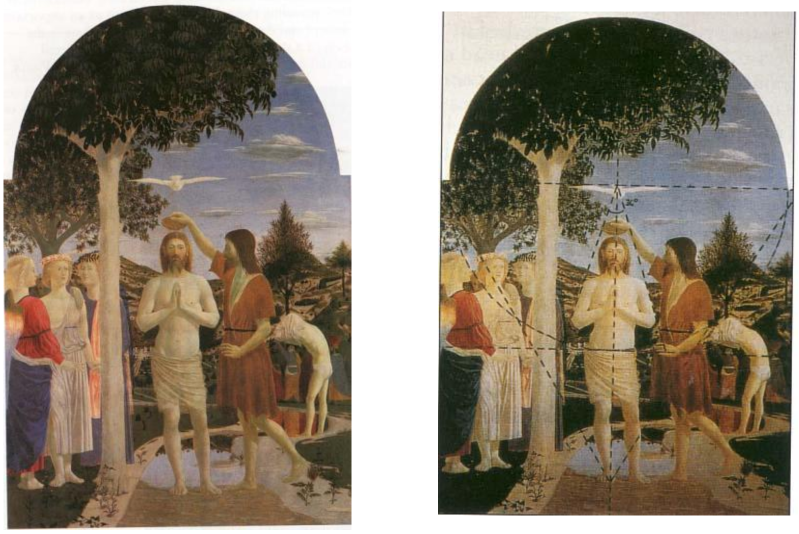

Figure 18: The Baptism of Christ by Pierro della Franscesca (1415/20-1492)

Francesco tempts people to do just that. For example, the outspread wings of the dove suggest a horizontal line that links the two short edges of the picture that jut out beyond the curve of the upper section. There is an obvious similarity between the shape of the clouds and the dove and it is not coincidence that a cloud lays on this horizontal line. In completing this line one also completes the square of the lower section. The dove marks a center line as it hovers above Christ's head, dividing the painting into two equal halves. Further, John the Baptist's left arm and the curved form of Christ's loin cloth echo the semi-circular top. This further invites the viewer to complete the circle. In doing so the viewer also imagines the horizontal line that touches its base, and discovers the distant town that lies along this line, and the two horizontals that divide the painting into three equal sections (Taylor, 1999).

The Baptism of Christ contains other less obvious mathematical features which form the foundation of this painting. If you think of the horizontal line implied by the Holy Dove's wings and the two jutting edges as the base of an inverted equilateral triangle, its other two sides meet on Christ's weight-bearing right foot. This lies on a central axis that is strongly emphasized by the column-like form of Christ's body and the dove. Christ's praying hands cause his upper arms to be angled. The lines they make suggest two sides of an isosceles triangle. They meet on the dove, forming an angle of 36 degrees (Taylor, 1999). s

The synthesis of the elements of design and mathematical principles such as space, shape, angles, symmetry, central axis and isosceles triangles serve to create a successful composition in this painting. During the discussion of this painting it is hoped that students will form an understanding of these concepts.

Similarities between Art and mathematics serve to complement each other in significant sculptural and architectural forms. Several popularised examples can serve as historical and cultural illustrations of how mathematical ideas have been encoded into architecture, sculpture, painting and crafts (Morgan, 2008; Grattan-Guinness, 1994). These include but are not limited to the Egyptian pyramids; Islamic designs in mosques throughout the world; African beadwork and more recently Escher art created through tessellation. Consequently, these disciplines are noticeable sandwiched between art and mathematics.

The examples of architecture, painting and sculpture discussed above, serve to demonstrate a challenging fusion between mathematical skills and the visual arts. How then can art be utilized more optimally in mathematical learning?

2.3.7 Value of implementing art

The following account provides a detail of mathematics learning in classrooms today starting at a concrete level as far back as Foundation Phase education more specifically from grade 1. Whether its coins or counters, learners work with tangible objects first before moving on to abstract sums in workbooks. Yet learners still struggle with comprehension and recall when faced with mathematics on an abstract level (Lang & Pagliaro, 2007). According to the NCS updated Numeracy for all teaching and accessing guide (2009), learners at primary level must have an understanding of counting and ordering numbers, number lines, grids, mass, subtracting, travelling, doubling, halving, shapes, counting money, direction, adding in 10s, patterns, measuring, planting, distances, looking from different views, number patterns, comparing lengths, buildings and shapes, telling time, fractions, measuring in metres, quarters, kilometres, measuring liquid, travel costs, grams and kilograms, symmetry, money, mass, number stories buying and selling and fractions and volume. In spite of the move in mathematical pedagogy from the concrete to the abstract, this theory has not proved highly successful in real life classrooms situations as learners still emerge with negative attitudes towards mathematics in secondary school. Questions may arise as to the background knowledge of the learners and the time constraints on both teacher and learner to consolidate large volumes of workbook progression for the lack of enthusiasm toward this subject.

It is for this reason, to enhance mathematical prowess, that Art makes maths more visual as the abstract becomes visible (Farsi & Freiberger, 2005; Morgan, 1998).

By combining the two fields a deeper interconnecting relationship with the world is constructed which in turn facilitates understanding of the world (Farsi & Freiberger, 2005). An additional benefit of seeing connections is that the relevance of certain mathematics in the real world becomes more apparent to the learners (Farsi & Freiberger, 2005). Presenting mathematics through art brings about an attitudinal change in learners since it helps to dispense common psychological barriers associated with mathematics such as dread of and dislike for the subject (Farsi & Freiberger, 2005; Morgan, 1998). Art helps to develop and to give expression to mathematical intuition (Farsi & Freiberger, 2005). Mathematics is visible in art in topics like perspective in painting, symmetry and musical scales (Aslaksen, 2001).

The intrinsic worth of implementing the art intervention program among deaf learners is derived from Piaget's view 'of the dependence of mental imagery on the growth of intelligence' (Youniss & de Shazo Robertson, 2007, p 2). Although the precise role of imagery in concept development is unknown (Lang & Pagliaro, 2007), it is a widely accepted fact that imagery plays a role in processing information (concept development). Piaget advocated that intelligence relied on the development of mental images. He supports the view that the use of images impacts and increases the brain's intellectual functioning. The link between mental imagery and intelligence and mental imagery and mathematics is further reinforced when students who reason from images tend to be powerful mathematic students (Bart & Clair, 2008). The ability to use mental images effectively in doing mathematics can be developed (Bart & Clair, 2008). All students can learn to use images effectively and therefore developing a spatial sense should be priority in school mathematics.

Consequently, a concerted effort needs to be made to teach deaf students mathematically related concepts in order to compete with the rapid production of knowledge. Some may argue that due to the rapid production of knowledge, it is skill and problem solving that is more important than learning concepts. However to the deaf learner, it is the understanding of concepts is foundational knowledge and it is this that serves to clarify a problem and paves the way to a solution. Furthermore, the new skills required today evolve around technology and therefore generate new vocabulary related to mathematical concepts. As it stands, deaf learners are deficient in many areas of concept formation. Sadly, more often than not adults involved in their lives are oblivious of the extent of this deficiency.

In light of such considerations, the degree to which art can be useful in the mathematical classroom seems a viable option and it may hold promise when considered from the perspective of deaf education. According to Glaserfield, students can experience satisfaction in mathematics if they are able to effectively fit mathematics into their own conceptual construction. "In creating for themselves, students are in essence generating knowledge and understanding of the world around them" (Glaserfield in Macdonald 2000, p14).

Subsequently, one of the gateways to conceptual insight may be possible by producing a visual prototype of the concept since deaf students access information visually (Ray, 2001). Several other merits for executing the art-mathematics paradigm at schools for the deaf can be advanced. In the mathematics classroom using art to develop a prototype may facilitate application in the abstract realm mathematics and help learners to appreciate the value of mathematics in every day living. Various researchers forecast additional advantages of mathematics. These include:

- Stimulating thinking and problem solving skills. The constructivist perspective in learning mathematics and problem solving emphasizes the importance of both short-term (working) memory and long-term (semantic) memory (Pagliaro & Lang, 2007). Therefore in stimulating thinking the working and semantic memory is activated easing recall.
- Multiplying vocabulary in both English and Sign Language as new knowledge is acquired.
- Augmenting personal confidence and self esteem as greater achievements are accomplished (Serra, 2003; Burger, 2007; Bart & Clair, 2008).
- Enhancing world knowledge (Lang & Pagliaro, 2007)

This research would like to combine the above assumptions by proposing that art, because of its visual nature, can be used as a bridge to facilitate Deaf learners' understanding of concepts that are not necessarily openly visible in their abstract mathematical format. In addition, art can provide a contextualized setting to make learners aware of how abstract mathematical concepts are relevant and applicable to every day living. In lieu of the benefits of the maths/art link, it would be insightful for art teachers at schools for the deaf offering art at FET level, to be aware of their twofold function, currently vacuous (van Heerdan, 2009[8]) that needs to be fulfilled. The first role the art teacher has to fulfil is as a typical teacher of art however, as a teacher to deaf learners, the second more crucial role is as a mediator to conceptual development.

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[8] Van Heerdan, J. Design and Visual Art Subject Advisor. Personal Interview on 27 August 2009

2.3.8 The role of the teacher

It is the teacher's good perception that seizes the moment to educate since according to research the child is full of potentials all waiting to be realised and transformed into outward abilities (Aeppli, 1986).The child is not equipped to walk the path to attain knowledge on his own. The child depends on the daily help of the adults in the environment. Therefore the teacher must also be a mediator to the child. He must empathize with the child's need and be able to relate to the outside world at the same time (Aeppli,1986). In this way the purpose of education is not to preserve the present but to prepare the future.

Learners must "learn more than just respond ….or else…. they become equivalent to a well –trained parrot" (Von Glasersfeld (1987) cited in Macdonald, 2001, p 1). Moreover, school mathematics in its higher forms consists of increasing abstract explanations communicated through mathematical symbols (Skemp, 1986). However, Deaf learners are at risk of not having strong enough reasoning and abstract representation skills to manage the symbolism. Put more directly, it was noted among the deaf learners that one severe preclusion to mathematics is the ability to think effectively. By thinking it is meant that concepts or ideas cannot be linked mentally. According to studies Deaf children compared to their hearing counterparts lag behind in many aspects of this development (Simms & Thumann, 2007). Deafness deprives children of this privilege because 90% of Deaf children are born to hearing adults who do not know how to communicate concepts to their children because they lack of knowledge of Sign Language.

Hence, one particular role of teachers in deaf education is to stimulate more effective thinking measures. A teacher could do so for example by accepting multiple answers in the mathematics classroom. Another approach is to give an answer and then ask students for ways at how they could arrive at an answer. That would illicit a variety of responses and ignite thinking.

Inspiring originality and creative thinking does not only serve to benefit the child in an art project but rather, as a long term goal, teach the child "explicitly relating the value of math to students' everyday lives, making math personally meaningful, and counselling students about the importance of mathematics for various careers" (Meece *et al.* 1990, p 69). Furthermore, Pink (2006) cited in Walkup's (2008) article on Multiplicity in the School Arts journal, accolades creative thinkers, by predicting that they will rule the future if accommodated in the school curriculum. In further reading, Pink (2006), shows how the success of the twenty first century will be based on diverse thinking. It is diverse thinking that plays a pivotal role in the technologically advanced world in which we live.

Following on from this it is thus pivotal that teachers are able to recognise cognitive and associated learning deficiencies among students and interact with individual learners proficiently.

The section below serves to summarize and reiterates the main underpinnings and tenets embedded in the literature review.

2.3.9 Summary

In summary the primary objective of this research is to investigate the effect of using art to create a model of mathematical concepts for the leaner before a mathematics lesson. It was explained that a prototype or model is a form of cognitive representation. Therefore in the orientation adopted here, the hypothesis is that forming a visual prototype of certain mathematical concepts can help bridge gaps and assist the deaf child to be on par with hearing peers. The potential benefits of possessing a prototype indicate accelerated learning, improved recall and self confidence. Engaging in the prototype as a foundation involves engaging with the learners own previously established knowledge structures, and bridging gaps if any by communicating with the learner in SL. One outflow of this interaction that was noted is the potential of creating an interest in mathematics. Students are more likely to flourish when something catches their interest. This in itself is a self motivating factor. Hence it was put forward that the spark of erudition either in the art or mathematics classroom; can serve to activate in the deaf learner, more than mere conceptual understanding. It was also argued that aside from a possible effect in motivation and emotional behaviour, the art-mathematics connection could play a decisive role in the process of transforming mental functioning from the initial word we use when we think through to the various levels of conceptual formation. Following on from Bart's findings, the input received through correspondence and research, the idea of creating a model of mathematical concepts with a view to making a visual approach to mathematics relevant for our deaf learners was reviewed. An art intervention program in this school was designed and will include creating a prototype that establishes a clear link between mathematics and the real world.

Under the circumstances it seemed feasible for the mathematics teacher and I (the art teacher) to remain working within our own subject disciplines while correlating content.

Primarily, the prototype or model in this research will be developed by forming a web of visual connecting ideas during art lessons that convey the essential attributes and characteristics of selected mathematical concepts. Based on the discussion above it is hypothesised that when learners are introduced to these concepts in the mathematic class, the visual associations of the concepts established in the art class will be launched. Subsequently, a more concrete rendering of the abstract concepts would be readily available in the minds of the learners.It must be emphasised that although this research presupposes integration, a direct transfer of concepts between art and mathematics is not always practically achievable. Hence, when learners enter the mathematical classroom the problem, the place and the purpose of the prototype may be different to that of the art room. In other words, they may be exposed to the same model but from a different perspective and a different realm of application. This will necessitate that learners adapt the knowledge they have encountered during art rather than neatly lifting their knowledge out of the art setting and importing it to the mathematics classroom in a ready-to-use fashion (Adler, et al. 2000). Stated differently, in this study the overarching goal of mathematics and art is to develop stronger prototypes that allow for more flexible forms of knowledge and not necessarily the direct transfer of problems and practices. Ausubel (1978, p 166) conveys a similar interpretation by saying that "in school learning we deal not so much with transfer in the literal sense of the term as with the influence of prior knowledge on new learning…". However, the focus is not on the prototype itself but on elevating self –esteem and mathematical success among the learners.

In essence, art and mathematics are all around us yet many are only aware of the world as it relates to art not mathematics. Using art to attest to the awareness of this reality mathematics can become as alive and exciting as it should be and function to ignite a similar enthusiasm in the deaf learner.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

Incorporating the arts into research methodology involves much more than adding a splash of colour or an illustrative image or an evocative turn of phrase or a new media track. There is much more to methodology than method (Knowles & Cole, 2008, p.27).

3.1 Introduction

This section of the dissertation presents the research design. The research design describes the major procedures followed in carrying out the research. Different methods of investigation are discussed and descriptions of these methods are used to test and evaluate (Neuman, 1998).This is so since differing approaches to research do exist and although approaches are rarely made explicit in research documents, each approach has its own set of philosophical assumptions and principals and adopts its own stance on how to do research (Neuman, 1998; Mouton, 2005). Ethical issues which were considered for the purpose of the study are elucidated in this section as well (Neuman, 1998; Mouton, 2005).

3.2 Research design

This study employs both qualitative and quantitative research design. Information has been retrieved to a large extent by observation and by student, teacher and parent interviews. The observations validate the interviews and further serve to investigate learners' responses to an art intervention programme. The rationale of both the designs are explicated below.

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3.2.1 Qualitative and Quantitative Research

Traditionally art has been associated with ornamental aspects of human production and emotional experience. However, in this study art is extended beyond something you savour for its aesthetic delicacy, to being allocated an epistemological role in enlarging human understanding. Due to the relatively 'newness' of art-informed research in education, it is significant that the processes and products that emerged from the study be detailed explicitly and described in depth to add authenticity to the work. Moreover, the study is about introducing a new method of teaching that spread across three primary disciplines i.e mathematics, art and deaf pedagogy. To describe and evaluate the process meaningfully I felt it necessary to capture the interactive processes at play in a bounded context, both overt and hidden, from multiple dimensions. This meant that I had to observe and document real events, record what educators and learners say with words, gestures and tones, study work produced by the deaf learners through art activities and examine the visual images they produce. The design framework and philosophical foundation that could most convincingly support these features and fulfil the aims of the research, to investigate the grade 9 learners responses to the role of art in teaching mathematical concepts to deaf learners, was the qualitative approach.

The epistemology of this research stems from the initial incidental experiences of the mathematics teacher and I, the art teacher. This is explained clearly in the rationale of this study. The motive for this research, designed to effect results in its natural environment, is that these results can be directly generalised to the real life situation of the grade 9 class. As a result this review is likely to have higher ecological validity (Neuman, 2000). Particular strengths that this study wanted to harvest from qualitative research is its ability and scope to accommodate an in-depth, deep, rich, thick nature of data (Neuman, 2000; Flick, 2009); explicit, detailed description of phenomena, inductive reasoning applied to evidence gained from sources and synthesized interpretations. This is in contrast to quantitative research where the emphasis shifts to discovering and predicting from universal laws in an objective and statistically relevant manner and producing results that can be replicated by others and generalised across multiple spectrums of society (Neuman, 2006).

The quantitative and qualitative philosophies lend themselves to three approaches to social science research viz. Positivist Social Science, Interpretive Social Science and Critical Social Science. The aim of any research depends on the objectives there are (Neuman, 2006). The objective of this social science research study is to investigate the effect of engaging art practices to create a model of mathematical concepts in the deaf child.

Consequently, this empirical investigation endeavours to develop and then evaluate the creation of a visual concept in the form of a prototype of specific mathematical concepts which is done within the art lesson as a structured intervention program. During the lessons each Grade 9 learners' responses are documented by way of multiple case studies. The lessons were manually recorded by another teacher so that the individual nuances of both the learners in the class and the lesson as a whole was objectively captured (Wong, 1995). Lessons involving art activities were filmed, but theory lessons involving discussions were manually documented by the observing teacher (Wong, 1995).

This research involves recording learners' responses to mathematical concepts and words before and then again after the introduction of an intervention program. Learners' responses will be elicited within a qualitative research design paradigm. In light of the aim to empower learners, critical social science was chosen as the approach to this study. It is deemed an appropriate approach given that critical research has the potential to equip learners with necessary life skills (Neuman, 2000). The reasons for this assumption are detailed in the next section.

a) The goal of critical research and its relevance to deaf learners

Critical research may be used to help people change conditions and build a better world for themselves (Neuman, 2000). As used in this study, the critical approach was chosen in order to redress the traditional approach to teaching mathematics to deaf learners (Wiersa & Jurs, 2005). Learners at this school are used to passively receiving instructions from the teacher because of a traditional teaching approach as opposed to being involved in active participation (Spady, 1998, as cited in Macdonald, 2001). The success of an art period necessitates engaging in creative activities thus encouraging learner participation. Therefore it is posited that in this school critical research can be used to empower deaf learners thereby preparing them for life outside school (Offe, 1981 as cited in Neuman 2000).

Critical research will be made relevant to the learners during the process of creating an understanding of the concept; the deaf learners will be exposed to a shift in paradigm from the traditional method of teaching mathematics to the constructivists approach. Both traditional and constructivist teaching is unpacked in the theoretical framework. It is during the art lesson that this paradigm is initiated when learners start developing the mathematical concepts. The paradigm is then continued in the mathematics class. The learners are given the responsibility to reason and make decisions or choices and encouraged to accommodate various answers. The critical approach is apt for this reason as deaf learners at the current locality of research have adopted a passive stance to education, accepting the hearing adults view to life with little introspection (Kincheloe & McLaren 1994 cited in Neuman, 2000). This posture to their education has been adopted due to their exposure to traditional pedagogy. Therefore their educational history has socialised them into becoming passive receptors of knowledge. When authority is complacently followed as it is during traditional teaching, information is filtered from only one perspective. According to the constructivists view for education, learners are motivated to follow their personal interests, make choices and combine materials in their own way (Isbell & Raines, 2007). Growing up in a traditional 'just-do-it' environment from primary school; collides with a constructive 'do-it-yourself' mentality in high school and goes against DoE expectations that teachers are a guide to children who prove to be 'mediators of learning' (DoE: Design 2003, p3). It is hoped that this intervention programme which is ultimately responsible for creating the visual mathematical model will arm the Deaf learner to move away from thinking that the teacher has all the answers and start to enjoy an indulgence of self thought.

In light of the current traditional situation in the primary school, learners come to the high school adopting the same submissive pedagogy. As a result of these trends, critical research design was regarded as apt because the deaf community at this school is currently disempowered for two reasons. The first is that the deaf community is a minority group and dependant on hearing people as one of the ways information is accessed i.e. via interpreters. Consequently many are not able to physically voice their own opinions and thus rely on interpreters to accurately convey their thoughts and feelings. Secondly, the younger generation of this deaf community, who are supposed to be subjected to OBE practices now are still being taught traditionally. Therefore a sluggish mode of erudition is created, stifling thought processes and hindering development of confidence and esteem which adds to further disempowerment (Neumann, 2000). It is within this environment that this study is conducted.

Moreover, the research design in its fullness will trace and analyse previous research in the areas of teaching mathematics using traditional and constructive approaches, the resultant effects of these approaches on deaf learners, the impact of current educational policies and the implications of enabling the learners to initiate and execute change. The relationships between these variables will be investigated.

The complexity of this study supports critical research methods involving a variety of techniques (Neuman, 1998).

Case studies will be used to investigate the students in the grade 9 class. Seven cases will be highlighted later on in the programme.

3.3 Methodological Paradigm

In the instance of this research, case studies were deemed a suitable technique to employ in investigating the effects of creating a mathematical model. How the data is collected and analysed is thereafter examined. Data collection is explicated in order to help evaluate validity and reliability of results and the conclusions drawn from them.

3.3.1 Defining the Case Study Method

Case studies demonstrate an argument about how social forces shape and produce results in particular settings (Feagin,*et al*. 1990). Moreover, the quintessential characteristic of case studies is that it strives towards a holistic understanding of cultural systems of action (Feagin, 1990). Data come largely from documentation, archival records, interviews, direct observations and participant observation (Yin, 1994). In a case study, a researcher may intensely investigate one or two cases or compare a limited set of cases focussing on several factors (Neumann, 2000). Hence a case study tends to be selective in that it focuses on one or two issues that are fundamental to understanding the system being examined (Yin, 1994). In addition a case study allows a researcher to study people or units either in one time period or across time periods.

a) Advantages of Case Studies

There are several advantages to using case studies. In this investigation, the case studies are anchored in a real-life situation which results in a holistic account of the phenomenon being investigated. Explanations in their entirety provide us with data that are detailed, varied and extensive. This type of data can carry several benefits. Firstly, it may provide in depth insight into the reasons for specific behaviour among students. Such information can help structure further research (Thijsse, 2002). Therefore, the questions raised in case studies can generate new thinking and theory. Secondly, a specifically salient point of this calibre of data is that it brings out the details from the viewpoint of the participants. As a result, case studies can give a voice to the powerless and voiceless (Feagin, Orum & Sjoberg, 1991).

Not only do case studies allow the researcher to consider the voice and perspective of the participants, but they are in essence a multi-perspective analysis (Yin, 1994). This means that in this study, the researcher also considers the relevant group of participants and the interaction between them and other role-players in their lives such as parents, teachers or other care givers. In other words, the background, development, current conditions and environmental interactions of many individuals were observed recorded and analysed for stages of patterns in relation to internal and external influences (Wilson, 1995). In this manner a case study can be seen to satisfy the three tenets of the qualitative method of research viz. describing, understanding, and explaining (Neumann, 2000). All case studies vary in their nature, some are intensive descriptions of a program, event or process and some go beyond descriptive and are interpretive in nature, the data being analysed and interpreted (Yin, 1994). Case studies can be investigative and evaluative in that they assess the merits of a particular practice or program as in this case whereby an intervention program is introduced to the Grade 9 learners.

Ultimately, each individual case study consists of a "whole" study, in which facts are gathered from various sources and conclusions drawn based on those facts (Yin, 1994). A disadvantage of qualitative research and one that is associated with case studies is that conclusions to other situations are not a concern in general (Wiersa & Jurs, 2005). In the next paragraph the setting of this particular case study is detailed.

b) Describing the case study context

The current learning environment of the school is a deaf high school where the medium of instruction is South African Sign Language. The study participants are learners of the Grade 9 class of one school for the deaf. The students who will participate in the research are from the same grade in the same school. The Grade 9 class consists of 6 female students and 1 male student. These 7 students have varying degrees of deafness and come from diverse socio-economic backgrounds with parental support varying from very strong to little. Although as indicated, the dominant mode of communication is Sign Language each student has particular individual communication preferences ranging from Total Communication, to Oral, to Sign Supported English. The varying communicative structures are worthy of report as they relate directly to access to knowledge and relationship to the class teacher. These issues will expand on during the course of the study. This student uses a combination of South African and another international Sign Language.

Any case study context will be subject to specific constraints relative to is unique setting and this one is no exception as is noted below.

c) Limitations to the Case Studies

These case studies are confined to a particular grade in one school. Therefore the findings cannot be generalised to the larger population of deaf learners. Moreover to curtail investigative bias multiple sources will be consulted to establish a chain of events. Furthermore, key informants will review a draft case study report. The above recommendations to secure validity were drawn from the work of Yin (1994). Triangulation was also used to ensure validity. It was applied in this study by comparing the learners, teachers and parents responses towards the mathematical situation at this school.

Case studies were chosen in the presentation of the whole research to paint a full picture of both the observer and participants. This study will include, field observation in which participant observation is conducted by an investigator who shares the lives of those who are studied (Wilson, 1994; Wong, 1994) through interviews, focus sessions and video recordings. The first stage involved collecting the data; second required constructing the cultural portrait of the students concerned and the role players in their lives and the third phase evaluates the intervention across the relevant audiences. Seven data collection tools will be used to collect the data.

3.3.2 Data Collection Tools

The seven methods of collecting the data took the form of formal and informal student interviews, parent and teacher interviews, video recordings of class activities, photographs and observation (Mouton, 2005).

Four focus group sessions were distributed evenly across the art intervention session to allow a window period of assessment to ascertain how learners were perceiving and relating to the process. At the end of the intervention period an individual interview was conducted with each learner to give the learners' a sense of personal space in which to voice their own opinion in private, and lastly a post-test was conducted to evaluate the degree to which conceptual development took place in the study. The progression is detailed in the figure below.

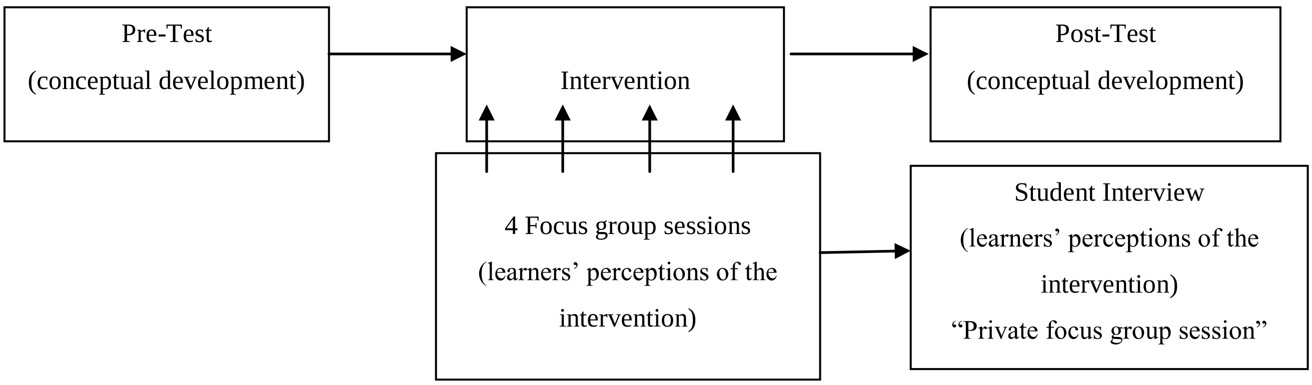

Figure 19 Progression of this study

Pre-Test

The pre-test was administered before the art intervention program in the form of an interview test. I signed each of the questions below to individual students and recorded the answers. The other teacher/researcher observed the process. Students' answers were carefully recorded. The test was conducted by displaying a series of mathematical symbols to the students (Appendix 11). They were then asked to:

1. Identify this mathematical symbol, by writing or using a sign.
2. Explain if they could find a link between the symbol and real life,

3. Using Sign Language, demonstrate a sign for the symbol.
4. Report whether they had ever seen the symbol before.

This pre-test was followed by the art intervention programme.

The intervention programme

The intervention took place over a period of two months. All seven students were involved in the intervention process. Students were involved in the programme for forty minutes three times a week. I administered programme using fluent SASL. The students were involved in hands on activities at each lesson. The other teacher/researcher was present during lessons and documented observations. In applying Skemp’s theory to my research, in order to exemplify the association between mathematics and art I plan the intervention by using a single mathematical word; 'symmetry', in this case and set out to build a picture in the students’ mind. I do this in various ways. Firstly, I show a slide of the Taj Mahal and discuss this architectural feature where I make reference to the equal proportions of the four slender minarets’ that frame the building. The effects of this repetition in turn create a balance. The symmetry in its structure and setting plays a pivotal role in creating a perfect building. There are many examples of symmetry in the picture including the divisions on the minarets, the trees on either side of the building the arched niches, the dome, the writing and patterns on the white walls and even the reflection in the water. Students are then given the opportunity to point out these symmetrical areas in the building. The objective: to practice the sign for the word *symmetry* and reinforce its understanding in the learners minds through active use. The ultimate aim is to achieve what Skemp (1998) refers to as ‘stored representation of the concept' symmetry.

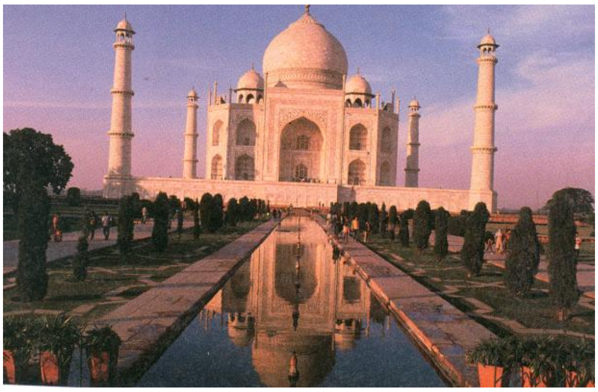

Figure 20: Taj Mahal

We then looked at nature such as in the segments of an orange, leaves, butterfly wings and other examples students may find whilst exploring their environment. This is obviously something students should be encouraged to do as motivation to find examples ensures students understand (Figure 2). I then finger-spell the word and write it on the board. I ask what these have in common and they sign [9]SAME_SAME. I have checked the sign for symmetry with the Deaf staff. I show them the sign and thereafter refer to symmetrical objects in sign. At about the same time an advert for Edgars (a fashion store) shows a beauty consultant using makeup to create symmetry on a face. She explains how people without realising are all drawn to beauty because of symmetry.

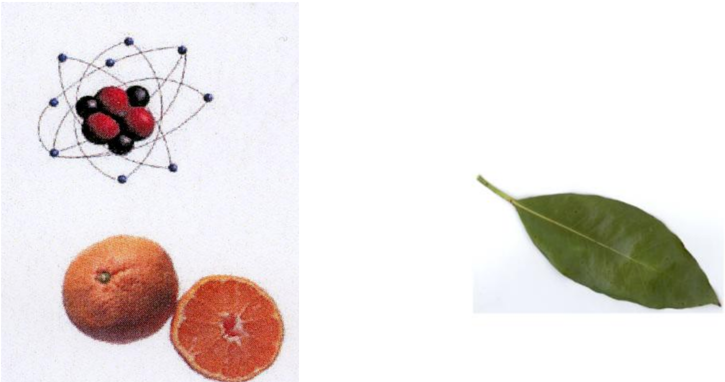

Figure 21: Symmetry in Nature

I then introduce experiential learning of the concept by a make-over session in class. Kids work on their friends' faces to hide blemishes with foundation cream, which will otherwise upset the symmetry, before applying other cosmetics. We sign symmetry again. During another exercise we make clay mobiles with clay leaves. To keep its balance a mobile has to have symmetry. In time the students begin to possess a strong data base of the word symmetry which is not only visual but empirical and therefore explicit. They have also attached a name and sign to the concept symmetry. According to Skemp (1998) it is the latter i.e. the actual naming process that helps students finalise the building of a mental prototype accordingly. By the end of the last lesson students will have extracted the common factor from all the other lessons. That common factor in this case being symmetry as 'red' was in example (Skemp's, 1998). By these means, I would have created a network, a web of connecting ideas with symmetry at the centre of that web.

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[9] Glossing

First hand observation was conducted. During observation, comprehensive field notes were documented to examine the change if any, from the initial level of understanding of the mathematical terminology to an understanding after the intervention. To this end the initial test was administered again.

Post-Test

The post-test was administered before the intervention program in the form of an interview test. I signed each of the same questions below to individual students and recorded the answers. The other teacher/researcher observed the process. Students' answers were carefully recorded. The test was conducted by once again displaying a series of the same mathematical symbols to the students (Appendix 11). They were again asked to:

1. Identify this mathematical symbol, by writing or using a sign.
2. Explain if they could find a link between the symbol and real life,
3. Using Sign Language, demonstrate a sign for the symbol.
4. Report whether they had ever seen the symbol before.

During this post-test, the field direct strategy, participant observation, used in this research is one that is common to qualitative research. Observation is often considered the method at the heart of qualitative research design (Flick, 1998). As in this study it involves the researcher observing from the members perspective. The other teacher/researcher was involved to offset any bias (Flick, 1998; Wong, 1995; Wilson, 1995).

There are differing dimensions of observation (Flick, 1998; Neuman, 1998). These dimensions throw light on the reasons specific observations were chosen for the purpose of this research. During the process of observation, field notes were used for documentation as opposed to structured protocol sheets so that the observation, in terms of sensitivity to the research is not restricted (Flick, 1998).

Observation of the students in the art class was overt in nature but was not intrusive as learners do expect a teacher to watch the work process for the purpose of facilitation. The other teacher/researcher was familiar to the students. Furthermore, it is common for teachers at this school to walk into the art class often; been merely interested in the students' art creations at that time. The observation dimension remains flexible and responsive to the processes in the study (Flick, 1998). Observations were done in the natural setting. In the case of this research, learners' responses to art activities and to each other in the art and the mathematics classrooms were observed. Observations were recorded on a daily basis in the form of a journal. Video recordings and photographs of learner activities were also captured at regular intervals.

One problem to the method of participatory observation generally visible under varying dimensions is how to select or delimit observational situations (Flick, 1998). The problem of selection arises when it is not possible to observe the students all day in an institution. In this regard one misses the after effects of students' classroom experiences. For this reason focus groups have played a significant role.

a) Focus Groups

Focus group discussions were used to identify issues, terms and interpretations by the seven individuals in this group (Denzin , 1999 cited in Mouton, 2005). Four discussions were planned in advance and all seven participants were invited. On one occasion two students were absent from these sessions because of a prior arrangement to go on an outing. Each focus group lasted forty five minutes and the discussions were aimed at an in-depth understanding of the attitudes, beliefs and perceptions. The questions that were selected can be found in Appendix 10.

Generally the questions followed a sequence but learners were allowed the space to diverge onto topics that appeared relevant to them at the time. These sessions were facilitated by the other teacher/researcher and me. I acted as an interpreter whilst the other teacher/researcher voiced the questions. We used each other as a form of member check to lessen potential interviewer bias. Another member check involved videoing the sessions and transcribing them with the help of a Deaf adult who signed confidentiality before the interviews. Due to the peer dynamics and apparent shyness of some learners to voice their opinions in a group setting it was considered useful, to supplement the focus group discussions with in-depth interviews using the same questions.

This study further used these qualitative interviews as described by Neuman (2002) to elicit individual responses.

b) Student Interviews

Careful consideration was given to the level and language used since written English is the second language of the deaf respondents. Several modifications ensured that ambiguities were obviated. Questions that were asked were succinct as opposed to being long and tedious. Questions were reviewed several times to amend the use of words that were emotionally charged. Thereafter these questioned were reviewed by a deaf adult to confirm comprehension. Questions were then piloted with two respondents to evaluate the questions, clarity of instructions, and responses.

One session was planned in advance with the intention of working with all seven students. Once again the same Deaf adult interpreted the students' responses. The student interviews were also video recorded. Each student was allocated an hour for this interview, however the actual time they took varied from fifteen minutes to an hour.

The rationale behind the interview questions 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 the art activities; underlying feelings towards mathematics; perceived anxiety towards mathematics and mathematics tests; aspects the learner identifies as having changed because of participation in the programme; changes in how learners feel about maths because of participation in the programme if any; the level of interest and belief in ability to pursue a career involving the sciences and mathematics; their personal view of the relevance of mathematics to the world and to their own lives; and their suggestions for change (Appendix 10).

c) Video recordings and photographs as instruments and objects of research

This method of data collection was especially relevant to the current research as the participants are deaf and communicate through the medium of sign which can best be clearly captured by video recording. A signed consent form (Appendix 3) provided written permission to use video recordings of participants. The camera as an instrument for collecting data not only records facts but allows for a holistic presentation of conditions for multiple reviews (Neuman, 1998). This type of documentation is also useful to non-art readers of this research as it elucidates the literature review which refers to examples of works of art.

Field observations were video recorded during the process of creating art works and photographs taken to show the effects of the make-up session. The photographs will not be included in this study to protect the identities of the learners involved in the research. The video recordings later remodelled and recalled responses which are otherwise easy to miss. Although this method of capturing information affords a more precise portrayal of the contents at hand, there are some disadvantages to video recorded observations. Firstly, when used in mainstream settings, using a video device is intrusive by nature to a hearing class from personal experience as it is not a device commonly used in class teaching. In deaf education however, it can be used to great advantage.

It has been noted that the students at this school are comfortable in front of a video camera. This may be so due to the device often used to record their Sign Language examinations and continuous assessments. Sign Language examinations, being visual in nature and involving movement, are conducted in front of a video camera allowing the teacher to mark from the tape after the examinations and permitting access for examinations to be moderated by another teacher. Converting the signed examinations into DVD format allows safe storage of examination content which is easily accessible to DoE officials at any time. It is a method commonly used at this school. It is therefore the premise that video recording is not seen as an intrusion to typical classroom set-up here.

However there are two disadvantage of using video devices at this school for the purpose of research. Firstly, in that reviewing tapes can be time consuming (Mouton, 2005) and secondly, the language has to be interpreted from Sign Language to written English. The researcher bore in mind these common problems associated with video observation and attempted to alleviate such setbacks by engaging the help of a Deaf colleague to correctly interpret the content each learner communicated. The information was signed to the researcher who voiced over the content to a third staff member responsible for capturing the information on computer. The Deaf colleague then inspected the typing to authenticate accuracy. The teachers involved signed a clause ensuring confidentiality. Although I understand the students signing well in general, the bias of the Deaf staff member also ensured that even the slightest nuance of meaningful expression was accurately captured. This gave me an opportunity to focus my observation on attitudes and academic progress.

d) Teacher Interviews

Following on from this an interview questionnaire was prepared for teachers. The mathematics teachers who were interviewed were asked how mathematics is taught in their classrooms to establish whether constructive or traditional methods are being used. Questions were directed to problems experienced in the classroom and suggested solutions if any (Rubin & Rubin(1995) as cited in Mouton,2005). The questions were presented in a logical sequence so as to engage and sustain the sequential trend of thought.

All the teachers at this school were interviewed as they had at some point taught the learners mathematics. An appointment was made with each teacher and a copy of the questions they would be asked was given to them in advance (Appendix 8). Each signed a letter acknowledging participation in the research. The other teacher/researcher asked the questions and I wrote down the answers. Each interview was about one hour long. The aim of the questions were to establish the opinion of the teachers of the deaf at the local school with regards to deaf learners performance in mathematics; and also learners ability to recognise written abstract mathematical concepts; and their aptitude to relate it to the real world.

e) Parent Interviews

Discretion of participants' privacy in contributions and involvement during this study has been ethically considered.

3.4 Ethics

Following on from this the ethical integrity of this study will be maintained by conducting the research in collaboration with the Department of Deaf Studies at the University of Witwatersrand. All research findings will be reported with full disclosure of the research methodology and the limitations of research (adapted from Neuman, 2000). Moreover, the privacy of the Grade 9 learners and the anonymity and confidentiality of their records will be secured as best as possible. As far as the video recording are concerned these will only be viewed by the research teachers and the deaf staff member who acknowledged a contract of confidentiality.

Sensitivity towards students was carefully considered to protect participants from physical, psychological and legal harm. To this end informed consent was obtained in writing from the participants' parents or guardians (Appendix 9). Subsequently, only learners whose parents or guardians provided written consent for their children's information to be used were included in the study. Furthermore, none of the learners were inconvenienced in any way, since they participated in the research during the normal mathematics class (Flick, 1998). Moreover, the content of the mathematics they engaged in corresponded with the Grade 9 mathematical learning outcomes specified by the Department. Further evidence of the specific topics covered may be found in the Common Tasks Assessment (C.T.A.) mathematics paper written by all Grade 9 learners during the forth term of the year 2008. The CTA was an external paper set by the Department of Education. It explicitly confirms and correlates a range of topics covered during the research.

One of the ways the learners' anonymity will be protected will be by changing the sex and names of the students in the class. This was deemed necessary due to the fact that the school has a small population and the deaf community forms a minority group in this country. All the students in the class will be boys from various race groups.

3.5 Conclusion

Against this background, the study was conducted within the qualitative paradigm using the above tools. One of the major distinguishing characteristics of qualitative research is the fact that the researcher attempts to understand people within their own definition of the world (Mouton, 2005). The type of information required for this study necessitated the above data collection techniques that were carefully chosen creating maximum access to the comprehensive case studies which follow in the next chapter. It is the aim of this study to endeavour to understand the subjects from within their own worlds in order to attempt to draw a correlation between the diversity of their lives and the impact thereof on classroom performance.

CHAPTER FOUR

DATA ANALYSIS

4.1 Introduction

The emergent data collection process during qualitative research is both recursive and dynamic (Merriam, 2009). During this research, data was analysed as it was collected and organised and refined later. Although analysis was done simultaneously to data collection the process of analysis was not over at the end. Once all the data was in, the analysis became more intensive. Comparisons soon gave rise to discriminating criteria and forming the categories which are recorded in the following paragraphs. To avoid confusion, the following terms are distinguished: approach, design, paradigm, strategy, technique and method. In research a clear distinction must be made between these terms as authors use different terms to organise qualitative research. For example Merriam, (2009) notes that Patton refers to theoretical traditions, Cresswell discusses approaches, Tesch divides approaches into design, techniques and orientations and Denzin & Lincoln refer to research strategies. In this research, method refers to a technique, system, mode, and strategy in the organising process.

SNOWBALL EFFECT. Initially I did not know all the questions that should be asked neither did I know all the persons who should be involved in interviews. One stage during the data collection process formed the foundation to the next. I worked on hunches and educated guesses and then probed further. Validity and reliability issues that arose from this exercise are debatable among the research community. No criteria exist for assessing reliability and validity if that is even possible (Merriam, 2009). However, several strategies can be used to enhance the validity and reliability of qualitative research. Since human beings are the primary source of data collection and analysis in qualitative research interpretations of the real world are also accessed directly through observation and interviews. Therefore internal validity, a definite strength of qualitative research (Merriam, 2009), was used in this research in the form of triangulation collected in interviews, documents and observations. Furthermore, investor triangulation further secured validity in view of the fact that two investors collected and secured data (Merriam, 2009). What the data analysis reveals in this qualitative research study is the parents', learners' and educators' understanding of their world and how they have made meaning of it based on their own set of circumstances.

The key to student productivity in the mathematics classroom is learners understanding mathematical concepts used during lessons. The school plays a significant role in developing such concepts. The aim of this chapter is to use the relevant data collected during student interviews, teacher interviews, formal and informal focus groups and listening sessions, video recordings and observations to describe and portray as accurately as possible the students in the grade 9 class, their efficiency in and attitude toward mathematics before and then again after an art intervention programme.

4.2 The demographical characteristics of the learners

The learners were taken from the only grade 9 class in the school. The grade 9 class was selected since it is the aim of this study to investigate the grade 9 learners' ability to cope with the Common Task Assessments currently standardised for South African education. The ages of the learners range from 13 to 19 years old.

Case studies analyse the following students: Andre, Drew, Erin, Kris, Charles, Uttar and Nkoli.

a) Case study one: Andre

Andre is a 19 year old male. He hails from a Zulu cultural group. The school history reveals that Andre came to the current school due to bad behaviour in his previous school for the deaf. His mother looks like a strong woman. She did not know Andre was deaf at birth and only came to that realisation when he was 6 years old. Believing him to be a slow talker, there was consequently little family communication whilst he grew. After keeping her son at home for many years Andre was eventually sent to a crèche for deaf children when he was 7 ½ years old and his mother then attended a course in Sign Language for two weeks. Thereafter he went to a school for the deaf for blacks only until he was in grade 7. He came to this school in grade 8 and has thus been in this school for 1 year at the time of the research.

He has a pleasant disposition today. He is not always like this. But today he is eager to talk about himself. He voluntarily participated in the research which involved him in focus group sessions, personal interviews and the intervention test. He was always enthusiastic about the outcomes of the research although not fully understanding it. He thinks: ‘if it is going to help me, it’s good’. The format of the interview (appropriate lighting, seating and the video camera) seem to gives him a sense of importance. Andre’s Sign Language is not clearly understood by the teachers or his peers. He has a strange blend of signs stemming possibly from the late identification of his deafness.

Andre’s mother did not attend any follow up courses in Sign Language since her two week course when Andre first went to school. It is too expensive to come to the city weekly for these classes. Now she learns to sign from her son. His older sibling who never attended a Sign Language class is a fluent signer. Therefore whenever Andre’s mother has something really important to say to him, his sibling is always present. Words and concepts are interpreted via this sibling.

Andre has struggled in all subjects since his arrival at the current school. He has missed out so much at foundation level that he will be encouraged to do a skills course in 2009. This will upset him as he has high expectations of himself.

b) Case study two: Drew

Drew is a 16 years old white South African. His home language is Afrikaans. Drew started deaf education when he was in primary school but was periodically removed and home schooled. Access and participation in school life has been limited due to this. His parents seldom attend the school’s quarterly parent meetings due to the distance from their home to the school. Transport costs impact on this non-attendance.

In class Drew displays behaviour related to poor concentration such as great difficulty to focus for more than a few seconds and being easily distracted by peers. His thoughts drift off during a lesson although there are times when he surprises his teachers with insightful answers or comments. Sometimes, during his mathematics lessons, Drew comes up with a brilliant answer but “refuses to demonstrate reasoning skills, especially in the presence of his peers”. The school nurse believes there is a definite Attention Deficit Disorder however, his parents don’t agree. His mother also does not believe that there might be other learning problems linked to Drew’s deafness. According to the school nurse, Drew is also prone to viral infections. His glands are often inflamed causing discomfort. He frequently goes to the school nurse during class times, his eyes water and he is visibly uncomfortable.

Drew is an extremely quiet boy. He has a shy disposition and is happiest going along with the flow. According to his high school teachers he is noted for not attempting homework from the time he was in primary school. He loses notes almost immediately resulting in sparsely filled files.

Drew's family is hearing. He is the only deaf member. Both Drew's parents are alive and live together with a hearing brother. Drew's family was devastated at the news that their child was diagnosed deaf. They had no idea what to do. Learning of this school, the parents reluctantly placed him in the care of house mothers. Communication at home is predominantly through Sign Language between Drew and his mother. His mother attended Sign Language classes for a period of time. His father supplements his Sign Language by writing letters or notes to communicate. Drew's mother maintains that communication at home is fine. Over and above SASL Drew's parents also use a home made Sign Language which consists of gestures, mime and pointing.

c) Case study three: Erin

Erin is a 15 year old white boy. His family speaks English and is hard-of-hearing. He has 5 other siblings. 'We were informed about his deafness (although we had had our suspicions). His deafness was not officially diagnosed until when he was two years old' his father recalls. Erin's younger brother has a 10db hearing loss in one ear. Samuel, Erin's third brother, has a learning difficulty.

Erin is easier to observe than he is to define. He is seldom conscious of a whistling sound his hearing aid makes which indicates a smile to his hearing audience. He struggles with his identity. Being hard-of-hearing he experiences a bit of both worlds.

Erin has been raised in an oral home and school environment. He used to attend a mainstream private school before he started deaf education. His parents have communicated with him "exclusively in speech (English) only. 'There are a number of gestures and signs which we use as well, but Erin has basically grown up in the hearing world', his father says. His parents felt that he did not cope well at this school. The teachers felt sorry for him and were unduly kind in compensation for his deafness. They wanted to put him in a school for the deaf so that 'he could be with his own kind, giving him a chance to be more truly himself and not have to make allowances as a deaf boy'. His parents say: Erin struggles in the "whole area of communication. He has a kind of 'verbal dyslexia' his father says in reference to his incessant chatter. According to his parents he babbles on and on using words he does not understand. We are unable to simply talk to Erin in 'normal' language. Often we have to 'translate' sentences we would normally use into more simple English. His parents do not know if this is right or wrong because sometimes he surprises them with what he knows. His dad says that they find it difficult enough just to make themselves understood in the normal run of things than to complicate life with 'unnecessary things'.

d) Case study four: Kris

Kris is 15 years old white boy. According to audiologist's report he has profound bilateral sensori-neural deafness. In 2004, when Kris was 10 years old, he was sponsored his only pair of hearing aids. Even with hearing aids he 'has limited awareness of sound'. Kris's parents were informed that Kris should always wear his hearing aids and that they should be well maintained. When he was 13 years old, two years ago, Kris refused to his wear hearing aids any more saying 'it irritated' him too much and besides 'I DEAF' he signed. 'NEED HEARING AID WHY?' Kris's parents, torn between their son's experiences and what the audiologist and medical fraternity advise, retorted: 'let him be'.

Regarding his health, Kris complains of being tired often. Other than that, he has a neurological problem which causes him to jerk his head repeatedly. His mother is concerned that the 'jerks' are being more pronounced and usually occurs when he is nervous. He comes from a family who are Christian but Kris is not interested in spiritual matters.

Both his parents completed their level one Sign Language course whilst Kris was still a child. Kris's father has developed his own Sign Language to communicate with his son. 'I always tell him not to sign in front of Kris's friends, because they will not understand him' Kris's mother recalls. 'Kris's signing has surpassed our level of understanding from around

Grade 6 and Grade 7, just before he went to high school'. Now Kris teaches his mother new signs. The grandparents are also very involved in Kris's life. They have learned some Sign Language but now that he is older they communicate at a deeper level by writing notes back and forth. Kris's father does the same. His hearing brother and he enjoy better communication. All four of members of the family share a special bond.

Kris endures a tiring schedule after school as his swimming practice has won itself top space in Kris's list of priorities. Kris practices for at least 2 hours everyday rain or shine. His zeal to swim has already earned him an opportunity to participate in the Deaflympics in Taipei. Kris hopes to make the South African team again this year and has set high goals for himself. He hopes to follow in the footsteps of his swimming hero, Terence Parkin. He then goes home exhausted, has supper and starts homework probably a reason for his constant tiredness. Over weekends, his mother tries to strike a balance allowing Kris to socialise with his Deaf friends and also resolutely expecting him to join the family when they entertain hearing folk. Kris protests with the latter arrangement but has no say in the matter.

'At home, it is a Deaf -hearing issue' his mother says. 'Because I am hearing, he feels I do not understand'. His mother senses she has lost her son to the Deaf community. Although family traits and values of an English South African culture have been passed down to Kris, he has adopted a strong Deaf culture and is predominantly swayed more to Deaf ways.

Kris's mother constantly feeds him a wealth of general knowledge by interpreting the news on TV; discussing current affairs and even planning and undertaking overseas holidays to keep her son in contact with the real world. Therefore Kris is always being exposed to informal and formal education. In spite of this, Kris who has academic potential has underperformed since coming into high school. He has a frivolous attitude and work ethic. Low test score do not deter this playfulness. Swim and socialising have taken precedence over academic work.

e) Case Study Five: Charles

Charles is a 15 year old Zulu boy. He is born to hearing parents. At birth, he was given a traditional name which means blessing. A name perhaps to refute the curse placed on his family for not being obedient to ancestral rites (deafness is regarded as a curse among traditional Zulu families). 'When a ritual is broken it is believed a curse befalls your children', Tembi, Charles' mother, recalls. Charles' grandmother accepted that Charles was deaf even before his mother did and found a way to communicate with him. According to the current school medical records Charles is profoundly deaf. He wears a hearing aid in both ears.

The first school Charles attended gave his mother mixed messages about her son's inability to hear. He was four years old then. But 'they refused to accept him there because they said he could talk and therefore he was not deaf'. Tembi did not even know that there were special schools for the deaf until she qualified as a teacher and was given a job at this school where her son was also accepted to study.

There are three languages currently used in Charles's home: Zulu, English and South African Sign Language. Although profoundly deaf, Charles is a speaker. He is able to communicate in Zulu and English and is clearly understood by hearing folk. He is also able to lip read well. Charles had hearing aids from the time he was two years old. At Grade R (4 years old) he started learning proper Sign Language for the first time. He communicates better orally i. e. by lip-reading and speaking in response. His mother cannot understand why. She talks in Zulu and signs to her son simultaneously. The school audiologists have struggled with getting Charles to understand an instruction before executing a test. They say that when he eventually understands what to do he responds well. One such test report paints a bleak but apt picture of Charles' response to sound. It reads: 'he has access to some sound but does not know what to do with it.' In other words he did not recognise what a sound was. Therefore nothing in terms of sound was mentally categorised.

Three of Tembi's children are in grade 9. Beside Charles, the other two grade 9 siblings are his twin brother and a sister. The twin is hearing and functions at a mediocre pace in class. He always has lots of homework to do compared to Charles who seldom gets any. The 2 year old baby interferes with books and competes for his siblings' attention. Charles chooses to entertain the little one and allow his mother a little space as she prepares the family meal. Besides Charles would much rather play with baby than do home work. Little time at home allows for inadequate focus on education even though Tembi herself is a teacher.

f) Case Study Six: Uttar

Uttar is a 15 year old boy. He sits coyly at the corner of the table we share with his parents. They both displayed a body language of gratitude I thought I did not deserve. However sharing their culture I understood that they received me with mixed emotions, and appreciation. In traditional Indian families the pyramid of honour starts at the top with God first, followed by one's teacher, then the parents. They were receiving me, their son's guru (a term they used to describe me), with much appreciation.

The parents communicate with him mostly through limited Sign Language, pointing, gestures or mime. Uttar loves watching sport on television with his father. His father explains that he longs to sit next to him and chat about the game as most fathers and sons do. He sighs heavily as he explains that he can't because he is unable to communicate well enough through Sign Language. Uttar's demure grin explains his amusement at the sight of his parents' mouth movement. He enjoys paging through magazines over the weekends and watches television when he is not doing his homework. He has no friends and refuses to socialise with the hearing neighbours' children.

The parents remain helpless to his future as a deaf person and look to the school for guidance in making the best choices for their son. Having emptied themselves of burdens in the form of thoughts and assumptions they had carried for 15 years, they where visibly exhausted but also relieved at being up-dated.

g) Case Study Seven: Nkoli

Nkoli is a 15 year old Zulu boy. He is representative of the Zulu culture only by the name he has on his birth certificate and the type of respect he sometimes displays towards adults. Otherwise he does not adhere to the cultural norms familiar to his family. He has some ties to the Deaf community. However this identity is weak. At one time he would attend church but now that he is older he has also isolated himself saying that he does not understand.

His soul interest lies in soccer where his small stature holds him in good steed. He dribbles the ball with prompt, swift transfers from one player to the next. At the blink of an eye he is already on the other end of the field waiting to receive the next interchange. He literally runs at waist level to the other players.

Nkoli made newspaper headlines when he was born. An unbelievable story including photographs of him flashed across the country's morning mail revealing no sex at birth. He fitted into the palm of his mothers' hand and nobody thought he would survive. Born pre-maturely, his mother arrived home with him in a cradle she constructed from a size 4 shoe box. Whilst regularly visiting the doctors, his mother continued to nurse him at home. A month later, doctors pronounced 'It's a boy!'

When Nkoli was one year old and through the promptings of his grandmother, he was assessed and diagnosed as being profoundly deaf. Almost instantly his paternal grandmother blamed his deafness on an evil from the mothers' side of the family. Although christened by his father according to Zulu tradition he was given his maternal grandmothers' surname. The grandmother said that this action indicated that 'Nkoli was mine'.

Two years and nine months into his life, his mother died. Soon after, his father followed her to the grave. Oblivious to his status as an orphan, Nkoli played outside during the weekends quietly and under the protective eye of his grandmother. Only in his early teens did he realise that he was an orphan.

He has been at the current school since he was a baby of 18 months old. He goes home over the weekends to gogo (grandmother in Zulu). Although Zulu is her first language, she is articulate in the medium of English and has an excellent command of the English language. Wrestling against the current of her family's tradition, to keep him at home and not expose him to the public eye for fear of ridicule, she decided that Nkoli should be educated as soon as possible.

Over the weekends, Nkoli grew up with his uncles and an aunt until they were married and left home to start families of their own. 'This is another example of breaking traditional norms' his grandmother explained. Families usually live in a communal set up, supporting and providing assistance to older folk. 'But my children are all professionals and want to live on their own. I encouraged them to go.' Therefore gogo is now alone with Nkoli over week-ends. A level 1 and level 2 Sign Language course taught granny the basics of SL. She felt this was adequate when he was in primary school but now that he is in high school she feels her vocabulary is limited making it impossible to hold lengthy conversations especially to explain concepts.

Noki teaches her some signs and she is able to pick up some new signs from her dialogues with him. When the conversations are lengthier she resorts to writing notes back and forth. Even in this way she can only communicate with him with about '50% of understanding.' Her receptive skills are not sharp enough. When she wants to explain a difficult concept to Nkoli, she writes the words down. 'Often Nkoli cannot read it. I try to look for the sign in the dictionary I bought from the school once. It is a big help. Once I sign to him, he is able to correct my sign because he begins to understand the context.' The home environment is relaxed in general and conducive to learning.

The case studies above paint a vivid picture of the learners in this grade 9 class. It reveals the diversity of learners' ages, home background, circumstances surrounding their deafness and exchanges in modes of communication at home. Collating the above demographical detail case study analysis foreshadows learners' responses to classroom mathematics and to school life in general. Learners' responses to the art intervention assessment tests, the individual interviews and focus group sessions, teacher and parent interviews follow in the next sections.

Firstly an analysis of the art intervention test investigates the learners' responses to the following questions:

1. Can you think of a word you can use to describe this? (Referring to each symbol below)
2. Have you seen this before?

3. What do you think this reminds you of in real life?
4. How will you sign and explain each of these words [mathematical flashcard with words such as ratio, congruent, reflection, symmetry]

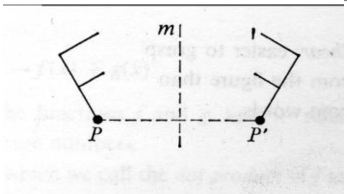
The information detailed below focuses on the patterns emerged from the results of the pre and post tests.

During the pre-test all the learners complained that the symbols were abstract to them. They were unable to recognise any and unable to find a word to identify the symbol with. This changed during the post test revealing most learners now able to formulate and attach a word or phrase to the symbol. Due to this change, learners' attitudes were positive. Furthermore learners were able to associate the abstract symbols to real-life content, something they were unable to do before. With regards to signing the word most learners reverted to concrete understanding of the term for example to explain symmetry one learners said: "LIKE THE CAR, LIGHTS- LIGHTS". [10]

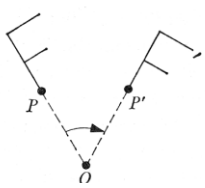
4.3 The art intervention test

The test took place at the start of the study. The goal was to establish the degree to which learners have a model or prototype (a concept linked to world knowledge); the quality/depth of the concept they have; and whether they are able to recognise the name (the written format) of the concept. Each test will take approximately 25 minutes per learner. Art lessons were taught around mathematical words such as reflection, symmetry, translation, ratio and proportion. The test was then administered again 8 weeks later. The goal this time was to assess if learners' answers to the initial test remained the same or to what degree it changed, if at all. The scheduled time for each learner remained the same as the previous test.

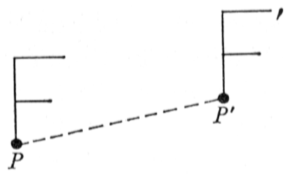
A.



B.



C.



[10] GLOSSING

D. **E.**

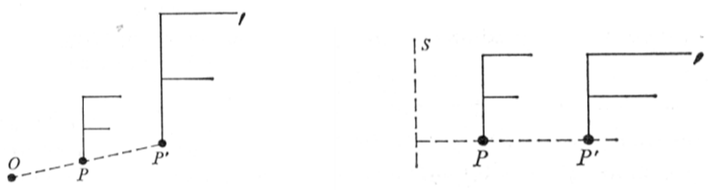


Figure 22: Symbols used in the art intervention test

The data was analysed in terms of pre and post test intervention for each learner.

a) Andre: Pre and post intervention test analysis

There was a notable difference between the pre and post tests. Andre was not able to link any of the symbols to real life examples during the pre test. However this changed during the post intervention test to him being able to identify 4 symbols out of the 5. His answers were amazing in that he was able to associate real life mathematics to his everyday life experiences. For example he associated objects like the badge on his blazer to symmetry, his circular aerobics movement to rotation, buttons on his bag to reflection and a long road to proportion where objects appeared large closer to you and smaller further away.

Furthermore, a notable difference was seen in his level of confidence during the post test session. Andre felt that teaching art first followed by mathematics helped him understand and recall better. ‘It is best to start with art first then followed by mathematics, if you start with mathematics first followed by art it is confusing.’ Andre experienced poor recall of the concepts in terms of being able to sign it during both tests.

b) Drew: Pre and post intervention tests

During the pre intervention test, Drew was extremely insecure in his disposition to the test. He looked baffled by each question and by the last question he appeared irritated. His answers to almost all the questions was “No”, “Nothing” or “I don’t know”. He was happy to leave. After the art intervention the test was administered again. Drew gave a confident answer to all the questions. Sometimes the answers were not correct but exuberance in his disposition was evident. He leaned forward to peer intently at the symbols as opposed to the pre test when he slouched in the chair uninterestedly. Now he would rub his hands together in a sign used for *excitement* before answering the questions.

Drew says: “At home; I study with my mum because the English sentences confuse me. At school; I need art to help me understand the mathematics.” (As Drew talks there are giggles and jeers from the rest of the class. He remains undeterred.) “I still feel grade 9 is better than grade 8 because it helped me understand more”.

c) Erin: Pre and post Intervention Tests

Although Erin is generally confident and reads widely, he was not poised to answer any of the pre test questions assertively. When he did make an attempt he answered on a concrete level. He seemed irritated at himself for not portraying a self-assured, positive self-image in this regard. He had to think deeply and still could not come with an answer. This triggered of excuses of being tired. During the post test however Erin demonstrated an ability to recall all the concepts taught. He seemed energised and enthusiastic. Further he confirmed a clear understanding of the related concepts by the examples he gave. His wild artistic imagination was put to test when he was asked to link mathematics to real world examples. He came up with novel links by often relating an entire made-up story to explain proportion, reflection or symmetry; with restored cheerfulness.

d) Kris: Pre and post test intervention

Kris is the in class who is most likely to attempt to answer a question. Therefore during the pre testing his body language sometimes conveyed boredom and sometimes embarrassment at not being able to answer the test questions. He spontaneously answered in the negative. “No, I don’t know, Nothing and Never” were his most common answers to questions 1,2,3 and 4 respectively. This was especially surprising at question 3, linked to world knowledge in the light of the fact that he is widely travelled. The post test revealed only a slight improvement in mathematical association to real world. During the post test he was able to recognise symbols as opposed to before the intervention. However his answers were always concrete. He displayed little use of imagination although he had the freedom do to so. For example for each of symbols A, B, C and D, he would say: ‘It looks like two Fs.’

e) Charles: Pre and post intervention tests

During the pre test Charles was asked if he saw any mathematics in the real world. He had no idea and laughed at the ‘ridiculous’ suggestion. After the intervention, he was just as confused. The intense art, hands-on activities did not serve to change his mind. Most of the other pre and post test answers were the same in that little effort was made to think through questions before providing an answer. There was one instance when he was able to associate the symbols to real life mathematics though. He associated a symbol A with ‘street lamps’. At other times Charles would sometimes describe exactly what the symbol looked like. He would say: ‘F on a straight line, big to small’.

f) Uttar: Pre and post intervention tests

A major change was noted in his level of confidence during the post test. Although he did not answer correctly he was more confident now. He enthusiastically attempted a question.

During this pre test, Uttar explained the symbols at face value. He made no association with real life examples. His facial expression had a baffled look as he tried to figure out the answers. Nevertheless, during the post test he was able to recall and associate a few of the art words related to the concepts taught. Although he could not recall by writing or spelling the English words he was able to offer explanations to its meaning. Other concepts were completely blanked out from his memory.

Uttar says that ‘Art has helped me to understand mathematics a lot. For example when I painted and measured for the ratio project-the mural’. He also enjoyed ‘painting the wool and making the perimeter shapes’. When asked if he revised his mathematics, Uttar says that he does and that means him paging through his books. He has no other knowledge of study techniques such as drawing mind maps or practicing mathematics by working out examples.

He enjoys learning bonds, and algebra. Any explanation that is step by step she enjoys. He likes mathematics but because the work is often repeated it becomes boring.

g) Nkoli: Pre and post intervention tests

The results of the pre test indicate no ability to identify the symbols presented. There was also no association of the symbols to the real world. Nkoli also had no way of explaining what he saw through the medium of Sign Language and indicated that he had never seen the symbols before. There was a distinct change in his demeanour after the intervention. He was able to recall the proper terms for two symbols. He did not recognise all the symbols but was noticeably positive in his disposition in spite of this. He seemed motivated to continue the testing and leaned forward in anticipation of the next question.

All his real life examples were associated with sport of some kind.

The results of the art intervention tests were presented in this chapter in a case study format. It summarises poor recall, low confidence and a lack of ability to associate mathematic symbols with real life before the intervention among learners in general. After the art intervention a marked level of increase in confidence was noticed in most learners, a slight improvement in recall among some learners, an increased ability to associate mathematics with real life. The learner, parent and focus group analysis that follow serve to expand the picture being created by the case studies in respect of contributing factors to learners mathematics performance.

4.4 The learner questionnaire

A copy of the learner questionnaire can be found in Appendix 10. The questionnaire was used for interviews. The questionnaire elicited the root of their current attitude towards mathematics, their responses to the existing class activities and the impact of art on mathematics if at all.

On reflection during focus group sessions, learners realised their negative attitude towards mathematics began as early as their primary school days but intensified in high school. Their reasons revealed low confidence due to an inability to target the ‘correct’ answers expected of them.

a) Reasons for learners negative attitude towards mathematics

Students felt they did not understand the mathematical words or the signs for the words and as a result were lost to the teachers’ explanation. The learners in the class moreover communicated via a wide spectrum of communication modes such as Sign Language, Speech only, Speech and sign and Signed supported English. This further aggravated their receptive understanding of the signing teacher since the teacher had no single way of pleasing all students at the same time. Another factor influencing mathematics negatively is peer pressure. Most students complained of continuously being interrupted by peers to entice them to engage in social conversations rather than attend to the teacher. Along these lines, they missed large portions of important information. These students felt annoyed at those who disrupted the class.

b) Learners’ reflections of their own positive change of attitude towards mathematics

Some students’ attitudes towards this subject changed after the art intervention programme as will be highlighted in Chapter five.

Clearly using art to develop mathematical concepts served to positively change attitudes in most learners.

c) Changes learners envisioned would help improve mathematics

Learners believed that teaching them in groups will alleviate many difficulties they currently experienced in mathematics. Some indicated possible ways of how the learners in class could be grouped for this purpose. For example they considered groups of stronger and weaker learners and learners who communicated via more or less similar modes.

d) Study habits

When learners were asked how they studied for mathematics they indicated that they did not know how to study. Some indicated opening their books are reading over the examples they had. They were not sure if this was the right way.

e) Associating concepts across the curriculum

Learners were able to apply the concepts learnt during the art intervention programme in both a mathematics setting and in real life. For example after patterns were made with triangles and square, one student commented that the triangle reminded her of pizza. She had never been so bold as to give her opinion before for fear of being laughed at. This was a positive burst of self confidence.

4.5 Focus group sessions

Two focus sessions were held. Responses to the focus group sessions differed from the first session to the last. During the first session learners protested against mathematics from various perspectives including lesson terminology, content and its relevance to real life and the abstract level of mathematics.

During subsequent focus group sessions, after the art intervention session, learners' attitudes were more positive in that they identified challenges and were able to offer solutions without fear of ridicule. Increased levels of confidence was noted when learners substantiated their solutions during the focus sessions. Their verbal solutions were validated during observation sessions and during the post-test interviews. Previously passive, learners now challenged each other and questioned the teacher.

Learners clearly enjoyed mathematics lessons which used real life objects and experiences to teach mathematics instead of chalk and talk methods, a clear reflection of the mathematics teachers' skill in pedagogy in the initiative she used to make the subject real. The learners vividly recalled art lessons covering the topic of *ratio* such as mixing equal proportions of paint to acquire new colours. Some recalled the word *proportion* that was frequently used during that time. One student still could not understand and recall the words *'double'* or *'increase'*. Complimenting the art intervention programme on developing the concept of *ratio*, the mathematics teacher used the proportions of a muffin recipe to bake with the learners during mathematics.

Moving on to teach a different area of mathematics, learners were taken outside at different times on a sunny day. They observed the length of the shadows cast by the palm trees. Learners recognised angles (90) degrees, created by the erect palm trunks and the extending shadows. A mathematical lesson ensued working out the height of the trees. Learners indicated a new interest in shadows whenever they saw one because of this experience.

When asked whether they enjoyed working on their own or in groups, most learners had a preference for group work although some of them preferred periods of time where they worked independently. The reason group work was a popular choice was that learners learnt better when friends explained. Those who preferred working individually only joined a group when they had difficulties. One student chose to work on his own always. In spite of declaring that he wanted to work in groups initially. This was due the assistance of a parent at home if he struggled, and one student was not sure whether group work or individual work was helpful as mathematics was still a challenge for him anyway.

They were able to provide examples between art, mathematics and the real world. A fresh interest and enthusiasm in mathematics was noted by other subject teachers and house parents especially in one learner who always strolled into the mathematics class late. The mathematics teacher also taught the same class English. On one occasion, this learner walked into the class early and asked if he could do mathematics first and then English. This was a noticeable change to his previously negative behaviour.

By way of summary it was also observed that learning concepts through art built confidence and improved recall amongst most learners. However, although the class understood and were able to recall mathematical concepts with more clarity after the art intervention, they still struggled to identify the concept in a problem solving context and apply it to mathematical problems. Among the general profile of learners, it was noted, that poor literacy levels, do not allow them to solve problems independently.

In the next section the responses of the teacher interviews during this study are discussed. All the teachers at the school were interviewed. The teacher interview questionnaire can be found in Appendix 8.

4.6 The teacher questionnaire

The teachers who were interviewed were all teachers of mathematics at this school from the primary through to high school level. The aim of including the primary staff in the interview was to investigate all role players in the child's life and penetrate the root causes of negative attitudes towards mathematics at high school level.

The demographic nature of the teachers interviewed ranged from deaf to hard-of-hearing (HOH) to hearing. The readers' attention is drawn to the appropriate use of the term deaf/Deaf amongst the teaching staff. The demographics also provide varied cultural backgrounds and race groups inclusive of White (W), Indian (I) and Black (B). The weighting of teacher qualifications and number of years of service and teachers personal beliefs on deaf education was also considered important to this study. An amalgamation of these demographics is significant since it directs us to teachers' individual methods and responses to educating the deaf child. Table 5 explicates the demographics of teaching staff within this school.

Common arguments that emerged will be revealed in the paragraphs that follow. The arguments focus on teachers' experiences, barriers in the classrooms, communication, peer dynamics and poor recall.

a) Educating the deaf child at this school: teachers experiences

Classroom pedagogics differed according to the variables displayed in Table 1. According to the findings in Table 1, 81% of the teachers at the school are white, 13% Black, and 6% Indian. 69% of the teachers are hearing. 6% are hard-of-hearing and 25% Deaf. The teachers differed according to their communication preference.38% preferred oral communication, whilst only 44% supported the use of SL. Other teachers preferred a variety of communication methods. This goes against the school's language policy which advocated pedagogy via SASL. The community of learners at the school are profoundly deaf with about 3% hard-of-hearing. This data was significant as the majority of teachers are working within a cross cultural set up, requiring much effort on the part of the teacher to understand the child's cultural background and language. Yet further data pertaining to the teachers' effort at this school revealed that with the exception of both the researchers, none of the other teachers have specialist qualifications in Deaf education. Almost 44% of the teachers were in the teaching profession for over 15 years and the rest were teachers for less than 10 years now.

When commenting on the level of mathematics deaf learners functioned at; most teachers said learners underachieved due to poor foundations in mathematics. When teachers try alternate, creative and more concrete pedagogics, it was reported that learners do not respond positively since they are used to traditional methods of teaching.

> The basics are not there (TS 227)

> They are used to rote learning (TS 228)

Teachers declare that learners have no real understanding of a concept. For clarity on the absence of 'the basics'; these comments were then traced further back to learners' preschool education and family backgrounds. The following surfaced: Teachers transported their education methodology from mainstream school to the deaf classroom. When methods fail teachers become despondent. Conclusively they pronounce deaf children as unable to count, unable to recall and unable to achieve at the same pace as mainstream learners if at all. They believed language and literacy to be the fundamental challenge for lack of conceptual understanding and ability to associate what was learnt in the classroom to real life settings. This is evidenced in the following quote:

> I taught the word 'tree' to the kids and used many drawing to show them what tree was. But then I took them outside and asked them to show me a tree, they could not. I pointed to a tree and they said:

> ‘no not the same’. I tried to convince them but I still don’t know what they believe (TD 312).

The school management intend for all teachers and learners to be fluent signers and in this way build concepts. Teachers are encouraged to attend free SL lessons to improve they signing skills. As this is a long term process, deaf role models as teacher assistants were introduced to the primary school classes as a proactive stance preventing barriers to conceptual development.

b) Barriers in the classrooms as perceived by teachers

Data collected during this study threw light on several barriers identified by the teachers to conceptual understanding in classroom mathematics.

b 1) Communication

Both the Deaf and hearing staff described communication as one of the biggest barriers to education. Hearing teachers included their own inability to sign fluently as a hindrance in the classroom. Although they attended SL lessons they still struggled especially with their receptive signing skills. They were therefore unable to explain concepts in detail at school. When the learners went home, communication was equally poor. Consequently the learner did not experience access to life as a whole. Teachers pointed to parents to take a more active role in their child’s life in the hope of effecting change.

b 2) Peer dynamics

The dynamics amongst the learners in the classroom was described as another barrier to teaching mathematics in this particular class. One teacher explicated this:

> One day we had an unexpected visiting student in class. They responded like a normal class. They put their hands up to answer questions. I was totally shocked. All were trying to be alert. Everyday the dynamics change. Friendships influence class performance. If two people are

> friends they will both answer questions in class. If they fight, then there is a complete behaviour change in their class-work as well. They are more concerned about their peers than the teacher. They think their teachers are idiots. Maybe it's because they are young. There is a lot of rejection by hearing peers outside. So they have a distorted and rather fierce loyalty amongst each other. That is what is most important to them (TH 95).

The dynamics within this class was further extended into their academic performance when learners jointly refused to complete homework. Observations recorded reveal subtle eye contact, slight smiles, foot movements or nudges connected learners to each other. These subtle nuances became a clandestine language shared only among learners in this class, a language unknown to the teacher. At just one of these secret signals, learners embarked on joint action against the teacher. These repeated actions fuelled negative approaches to mathematics.

b 3) Poor recall

All teachers agreed that the poor work ethic, limited communication at home and a lack of discipline in this class aggravated learners' ability to recall and make associations across the curriculum and into real world situations thus misunderstanding concepts they ought to be familiar with at grade 9 level.

b 4) Pathelogical vs Socio-cultural view to deafness

Pathelogical vs Socio-cultural view to deafness was explicated in the theoretical framework of this study. Deaf teachers felt very strongly that many hearing teachers placed a higher value on hearing and oral/aural education and that this was contributing factor to barriers in the child's education. According to the Deaf teachers, the audistic mentality arises when hearing teachers adopt a pathological view to deafness. Deaf teachers were of the belief that hearing teachers were not given enough exposure to the social model by means of reading articles or attending workshops on deaf issues. Therefore teachers follow a pathological view of deafness.

> Hearing teachers for example worry about sound, lip-reading and not about education. The key to teaching deaf is through SASL and visual. If literacy is good, the deaf will not struggle with mathematics (TA 134).

Deaf staff felt that deaf learners are capable of rich real-life simulated mathematics. They struggle to think at high school level because from birth they have been spoon fed by parents and then spoon fed again at school. Whilst hearing staff felt deaf learners could not carry out mathematical tasks. Deaf staff did not agree. Instead they came down harder on the deaf child blaming among other issues the deaf child's own individual acts of laziness for not improving marks.

One Deaf staff member, also a member of the deaf community, did not agree that the pathological view of deafness was an issue to deaf education. Instead she said that a lack of discipline among the staff and the repeated changes in the educational system was the problem. She said staff in the primary school kept the text books to themselves and cut out and photocopied what the deaf child should learn. Therefore it is as a result of their limited signing skills that a watered down version of what the deaf child ought to have learn is provided. Said differently, staff teach only what they were capable of signing. In this way, they bring education down to the level of their interpretation of the text.

Deaf staff as a whole felt that although the standard of deaf education is low at schools for the deaf, schools could not accept full responsibility deaf education is all about the educating system. One Deaf teacher explained:

> There is not enough lobbying at this school. We need to get therapists and professional involvement. Furthermore, there is lack

> of parental support. Back in my days we had a special reading time etc. We were drilled to read and understand (TL 61).

The paragraphs above detailed teachers' experiences in the classroom and their expectations of the deaf learner. Teachers clarified barriers to educating deaf children in their classes. According to the teachers, poor communication experiences on the home front presents the learner with initial barriers to learning. The research therefore included parent interviews in the data to appreciate the perspective of the parent.

The next section provides data collected during parent interviews and throws light onto the parent views of their child's education.

	Teacher	Deaf/ HOH/ Hearing	race	Qualified in deaf education	Years of service	Preference to communicating orally	Preference to communicating through S.L.	Uses a variety of methods of communication
1.	A	hearing	W	No	Over 20	✓		
2.	B	hearing	W	No	4			✓
3.	C	HOH	W	No	8		✓	
4.	D	Deaf	W	No	4		✓	
5.	E	hearing	W	No	Over 20	✓		
6.	F	hearing	W	No	2			✓
7.	J	hearing	W	No	Over 20	✓		
9.	K	hearing	W	No	Over 15			✓
10.	L	deaf	B	No	Over 15		✓	
11.	M	Deaf	W	No	2		✓	
12.	N	Deaf	W	No	5		✓	
13.	O	hearing	W	No	3		✓	
14.	P	hearing	W	No	Over 20	✓		
15.	Q	hearing	I	No	10		✓	
16.	R	hearing	W	No	Over 20	✓		
17.	S	hearing	B	No	10	✓		

Table 1: The demographics of the teachers at this school

4.7 The parent questionnaire

A copy of the parent questionnaire can be found in Appendix 9. Each of the interviews was conducted at a place convenient to the parent. The interviews were scheduled for approximately one hour but at times went on for a total of three hours. One student was an international learner. The parent of this student was interviewed via e-mail.

Several patterns emerged from the parent interviews. The theme that surfaced which shadowed the one theme during teacher interviews was *communication*. Similar patterns becoming apparent from the parent interviews include homework, parent’s observations of their child’s change of attitude towards mathematics or art, parents’ opinions of factors influencing their child's progress in mathematics and parents' expectations for their children's future.

a) Communication

Levels of communication flow from the perspective of parents indicate that from birth communication on the home front is poor in general. Only 1 parent expressed satisfactory levels of communication. This does not mean that it was in fact satisfactory but it was a parent's report based on their experiences. The general poor communication meant that certain concepts were difficult to communicate with most parents. 1 parent out the 7 enjoyed good communication.

Parents revealed better communication when their children were young but struggled during the teenage years as the need for explanations of more abstract words emerged. Only if there was an experience that they could use to relate to their child then an attempt was made to explain a more abstract concept. Therefore information related to concepts such as puberty and world knowledge in general was left to teachers and adults in the deaf community. Parents' limited signs were a cause of a widening wedge between themselves and their child.

b) Homework

As a result of limited vocabulary, 86% of the parents were often unable to help their children with homework. 14% are able to assist but do not; believing that the children are responsible for their own progress.

There are two areas of frustration for most parents: their inability to understand the subject content and their incapacity to sign at their child's level of understanding. This can be linked to the section on communication and the barriers that befall concept development. As a result of a breakdown in communication, parents have no way of assessing if homework is complete or if there is any difficulty which might need intervention.

c) Parents observations of their child's change of attitude towards mathematics or art

According to Kris's parent a change in attitude towards mathematics was noted during the course of the research term. Other parents did not notice a change in this subject however, two parents observed increased activity in art during weekends. Most parents believed that mathematics was difficult because of conceptual understanding and problem solving examples. According to parents' opinion, the root of problem solving was poor literacy.

> I thought putting my child at a school for the deaf will make him be able to read. He has been there since primary school and he still can't read (PU 48).

> Some teachers struggle to sign and they are teaching my child. I cannot sign but I am not educated. My son hates maths but I can't help him. They are the professionals (PA 125).

Parents believed that if schools improved pedagogy their children's understanding of mathematics will develop because in order to understand problem solving examples, one needed a satisfactory knowledge of English. From parents' personal encounter with mathematics, it has always been a difficult subject.

d) Parents' opinions of factors influencing their child's progress in mathematics

Parents listed dissimilar factors, such as difficulties understanding concepts, a negative attitude towards mathematics and peer pressure as some of the factors which influenced their child's mathematic class performance.

Parents noted that it was mainly three areas which impacted each other contributing to poor performance. Initial misunderstanding of concepts foreshadows a negative attitude towards mathematics and is aggravated by peer pressure not to do homework. According to parents learners in this class would text each other using cell phones to jointly not do their homework because they disliked mathematics. The next day they would inform the teacher that her explanations were inadequate. The parents admitted that their signing was a major challenge to their children's education and provided various reasons, such insufficient time, lack of transport and distance to and from the free SL lessons, as to why their SL skills were limited.

e) Parents' expectations for their children's future

Parents' recognised the delays in their child's education. They despaired at the thought of a career path and depended on the school for guidance in making a choice for their child. Three parents have high expectations for their children pursuing careers in photography, designing and engaging in small business.

The overall parent interview disclosed and confirmed teachers' suspicion of poor communication and the negative impact this had on education often due to late intervention and lack of support for the parent in making informed choices for their children.

In this chapter, peoples' attitudes, behaviours, and experiences are illuminated through case studies, interviews and observations. Explanations were sought in order to address the questions that triggered the research. Moreover, issues and patterns of behaviour which arose from the research itself were detailed.

During the study one of the main concerns that emerged highlighted the lack of early intervention in communication with deaf babies and as a result a lack of facilitation of the world around them as they grew.

> I did not know what to do. I was scared that my family would disown me for having a deaf baby. So I hid my child at home. Somebody told me about a school for the deaf. By then he was six years old. Only when he was six years old, I made up my mind to stand up to my family and send him to this deaf school. I went for SL lessons for two weeks only because I live so far away from the school. There's no money for transport. But my other child just learnt SL with no lessons. I explain a lot about life through this one (PA 167-169).

> I was terrified but I stayed positive. I thought: why would God give me a baby like this. Nobody else in my family had a deaf baby. Who was going to help me? The doctors examined him and sent us home with this news (PD 49)

Through the patterns and processes stemming from analysing the data, it may be possible to develop strategies for change which arise directly from the qualitative material itself. In the next chapter, the finding of the topics which consistently surfaced during the analysis will be discussed.

CHAPTER FIVE

DISCUSSION OF THE FINDING

In the previous chapter a collective case study approach analysed the data from respondents. This allowed for the emergence of individual perspectives Findings will now be presented in order to address the research questions below.

- What are the main contributing factors of poor mathematical results among Deaf learners?
- What is the quality of mathematical concepts Deaf learners currently possess?
- What are the factors which inhibit or advance the development of a prototype in Deaf learners?
- How can a comprehensive concept be constructed and modelled in Deaf learners using art?

Ultimately, the questions above will be tied together by discussing and reflecting upon the role that art has played in this study and can potentially contribute to the overall development of deaf learners, both on a conceptual plane but also on a psycho-social level extending even into the therapeutic.

During the research several aspects emerged that can be regarded as contributing factors to poor mathematical results. These include the transition from traditional teaching to an outcomes-based (OBE) pedagogical system; the diverse mode of communication embedded in the system; the issue of literacy; anxiety experienced by learners as well as time constraints and parental involvement.

5.1 Art and OBE

The above features which materialised during my study saw art catalyse the various challenges that came with the restructuring of education at this school to a more positive end.

5.1.1 The interpretation of OBE

One of the demands that contribute to feelings of teacher dissatisfaction at the project school is internalising and implementing the OBE system. As predicted by Jansen (2003) in his criticism against such a restructuring, the introduction of OBE into this particular school agitated the internal educational framework by introducing challenges relating to interpretation, time managements, collaboration, integration and interaction with stakeholders. Moreover, learners were found to be very teacher- dependent. Within this current framework of the grade 9 learners, the Common Test Assessments (CTA) they had to still be prepared to write and continue with FET mathematics. The focus of the CTA is on problem solving. It was hypothesised that art be used as a guide and a platform to build mathematical concepts in order to prepare learners for the CTA and ultimately for FET mathematics.

With respect to the former, much of these developments confronted the more traditional pedagogical patterns and instead required teachers to teach modern content in pristine ways almost immediately after OBE's introduction. For example OBE came with demands of implementing wider content knowledge through creating linkages to other subjects and the real world. Perceptibly this would require extra teacher preparation schedules; a factor which nonetheless did not change despite its necessity. Subsequently, almost all the teachers who were interviewed at this project school in reference to mathematics exclaim there is 'too much content and too little time', let alone opportunity for the implementation of creative teaching methods to educate the deaf learner.

a) Time Management

The time management situation is further exacerbated by the need to prioritise administrative issues pertaining to teachers across the teaching spectrum and at the same time compile sets of differentiated programmes that will accommodate the diversity of learning barriers and needs in their classrooms. Findings reveal that an additional factor that impedes on time allocation during lesson planning is that according to the high school staff, there is little or no foundation in the respective subjects on which to build. Almost all high school teachers who were interviewed expressed a concern that the learning difficulties originated and are not nipped in the bud at primary level. This view led the investigation to interview the teachers in the primary school. Results reveal that the head of department and teachers here are in agreement with high school staff about learning deficits not being fully addressed at entry level. Like the high school staff, the primary school felt too limited by the clock and thus too pressured by the syllabus to intervene on a remedial level. It is against this backdrop that the principal started talking about returning to a "back to basics" approach and the possibility of limiting teaching to a set of key outcomes only which will be determined by the teacher.

It was interesting that the research programme encouraged the primary and high school teachers to communicate about mutual challenges within the learning setup. It thus began to advocate solidarity and joint effort among both staff. A particular tenet of OBE is the emphasis not only on close collaboration amongst educators across phases and grades, but also an earnest intention to extend the principle of partnership to a variety of stakeholders. Of the multiple stakeholders, parents continue to play a pivotal role.

b) Parental involvement within the OBE framework

A resurgent debate within the project school concerns how one secures effective parental involvement and empowerment. It is a common trend that very few parents attend formal parental meetings and contact between most parents and their child's teachers are thus very infrequent. This study facilitated the meeting for scheduled parent interviews. Arrangements were made that I would go to them, rather than expect them to travel to the school. During these visits I encountered a deep appreciation from the parents. It appeared as a tremendous relief to them to have someone from school to communicate about their child. I sensed in the parents a profound sense of inability to effectively crossover into the world of their deaf child that caused them to withdraw rather than engage in their child's everyday experiences. As we conversed, a sense of loss, guilt and hopelessness was present. Parents expressed these feelings in different ways.

"Because I am hearing, she feels I do not understand. I feel like I have lost my child to the Deaf community" (PJ 149).

During the interview mum bursts into tears: "I'm cursed by God because I have a deaf child" (PZ 121)

There were also additional issues that tend to constrain more advantageous parental support. Parents reflected during the interviews on how communication barriers were brought to the homework table. These parents feel helpless to assist their children because their ability to sign cannot support the conversation beyond a basic form of social dialogue. Several parents self-reported that their delivery is further inhibited by their own lack of familiarity with the change to FET and in particular with the content knowledge required by mathematics. One parent dismissed his child's poor performance in mathematics as simply a personal aversion that a child has to mathematics the same as one would have to certain colours or food.

In this context there is thus a need for further action research that will carry both practical and theoretical implications as to how to empower South African parents of deaf children to connect with their children and also with the schools for the deaf. This study has shown how effective it is to initiate home visits. Perhaps this is a practice that should be given more consideration in deaf pedagogy.

It is interesting that the art department, apart from the additional administrative responsibilities seems to have made a smoother transition into OBE and did not appear as unsettled by the systemic issues that came with the restructuring. The following section will discuss how this department adapted to OBE and how the art intervention managed to confront some of the barriers experienced by the teachers.

Art seemed to have adapted more readily to the restructuring of OBE and OBE philosophy as a whole. A contributing factor may be that my art department has always been underpinned by "hands-on" philosophies such as the Deweyian approach. In a similar vein to Dewey, art as a subject has also attenuated the practical side together with theory, thus never allowing the displacement of 'knowing how' with pure theoretical constructs but rather nurturing it by encouraging active engagement and conscious reflection. The didactical split that OBE implementation thus came up against in other subjects between knowing and doing remained relatively absent within the art class environment allowing for a much smoother transition into roles where teachers become facilitators and learners become co-producers of knowledge through authentic art activities.

Moreover, the philosophy of OBE created a space for this particular project by allowing for the creative cross-disciplinary operations. This would not be possible in the previous education system where mathematics is confined to its own insulated space clinically kept pure by divorcing it from other subjects and from reality itself. The implementation of the study of art provided educators a possible solution with regards to time management issues and lack of integration. The art department has suggested a way forward by taking concepts that were mutual to both departments from the mathematics learning area and integrating it into the art and design syllabus in an attempt to disentangle the situation, expand on learners' conceptual knowledge and save time in the process. As was noted in the intervention, learners were thus exposed to the concepts such as ratio and symmetry in the art class before entering a week or two later into the mathematics class where they engaged with the same concepts, albeit in a different context. The mathematics teacher expressed that she was able to move more rapidly through her lesson plans, since learners came to the lessons with 'previous knowledge' (in this study I refer to it as having acquired a more comprehensive prototype), rather than entering the class with little prior knowledge to work from as was typical before the intervention. In light of the lack of incidental learning that commonly leave deaf learners 'information deprived' and Ausubel's view the most important factor that influences learning is what the learner already knows (See paragraph 2.2.1), the appreciation of the mathematics teacher for the input from the art department becomes clearer, considering that according to her feedback learners could now much more readily link conceptual and semantic representations acquired during the art activities to the mathematical material. In future, one can even take to create an extension of this venture into all other subject areas as is envisaged by philosophy of OBE. Furthermore, by working as an art teacher with the mathematics teachers in such a joint manner, this study was able to break new ground within the institution by exemplifying integrative reform in a reciprocal and communally beneficial manner.

A final element that emerged with regards to OBE in this research, was the issue of the management of OBE.

c) The Management of OBE

The implementation and the maturation of FET were directed differently by the management of the high school to that of the primary school. In contrast to the latter, this study uncovers that at the secondary school level, in this particular school, teachers have been given the educational space to reconfigure procedures and structures in accordance with the school's unique circumstances. The rationale behind this controlled autonomy is rooted in the awareness that the outworking of policies in practice is frequently different from the intentions contained in theory. Simply put, educators in the high school are given the freedom to teach the subjects they are qualified to teach and in any way they see fit and most have adopted aspects of a learner-centred approach.

In contrast, in the primary school a more teacher-driven approach is enforced. Primary school learners are thus use to being recipients of knowledge. If they do not answer or if their answer is wrong the teacher gives them a 'correct' answer. That is what they learn and give back to the teacher during a test or examination.

One particular problematical offshoot of the primary school's philosophy is that learners appear to become locked into a teacher-dependent role. The source of controversy is the teachers' willingness to 'do things for the students' rather than to sanction an educational space of self-help. Teacher L, a Deaf staff member, currently completing her teaching degree via correspondence at a local university, congenitally deaf, and a teacher in the primary school argues that deaf students currently possess poor or no understanding of concepts because they are spoon-fed by teachers at primary level. As a member of the Deaf community she is angered at the situation of deaf education. She further adds:

> "They do not let the child think for himself. They give answers too quickly in a parrot fashion. They are not patient. They are too much in a hurry. They should try other ways first but they spoon-feed. In this way students are trained to give back what they are taught. They do not really

> understand the question. For example when I ask them: Who is going to the shop? They answer WATER or HUNGRY. I say no! Who is a person! (TI 66).

The outworking is that teachers are doing more and more for their students. Referring back to Vygotsky's theory of how learning should occur in the ZPD (Isbell & Raines, 2007), one finds the emphasis on the facilitation between the learner and the teacher. However, within the context of the research the teachers do not necessary uphold the participatory nature of the developments in the ZPD. Rather, they tend to go beyond mediation, facilitation and participation to 'doing everything for the learner'.

Teachers at the school felt that they were compelled to act in this manner since the learners were firstly, 'unable to think for themselves' and secondly, 'unwilling or incapable of transiting from the concrete to the abstract'. Teacher C exclaims that 'learners in grade 9 are about 8 to 9 years behind. They are functioning at the same level as a hearing child of Grade 1 or 2.' Disturbed by their inability to operate at a mainstream standard she says: "they do not want to move from the concrete to the abstract." Research shows that "although there is no evidence to indicate that deaf individuals are unable to think abstractly, it appears that deaf children need to be guided in developing their thinking at levels beyond the concrete" (Schimer cited in Storbeck 2003:15).

Some other comments from teachers who support this view include.

> There is no difference from weak mainstream learners because weak students can also not think in abstract terms (TE 260).

> They don't want to move from the concrete to the abstract (TC 74).

From the teachers' perspective, teachers experience a sense of frustration as a consequence of doing more for their students than is usually expected. Especially at the high school echelon entertaining this extent of teacher-dependency becomes both time-consuming and tedious. From a learner perspective, an associated consequence is that the learner is forced not to think. Subsequently, repeated episodes of over-accommodation from the teacher may impact student low performance in both class-work and homework and ultimately produce a poor work ethic.

Working from the assumption that the teachers' at primary school level maintain overindulgent roles in the ZPD and very traditional teacher-imposed approaches to pedagogy facilitating a stagnation in learner meta-cognitive process, is it then fair to expect the teenager who comes to high school to engage in abstract practices such as reasoning, hypotheses testing, logical sequencing and critical thinking? In contrast to the primary school's approach style of teaching through imposition, an inquiry based approach is implemented in the high school where students are required to reflect, recall and apply knowledge suitably. That implies practices such that learners must conduct research projects independently of each other, and students are encouraged to ask questions. The grade 9 year is their second year of experience in secondary school and they have not fully adjusted, still expecting to learn the old traditional way. Does it not stand to reason that we are deliberately putting the learner in the embarrassing line of fire in showing him up as the poor performer by immediately insisting on these practices as they enter high school mathematics? The Grade 9 learners became very agitated in the mathematics class when their belief that the teacher has the answer to mathematical problems were challenged by their class teachers insistence that to construct their own hypothesis and solutions to specific mathematical exercises and to consider how to apply mathematics to everyday life. It is in this regard that the art intervention as a study was useful. As explained earlier art follows a more guided learning approach and this style of pedagogy can ease learners' entry into an inquiry based system. Below, three cases have been selected to illustrate the adjustments learners underwent in the process of trying to mange their own anxieties at high school level, and thereafter to analyse the difficulties the learners experienced from a theoretical position. It is in this context that art surfaced as a powerful learning tool with therapeutic benefits.

5.2 Art as a vehicle for therapy

I would like the reader to focus on the range of negative behaviour that manifested and was described in these case studies as learners were trying to adjust to the high school's academic expectations and demands.

a) *The case of Nkoli*

> *Nkoli : (An angry look wiped across his face as his hands flay wildly in the air) "The teacher goes too fast. Mathematics is important right? But I need deeper explanations".*

Nkoli's outburst against the teacher is most likely a culmination of pent up frustration against his repeated failure in understanding mathematics (as is shown in his reports) couple with his anxiety over their inability to cope with higher level thinking and increased work load over the years (as reported by his mathematics teacher and other teachers who has previously taught him mathematics). At the same time, one needs to take into consideration Meece's notion that hormonal changes is during this time of life common and can add to mathematical anxiety. Although quiet during the primary years of their school lives, teenagers like Nkoli are now struggling through puberty and with the quest of finding themselves. The need for identity may be accompanied by false display of authority and power games as I observed in Nkoli's behaviour during this session. Further probing into Nkoli's behavioural patterns showed that similar immature power struggles with adults appears to be a frequent experience wherever he goes. It reaffirms his grandmother's statements of him being short tempered and verifies teachers' reports of his unruly behaviour at school and on school trip excursions. However, there are additional aspects of Nkoli's behaviour that can also be considered from other psychological views. His general playful behaviour is not modified to a more serious attitude during the mathematics class indicating an apparent reluctance to accept responsibility for his role in mathematics progress. According to Feurestein's cognitive research programme, behaviour such as Nkoli's needs a mediated intervention of self regulation and control of behaviour with a view to encourage children to accept responsibility for their own behaviour. In contrast, Nkoli's teacher adopted a different stance to explain his mathematical performance and behaviour outcomes during class time by retorting that he had missed far too much of foundation mathematics that it was almost impossible to teach him grade 9 level mathematics especially since he contributes little effort. The primary school teachers, however, defend themselves by passively emphasising that the work was taught repeatedly, but was for a reason unbeknown to them not retained.

b) The case of Andre

Another learner Andre, was introduced to language when he was 7 years old. Before that his mother did not know what to do with him in terms of communication. His delayed English language further adds to his inability to grasp concepts and sequence them. With deficits such as these, Andre, together with many Deaf learners may be limited in their use of logical thinking and therefore what they perceive in the immediate environment seldom makes sense if it is not explained in full by a facilitator of knowledge. Lack of a logical train of thought may impact a student's sequencing in problem solving, the crux of current mathematics. From research we can conclude that all children, to develop normally, need a language in which they can express their wants, needs, desires, fears etc. Vygotsky (1981) cited in Storbeck, (2003); Watkins (2004). In the absence of an active language immense frustration and behavior challenges develop. The tone of Andre's statements echoes such frustrations when he said:

> *I need motivation for mathematics. I need to go ask teacher for help every afternoon. If teacher refuses to explain me privately, then I will become indifferent (SA 6).*

Andre has a real desire to learn. However, only introduced to a signed language at the age of 7, he has missed out a great deal of meaningful interaction and therefore communicating with him is almost impossible. Like Nkoli in the paragraphs above, he too is a foreigner to the mathematics class. Further, Andre has restricted mathematics ability. He is a highly emotional person and appears to be in need of assistance on how to manage his emotional stress in all areas of his life.

c) The case of Erin

Findings amongst responses of other learners in this research divulge a resort to resilient form of pretences of being good at mathematics hoping to maintain an auspicious impression in front of their peers and teachers. Some students are too embarrassed to admit how far behind they are. For example Erin's father said: "Erin has always hated mathematics." His sentiments are echoed by some of the students during the focus group *sessions. The mathematics teacher is mindful of his dislike towards mathematics, according to the father's report, and is baffled at Erin's preference at spending many lunch breaks inside the class room as opposed to enjoying the time with friends as is typical of most high school students. He instead uses this time to write mathematics on the board. Although in grade 9, he copies pages of numbers and formulas from the grade 11 answer books, across the board, and tells his teacher that he enjoys and understands doing this type of mathematics: grade 11 level of work. Erin generally performs poorly therefore his behaviour appears odd. The case studies in the previous chapter divulge that Erin is hard-of-hearing and attended a mainstream school before arriving at this school. His fear of mathematics resulted in odd behaviour not necessarily mentioned by authors such as Bart and Newstead, but still I would argue, related to mathematical anxiety. I feel that Erin's outlook to mathematics may be related to some of his teachers working from an audistic perspective. Although his teachers did not plan detrimental outcomes, they did not expect as much from him compared to the other typical learners in the classroom. Erin's father confirms this hypothesis when he explained why he moved his son to a school for the deaf. He said: "Erin was being given awards we know he did not earn because the teachers felt sorry for him. Being with his own kind meant he would have fair competition".*

As the study progressed it was confirmed that art possesses measures of versatility with regards to dispelling emotional/confidence barriers similar in nature to those vignetted above. In analysing these overlaps with Bart's findings can readily be identified, yet it is necessary to acknowledge that Bart was working within a different education space. Whereas Bart dealt with hearing adult learners in a tertiary institution, this study concerned itself with deaf, secondary school learners. In spite of working within different realms of education, like Bart this study also found a definite shift in learner attitude towards mathematics through engagement in art activities.

Bart expressed enthusiasm over the effectiveness of art in breaking down fear-related barriers. An aspect she particularly commented on in this regard was the dissipation of the 'low self-efficacy' perception that was common amongst some of her art students and that partly related to previous failure and a strong dislike of the subject of mathematics. Students were asked if art helped them understand mathematics in general. Although compared to the pilot study class, the students in this grade 9 class responded less enthusiastically and showed less mathematical progress after the art invention, a positive change was certainly noted to which the segments below bear testimony.

> Andre: I feel that teaching art first and then doing maths later, helps me to understand maths better (FG 28).
> Utar: Yes, art has helped me a lot. For example with painting and ratio and using the spoon to measure and rotation. It does help me (SI 395).
> Drew: I need art to help me understand mathematics (SI 503).
> Kris: Yes, I feel art has helped me for example with ratio. What I have learnt in art, I understand better in maths (SI 121).
> Charles: When art and maths are taught together, I understand clearer (SI 140).

Similar to Bart's findings there are indications that relate to learner perceptions that art assists them in understanding mathematics better. Art seems to facilitate a learners' transition into mathematics by bridging specific barriers, in particular the fear and negative attitudes. Learners' responses also suggest that they are feeling confident in dealing with mathematics after the art intervention. The art intervention was able to provide the learners with fresh perspectives to the point where their old habits of mind did not dominate their reactions on the post-test and in depth personal interview sessions with stock responses about their dislike of mathematics. The learners were now expressing new ways with which to perceive and interpret their mathematical world. For example, they were relating mathematics and a 'sense of clarity' in a positive manner. Hence, the art intervention gave learners opportunity not only to build a mental prototype of a concept based on external properties of objects, but they were also re-constructing private representations in their inner world, which helped them to develop new insight and motivation. Whilst art can serve as a decoration or hanging in a gallery, the other purposes of art emerged during this study – ones that are connected to self understanding, a search for meaning and personal victory, self-esteem and healing. Essentially, the art intervention began to create such powerful image that resulted in the Grade 9 learners beginning to see their world in terms of mathematics, and not mathematics in terms of their world.

Another feature of the art intervention was its role in concept development.

5.3 Art as a tool in conceptual development

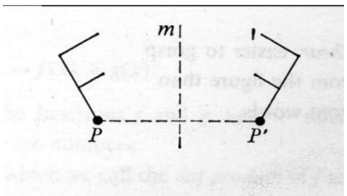
In addition to infusing learning with a therapeutical element, I argue that art intervention as was used in this study is powerful in affecting conceptual development at both a subject specific level and at a general level. At a general level emphasis was given to the place of particular mathematical concepts (symmetry, ratio, proportion) within the person's wider knowledge of the world and how it works. Using Vygotsky's way of thinking, one of the primary purposes of schooling is to develop and advance scientific concepts in learners. Vygotsky advocates that for mature concepts to develop scientific concepts has to link to every day concepts in meaningful manners within the ZPD. Working from within his framework, it soon becomes clear that concepts and conceptual development, and their dependence on forms of integration or connectivity, are primary features in education and in cognitive development. However, the trajectory of conceptual development in deaf children is often unique, considering that it is delayed or hindered by several barriers of which adequate access language is perhaps the most profound. The reasons why deaf learners' experience several barriers to language together with current thought on the nature and promotion of conceptual development were fore grounded in the literature review.

a) The cognitive benefits of the prototype

Essentially the idea of a prototype, as was defined in chapter 2, concerns building a concept through multiple entry levels by abstracting examples from the physical and socio-cultural environments in an authentic and meaningful manner. A prototype was tested as a means to stimulate conscious reflection in the learners and to build a (re)-establish both intra but in particular inter-domain relationships between mathematics and art. This was primarily done by exploring examples with learners of the two subjects's synergistic extension into real world applications. As was detailed in a previous chapter, the learners experienced cyclical exposure to the same knowledge but represented and applied in different contexts eg. the concept of symmetry as in the Taj Mahal building, in beauty therapy (make up) and eventually in the Cartesian plane within the mathematical context. This notion of multiple encoding is important in so far as the post-test results showed that learners were now more capable of theory building. An extract from the results of the intervention test bears testimony to this statement.

1. Can you think of a word you can use to describe this? (Referring to picture A below)
   Learner pre-test response: I don't know. (Shaking her head and shrugging shoulder)
   Learner post-test response: SAME. SAME
2. Have you seen this before?
   Learner pre-test response: No. Never! (Shaking her head)
   Learner post-test response: Yes
3. What do you think this reminds you of in real life?
   Learner pre-test response: (Shrugs shoulder) I don't know. Nothing.
   Learner post-test response: It reminds me of two flags or a ship.
4. How will you sign and explain this word [mathematical flashcard with word such as congruent, similar, reflection, symmetry]
   Learner pre-test response: I don't know. (Expression of disbelief) Difficult to explain. I may say "F" and "F" opposite. I don't know.
   Learner post-test response (Signs the word symmetry)

A.



Moreover, some of the learners indulged with the representations in a manner that produced creative and cognitively flexible outputs whereas before they would simply shake their head and utter mono-syllables at best. By contrast, at the end of the intervention they were telling stories and coming up with imaginative interpretations and usages of the symbols. The learners' attempts at theory building also show that they were beginning to exploit internal information that was acquired by presenting it in new formats. The shift towards increasingly access and explication of internal information may be positive indicators towards resolving some of the memory and transfer processes mentioned by the teachers of this school. Moreover, establishing relational links between concepts is both an aggressive and imaginative move towards breaking down the notion to compartmentalise significant aspects of deaf education. At school the timetable creates clear boundaries. In order to maintain a routine, it separates subjects, it separates activities and it separates time. This separation is physical in so far as the learners must commute from one classroom to the next at the end of each period. The question that emerges is the extent to which the cognitive activities in mental space subconsciously parallel the movements on the psychical plane? In other words does the mind divorce itself at the end of each lesson from what happened before and then reposition itself anew at the start of a new class? Or does the mind make room for integration across the school day and eventually across the curriculum? Bart (2007) suggests that tertiary learners are able to make connections more abstractly on their own, however secondary students need facilitation to lead them here. The post-tests results compared to the pre-test results show that the learners were able to recall significantly after the art intervention. Such pedagogic practice means aiding learners to make connections which in turn may help to trigger recall in classroom mathematics. An additional aspect of guiding learners into making connections relate to facilitating cognitive processes such as recall. The systemic and deliberate establishing of relational links is also important for counteracting the effects lack of incidental learning on reasoning. Lack of incidental language experiences

Research discussed in the literature suggested that a large percentage of incidental language leads to concept development. As was predicted, in the absence of incidental language significant gaps in concept development did exist among the deaf children in this school. A teacher, supports this statement and adds “Language is the barrier. Concept understanding is a barrier” (TC 275). Yet, learners of mathematics are still expected to master complex concepts and manage mathematical textbooks that do not necessarily have sufficient scaffolding to support their lack of exposure to incidental language. Considering Van Hiele’s argument that reasoning depends on making interactive connections between established concepts, one can imagine how gaps in conceptual development make it even more complicated to grasp further concepts and proceed to effectively ingest mathematics. Weak conceptual connections exacerbated by lack of incidental language experiences, may thus be responsible for a fragmented form of cognitive mapping which further impedes reasoning powers and recall.

b) Recall

Following on from the ability to associate prior mathematical knowledge with new knowledge, Vygotsky (1978) cited in Macdonald, 2001, p 409, advocates that children's "thinking depends on memory that in teenagers the function of the memory is reversed". The connotation here is that, in younger children "to think means to recall; but for the adolescent, to recall means to think" (Vygotsky, 1978) as cited in Macdonald, 2001, p 410). Teenagers at the project school find it difficult to recall, a process evident in Erin's following statements: "It is difficult. It is hard, same as a rock. I struggle and struggle. I forget all the time…a lot of things like area and other things." The questions that emerge are concerned with which factors may be impeding the recall of deaf students.

Teachers at primary level support the fact that poor recall is due to a multitude of factors. One such factor is inadequate supervision during homework time.

i) The connection between recall and homework

Ineffective supervision means that class-work is not reinforced sufficiently, findings uncover. For the students who travel to school daily, parents' are expected to make sure homework is done. Some struggle with helping to reinforce content their children do not understand often because they do not have adequate S.L. to teach their children the content and also due to having insufficient subject matter knowledge themselves. Other parents finish work late and do not have the time to work with their children. The students who board at the school have a special time set aside for homework. Two educators supervise homework for one hour each day. Being one of the educators supervising homework twice a week for the past ten years, I fully support the concern regarding homework. Over the years we have raised concerns regarding the structure of homework. To elucidate further, students from grade 3 to grade 12 sit in the school hall for homework. It is almost impossible to facilitate challenges each learner has with homework due to time constraints and knowledge of subject matter.

Another challenge is that students in the primary school finish homework in twenty minutes during a one hour homework slot. It is difficult for the homework supervisor to assess if all homework has indeed been completed at all. That means the supervisor has to test each learner in the primary school to verify this. For those high school learners offering an academic course, one hour of homework time is insufficient in view of the new FET syllabus they now follow. Whilst they work hard to get in as much homework as they can, other students offering the skills courses do little or no homework. Therefore a rather poor homework ethic exists at the school. Yet another concern teacher's have is the students' lack of attempting homework as a result of disapproving peer pressure. Such attitudes and resulting behaviour are further hindrances to poor understanding of mathematical concepts.

A case in point for example: one mother intercepted her son's SMS was surprised at the message she read. It indicated that nobody should do any mathematics homework which was due the next day. This message was sent to other students in the class as well who without question followed the instruction. The plan was that the next day the teacher will believe that there might be something wrong in her method of teaching as nobody was able to complete the homework. The mathematics teacher at the time changed her method of teaching and the books she used several times as a result of the class simultaneously "not understanding" the work. Such is the level of social immaturity and mischievousness among the students. The educators are not sure where this stems from. As a result of this attitude, at the start of the next day's work there is little or no foundation from the day before because it is forgotten and students are back to struggling with making appropriate connections. Many times teachers re-teach the lesson starting from scratch as a revision and then add on another concept during the same lesson in the hope of making the connection more visible to learners. Such an activity works at the start of a school term but is impossible to maintain as the body of knowledge snowballs. Time does not allow constant re-teaching. It is important to note though that if teachers continue to make the connections for their students then they are not teaching learners to think for themselves. It is difficult to strike this balance. Teacher B reflects and reiterates:

> Yes, recall is a problem. I teach them. I give examples. They find it difficult to follow examples. I give them homework but there is no supervision at home. Supervision is not happening in the boarding school either. Therefore they make no connections between prior areas they learnt and the new work. For example, I do vocabulary

> in one subject and a while later they see the same word in another subject, they cannot remember it. I tell them, to look in the relevant subject book to find the information we just used. It is totally foreign to them. But they do not recognise words when placed in other contexts. It is totally foreign to them. Some remember when they go back to the original context. I have to do a lot of repetition. They don't bother to listen the first time. But I think we make them lazy by repeating so much.

ii) The connection between recall and speech therapy

Drawing on patterns in the findings it surfaced that there is a pocket of teachers in the school who believes that continuous speech therapy from early age may be beneficial to recall (TI 310). Teacher M explained how the learners in her class suddenly started to improve. She said: "Recently speech therapy was started with some students in the school. I see an improvement already. Personally I see a link now between speech and recall. They are using both senses-hearing and seeing. Normally a deaf child uses only one sense, seeing" (TI 310).

iii) The connection between recall and teaching methods of the past

As discussed earlier, traditional methods of teaching are still implemented. The child learns what he is given and gives this back to the teacher. The learners don't have their own answer but believe that there is only one right answer and that the teacher possesses it. This is not an indictment on the deaf child. It is the way he has been taught to learn. However, traditional methods may impede imaginative thinking if it means that a learner must recall a concept or a section of information often not fully understood. Unable to remember a concept, makes learning difficult. Therefore, recalling later either during the same lesson or in subsequent lessons is problematic.

Ultimately poor recall does not only affect the learners own delivery, but also that of the teachers. Von Glasersfeld (1987) says that a child must find a solution to a problem with material he already has. That material refers to the conceptual sequences of knowledge he has arranged for himself from prior experiences. This is so since, when a concept is not understood at its most basic level there is nothing to build on. When the learner already knows something it is easy to build on and expand from that (Ausubel et al. 1978, cited in Macdonald, 2001). Observations and teacher interviews witness, in many of the deaf students in the grade 9 class, there is either little experience or little or no recall of prior experiences. This school sees the primary school learners being passed from grade to grade without grasping prior knowledge of the concepts needed for high school mathematics. Conclusions may be drawn that if concepts are not fully understood there will be little or no recall and therefore little or no understanding. High school teachers hold the mathematics teachers in the primary school responsible for not bringing the students levels up to standard since in a mathematical context recall is particularly problematic among the deaf learners (Pagliaro & Lang, 2007). Aspects of cognition such as recall can be influenced by linguistic ability.

5.4 Art as a language builder

As was explained in Chapter 2 the prototype had two parts, viz. a knowledge element and a semantic connection. These were treated as two separate entities. With regards to the latter, any attempt to introduce language development at this particular institution has to be filtered through and considered against the light of the historical and political trajectory of the school. Attempts have been made largely by the hearing community who are technically outsiders to the deaf community; for example educators, doctors and legislators in a manner similar to what Simms & Thuman (2007) refer to as "trying to change either the method of instruction, the mode of communication, or deaf children themselves" in search of answers to the literacy challenge.

Following on from this argument at this school, over the past ten years, hearing teachers here have tried to change the method of instruction by receiving training in literacy programmes overseas and then implementing it on return. The success these programmes encounter in first world countries cannot replicate succinctly in South Africa, a third world country. Therefore when tested minimal success was experienced at this school. Whilst the hearing staff focus on literacy programmes and their associated philosophies, many of the Deaf staff members lobby instead for single-mindedness on Signed Bilingualism. Signed Bilingualism means that students use Sign Language as their language of communication and learn the written form of English at the same time. Although the principal of the school supports educating the deaf child in this manner from primary to secondary school, the actual management of a bilingual system has proved complex. At the same time the school has created a partial support system for learners who wish to improve their speech practices. Consequently, those students who choose to learn speech are encouraged to see the speech therapist who visits the school weekly. Thus in spite of a documented policy on Signed Bilingualism, in practice a space still exists for oralism and other alternative modes of communication what is commonly called 'Signed English' in the context of the school, but practiced in a format that does not necessarily comply to those of the true standards of a Signed English system. Although the oral route is a suitable means to educate some deaf students and in particular those who are hard of hearing, it goes against the beliefs of the strong group of culturally Deaf teachers at this school (Swannack & Chowles: personal interview on 4 November 2008) [11]Further, these Deaf staff members from personal experiences express that Deaf students struggle using the oral mode of communication as it is not their natural language and therefore have difficulty grasping concepts.

In line with the SL challenge, knowledge of a *common* SL is a trial especially at high school level. At this stage SL is not only a contest because of the teachers' limited signing but because many of the students themselves come to the higher grades with minimal signing skills for a number of reasons. As a result of this some of the teaching staff members are more knowledgeable of signs than the students themselves. Further, because of poor literacy levels in general students and Deaf staff members cannot teach hearing staff new signs as use to be the case in the past. For example a hearing person asked five Deaf adults the sign for the word 'sincere'. Four did not know what the word meant. It was explained to them by using examples before they understood. They then gave the teacher the sign for another word 'true'. A sixth Deaf adult, who was asked, immediately knew the sign because she was familiar with the concept sincere. Hence, although the official language policy of the school is Signed Bilingualism, miscommunications seem common at this school and consequently magnify the students' problem since both modes, English and Sign Language now present a barrier and thus access to information is denied. This situation of lack of conformity to and fluency in SASL is understandably a major irritation and struggle for learners and one that learners repeatedly voiced in the study.

[11] Swannack & Chowles: personal interview on 4 November 2008

Teachers felt that the logistics of access to information was further compounded by pressure to write national exit exams through English as an additional language and learners entering into formal and informal spaces where they are exposed to and need to relate to multiple language and cultural interactions.

a) English as an additional language

Both the lack of being able to access incidental language and learning experiences spontaneously, compounds the learners difficulty in deciphering written material meaningfully. Hence, it has surfaced that pressure is placed upon deaf students to first familiaris themselves with the vocabulary, placing the vocabulary in a mathematical setting and then attempting to solve mathematical problems. A learner, Erin, protested that 'it is difficult. Some are so hard…same as a rock. I struggle and struggle. I forget all the time' (SE 336). Similar language difficulties may be experienced especially by students who are second language users of English as are the deaf learners at this school. Full attention can therefore not be given to the mathematical concepts, as focus needs to be diverted towards the cognitive demanding task of code-switching. Subsequently, mathematical activities becomes even more complex when one considers that the learners need to translate meaningfully from English to Sign Language to mathematical symbolism before being able to effectively address the questions posed. This not only affects the learners but the teacher's own lesson planning as well. Teachers may find themselves diverting to lengthy English explanations of a word, whilst sacrificing the actual mathematical content during a lesson.

By their own admission, based on experience teaching deaf learners, teachers confess that deaf learners in their classes are poor readers and that in general literacy levels are low. Therefore not maintaining a focus on developing concepts but rather allowing the mathematics lessons to evolve around the procedures is an obvious oversight due to pre set work that has to be completed within a stipulated period of time. Therefore teachers continue to teach, allocating minimal time to literacy development. Given the status quo that poor literacy is a common issue in deaf education, they continue to teach typically in spite of. It could also mean that because teachers are overlooking this important link literacy can make, students are possible underachieving.

Teacher M, has a teaching diploma from a local university and teaches the grade3 class at this school. She is a hard-of- hearing staff member and chooses to align herself to the Deaf community. Teacher M says:

> As soon as language is introduced then children come up with barriers. These are cognitive barriers. There is no first language compared to hearing peers. These cognitive delays seem to interfere with their understanding of mathematics. Also hearing teachers don't understand how to teach deaf children. Maths needs to be perceptual for deaf students. First you use objects the learners can identify with like apples and cakes. Then you teach math. Maths can't be copied out of a text book. Some teachers sign and speak at the same time. That is not proper signing. So the child is not learning any new concepts. The deaf child is missing out a lot in this way (TI 240).

It is of interest to this research that Teacher M was also an ex student at this school. She was taught the oral route, a time in the early life of the school when no S.L. was allowed. She is also fluent in her speech. Her ex-teachers say that they spoke and signed to her…a mode of communication they still use when communicating with her today. FM Systems were used in her classroom to amplify her access to the spoken word. However she has chosen to teach her classes through the medium of SASL, voice off. She advocates that concepts can best be learnt via Sign Language. Her biggest frustration in the mathematics class is that the class is not able to understand the literature in mathematics. Moreover it is assumed that if a learner fails to improve in literacy it is due to the learners own inadequacy. Deafness impairs linguistically (Magne, 2003). Therefore the teachers need to modify lesson plans to accommodate the level of learners vocabulary. It is seldom reasoned after introspection that the failure may be the result of the teachers' poor communication skills (Johnson, Scott & Erting, 1989).

One needs to bear in mind that the learners' challenges with English literacy may also be related to the rich diversity of their upbringing.

b) A background of multiple languages

Learners are raised in a South African society where multiplicity of languages and cultures are hosted even within the same family or household. Hence, very often, although Sign Language is the students' first language, Zulu is the second language and English the third. Teacher L affirms that this is a problem since: "the learners are exposed to too many languages. They are exposed to Zulu at home and English at school." The educator using English and some signs is targeting lessons at an almost inaccessible level since the student is unfamiliar with English. A Deaf staff member, teacher L, affirms this:

> Because the language is not fully understood they have no foundation to the basics in thinking and reasoning. It also affects their reading, writing and speaking. SASL is their first language and parents do not learn it. So really, there is no first language. Combined with the fact that there is also no early detection and diagnosis of deafness, there is therefore no communication at home. So they battle to understand.

Given that these students have barriers to language; another challenge which may arise out of a lack of knowledge is the possibility of failing to recognise dyslexia. This is a potential rationale for students' inability to learn to read.

c) Dyslexia

Although the syndrome of dyslexia was discussed in the literature review, the topic of this dissertation does not allow an in depth investigation into dyslexia and the deaf learner. Yet, possible signs of dyslexia have been noted during the research. Along the continuum of dyslexia is the inability to clearly identify colours and shapes, (Clayton, 2005). Observations reveal similar experiences in classrooms, in both the primary school and high school. These are briefly mentioned below, but will require further and more deliberate investigation in another study. Teacher E corroborates this notion:

> The other day I asked Tom to put a green file on top of the red one. He was so confused. He walked around the classroom not knowing what

> to do. I noticed that when he is exposed to two different items and two different colours he is always confused. If there are both green or both the same colour he can correctly identify the colour.

Although colour confusion is one of the possible signs of dyslexia, as is seen in this case, the teacher did not consider this. Instead the resolve was quickly associated as a 'deaf issue'. Gray's (2005) research, *Troubleshoot guide for the bewildered,* provides parents and teachers access to suspected dyslexia by drawing there attention to telltale signs. Furthermore, a trend at this school reveals that when parents are unable to contribute to the child's academic performance in the form of homework, the child's progress is delayed. These issues are probabilities but until tested cannot be conclusive. Furthermore, there are volumes written on how to educate children who are dyslexic and special exercises to correct and reinforce letter and number formation and colour correction. This information is further expanded in the literature.

Against this conglomerate of linguistic formats, the art intervention played a significant role to facilitate semantic development of important concepts in a way that would be both accessible hands-on and enjoyable.

Hence, through using art as a language builder, deaf learners where able to establish communicative report without being confronted with the need to defend their deaf identity. Rather, the learners seemed interested in the concepts and enjoyed the challenge of code-switching and re-encoding information into alternative formats.

5.5 Refining social skills

The personal development of the learners as indicated by the pre and post intervention test shows that the products and processes of the art intervention increased awareness of the world, of self and of others.

According to class observation the extract below paints a picture of individual students' attitudes, experiences and personality differences all of which impact mathematic performance (Bottge, Heinrich, Chan & Serlin, 2001). In this extract a teacher facilitates a discussion to encourage learners to take responsibility for their actions and come up with solutions to the mathematics challenges they faced.

> Teacher: Why do you struggle so much with mathematics?
>
> Erin: But to be honest, I am lazy with maths(SI 376).
>
> Erin: Before the exam, I did not study for maths for two weeks. I felt lazy. I did not bother. I thought I could pass. The government gives me lots of work and makes me tired…. But when exam started it was difficult. I forgot everything. I have a memory problem (SI 387).
>
> Utar: Mathematics is difficult (FG1).
>
> Teacher: Which areas don't you like the most?
>
> Andre: Everything in maths, I do not like (SI 290).
>
> Andre: I hate math. But it depends whose teaching….when I am cross with the teacher I will not do my homework to get back at the teacher (FG 4).
>
> Kris: I think I will try to stop talking so much (SI 234).
>
> Charles: We will stop talking! We will sit like nerds. When we keep talking, (teacher) must put a white cardboard between us so that we cannot see each other (SI 236).
>
> Nkoli: Putting up a board is abusive. We must be free (SI 238).
>
> Kris: We must not have the tables arranged like this, where we can see each other. It must be like a hearing school where we sit behind each other (SI 240).

Another student retorted that then they would all need to turn around and look at the person talking (signing).

> Kris: That is fine. We can turn around and look (SI 242).
>
> Nkoli: 'That is not fine. Sometimes you turn around and the person is already finished talking (SI 243).

> Charles: If a person needs to sign the answer, the person must go to the front of the class and then go sit down again. Each person needs to do that for every answer (SI 244).
> Nkoli to Charles: You are being silly (SI 246).
> Andre to Charles and Nkoli: You must be serious and stop looking everywhere and focus on maths (SI 248).
> Nkoli: No! (SI 249)
> Andre: Concentrate (SI 250).
> Charles: No! (SI 251)

The above extract reveals the maturity levels of the grade 9 class. Whilst some are advanced and honestly desire answers others display a child-like posture unable to see mathematics from their peers' perspective. This research identified 3 areas of lack by deaf students that most need improvement : accepting responsibility for one's actions; awareness of one's values, strengths, weaknesses, interests, and goals; and making sound decisions.

Consenting that students generally possess a pessimistic view of this subject, Courant (1953) as cited in Grattan-Guiness (1994, p 1) adds that a negative sentiment towards mathematics is not a new observation in the research field. He attributes such a disposition to the place of mathematics in life and society, and especially in education. Consequently, in spite of the disparities among the learners in this grade nine class, they stood united on issues of disapproving social behaviour. One student, Kris, introspected and for the first time admitted to too much socialising in class (line 234) He was abruptly interjected by Charles with contrary and negative views to Kris' desire for positive change. As the discussion progressed a barrage of well thought of interjections ensued. Observations by the teacher researcher disclose that self esteem has never been so high before.

Using the class's spirit of co operation (with each other) the teacher tried to channel the negative influence they were having on one another to a more positive one. Empowering the learners to think independently of each other and the teacher, they were asked to set their own goals every two weeks.

When asked what changes they wanted to see in the mathematic class the following week the students suggested dividing the mathematics class in two groups according to individual levels. This was done successfully in the English class they said.

They were sure their attitudes would change and results would improve if they were grouped. The students discussed how attitudes and behaviours could change to bring about progress in mathematics.

> Charles and Kris: We want to be in the high group (FG 317).
>
> Utar: I want to be in the low group (FG 318).
>
> Nkoli: Kris. Do you want a high level of maths? (FG 320)
>
> Kris: I don’t know (FG 321).
>
> Utar: You said you wanted to be in the higher group (FG 322).
>
> Kris: I don’t know (FG 323).
>
> Nkoli: I want a low level (FG 37).
>
> Andre: It is not important which level you are in. Make one class- include the weak and strong in one group (FG 38).

Andre protects his self esteem by encouraging the class to stay in one group. He is one of the weaker learners and will fall into the weaker group if the class is divided.

> Kris to Andre: How do you feel? Do you want work of a high or low standard? (FG 39)
>
> Utar to Andre: Both of us need a low level (FG 40).

Andre remains non-committed and Utar answers for the both of them offering Andre support that he will not be alone in the weaker group. Andre retorts:

> Andre: I need work of a high level. No. A middle level (FG 41).
> Charles: I am down- up down (FG 42).
>
> Utar to Charles: You must choose (FG 43).

Kris and another student communicate with each other with their eyes (open eyes wider and roll over in direction of speaker). We track Andre's thoughts and find him to be avoiding the group system at all costs.

> Andre: If I am in the weak group and I have a problem can I ask someone in the strong group to help me? (FG 45)
>
> Nkoli: Kris, you are lucky to be so clever. Not like the two of us. (Referring to himself and Utar) (FG 46)
>
> Kris: You are missing the point. Focus on the topic (FG 49).
>
> Utar to Andre: If you always don't do your homework then how are you going to be helped? (FG 50)
>
> Teacher: How can we help Drew? He is always not doing his home work.
>
> Andre: She does not do homework that's why her mathematics levels are low (FG 53).
>
> Nkoli: I do no understand mathematics at all (FG 94).

> Utar to teacher: Nkoli is not interested (FG 95).

A few students did not agree with the issue of grouping:

> Charles: If we have two groups with different levels the teacher will waste time. It is better to have one group (FG 313).

During these focus group session learners worked towards a solution for the first time. Although there are hints of deviating from the point, the main discussion evolved around the formation of intellectually similar groups. Almost immediately the learners started classifying the groups naming them *high* and *low* according to abilities. This broke out into an argument with learners not wanting a low classification. Eventually Andre finds a solution to the challenge by 'inventing' a "middle level" (line 41).s None-the-less the challenge has already seen him classified into the low group and this must affect his self esteem. There is thereafter an observed deviation from this topic to 'homework' and a focus on an attempt at associating poor mathematical results with lack of interest in homework. The learners, even those guilty of habitually not completing homework, challenge each other. Charles concludes in line 313, by proposing to scrap the group system.

This excerpt reminds one that the role of social skills in learning has also undergone renewed scrutiny. Social interactions in this study served as an early warning system to the teaching signalling topics and experiences that the students find troubling and off-putting but also conveying what students pleasurable to engage in. Creating an educational environment to sustain this type of negotiated interactive dynamics is important. Part of the significance of such a system, is that social facilitation amongst peers can structure and influence their willingness and commitment to participate in education. It also teaches them how complimentary and conflicting messages can somehow be represented and reconciled through social pragmatics. One is also reminded of Vygotsky's position that social engagement produces higher levels of cognitive functioning and more robust logic. Although this particular type of interaction took place in the context of mathematical classroom issues, the previous section on conceptual development has shown how art can bolster the process of mapping words and signs onto actions, thus affecting social interaction.

Thus far the study has largely focussed on the deaf students and their cognitive and linguistic challenges. However, this would be very one-sided if one fails to comment on how teachers contribute to the present scenario in South African deaf schools such as was investigated in this study. One of the biggest concerns regarding teacher characteristics is their lack of formal qualifications in deaf pedagogy.

5.6 Teacher qualifications

Research among mainstream schools in South Africa reveals that "the result of poorly qualified teachers has had international researchers rank South Africa 120th for mathematics proficiency levels" (Mohlala, 2008 p2). Deaf students experience two setback in mathematics compared to their hearing peers. One is that some of their teachers are unqualified to teach mathematics and secondly these teachers are also unqualified in Deaf education. The reasons for the challenges related to mathematics as seen through the eyes of the school's senior staff members reveal the need for better qualified teaching staff, one staff member hypothesised that the lack of highly qualified teaching personnel was the result of the poor mathematical performance. Teacher M: "This can be compared to the teachers in rural areas. They have the same attitude: a lack of effort because they are not necessarily the best teachers out there. The maths problem in this school is a teacher problem not a kids' problem and can be compared to the maths problems in rural areas for the same reason" (TI 258-259). This statement implies that the current school does not have the best mathematics teachers and therefore poor results are a reflection of poor teaching and poor outlook to educating the deaf learner. These claims are supported by global research which states that "It is a common practice in the education of deaf/hard-of-hearing students to assign mathematics teaching responsibilities to teachers who do not have degrees or certification in mathematics education" (Lang & Pagliaro, 2003:449). The statement by Lang & Pagliaro (2003) corroborates with Teacher M's observations evident at this school. There are simply insufficient qualified teachers in both fields to place at schools for the deaf in South Africa.

5.7 Summary

Taking into account systemic barriers produced by the transition into OBE, cognitive, linguistic and experiential risk factors associated with deafness, and characteristics of teachers such as low qualifications and audism, I feel that the art intervention contributed much to the needs of deaf learners. Art was found to encourage theory building through the conscious construction and exploration of analogies between art and the real world. Through the intervention learners managed to take implicit knowledge acquired through activities and make the knowledge explicit. There was also evidence of the representations in the post test becoming more manipulable and flexible providing evidence of conceptual development. At the same time the art intervention had therapeutic aspects with regards to removing fears and insecurities and slowly replacing it with perceptions of self-efficacy and feelings of progress and confidence. How to sustain these positive outputs and take them further will be detailed in the following section.

CHAPTER SIX
SUMMARY, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

The purpose of this study was to investigate the grade 9 students' responses to an art intervention process. This intervention was deemed a worthy initiative after positive responses from a pilot study conducted on a different mathematics class the year before. The grade 9 class was chosen since the motive for this investigation was to prepare and then evaluate the grade 9 learners for Further Education and Training (FET) mathematics. The evaluation process involved testing the learners before and then again after an art intervention programme. The focus was on learner responses before, during and after the intervention to establish its success. The responses of the individual learner were taken into consideration by observing classroom behaviour and by interviewing parents, teachers and the learners themselves. In particular this study evaluated the contribution art made, in developing mathematical concepts in the deaf learner. The class observations also made available valuable information on the role of art in enhancing varying degrees of confidence in the mathematic class and in expanding world knowledge by indulging learners in a range of art activities. This is evidenced in this study by what learners have demonstrated during interviews and by class observation.

Two researchers worked simultaneously during this study: the mathematics teacher and I, the art teacher. The role of the mathematics teacher in my study was to objectively observe and record the students' responses during the art lessons. Furthermore, when students attended the mathematics class after the art intervention, the mathematics teacher was again able to observe and document student responses in her own class and compare these to before the art intervention. On a few occasions, I documented my own observations with regard to student's attitudes and their general responses to mathematics and the teacher during the mathematics lessons. On the whole we remained working within our own subject disciplines and correlated content.

The following paragraph provides a summary of the actual intervention process. The art intervention program was designed and included creating a prototype (model) of a mathematics concept that established a clear link between mathematics and the real world. A model of a concept is created to this end by associating the concept to various situations it can be used or found in. The model is further linked to the English language and SL. How this ensemble of real world situations is internally associated to the concept is eventually synthesized, abstracted and tied to a single word or sign is difficult to answer in terms of actual pedagogy. My own answer, though, is that the more time and effort one devotes to creating this model, the more likely it is that learner will make appropriate connections.

For the purpose of this summary one mathematical concept will be used to explicate the intervention. It must be stated that there is no single privileged way to enter the learner's mind in developing a concept. An educator must draw on base-line assessments of learners within the classroom and couple that with blends of attentive imagination.

6.1.1 A summary of the art intervention

It was necessary for the students to understand the term "reflection" as the mathematics teacher intended teaching the Cartesian plane. Conducting a base-line assessment, she realised that the students did not understand the concept. They could not recognise the word nor did they know the sign. Therefore she would have to first teach the concept wasting much of the limited time allocated to mathematics. It was as that point that I used art to intervene and to develope the concept of reflection in the learners during the art lessons.

a) Pre-intervention test

The learners' ability to express their thoughts through words and through SL was initially assessed. Moreover, their capabilities in associating mathematical symbols with real world knowledge were analysed. The same test was administered to all students. It was discovered that in general the students were unable to relate symbols to real world examples, had no knowledge of or could not recall an English equivalent and had a *concrete* understanding of the symbol in SASL. Furthermore, learners were reluctant to attempt an answer for fear of being wrong. When persuaded to try, they either refused or displayed impatience at the testing.

b) The art intervention

I integrated the word reflection during both my theory and practical art lessons with great ease. I encouraged the students to create patterns with their initials by reflecting them. When asked what they had done they used a sign they usually use for “opening a book” to explain. I wrote the word reflection and associated *their* sign with the word. I showed them pictures of the reflection of a sunset in water and they use *their* sign for reflection to again explain. In art theory, I taught a lesson on the Taj Mahal. At the first sight of its picture they signed reflection because the building is also reflected in water. They also sign “SAME-SAME” with reference to the symmetry of the building. I locate and learn the correct sign for reflection and symmetry from the Deaf educators and demonstrate these. After several references to everyday life objects students were able to demonstrate a ‘stored representation’ of two concepts (Skemp, 1998): reflection and symmetry. Their world knowledge evidently broadened in the process.

Once again there are no fixed entry points in creating this ‘stored representation’, but when an interest has been created, the moment should be grasped and students should be brought into full contact with rich topics. The memories of these rich art experiences seem to have influenced the learners as is evidenced during the post intervention test.

The mathematics teacher then proceeded to teach the Cartesian plane again. This time she observed an enthusiastic responsive class and was able to get on with teaching mathematics instead of delving into the mathematical vocabulary at length.

To underscore the central point, the creating of a model, none of the individual experiences or projects can be said to be solely responsible for expanding the concept. All contribute. It is the learner whose memory is able to interweave the processing of these individuating features and piece them together who ends up with the most succinct understanding.

Other concepts which were developed and extended in the same manner include: symmetry, rotation, reflection and ratio.

c) Post-intervention test

After the art intervention programme the same test was administered again. The test involved presenting learners with the identical set of questions they were asked one month before the art intervention occurred. Results were elicited through tests, questionnaires, observations and video recordings. A distinct positive outlook characterised learners' responses during this session. It seemed as though the inter-subject indulgence further served to broaden learners' world knowledge boosting confidence. Hence, when learners were tested during this post- test session they were now able to articulate their thoughts through SL with visibly renewed confidence. By and large the learners saw relevance in learning the particular concepts not only to mathematics but across the curriculum, to their own lives and in the real world.

6.2 A summary of the study

The research was set at a time when much criticism evolved around OBE. Schools in general struggled with its implementation. School for the deaf faced equally challenging processes of restructuring to accommodate OBE; a situation which agitated the internal educational framework by introducing challenges relating to interpretation, time managements, collaboration, integration and interaction with stakeholders in deaf education. On the whole, the traditional pedagogic atmosphere at the school found learners who were mired in mediocrity, very teacher- dependent and largely lacking in conceptual understanding. Referring back to Vygotsky's theory of how learning should occur in the "zone of proximal development" one finds emphasis on facilitation between the learner and the teacher. However, within the context of the research the teachers do not necessary uphold the participatory nature of the developments in the ZPD. Rather, they tend to go beyond mediation, facilitation and participation to 'doing everything for the learner' at primary level. Therefore when learners are placed in a mathematics class in the secondary school and are expected to carry out tasks specifically related to the subject, it was found that the grade 9 learners were unable to function at levels typical of grade 9 learners with reference to the mathematics syllabus at hand. *Understanding* of the basic mathematics concepts have proved to be the main deterrent in the quest to solving mathematical problems among the deaf children here. When learners were confronted with different mathematical tasks diverse unconstructive reactions on a continuum of behaviour dispositions were stimulated. As an outcome of adverse conduct, learners made a great effort to focus. Stemming from this lack of concentration, interaction between teacher and learner fluctuated. Consequently communication was a strain between learner and teacher. However it was not fluency in SASL that was identified as the barrier but a lack of conceptual understanding and the inherent frustrations that followed which gave rise to discord within the mathematics classroom.

In spite of the pedagogical framework peculiar to this school, deaf learners had to be prepared to write the common task assessment (CTA). The focus of the CTA is on problem solving. This required a high level of conceptual acuity which deaf learners lacked. It was hypothesised that art can be used as a tool and a platform to form pathways of access to mathematical concepts in order to prepare learners for the CTA and ultimately for FET mathematics during the learners senior years.

Art was able to facilitate conceptual understanding within the OBE framework as it seemed to have adapted more readily to its restructuring and OBE philosophy as a whole. A contributing factor may be that my art department has always been underpinned by "hands-on" philosophies advocated by OBE. As a subject, art has also attenuated the practical side together with theory, thus never allowing the displacement of 'knowing how' with pure theoretical constructs but rather nurturing it by encouraging active engagement and conscious reflection. The didactical split that OBE implementation thus came up against in other subjects between knowing and doing remained relatively absent within the art class environment allowing for a much smoother transition into roles where teachers become facilitators and learners become co-producers of knowledge through authentic art activities.

During the course of writing the dissertation connections with literature on the role of art in conceptual development were established. Moreover, attempts were made to prove in a South African context some of the internationally researched ideas about an apparent need by deaf children for guidance in developing their thinking to levels beyond the concrete (Schirmer cited in Storbeck, 2003). Vygotsky corroborates and advocates mediation to guide the student's thought processes (Dixon-Krauss, 1996, cited in Storbeck, 2003). This study supports Vygotsky's pedagogy by the results of experiential investigation, testing and evaluation. Therefore with this in mind an attempt was made to assist the deaf learner to move away from the concrete to higher levels of abstract thinking using the art as a channel. Several case studies, parent and teacher interviews paint an explicit picture of the characters of learners in the grade 9 class. Findings revealed that:

- When the mathematics teacher used a word they had already learnt in the art class, learners became more confident for the duration of and after the mathematics lesson. They then paid more attention to subsequent mathematics lessons and focussed on the mathematical content at hand. Learners displayed confidence in responding to questions irrespective of the ‘wrong’ answers they might be offering.
- Some of the students became aware of an association between mathematics and real life.
- Student interviews revealed that beliefs and attitudes about mathematics changed positively.

6.3 Recommendations

By the time this study drew to close, audible whispers echoed the echelons in the DoE declaring a likely removal of OBE from the school structures. In spite of this possibility, following on from the findings, I recommended that, at schools for the deaf, integration across the curriculum is the key. Accordingly, I recommend that art should function as an integral part of creating pathways towards the goal of mathematical conceptual attainment. Mathematics is enriched using art and serves to create a calm environment where learners do not feel threatened if they get an answer wrong. This relaxed environment provides fertile ground for learners to explore their minds on paper. This application of mathematics may seem ideal. Yet it is an attainable ideal if educators are free to use different strategies that work for them in their mathematics teaching.

It is further recommended therefore that regular staff meetings discuss the way forward. Educators need to be reminded of new pressures and opportunities in the world today; ones that were less visible during their own school days. Throughout this process the school leader should voice its vision and receive contributions from the staff. As far as possible the teachers themselves should embark on learning. They need to stretch their understandings of relevant materials and procedures by improving their knowledge in deaf education. Only then will there be a chance that they will be able to do the same for their learners.

The quintessence of excellence in Deaf Education will be realised when only teachers who are qualified in Deaf Education are employed at schools for the deaf. Teachers who are otherwise involved in education the deaf learner must keep abreast with the latest information on the education of deaf learners by reading or improving teacher qualifications. In line with this, a positive approach to Deaf Education is envisaged promoting high expectations among teachers. In addition teachers of the deaf across the province and across the country should work in partnership with each other. Deaf education is unique in that it presents a set of challenges foreign to other schools. This fact should activate a bond among all schools for the deaf across the country.

Partnerships with the DoE should be strengthened and ongoing with a view to enhance effective change. For that reason, the DoE should structure support groups and work shops specific to deaf education. Currently, teachers at schools for the deaf attend workshops together with mainstream schools. They then come back and grapple to implement the theory they have learnt in their classroom practice. Hence regular meeting of teachers of the deaf, coupled with classroom- based support has been recommended. Teachers who are new should be orientated within the school and become part of a support structure for new teachers.

As far as the most significant role player in the deaf child's life, the parent, the school should initiate drawing these closer to the educational platform of their learners. For too long now, parents are blamed for lack of accountability yet little constructive effort is being made to get them on board as participating role-players. It is given that parents play a pivotal role in expanding concepts in their children but give up this responsibility to the teacher or school houseparents because by their own admission, are unfamiliar and uncertain with the peculiar needs of educating a deaf child. Parents therefore need positive exposure to the possibilities of extending a deaf child's psychology instead of fretting over their weaknesses.

Every individual has strengths and weaknesses. One way to identify and build on parents' strengths is to hone in on home visits. From my own experience one home visit fosters a more intimate bond with this significant role-player in the child's life than several quarterly joint parents meetings held at school. In this way the school creates a sense of a community that cares.

6.4 Limitations of the study

There were a number of limitations whilst carrying out this study. The study was conducted across two classrooms by two researchers. When I was in my classroom, I was full participant researcher. The role of the mathematics teacher was to observe interactions and provide results from the observations. We swapped roles when I then sat as a silent observer in the mathematics classroom. Although the researchers were known to the learners it is not common to have two educators in the mathematics classroom during a subject especially since the teachers were known to teach different subjects at the school: art and mathematics. Although the research situation was explained to the students this could have evoked self consciousness among the learners and may have resulted in a slightly different response to their subject teacher than normal.

Although Mathematics is taught in the child's first language, SASL, the teachers' ability to sign the mathematical content precisely may be questioned since most teachers at the school have average SASL and receptive skills making communication in the classroom less ideal. A further barrier in the mathematics class is that although content is presented in SASL, students are expected to read mathematic instructions and write answers in English, their second language. Identifying and understanding the written word is challenging for the deaf child in this class and as explained in the research why art practices and experiences were used to make the written word visual.

The teacher in this research was also the researcher and although this was counteracted by another teacher making observations as well, the teacher could have subconsciously influenced the results of the investigation. For example the learner could have been taught in the way the researcher intended the results to go.

The research was conducted over one term. On reflection, observation during a longer period of time may have produced different results.

Since class sizes are small in number, the results cannot be generalised to a larger population. Consequently a more extensive study involving a larger group is crucial for results to be generalised within a South African context.

6.5 Suggestions for further research

Visual, hands-on mathematics is not common in the South African classroom in spite of the tendencies for the external mathematic papers, such as the CTA grade 9 papers and the matriculation paper's focus on problem-solving mathematics.

The research highlighted the issue of teachers being inadequately qualified both in mathematics and in deaf education. In spite of this, learners must still write high content examinations. In view of the focus on problem-solving in the syllabus and examinations, I would like to suggest research on statistics related to qualified teachers of mathematics and of the deaf across the country. Following on from this, research may also be conducted on the extent of departmental support for a more effective implementation of the new mathematics curriculum at schools for the deaf. Suggestions for further research also include all aspects of the current level of deaf education with the intent of striving for excellence in Deaf Education.

Taking cognisance of the role of art, more research would benefit how art products, practices and experiences may be used to develop mathematical concepts from the child's earliest years.

6.6 Conclusion

The decision to absorb learners in constructivist activities in developing concepts at the earliest possible age remains pivotal. One of the key ways to achieve this engagement is creating an interest in hands-on art projects. The role of art was highlighted in this study when particular art activities were used to assist the deaf child build concepts internally. Conceptual understanding channels connections to rich language. This study revealed that through these art actions, learners recall improved, levels of confidence were elevated, attitudes towards mathematics changed positively and some results improved. Therefore encouraging art during teaching and learning should be an integral part of the school mathematics curriculum in all grades.

Moreover, if the goal in deaf education is learners' conceptual understanding, then learners must be given many opportunities to perform individual understandings under varying conditions and receive constant evaluation.

Our world has changed so much this century. Knowledge continues to grow at an alarming rate and it is therefore up to us to keep our deaf learners abreast of changing times. Art was seen to stimulate the learner by creating an interest in insightful activities. The result of this saw learners cognitive processes jump to action and proceed from recognition of the pictures, lessons or activities in the art class to appreciation of mathematical content and a seldom seen enthusiastic poise during the mathematics lesson. I saw an intrinsic motivation as arising from a love of hands-on projects. It is this type of motivated learner who will continue to independently seek knowledge even in the absence of outside rewards.

From the beginning of life we innately communicated with everyone and everything in our environment from non-verbal expression to articulate communications. Eventually we became connected to those who responded to us whether negatively or by encouragement. Our own behaviour patterns adopted an outward expression: smiles, frowns, outstretched arms and finally we learn language to express our internal feelings appropriately.

How does a life in the absence of communication with other human beings formulate its patterns? Many are not alone and live in a language-less world. This study demonstrated that art is able to penetrate this internal world and through its non-verbal mode of universal communication; extricate and intervene in higher levels of communication. The art connections in this study do more than develop a model of mathematical concepts in the deaf learners. It seemed to have stimulated a cascade of positive effects in the brain. This was only visible later on. The positive results outlived the initial resistance of challenging the brain to think. I therefore contend that art has the ability to develop higher level thinking skills in the deaf learner. These are the learners who, at least in the grade 9 class, lack communication until it is almost too late.

This study shows that when art intervenes, it entices learners to take a bold step into a new life; a life with meaning now. It concludes that art plays a vital role in developing mathematical concepts among deaf learners and in doing so expands world knowledge, elevates self-esteem and so augurs mathematical progress Ultimately, art can potentially contribute to the overall development of deaf learners, both on a conceptual plane but also on a psycho-social level extending even into the therapeutic.

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LIST OF APPENDICES

Appendix 1

Informed consent form for parents and guardians

Researchers: Rina Scott-Wilson and Desireè Seekola
Name: --------------------------
Address: -------------------, Kwa-Zulu Natal
Phone: 031 767 1215 or 072 856 1072

INTRODUCTION
We are Desireè Seekola, the Grade 9 art teacher, and Rina Scott-Wilson, the Grade 9 mathematics teacher at --------------------------------As part of our Masters programme, we would like to do a study of your son or daughter's Grade 9 class. For this study, we need your permission to observe your child in his/her maths and art lessons.
This form outlines the purposes of the study and provides a description of your child's involvement and rights as a participant.

PURPOSE OF THE STUDY
The purposes of this project are:

1) to fulfill requirements for Master in Education supervised by Dr. Claudine Storbeck at the University of the Witwatersrand.

2) to gain insight into the topic of how Deaf learners experience different ways of being taught mathematics. In particular, we would like to focus on building abstract mathematical concepts through art activities which we hope would help Deaf learners to better understand classroom mathematics.

PROCEDURES
To get the information we will need for the study, we will do the following:

Firstly, we will ask your child to fill out a questionnaire. The questionnaire asks about their current feelings, attitudes, beliefs and study habits with respect to mathematics.

Secondly, we will show your child pictures resembling abstract mathematical concepts that are covered in their syllabus. We will ask them if they recognise and name the concepts, and discuss where it is being used in everyday life.

Thirdly, we will give your child art activities related to the mathematical concepts. At the same time they will be exposed to the concepts, in the realm of mathematics. The concepts that we refer to in both mathematics and art, are concepts they need to know and are part of their national syllabus. None of the concepts fall outside of the required Grade 9 curriculum as specified by the Education Department.

Fourthly, every two weeks your child will be asked to comment on both the maths and art lessons in a group setting. The goal of the group is to discuss whether the art and maths activities are helping them or not. It would also be a group where the learners can talk about any changes they would like to see happen in order to improve their attitude and mathematical performance. These sessions will be filmed.

Lastly, an individual interview will be conducted with your child to ask if they have benefited from the programme in any way. The individual interview will be filmed. They will answer the same questionnaire as in the beginning, to see if there was any change in their feelings, attitudes, beliefs and study habits.

During this time we will also observe your child as he/she does maths are art activities in class. We will take notes about what we see. Sometimes we will also film how they work in class as well.

QUESTIONS ABOUT PARTICIPATION
You are encouraged to ask any questions at any time about the nature of the study and the methods that we are using. Your suggestions and concerns are important to us; please contact us at any time at ------------------------on-------------- or after hours on 072 856 1072.

RISKS
We do not anticipate that this study will put your child at risk in any way. The children may not always agree with each other on mathematics strategies. In such instances, the teacher will take responsibility to work with the group in solving their differences. Alternatively, counselors could be called in to help the group work within its own diversity.
Nothing in the process of the research will be in any way used against your child.
Your child's school work will be assessed as it normally is.

BENEFITS
This study gives your child an opportunity to voice how he/she is experiencing mathematics in a Deaf classroom environment. This means that he/she has the opportunity to work with the teacher on possible solutions to their mathematics problems. Their feedback could also be valuable in assisting us in improving the standard of maths teaching in Deaf classrooms. Moreover, it is hoped that the study will reveal behaviour or beliefs that hinder mathematical performance such as mathematical anxiety or poor study habits. In such instances, intervention can take place after the study. Needful intervention will help your child progress more positively in maths.

PAYMENT TO PARTICIPANTS
There will be no remuneration for participating in this study.
Neither will your child be allocated a higher percentage in maths nor in maths-related projects should he/she choose to participate in the study.

PARTICIPANT CONFIDENTIALITY
We guarantee that the following conditions will be met:

1) Your child's real name will not be used at any point of information collection, or in the written case report; instead, you and any other person and place names involved in the study will be given pseudonyms that will be used in all verbal and written records and reports.

2) Giving permission for your child to participate in this research is voluntary; you have the right to withdraw your child at any point of the study, for any reason, and without any prejudice, and the information collected and records and reports written will be turned over to you. If you cancel permission to use your information, the researchers will stop collecting additional information about your child. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION
You are not required to sign this Consent form and you may refuse to do so.
PARTICIPANT CERTIFICATION (PARENTS)

I have read this consent and authorisation form. I have had the opportunity to ask, and I have received answers to any questions I had regarding the study.

I agree for my child to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this consent and authorisation form.

I grant permission for my child to be quoted directly?

Yes ______ No ______

I agree to the terms

Appendix 2

Recorded personal interview minor assent form

The personal interview will take place at the end of the term. Like the focus group, I will be asked questions about my attitudes, experiences and suggestions of the mathematics and art lessons I received over the last term. This will give me an opportunity to tell my teachers whether the activities I did over the last term help me in my maths or not. It will be filmed.

The interview will take about 30 minutes.

I understand that:

1. Taking part in this study is entirely voluntary.
2. It is my right to NOT answer any question that I am asked.
3. I am free to end my side of the discussion at any time.
4. I may ask that my comments not be taped.
5. I can leave the interview at any time I want to.
6. My name and identity will remain confidential in any publications or discussions.
7. I understand that nothing in the process of research will in any way be used against me.
8. My school work will be assessed as it normally is.

I understand the consent form that was signed to me.

I agree to take part in this research.

Signature of interviewee__________________________________

Signature of guardian__________________________________

Signature of interviewer__________________________________

Appendix 3

Consent agreement for video recording

(to be attached to written consent form)

I have received an adequate description of the purpose and procedures for video recording sessions during the course of the proposed research study. I give my consent to allow my child to be video recorded during participation in the study.

I give consent for those video recordings to be viewed by persons involved in the study.

I understand that all information will be kept confidential and will be reported in an anonymous fashion.

I understand that the video recordings will be kept at Wits School for 3 -5 years and thereafter it will be destroyed.

I further understand that I may withdraw my consent at any time.

I understand that nothing in the process of research will in any way be used against my child.

My child's school work will be assessed as it normally is.

There will be no compensation for allowing your child to be taped.

Print Name of Child____

Signature of parent/legal guardian____________________________Date_________

Appendix 4

Minor Assent for Recording

I understand that I will be filmed during the group sessions, the personal interview and sometimes while working in class. This is OK with me. I agree to be filmed.

I understand that I can ask that the filming be stopped at any time.

I understand that I can ask not be filmed at any time.

My name and identity will remain confidential in any writings or discussions.

I understand that the DVD will be kept at Wits School of Education for 3 – 5 years and thereafter it will be destroyed.

I understand that I will not be paid for participating.

I understand that nothing in the process of research will in any way be used against me.

I understand that my schoolwork will be assessed as it normally is.

____

Child's Name

____

Signature of child

____

Date __________________________________

Appendix 5

Certificate of Assent

I understand that the research involves maths and art. I understand that Desiree and Rina would like to try and prepare me for maths using art. I can help teachers like Rina and Desiree understand how Deaf learners would like to be taught maths. I can also tell them some of the things Deaf learners struggle with in the maths class.

- **I know that I can choose to be in the research study or choose not to be in the research study for one term. I know that I can stop whenever I want.**
- **The information was signed to me. I understand it.**
- **I have had my questions answered and I know that I can ask questions later if I have them.**
- **I understand that any changes will be discussed with me.**
- **I agree to take part in this research.**

OR

- **I do not wish to take part in the research and I have not signed the assent below. __________ (initialed by minor).**

Only if child assents:
- **Print name of child:________________**
- **Signature of child: ____________**

If illiterate:
A literate witness must sign (if possible, this person should be selected by the participant, and should have no connection to the research team).

I have witnessed the accurate signing of the assent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given assent freely.

Print name of witness (not a parent): _________________________

Signature of witness: _________________________

Date: _________________________

Copy provided to the participant ________________ (initialed by researcher)

Parent/Guardian has signed an informed consent _______Yes _______No (initialed by the researcher/assistant)

Appendix 6

Recorded focus group minor assent form

The focus groups will take place every two weeks for one term. In the groups my attitudes, experiences and suggestions of the mathematics and art lessons I received over the last two weeks will be explored. Group time will give me an opportunity to tell my teachers whether the activities I did over the last two weeks helps me in my maths or not. It will be filmed.

Each group session will take about 1 ½ hours. Altogether there will be about 5 group sessions which add up to 7 ½ hours over one term.

I understand that:

1. Taking part in this study is entirely voluntary.
2. It is my right to NOT answer any question that I am asked.
3. I am free to end my side of the discussion at any time.
4. I may ask that my comments not be taped.
5. I can leave the group at any time I want to.
6. My name and identity will remain confidential in any publications or discussions.
7. Nothing in the process of the research will be in any way used against me.
8. I understand that my school work will be assessed as it normally is.

I understand the consent form that was signed to me.

I agree to take part in this research.

Signature of child__________________________________

Signature of interviewer__________________________________

Date ____

All questions regarding this project can be directed to:

Desiree Seekola and Rina Scott-Wilson

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084 455 6810

Appendix 7

Subject information sheet

[only the children whose parents have given permission will be invited to participate]

PART 1

Rina, your Maths teacher, and Desiree, your art teacher, would like to invite you to be part of research at school.

The research is trying to find ways to help improve Deaf learners' feelings towards maths and understanding of maths concepts.

We have asked you to be involved in the study because this is your second year in high school. This means that you are more settled into high school than the Grade 8's. You are also used to the teachers and their way of signing and teaching by now.

Procedures: What is going to happen to me?

If you agree to participate in the research, we would like you to do several things. One activity is to answer some questions about maths.
The questions will be about how you feel about maths; your study habits and some of the thoughts you have towards maths.
Also, we would like you to participate in some art activities during art time.
The maths we give you in maths time will not be the same as the maths you have done before. You will have to work in groups to solve problems. The problems (and homework) involve more language than normal maths. Every two weeks we would like to meet as a group. This is a time for you to talk about the maths you are doing and to suggest any changes you would like to see in the maths class. We will then try and do what you suggested. Two weeks later, at the next meeting, you can comment on whether the changes are helping you or not and even make some new suggestions.
At the end of the study we would like to interview you personally and ask you what you thought of the way we combined maths and art, and what you feel will help Deaf learners with maths in the future.
I have checked with the child and he/she understands the procedures. _________ (initial)
Right to refuse or withdraw: Can I choose not to be in the research? Can I change my mind later?
Your parents have given permission for you to participate in the study. However, you can choose for yourself. If you do not want to be involved you can say that. You will not be punished in any way if you do not want to be involved. Also, you may say that you want to be involved and then later change your mind and decide not to be involved. This is OK. You can change your mind at any time.
I have checked with the child and he/she understands that he/she chooses freely and can change his/her mind at a later stage. _________ (initial)

Risks/Discomforts

You will not be hurt by taking part in the research. Sometimes someone in the group may disagree with your view. The teacher will be there to help you sort things out. If the disagreement gets too bad, we will ask a counselor to help you and the group solve the problem.
Nothing in the process of the research will be in any way used against you.
Your school work will be assessed as it normally is.

I have checked with the child and he/she understands the difficulties that may arise in the research. _________ (initial)

Benefits: Is there anything good that happens to me?

The good thing about being involved in the research is that you can think of ways to help the teacher teach maths so that you can understand. You can also tell the teacher which mathematical teaching helps you and which does not help you. This will also help other Deaf children that may be experiencing the same difficulties, as you are experiencing.
I have checked with the child and he/she understands the benefits. _________ (initial)

Incentives: Do I get anything for being in the research.
Nobody gets paid for being part of the research. You also do not get any extra marks for your projects or assignments.

Sharing the findings: Will you tell me the results?
The research will take place for one term. At the end of the research we will share with you what we found out. We will share the same information with your parents.

Confidentiality. Will everyone know about this?

Confidential information however, will not be shared. Confidential information means information that is private. Something private is not shared to protect you and your classmates. This means we will not share things that will embarrass you in front of others. Also, when we write a report of what happened for the university your names will not be put in the report. We will use special codes for your names that other people will not know.

Who to contact: Who can I talk to or ask questions to?

You can talk to any one you want to about the research. If you have questions you can speak to Desiree or Rina, or (school principal) at school.

If you choose to be part of the research, we will give you a copy of this paper. You can keep it for yourself. You can also ask your parents to look after it if you want.

Appendix 8

Semi structured interview schedule with teachers at the local school

1. Comment on the general level of mathematics that our Deaf learners are functioning at.

2. In your opinion, what (if any) factors are hindering Deaf learners from progressing in mathematics? (What are the barriers in Deaf classrooms with respect to mathematics?)

3. What do you feel is necessary in Deaf classrooms to enhance the performance of Deaf learners in mathematics?

4. How much general knowledge would you say Deaf learners have of the concepts before they are exposed to them in mathematics?

5. Comment on Deaf learners' ability to recognise, and manipulate abstract concepts?

6. Comment on the written language level of Deaf learners?

7. To what extent are Deaf learners able to comprehend abstract mathematical words without repeated input?

8. Would you feel that 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.

Appendix 9

Semi structured interview schedule with parents at the local school

1. Tell me more about:
   a. The ways you communicate with your child at home
   b. The degree to which you use abstract vocabulary/signs
   Example: Reflection, Symmetry, Ratio, Proportion, Perspective
   c. How do you sign complex subject matter to you child?

2. How many hours does your child sp end with homework every day?
   a. To what degree is homework voluntarily or coached?
   b. What is their attitude towards homework?
   c. How does your child study?
   d. How do you assess that your child has learnt something while studying?
   e. How much time is spent daily revising work other than the normal homework?
   f. What are some of the main difficulties or frustrations your child experiences when doing homework/studying?
   g. What are some of the main difficulties or frustrations you experience in helping your child study/do homework?

3. Have you noticed any change in your child's attitude and behaviour towards mathematics and art or both? (Explain)
4. What are some of the difficulties your child is personally experiencing at school that could be influencing his/her academic progress?
5. What are your expectations for your child after school?
6. What academic results do you forecast for your child's final year at school based on his/her current school reports and academic performance?
7. What are the normal discipline procedures in your home if your child is neglecting his/her homework or underperforming in school?

Appendix 10

Semi structured interview schedule with learners at the local school

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?
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?
9. Do you feel that the art activities help you to understand the maths concepts better?
10. How are the concepts that you use in art different (if at all) from the concepts that you use in maths? Give some examples using the concept
11. How would one use the concepts you are learning in the real world?

Appendix 11

The Intervention Test

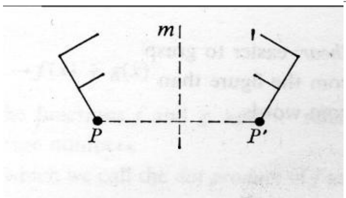
(Assessment of learners knowledge of concepts)

This assessment will take place at the start and at the end of the research. The goal is to establish the degree to which learners have a prototype (a concept linked to world knowledge); the quality/depth of the concept they have; and whether they are able to recognise the name (the written format) of the concept.

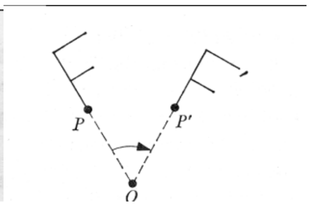
5. Can you think of a word you can use to describe this? (Referring to each picture below)
6. Have you seen this before?
7. What do you think this reminds you of in real life?
8. How will you sign and explain this word [mathematical flashcard with words such as congruent, similar, reflection, symmetry]

Time: approximately 25 minutes per learner

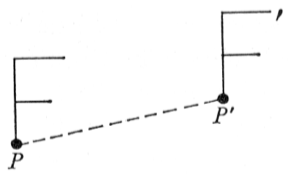
A.



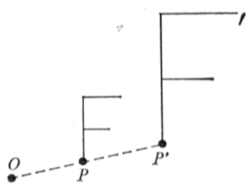
B.



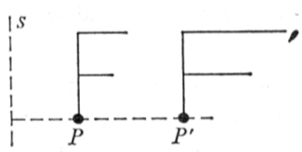
C.



D.



E.



Appendix 12

Taken from the Africa meets Africa project 2006/7 by Smuts, H.

Worksheets and lesson plans may be found on www.africameetsafrica.co.za and www.shuttleworthfoundation.org

WORKSHEET 1 RECOGNISING AND NAMING POLYGONS

An ukhamba (round, lidded basket) made by Reuben Ndwandewe

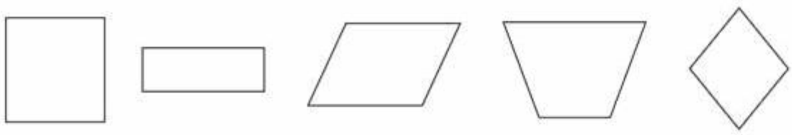
An isichumo (pear-shaped basket with lid) made by Beauty Ngxongo

As you can see from the above photographs, polygons are often used in basket designs.

What is a polygon?
A polygon is a plane closed figure whose sides are straight lines.

NOTE:
- A ***plane*** figure is a two-dimensional figure.
- The sides of a ***closed*** shape join up and do not cross each other.

Polygons are given different names according to the number of sides they have.
- A polygon with four sides is called a ***quadrilateral***.



A ***square*** is a quadrilateral | A ***rectangle*** is a quadrilateral | A ***parallelogram*** is a quadrilateral | A ***trapezium*** is a quadrilateral | A ***rhombus*** is a quadrilateral

In the same way:
- A polygon with three sides is called a ***triangle***.
- A polygon with five sides is called a ***pentagon*** (penta-gon).
- A polygon with six sides is called a ***hexagon*** (hexa-gon).
- A polygon with seven sides is called a ***heptagon*** (hepta-gon).
- A polygon with eight sides is called an ***octagon*** (octa-gon).
- A polygon with nine sides is called a ***nonagon*** (nona-gon).
- A polygon with ten sides is called a ***decagon*** (deca-gon).
- A polygon with eleven sides is called a ***hendecagon*** (hen-deca-gon).
- A polygon with twelve sides is called a ***dodecagon*** (do-deca-gon).

REFERENCES

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

Aeppli, W. (1986). *Rudolf Steiner Education and the Developing Child.* United States of America: Anthroposophic Press.

Andrews,A.(1996).*MathematicsoftheDay*.http:://www-groups.dcs.st and.ac.uk/~history/Mathematicians/Leonardo.html//www-history.mcs.st-andrews.ac.uk/Mathematicians/Leonardo.html

Angerby, K. (2000. January) *Swedish Delegate to the FEAPDA council,* BATOD

Number 8, August, 7.

Aslaksen H. (2001). *A Contrarian View to Teaching Mathematics and Art,* Teaching and Learning Geometry. The Royal Society: “Art+Math=X”, Carla Farsi (ed.), University of Colorado, 1-4

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

*Bart,A.&Clair,B.(2007).*EuclideanandNon-EuclideanGeometry *http://math.slu.edu/prep08/index.php/Workshop_Overview"*

Bart, A. & Clair,B.(2008). *Euclidean and Non-Euclidean Geometry Introduction to MathematicsandM.C.Escher*

Retrievedfrom"http://math.slu.edu/escher/index.php/Main_Page" August 2008

Berry, B. (1997) *Challenging Behaviors of Young Children Who Are Deaf And Hard Of Hearing*, Ski Hi Curriculum, 2004: p. 987.

Bottge B.A. Heinrichs M. Metha Z.D. Hung, Y. (2001). Weighing the Benefits of Anchored Math Instruction for Students with disabilities in General Education Classes *The Journal of Special Education* Vol. 35/No. 4/200(2/PP. 1 86-200) 148, No 3, 255.

Bourne, M. The Maths behind the Beauty http://www.intmath.com/Numbers/mathOfBeauty.php. Retrieved on 30 July 2008

Bowie, L. (2000). A learning theory approach to students' errors in a calculus course**.** Pythagoras (52):33. – 46. ISSN -1012-2346

Breakwell, G.,Hammond S. & Fife-Schaw C. (1995). (25th ed). *Research Methods in Psychology;* London: SAGE Publications Ltd.

Brunner, J. (1977). (27th ed). *The Process of Education: A Landmark in Educational Theory.* Harvard University Press.

Cain, K. & Oakhill, J. (2007). Children's Comprehension Problems in Oral and Written Language. The Guilford Press.

Chen-Chug L**. ,**Chien-Chia C. , Baw-Jhiune L. & Jui-WenY. (2006) Improving Mathematics Teaching and Learning Experiences for Hard of Hearing Students with Wireless Technology-Enhanced Classrooms, American Annals of the Deaf Volume 15 1, No. 3

Chisholm, L. (2004). *Changing Class Education and social change in post apartheid South Africa*, South Africa: HSRC Press.

Clayton, P. (2005). *How to develop Numeracy in children with Dyslexia*. UK: LDA. 5-12 & 22.

Constandius, E. (2008). The Only Way Forward for Design Education. OBE Conference. University of Stellenbosch

Cresswell, J. (2003). *Qualitative, Quantitative & Mixed Method Aproaches*. 2nd ed. Sage Publications. United States of America.

Dalziel, T. & Gourvenec, S. (2008). Partnership in outcomes based education. University for the Western Australia: working paper. Adelaide.

Denzin N. & Lincoln Y. (2003). (2nd ed). *The Landscape of Qualitative Research*, Sage Publications. Califonia.

Department of Education, (2003). *National Curriculum Statement: Mathematics* www.**education**.gov.za/**Curriculum**/.../LPG

Department of Education, (2003*). National Curriculum Statement: Visual Arts* www.**education**.gov.za/**Curriculum**/.../LPG

Dixon-Krauss, I, (1996) *Vygotsky's sociohistorical perspective on learning and its application to western literacy instruction.* In Storbeck (2003) Psychology of Deaf Education. Johannesburg. University of the Witwatersrand

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 Deaf. 151(4), 385-397

Efland, A. (2002). *Art & Cognition, integrating the visual arts in the curriculum.* Teachers College Press. New York

Eglash,R. & Odumosu, T. (2005). *Fractals, Complexity, and Connectivity in Africa.* G.Sica (Ed.) *What Mathematics from Africa?* Polimetrica International Scientific Publisher Monza/Italy.

Eglash, R. (2008). Mathematics of the African Diaspora. http://www.rpi.edu/eglash/English.htm. Accessed on 1 August 2010.

English L. (2008). *Mathematical Thinking and Learning: Revoicing in a Multilingual Classroom.* Routledge: Taylor & Francis Group.

English L. & Sriraman B. (2005) In Chick, H. & Vincent, J. (Eds.), *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*, Vol 1, pp 170-207. Melbourne: PME

Eysenck M. (2001). *Principles of Cognitive Psychology*. (2nd ed)

Psychology Press. Taylor & Francis Group.

Farsi, C & Freiberger, M. (2005). Art+Math = X. http://plus.maths.org/index.html. Accessed on 16 December 2007.

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

Feagin, J., Orum, A., & Sjoberg, G. (1991). *A Case for Case Study.*, NC: University of North Carolina Press. Chapel Hill.

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

Gardner, H. (1980). *Art Through the Ages*. (7th ed). Harcourt Brace Jovanovich, Publishers.

Gardner, H. (2000). *The Disciplined Mind.* Penguin Books. USA.

Geldenhuys, J.L. (2000). *Mathematics Anxiety.* Pythagoras.(52). 24 – 29.

Gerdes P. (1999) *Geometry from Africa. Mathematical and Educational Explorations.* The mathematical associations of America incorporated. Printed in the United States of America.

Goodwin, P. (2004). *Literacy through Creativity* David Fulton Publishers Grattan-Guiness *Companion Encyclopaedia of the History and Philosophy of the Mathematical Sciences.* Volume 1. Baltimore and London: The John Hopkins University Press

Grattan-Guiness, I. (Ed). (1994). Mathematics and Culture. *Companion encyclopaedia of the history and philosophy of*
the Mathematical sciences. Volume 1. Baltimore and London: The John Hopkins University.

Gray,M. (2005) *Dyslexia-a trouble-shooting guide for the bewildered*, BATOD Magazine November, 2005. 10.

Guba, E.G. & Lincoln, Y.S. (1989). *Fourth Generation Evaluation,* Sage Publications:

Newbury Park.

Huntley, M. (1998) *Art in Outline, an Introduction to South African Art*. Oxford University Press.

Isbell R. & Raines S. (2007). *Creativity and the arts with young children*. (2nd ed) Clifton Park, NY : Thomson Delmar.

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.

Jansen, J. (2001). Editorial introduction: *Questioning fidelity in policy making: Research* *stories across fields of educational enquiry*. UCT Press.

Johnson M. (2006). *Mediational Strategies for Deaf Students:Implementing Feuerstein's Instrumental Enrichment To Address Cognitive Deficits.* North Carolina School for the Deaf

Jovanavic,R.2001-2003.TheGoldenSection http://milan.milanovic.org/math/english/golden/golden5.html

Kernen,A.(2009). http://math.slu.edu/escher/index.php/Reflections_and_Rotations_Worksheet

Knowles, J.G & Cole, A.L. (2008). Handbook of the ARTS in Qualitative Research. London: Sage Publications.

Kuper A. & Kuper J. (1996). *The Social Science Encyclopedia*, (2nd ed). New York and London: Routledge. 262

Kurweil,R (2001). *The Law of Accelerating Returns*, Published on KurzweilAI.net March 7, 2001. 1

Lang H. Paglioro C. (2007). Factors Predicting Recall of Mathematics Terms by Deaf Students: Implications for Teaching, Journal of Deaf Studies and Deaf Education 12:4 Fall 2007

Liamputtong P. & Ezzy, D. (2005). *Qualitative Research Methods*, (2nd ed) Oxford University Press,

Linsell, D. (2005). Cape Media Coporation, Achiever *(advanced education and training for industry in South Africa)* Issue 14.

Livio, M. (2003). *The Golden Ration. The Story of PHI, the World's Most Astonishing Number.* Broadway Books. New York

Livio, M. (2006). The Equation That Couldn’t be Solved. How the Mathematical Genius Discovered the Language of Symmetry. Simon & Shuster. New York

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. Volume J.

Markey, C., Power, D. & Booker, G. (1990) *Predictors of Math Anxiety and Its Influence on Young Adolescents' Course Enrolment Intentions and Performance in Mathematics* Journal of Educational Psychology. Vol. 82, No. 1, 60-70

Marschark, M. & Spencer, P. (2005). *Oxford Handbook of Deaf Studies, Language, and Education* Oxford University Press: US.

Martin, D. (2003). Lecture on “ Rapid Rate of the growth of Knowledge” Witwatersrand Education Campus, 23 September 2003.

Marsh, H.W. (1987). *Content Specificity of Math and English Anxiety: A High School Study and Beyond.* Faculty of Education, New South Wales, 2006. Australia

Macdonald, C. (2001). *Teaching and Learning* Course Reader Units 1&2 Educational Theory EDUC 467 University of the Witwatersrand, Johannesburg.

Meece, J.L., Eccles, J.S. & Wigfield, A. (1990). Predictors of Math Anxiety and Its Influence on Young Adolescents’ Course Enrolment Intentions and Performance in Mathematics. *Journal of Educational Psychology* Vol. 82, No. 1, 60-70

Merriam, S. (2009). *Qualitative Research. A Guide to Design and Implementation*. San Francisco: Jossey-Bass.

Mohlala, T. (2008). Teachers Reject Mathematics Format, *The Teacher*: Volume 13 Number 8, Mail & Guardian. 2

Morgan, J. 1998. *Visual mathematics – maths for art students.* Black Issues in Higher Education. Available at: http://www.diverseeducation.com/artman/publish. accessed on 16 December 2007.

Mouton, J. (2006). *How to succeed in your Master's & Doctoral Studies.* A South African Guide and Resource Book. Pretoria: Van Schaik.

Naidoo, D. & Parker, D. (2005)., The implications of mathematics teachers' identities and official mathematics discourses for democratic access to mathematics. *Perspectives in Education* Volume 23(1).

National Curriculum Statement (2009). NCS updated. Numeracy for all Teaching and Assessment Guide. Macmillan: South Africa

Neuman, W.L. (1998). *Social Research Methods, Qualitative and Quantitative Approaches.* (6th ed.). Pearson.

Neuman, W.L. (2000). *Social Research Methods. Qualitative and Quantitative Approaches*. (4th ed.). Allyn & Bacon: Boston.

Newstead, K. (1998). Aspects of Children's Mathematics Anxiety*, Educational Studies in Mathematics,* 36 (1), 53-71.

Orton, A. (2004). *Learning Mathematics: issues, theory & classroom practice*. Continuum International Publishing Group. Great Britain.

Parkins, I. (2009). National Director of Deaf Education, DEAFSA: (Personal communication 5 September 2009.

Patel, R. (2001). Symmetry in Patterns on Swazi Grass Mats. *Special Issue of Symmetry Culture & Science.* Symmetry in Ethnomathematics, Budapest, Hungary: International Symmetry Foundation. Vol. 12 (1-2) pg 127-157.

Pagliaro,C. Kritzer, K. (2005) Discrete Mathematics in Deaf Education: A survey of Teacher's Knowledge and Use, *American Annals of the Deaf* Volume 150, No 3, 251 - 256.

Pandor, N. (2007). Government Gazette No. 29832. Vol. 502. Pretoria, 26 April 2007

Pimm, D. (1995). *Symbols and meanings in school mathematics*, Routledge: London..

Piaget, J. (2003). *The Psychology of Intelligence.* Translated by Malcolm Piercy & D.E. Berlyne. Routledge: London.

Pritchard, P. (2005). *Provision for the education of deaf pupils in Norway*, BATOD magazine, January 2005. 21

Presseisen, B. & Kozulin, A. (1992). *Mediated Learning: The Contributions of Vygotsky and Feuerstein in Theory and Practice.* Research for Better School Inc. Philadelphia,PA Paper presented at the annual meeting of the American Educational Research Association (San Francisco, CA, April 20-24, 1992).

Ray, E. (Nov, 2001*). Discovering mathematics: The challenges that deaf/hearing-impaired children encounter.* ACE Papers, Issue 11. Accessed in full text at http://www.ace.ac.nz/doclibrary/acepapers. July 2008.

Rockman, D. (2000). *The Art of Teaching art-for teaching & learning foundation of drama based art.* Oxford University Press.

Ruback, P. (2005). *Strategies for supporting dyslexic deaf pupils*, BATOD magazine November, 2005. 23-24.

Ryan, J. (2002). *Synthesis Report of Workshop on Assessing the Impact of Policy-Oriented Social Science Research, Impact Assessment, Discussion* Paper 15Washington, D.C.

Samar, V.& Parasnis, I. (2005) *Dorsal stream deficits suggest hidden dyslexia among poor readers: Correlated evidence from reduced perceptual speed and elevated coherent motion detection thresholds,* doi:10.1016/j.bandc.2005.02.004. Accessed/retrieved 25 March 2005.

Schick, B. (2004). *Theory of Mind*, Ski Hi Curriculum. Published by HOPE, inc.1126-2120

Secada, W. (1998). In English, L. (2002). *Handbook of International research in Mathematics Education*. Lawrence Erlbaum Associates. Mahwah: NJ.

Seale, C., Giampietro, G., Gubrium, J.F. & Silverman, D. (2004). *Qualitative Research Practice.* London and Thousand Oaks, CA: Sage, 420-434.

Segal, J. Chipman, S. Glase, R. (1885)???.*Thinking and Learning Skills: Relating instruction to research.* Lawrence Earlbaum Associates Inc.

Serra, M. 2003. *Discovering Geometry. An investigative approach.* USA: Key Curriculum Press: Emeryville, CA.

Shapiro, C. & Varian, H. (1999). *Information Rules A strategic Guide to the Network Economy.* Harvard Business School Press Boston, Massachusetts.

Simms, L. & Thumann, S. (2007). In search of a New, Linguistically and Culturally sensitive Paradigm in Deaf Education, *American Annals of the Deaf*, Vol 152, No. 3. 302-311.

Skemp, R. (1971). *The Psychology of Learning Mathematics,* (2nd ed.). Penguin Books.

United States of America: Lawrence Erlbaum Associates.

Smuts, H. (2006) Making a Living through the Mathematics of Zulu Design. www.africameetsafrica.co.za Accessed on 2 August 2010.

Spady, W. (2007). *It's Time to End the Decade of Confusion about OBE in South Africa.* Paper presented to teachers at a nationwide OBE tour in South Africa.

Stake, R. (1995). *The Art of Case Research.* Thousand Oaks, CA: Sage Publications.

Steinberg, A. Sullivan, V. & Loew, R. (1998). Cultural and Linguistic Barriers to Mental Health Service Access: The Deaf Consumer's Perspective. *Am J Psychiatry,* 155:982-984. American Psychiatric Association.

Stewart, D.(1994). *The Unwritten Curriculum: Teaching Deaf Students in the '90s* PEC-sponsored mini-conference. Deaf Students at the Post secondary Level Atlanta, Georgia.

Storbeck, C.2003. SPED 4001. *Psychology of Deaf eduation*. Course Reader. Johannesburg: University of the Witwatersrand, School of Education

Swannack & Chowles (2008) personal interview on 4 November

Swanwick, R. (2001). *The demands of sign bilingual context for teachers and learners: an observation of language use and learning experiences. Deafness and Education International,* 3(2),. Whurr Publishers Ltd. 79.

Taylor, R. (1999). *Understanding and Investigating Art*. Hodder & Stoughton.

Thijsse, L.J. (2002). *The effects of a structured teaching method on Mathematics anxiety and achievement of Grade 9 learners. Unpublished Masters dissertation.* Pretoria: University of South Africa.

Van Hiele, P. (2009). Van Hiele's Level of Geometric Reasoning.

Van Heerdan, J. (2009). Design and Visual Art Subject Advisor. (Personal Interview on 27 August 2009).

Viljoen, A. (2009).. One of the architects at BKS for the Moses Mabidha Soccer Stadium in Durban. Personal interview in June 2009.

Von Glaserfeld, E. (2002). *Radical Constructivism: A Way of Knowing and Learning*. Anthony Rowe, Ltd: Eastbourne.

Vygotsky, L. (1978). *Mind in Society, The Development of Higher Psychological Processes*.. Harvard University Press.

Walkup, N, (2008). *Multiplicity*, School Arts. May/June 2008, Davis Publications.5.

Walser, H. (2001). The Golden Section. (2nd ed.) *The mathematical association of America.* Oxford University Press.

Watkins, S. (2004). *Literacy*, Ski Hi Curriculum. Published by Hope inc. 1991-1996.

West, J. & Kahn, J. (1993). *Research in Education*, (7th ed) Allyn and Bacon.

Wey, H. (2008) Teaching_Symmetry http://math.slu.edu/prep08/index.php. accessed on 30 July 2010

Wiersa W. & Jurs S. J. 2005. *Research Methods in Education;* (8th Ed) Pearson Education, Inc

Wiersa, W. & Jurs, S. J. (2005). *Research Methods in Education;* (8th ed.) Pearson Education, Inc.

Wilson, S.M. (1995).*Not Tension but Intention: A Response to Wong's Analysis of the Researcher/Teacher* Vol. 24, No. 8, (Nov., 1995), 19-22 American Educational Research Association Stable URL: http://www.jstor.org/stable/1176889 Accessed: 25/07/2008 10:57.

Wink, J. (2005). *Critical Pedagogy Notes from the Real World*, (3rd ed.). Pearson Education, Inc:

Wong, D.E. (1995). *Challenges Confronting the Researcher/Teacher: Conflicts of Purpose and Conduct* Vol. 24, No. 3, (Apr, 1995), 22-28 American Educational Research Association Stable URL: http://www.jstor.org/stable/1176021 Accessed: 25/07/2008 10:54.

Yin, R. K. (1994). *Case study research: Design and methods* (2nd ed.). Newbury Park, CA: Sage Publications.

Zarfaty, Y., Nunes, T., & Bryant, P. (2004. The performance of young deaf children in spatial and temporal number tasks. *Journal of Deaf Studies and Deaf Education*. 9(3), 315 – 326.