RHODES UNIVERSITY
LIBRARY
Cl. No. TR 01-12
BRN 208795

PROJECT 1

STUDENT TEACHERS' EXPLORATION OF BEADWORK: CULTURAL HERITAGE AS A RESOURCE FOR MATHEMATICAL CONCEPTS

PROJECT 2

IN-SERVICE TEACHERS' CONCEPTIONS OF CULTURE-RELATED OUTCOMES IN MATHEMATICS WITHIN THE NEW CURRICULUM IN SOUTH AFRICA

PROJECT 3

FACELIFTING THE IMAGE OF MATHEMATICS: WHITHERTO SOUTH AFRICA?

Submitted in fulfilment of the partial
requirements for the Degree of
MASTER OF EDUCATION
of **Rhodes University**

by

Nomonde Patience Dabula

December 2000

OVERALL ABSTRACT

This portfolio consists of three research projects that predominantly lie within the socio-cultural strand. The first project is a qualitative ethnomathematical study that links students' knowledge of mathematics to their cultural heritage. The study was conducted with a group of final year student teachers at a College of Education in Umtata, Eastern Cape. These students visited a city museum where mathematics concepts were identified from beadwork artifacts. Mathematics concepts that were identified consisted of symmetry, tessellation and number patterns.

Students' views about the nature of mathematics shifted radically after their own explorations. Initially students did not perceive mathematics as relating to socio-cultural practices. But now, they have reviewed their position and see mathematics as inextricably interwoven in everyday activities and as such, a product of all cultures. They also pride themselves of their own cultural heritage to have mathematical connections. A more positive attitude towards studying mathematics in this approach was noticed. Data was collected by means of interviews, reflective journal entries and photographs.

The second project is a survey with a group of practising teachers who have already implemented Curriculum 2005, and a group which is about to implement it in 2001. The study sought teachers' understanding of connections between mathematics and socio-cultural issues. The new mathematics curriculum in South Africa calls for teachers to grapple well with these issues. About a third of the articulated specific outcomes specifically relate to socio-cultural issues. If teachers' understanding of these issues is poor, implementation of the new curriculum will remain a mere dream.

The findings of the survey revealed that the majority of teachers could not identify the culture-related specific outcomes in the new mathematics curriculum. Complicated language used in the OBE policy documents was found to inhibit meaning to these teachers. Although, all teachers showed a positive attitude towards the inclusion of socio-cultural issues in the mathematics classroom, the implementation of these outcomes was found to be very problematic. In this survey data was collected by means of questionnaires.

The third project is a literature review on the need to popularise mathematics to students in particular, and to the broader public in general. The 21^{st} century places great technological demands. Mathematics underpins most thinking behind technological development. The role played by mathematics in advancing other fields is largely hidden to the majority of people. There is, therefore, a need to bring forth the vital role that mathematics plays in these fields.

The number of students participating in mathematics is decreasing. Mathematics, as a field, is experiencing competition from other science fields. There is a need to bring some incentives to attract more students into this field and retain those mathematicians already involved. Also important, is the need to change the negative image that the public often holds about mathematics. Many people are mathematically illiterate and do not see mathematics as an everyday activity that relates to their needs. There is, therefore, a need to change the face of mathematics.

ACKNOWLEDGEMENTS

This study has been a challenge to me as a person, in that I now see the world differently. My fundamental worldview as to what constitutes knowledge has been reviewed. This would not have been possible without the invaluable contribution of the following:

- my supervisor, Mr Marc Schäfer, for his patience, understanding and probing techniques in challenging my sometimes naïve thinking, I will always be indebted to him;
- Rhodes University Mathematics Education Project (RUMEP) staff, in particular Mr John Stoker and Miss Rose Spanneberg and visiting lecturer Mr William Gibbs, for opening my eyes to see beauty in the hidden mathematics;
- my students and teachers who participated in the studies for the kind of insight they showed;
- Mr Phil Mnisi, for his support, encouragement and thought provoking comments;
- my colleagues at Cicira College of Education for understanding when I had to take some time to Rhodes University;
- Mrs Nosipho Bangeni and Ms Monica Hendricks for proof-reading some of the material;
- Mrs Judy Cornwell and Mrs Gill Boltt for their support and understanding;
- my family, especially Mfundo and Xola for understanding when I could not be disturbed;
- the NRF and ESKOM for their financial support;
- God, the Almighty, for giving me strength and health to realise my dream.

To these I will ever be thankful.

Pencil, ink marks and highlighting ruin books for other readers.

DEDICATION

To my late mother, Nomaphuthukezi, for instilling the love of numbers and enquiring mind, and to my father, Qhinqitha, for his support and encouragement to press on.

PROJECT 1

STUDENT TEACHERS' EXPLORATION OF BEADWORK:
CULTURAL HERITAGE AS A RESOURCE FOR
MATHEMATICAL CONCEPTS

ABSTRACT

Traditionally, mathematics has been perceived as an absolute and universal subject that is devoid of social and cultural influences. The newer perspectives are, however, strongly marked by relativity and uncertainties. There is a group of mathematics educators who perceive mathematics as inextricably linked to the contexts within which it has developed. They view mathematics as a human activity and therefore fallible.

This study rests on the premise that mathematics teaching needs to incorporate socio-cultural factors. Students' background experiences should be acknowledged and exploited for effective teaching of mathematics to take place. In order to access mathematics, context is regarded as important, without which some students could get alienated.

This project reports on a qualitative study carried with student teachers, from a college of Education in the Eastern Cape Province in South Africa. These students were engaged in exploration of Xhosa beadwork artifacts from a city museum. Mathematical concepts were sought in a quest to connect mathematics to their cultural heritage. Students could link their classroom knowledge of mathematical concepts to the beadwork designs found in various artifacts. From the concepts identified, reflectional symmetry was the most prevalent. Translational symmetry, tessellation of squares, rectangles, rhombi and hexagons were also found. Number patterns, especially triangular numbers, were noted.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The relationship between mathematics and culture has been of concern to researchers for the last few decades. It was noticed, in Britain for example, that children from minority cultural groups had problems in learning mathematics. The mathematics taught in class was found to have an alienating effect on such pupils, as the context within which learning occurred was foreign to their background experiences (Bishop 1991). Bishop (*ibid.*) further contends that such children do not only have to be bilingual but bicultural as well, as they have to cope both with their home and school cultures. He therefore appealed to mathematics teachers to be sensitive to this by acknowledging such diversity in their classrooms.

This problem is however, not particular to Britain. In South Africa, for example, Adler (1991) found that for every 10 000 Black students who register for Sub A, only one achieved a high enough Std 10 mathematics symbol to gain entry into a university. The situation is unfortunately not improving as recent statistics reveal that only 1% of Black students pass Std 10 Mathematics HG with symbols A or B (Adler *et al.* 2000). This scenario contributes significantly to South African poor performance in overall matric results. This has led the Minister of Education, Prof. Kader Asmal, declaring mathematics as the 'priority of priorities' (Brombacher 2000). Various reasons have been given as the cause of the apparent crisis. Amongst others, the Community of Mathematics Education in South Africa has registered its concerns and suggests that mathematics seems to alienate students of non-European origin, especially Africans (Adler *et al.*2000). They argue that the majority of these students show an 'impoverished' view of mathematics Adler *et al.* (*ibid.*). This is disturbing, in view of the fact that achievement in mathematics is often used as a screening process for entrance into many career fields

Amongst the various recommendations that have been suggested by researchers, the incorporation of contextualised knowledge is advocated as an appropriate strategy in addressing the issue of alienation (Bishop1988, Shirley 1995). Taking cognisance of and recognising students' background experiences are considered crucial for meaningful learning to take place (Ernest 1991, Bishop1988, Gerdes in Frankeinstein & Powell 1997). The argument raised is that mathematics is a cultural product as all peoples of the world practice some form of mathematics. In helping students access mathematical knowledge, their social and cultural contexts should not only be acknowledged, but be maximally exploited to the benefit of the students. The premise on which this study is situated is that effective teaching of mathematics needs to incorporate social and cultural contexts.

This research project stems from my personal experience as a Rhodes University Mathematics Education Project (RUMEP) student, five years ago. A visiting lecturer from Leeds University, William Gibbs, led us to the Albany museum to look for number patterns in Xhosa beadwork. This was such an eye-opening event in my life that I have since exposed my students to this kind of activity whenever college funds permitted. Our students generally display a lack of confidence and motivation when it comes to mathematics, as they fear it. It is envisaged that in exposing students to this kind of activity, a more positive attitude towards mathematics could be developed as it did to me.

1.2 GOALS OF THE RESEARCH

This study reports student teachers' exploration of Xhosa beadwork from the Umtata museum in the Eastern Cape. It aims at examining students' ability to connect their classroom mathematical knowledge to their cultural heritage using beadwork artifacts. Also embedded in the study are the students'perceptions of the nature of mathematics before and after the visit to the museum.

1.3 FRAMEWORK OF THE RESEARCH

The background of the study stems from the concern about the high failure rate in mathematics, especially among Black students. Various reasons have been forwarded and in my view include the notion that, unless mathematics teaching acknowledges and incorporates students' background experience, it is difficult to access new knowledge. The study seeks to investigate students' ability to connect classroom mathematical knowledge with their cultural practices. Also embedded in the study is the investigation of students' perceptions of the nature of mathematics before and after the visit to the museum.

Chapter 2 examines the context of the study. It analyses the definitions, the rationale for ethnomathematical approach and a brief historical overview of this field. It also discusses underpinning philosophical assumptions of ethnomathematics.

Chapter 3 deals with the research methodology employed in this qualitative study.

Chapter 4 reports on the findings of the study, with special reference to symmetry, tessellation and number patterns as the mathematical concepts identified. Students' views about the nature of mathematics are also reported on.

Chapter 5 analyses and discusses the findings.

Chapter 6 consolidates the study and draws threads together by concluding that student teachers could establish a connection between mathematics and their cultural practices. Their previously held views about the nature of mathematics were challenged. Some recommendations for further studies are also made.

CHAPTER TWO

CONTEXT OF THE STUDY

2.1 INTRODUCTION

Towards the end of the twentieth century, global trends have been marked by substantial challenges as to what constitutes knowledge (Welch 1998). This has inevitably led to major curriculum reforms as education began rethinking itself. Even the so-called 'hard sciences' could not escape this global turbulence (Knijnik 2000). This has led to the rise of the "newer perspectives that are strongly marked by relativity and uncertainties" (Knijnik 2000:1). These narratives challenge the notion that mathematics is founded on solid eternal truth (Ernest, 1991).

Ancient Greeks such as Euclid presented Mathematics as founded on absolutely certain assumptions, which were not seen as problematic. These were " assumptions of axioms and definitions, and those of logic concerning the assumptions of axioms, rules of inference and formal language and its syntax (Ernest 1991: 8). This absolutist view portrayed mathematics as resting on complete systems. It was in the twentieth century that this perspective encountered challenges. Gödel's Incompleteness Theorem proved these assumptions otherwise and therefore shook the foundations of this philosophy. This theorem showed that "deductive proof is insufficient for demonstrating all mathematical truth"(Ernest1991: 10). Mathematics has since been perceived as fallible. Also, the rise of Einstein's Relativity Principle challenged the theory of Absolutism. Burton (1994:73) argues that " proofs are now seen to be demonstrations which take place in fixed systems of propositions and are consequently relative to these systems." Challenging absolutism has led to the rise of the principle of contextualisation, as objectivity is questioned and rather preferred as relative. Thus fallibilists show a shift from viewing mathematics as certain to conjecture, and from absolute to relative. They no longer perceive mathematics as a complete system whose truths are eternal (Burton 1994, Ernest 1991). The greater narrative's argument, on the other hand, has led to portraying mathematics as independent of social, cultural and political influences (Knijnik 2000).

In turn this has resulted in making it "inaccessible and apparently inappropriate to the majority outside the circle" (Burton 1994:73).

2.2 UNDERPINNING PHILOSOPHICAL ASSUMPTIONS

Social constructivists assert that learning is a social construct (Ernest 1991). For meaningful learning to take place students' social background need to be acknowledged. Cobern and Aiken (cited in Fraser and Tobin 1998:40) contend that "learning is about meaning-making within a cultural milieu". Also, Rawn (as cited in Gerdes 1996:911) asserts that "one of the principles of good teaching lays down the importance of understanding the cultural background of the pupils and relevate teaching in school to it". Mathematics educators need to incorporate students' background experiences into their lessons to help scaffold learning within the zone of proximal development; which Vygotsky (as cited in Ernest 1991:26) defined as:

> The distance between actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers.

In helping students to make meaningful constructions "the teacher should maintain the view that students are attempting to make sense in their experiential world" Von Glasersfeld (as cited in Ernest 1991:26). Our experiences are embedded in our social and cultural backgrounds. In constructing meaning students refer to their experiences. Such experiences should be encouraged rather than perceived as irrelevant, Bishop (1991) advocated. Students refer to their past experiences and modify them to accommodate new information. Learning is therefore discursive (Ernest 1991).

It is in integrating old knowledge with the new experience that meaningful learning takes place. This happens when reflection on the existing information is applied and modifications are made. This reflection may be messy and discursive. In my observations with students, it appears that those students, who fail to master this integration, merely memorise concepts with little meaning. This then leads to misconceptions, which contribute to the general failure rate in mathematics.

2.3 BRIEF HISTORICAL OVERVIEW

As suggested above, learning is not always linear. This, in my opinion, also applies to the development of the history of mathematics. Various cultures have contributed to its origin and development. But some historians of mathematics portray it as having developed in a neat and orderly fashion from Ancient Greece around the 5^{th} century BC, (Joseph 1991). This view presents and portrays mathematics as mainly European product, since the contribution of other cultures is marginalised as Vithal & Skovsmose (1997) lament. Some contemporary historians of mathematics object to this view and contend that mathematics has been practised by all cultures since the history of mankind (Zaslavsky 1973; Bishop 1988; Joseph 1991; Gerdes in Bishop 1996). Bishop (1988:4) contends thus:

> Mathematics must be understood as a kind of cultural knowledge. Just like all human cultures generate language, religion, rituals, food processing techniques etc., so it seems all human cultures generate mathematics. Mathematics is a pan-human phenomenon.

Also White (as cited in Gerdes 1996:910) alludes to this view by arguing that "...mathematics did not originate with Euclid and Pythagoras or even in ancient Egypt or Mesopotamia, but is a development of thought that had its beginning with the origin of man and culture a million years or so ago." Mathematics therefore is as old as humankind. It is practised by all cultures in their different settings as part of their daily activities.

It is also apparent in studies carried out on the history of mathematics that European mathematics was actually developed and refined through the interaction of Greeks with the Arab world, Egypt, Babylon, India and China (Joseph 1991). The development of 'western mathematics' is partly owed to these countries, Zaslavsky (1973) contested. Zaslavsky (1973) further claims that the Egyptian engineering feats, such as the pyramids and temples, astound even the modern architects with their accurate constructions. Egyptians are also renowned for their outstanding contribution to the present day calendar (Zaslavsky 1973). Because of their interest in agriculture, they studied astronomy to know the seasons for ploughing. Barta (1995:13) however, laments that children are seldom taught in our schools that "...generally of the ancient mathematicians like Pythagoras and Thales (legendary founders of Greek mathematics) for instance travelled and studied in places such as India, Northern Africa where they acquired mathematical knowledge." Shirley (1995:34) also alluded to this contention by arguing that "high school students may be surprised to learn that Chinese independently developed the Pythagorean theorem, the use of Pascal's' triangle for binomial coefficients and a technique for solving simultaneous equations similar to using matrices," even far earlier than the people whose names these are attributed to. This shows that mathematics evolved from different cultures. It cannot be refuted that Ancient Greeks developed and shaped classic mathematics. However, Zaslavsky (1973:24) contested that, "...Greeks have been credited with discoveries that they merely transmitted from Egypt and the East". It is this distorted history that led to the portraying of mathematics as a product of Europe, which started around 5^{th} B.C.century, as mentioned earlier on in 2.3.

The argument above shows that the development of mathematics was not linear, as various cultures contributed to its growth. Mathematics has a history within which it developed. Its history has been influenced by social, cultural and political factors. The theorem which states that the sum of the interior angles of a triangle on a flat plane is 180°, for example, originated as a result of mutual understanding or convention. It is a negotiated result, which involved social dynamics; it is not a generalisation, which emerged in a vacuum. As Bishop (1988) and Ernest (1991) suggested, the history and context within which such generalisations emerged are not neutral. They further assert that effective teaching of mathematics cannot be divorced from social and cultural influences. Thus mathematics has a cultural history. It is for such reasons that ethnomathematics seeks to relativize the 'universality' of (academic) mathematics and moreover questions its very nature (Knijnik 2000).

Since mathematics has a cultural history the relationship between mathematics and culture has been of concern to researchers. Wilder, Rawn, Laquet and White are often referred to as the pioneers of connecting mathematical knowledge to socio-cultural influences (Gerdes 1996). For White mathematics and cultural connections are as old as humankind (Gerdes 1996). Rawn (as cited in Gerdes 1996:911) saw "education as truly effective when based on the culture and living interest". However, since the dominant view has been absolutism, not much hearing was given to these ideas. It was only in the past few decades that a growing awareness in socio-cultural issues and mathematical connections was noticed. This gave rise to the emergence of the field of ethnomathematics (Gerdes 1996).

2.4 WHAT IS ETHNOMATHEMATICS?

Ethnomathematics is a field of study that evolved in the former colonized countries as a reaction to colonial dominion. The historical misrepresentation of mathematics as the sole creation of the European countries has been the trigger to the rise of ethnomathematics (Gerdes 1996). This field seeks to problematize the 'neutrality' of mathematics as it is often presented in schools. Amongst other things, it calls for the inclusion of all and democratisation of mathematics (Shirley 1995, Visser 1991). The social, cultural and political dimensions that influence the development of mathematics are brought to the fore. Proponents of ethnomathematics advocate looking for mathematics where it is least expected and call for consideration of all forms of mathematics; be it academic, technical, everyday or recreational (Shirley 1995).

D'Ambrasio (1985:3) defined ethnomathematics as "the mathematics which is practised among identifiable cultural groups such as national – tribal societies, labour groups, children of a certain age bracket, professional classes and so on." Culture in this context is viewed beyond the traditional perspective of only confining it to ethnicity or geographical location. This includes social groups, be it professionals such as engineers, builders or children of a certain age bracket, vendors or beadwork designers. These social groups develop their own jargon, code of behaviour, symbols and expectations as well as their own way of reasoning and doing mathematics.

Bennet (as cited in Gaganakis (1992:48) sees culture as referring to the "level which social groups develop distinct patterns of life and give expressive form to their social and material experiences... [it] includes the 'maps of meaning which make things intelligible to its members". Culture is also perceived as a set of shared experiences among a particular group of people (Mosemege 1999). Equally acknowledged in this study is the fact that culture is also a fluid and dynamic phenomenon. As people grow into their cultural setting they in turn reflect and modify their constructions. This, Bishop (1991), refers to as the process of enculturation and acculturation. People are not passive recipients of their cultural expressions as they interact with them. They sometimes internalise or even reject some of their cultural practices.

D'Ambrasio (1985:5) has modified what he means by ethnomathematics and calls it "a study of the art or technique – (techne = tics) of explaining, understanding, coping with or managing reality (mathema) in different cultural environments (ethno)". He contends that there are many 'tics' in coping with reality as "diverse modes of surviving and transcending lead to different modes of thought", and the European mode is just one of them D'Ambrasio (*ibid.*) asserts. It is for those reasons, amongst others, that ethnomathematics calls on mathematics to be inclusive of all so as to diversify mathematical thinking. School mathematics is a very narrow subset of the range of mathematical thinking, D'Ambrasio (1985) contends.

Building on children's informal mathematics knowledge requires going beyond presenting it as a decontextualised body of knowledge. This necessitates that teachers should be prepared to learn from their students as well as their background; thus be students of their students (Guberman 2000). There is therefore a need to seek mathematical connections in other societies. For such development to happen teachers need to broaden their horizons and look for connections in other disciplines such as history, anthropology etc. (Almeida 2000; Gilmer 2000, Guberman 2000). D'Ambrasio (1985) argues that the way one conceptualises reality is directly affected by his/her cultural experiences. In the same way that language has power in enhancing or alienating understanding, so do mathematical constructions of one's world of reality. A person's approach to learning or teaching is influenced by values, norms, socialization practices of the background in which that individual has been encultured, Almeida (2000) asserts. Schools have a tendency of devaluing mathematical experiences that children bring from home. On the other hand, social constructivists call for bringing to the fore of such experiences in order to scaffold children's thinking (Bishop 1991, Gerdes 1996, Ernest 1991). Thus exposure of one's background experiences during classroom interaction helps in accessing new knowledge. This is pivotal to the proponents of ethnomathematics.

In using cultural experiences to enhance learning, it helps to identify and describe differences among people and use these for positive building of one another (Moore 1994). Diversity in culture should be used to enrich coherence. Alexander (as cited in Moore 1994:247) argues that:

> it is around a core of shared cultural meanings that any society or nation coheres. Within any healthy society there are differences. But underneath these differences there are shared values which unite the different forms of the expression of the core values, then difference is not divisive. It gives life and energy to unity.

Using the same argument, taking mathematics from different cultural settings would lead to coherence. Shirley (1995) advocates acknowledgement of all forms of mathematics from different social settings. These include academic, technical, everyday and recreational forms of mathematics. The academic is taken as the abstract rigorous mathematics that is practised in schools and universities. Technical mathematics involves the practical application of mathematics as practised in engineering and colleges. Recreational mathematics refers to the mathematics practised by children and adults in games they play. Everyday mathematics includes mathematical practices that arise out of daily activities, as there is an outstanding connection between mathematics and such practices Bishop (1988) asserts. The 21st century calls for mathematics for all, due to the demands of the advanced technology. In the present computer age, where banks use ATMs, for example, requires people to be numerate. Shirley (1995) calls not only for the need to access mathematics **for** all but, equally important, to consider the mathematics **of** all. Also Volmink (in Lerman 1994) concurs that mathematics should not only be made accessible **to** all but should be the mathematics **by** all.

There are four research strands that have emerged in ethnomathematical field of study according to Vithal and Skovsmose (1997). The first strand is that of the problematised traditional history of mathematics. This includes studies carried out in investigating the history of mathematics in Africa (Zaslavsky (1973). Also, in studies conducted by Joseph (1991) some mathematical contributions made by cultures other than Europe, were identified. A study carried by Bishop (1988) found that there are many different counting systems in the world. In Papua New Guinea alone there are about five hundred counting systems. There are also different ways of perceiving space. Among the Navajo people in North America, for instance, space is perceived as something that can be broken into smaller pieces and everything is moving around it. Space is seen as relative and context-bound. For example a table is a table when it performs certain duties. It would therefore appear that although different mathematical manifestations are found throughout the whole world, however, there are similarities (Bishop 1991). Bishop (1991:2) cautions that:

> The important message for mathematics educators everywhere is that the mathematical knowledge they possess, and which they are teaching, is a particular kind of mathematics, and may well differ in significant ways from that known and understood by other cultural groups in their society. They should beware of adopting assumptions of either generality, or universality or superiority of their own mathematical knowledge. They should recognise that they too are a part of a cultural history which may, or may not, be the same as that of their pupils.

The second strand deals with mathematical connections in everyday settings. Various studies have been conducted in this area where everyday practices show some strong connections between mathematical concepts and cultural practices. In her study, Abreu (1999) found uses of mathematics in traditional sugar-cane farming practice. The study sought understanding of how children experience connections between school and out of school mathematics. Saxe (1988) in his study of candy sellers and their computational strategies found that their methods were different from those practised at school although they were accurate. Mosemege (1999) in his study on string games children play found mathematical connections in number patterns. Gilmer (2000) conducted a study of hairstyles in African American. In this study abundant tessellation patterns were found. The study aimed at determining what hairbraiding and hairweaving enterprise can contribute to mathematics and what mathematics can contribute to the enterprise. Triangular, rectangular or square and hexagonal patterns of tessellations were found. These kinds of patterns also abound in nature, e.g. pineapples, beehives. Gilmer (2000) defines tessellation as "a filling up of a two dimensional space by congruent copies of a figure that do not overlap". In a study conducted by Getz (1999) in connecting mathematics to woven copper wire baskets (izimbenge) of the Zulus, some mathematical concepts with an emphasis on fractal geometry were noted.

The third strand is that of seeking relationships between mathematics and ethnomathematics such as found in Vithal & Skovsmose (1997), Vithal (1993), Gerdes (1996) and Knijnik (1999). These mathematics educators want to formalise ethomathematics into main- stream mathematics curriculum. This is, however, a relatively under-researched strand as Vithal & Skovsmose (1997) lament.

The fourth strand is that which looks for mathematical connections in traditional cultures, which though colonized, continued with their indigenous practices (Vithal &Viskosmose 1999). These include activities such as those found in weaving and beading artifacts. This study predominantly lies within this strand. Several studies conducted show a link between mathematical concepts and the indigenous practices. Gerdes (1999) has done substantial studies in weaving on the Southern African artifacts. In dedicating one of his books to women in geometry, he commented that it is meant as a contribution to the valuing, reviving and development of traditions which otherwise would simple vanish without being noticed. Symmetry patterns have been dominant in most studies carried out. Patterns are generally abundant in life. People often copy and utilise these in their art activities. One of the divisions of the discipline of mathematics includes mathematics as a science of patterns (Gilmer 2000).

Mathematicians describe symmetry pattern as a rigid motion or transformation (Gilmer 2000). There are four such motions. They are reflectional symmetry, which is a mirror image of a figure. Rotational symmetry is when a figure has a centre about which it can be rotated. Translational symmetry is when a figure can be slided or shifted in a certain direction. The fourth type of symmetry is a glide, which is a combination of both translation and reflection (Barkley1998; Nishimoto & Berken 1996). Gerdes (1999) has conducted numerous studies in the Sub-Saharan region. These include mat weaving of the Chokwe people in Angola where magic squares and Pythagoras theorem were identified. Symmetry patterns in Sotho wall decorations (litema) were noted. Hexagonal weaving has been identified in Mozambiquean hats. Barkley (1998) also conducted a study by investigating mathematical connections in Ute Indian beadwork. Three kinds of symmetry were identified. These were reflectional, rotational and translational symmetry. Also, in a study conducted by Nishomoto and Berken (1996) on border design and beadwork of the Wisconson Woodlands Indians, mathematical concepts were identified. The same symmetry patterns as discovered by Barkley were also noticed. In both cases reflectional symmetry was the most prevalent.

Ethnomathematics is a relatively new field that seeks to connect mathematical practices to the social, cultural political and historical influences. It is however, not without flaws or challenges. In a study conducted by Mogari (2000), problems associated with the implementation of the ethnomathematical approach were noticed. Teachers showed a tendency of wanting to tell and direct students rather than give them a chance to make their own explorations. Despite prior exposure of teachers to workshops about the principles of this approach, their previously held views about teaching were seemingly not challenged. Also in South Africa in particular, culture is seemingly a contentious phenomenon, as some people do not see it as mutually exclusive to race. This has problematized the ethnomathematical perspective. Vithal & Skovsmose (1997) challenge the broad definition of culture by problematizing its meaning. They argue that, "...the end of colonization marked the beginning of not only a politicized but also a racialized concept of culture as Apartheid came into being. Culture came to refer to race" (Vithal & Skovsmose 1997:138). Generally the broad interpretation of the notion of 'ethno' is recognised, however there seems to be a problem within the South African context. The contention raised is that although it is made explicit that ethnomathematics is not a racist doctrine, it is vulnerable to being associated with meanings that relate to the racism of Apartheid. This group of critics rather prefers critical mathematics education to ethnomathematics. The argument raised by Powell *et al* (2000: 1), amongst others, is that:

> The critical strand, for example, is not just interested in the mathematicsof Angolan sand drawings and their use in story telling, but also in the politics of cultural imperialism that discounts the mathematical activity involved in creating Angolan sand drawings

Vithal and Skovsmose (1997) further argue that the contribution made by ethnomathematics in registering its opposition to the 'so called' neutrality of mathematics is recognised as, "Ethnomathematics emerged as a term representing an oppositional stance. It has achieved that purpose. It has established an understanding of mathematics and mathematics education as culturally and socially negotiated (Vithal & Skovsmose 1997:153).

In my view, ethnomathematics is still relevant in South Africa. The international community of mathematics educators could be well versed with it, but in South Africa it has not yet filtered down to the classroom situation. This is apparent in the few classroom-based ethnomathematical studies done in this country. Among the few studies conducted, students' attitudes are often reported as changed to be more positive towards mathematics. Thus students generally become motivated (Laridon 2000; Mosemege 1999). In South Africa the problem of alienation, demotivation and fear of mathematics has been identified as one of the root causes of the failure of this subject (Adler 2000). To short-circuit this alternative view even before many people have tried it could be detrimental to one of the possible solutions of the crisis we face in our country. Access could remain an impossible dream. Also in the new curriculum in South Africa, three mathematics specific outcomes connect mathematics to culture. In my experience the dominant view of teachers is that mathematics is not related to socio-cultural issues. If there is already a move to abandon an ethnomathematical approach, as some consider it to have registered its point, mathematics could remain exclusive and inaccessible to the majority of the people. Thus perpetuating the status quo could become the order of the day. I would rather concur with Kuiper (1999) when he advocates a balance between contextualised and universal knowledge. In order to access universal knowledge, contextualised knowledge should be used as a springboard. In our era of knowledge explosion and Internet connection, it would be detrimental for any nation to advocate exclusive localised knowledge. Our contexts should be exploited to scaffold better enhancement of formulation of our realities. This would hopefully lead to better understanding and access of the 'universals' through our own local and contextualised understandings.

2.5 WHY ETHNOMATHEMATICS?

There is a need to democratise mathematics by making it accessible to all. The history of mathematics reveals that Plato (as cited in D'Ambrasio 1985:2) claimed that:

> All these studies (ciphering arithmetic, mensurations, relations to planetary orbits) into their minute details is not for the masses but for the selected few...We should induce those who are to share the highest function of state to enter upon the study of calculations and take hold of it ...not for the purpose of buying and selling as if they were preparing to be merchants or hucksters.

Historically there were clear distinctions between mathematics for scholarly as well as practical, for different social classes from its formal inception. So, the exclusive and elitist nature of mathematics is by no means an accident of nature. In South Africa also the same view was entrenched by Verwoed (cited in Adler *et al.* 2000: 4) when he said, "What is the use of teaching the Bantu child mathematics?". Adler *et al.* (2000) lament on the impact of this statement to the majority of South Africans as most Black people fail mathematics. They fear it and see it as the territory of the chosen few. Burton (1994) also alludes to this by arguing that mathematics image persist to have a ripple effect on attitudes as well as performance of those who remain outside it. Teaching mathematics as devoid of cultural connections could be one of the main obstacles to achievement to many historically underrepresented in mathematics. These students might perceive mathematics as having little meaning or value for their present or future lives, Strutchens (2000), argues. Strutchens (2000) further contends that such students could develop a defeatist attitude to mathematics. Calling for demystification is therefore advocated.

The South African legacy of apartheid has left its footprints. That the majority of South Africans remain outside the mathematics discipline is impacting negatively on the country. South Africa was rated the lowest achiever in the Third international Mathematics and Science Study (TIMSS) (Beaton *et al.* 1996). Also in the proposal submitted to the minister of education, the Community of the Mathematics Education in South Africa, laments the matric mathematics results as the worst of all subjects, in terms of pass rate and participation (Adler *et al.* 2000). The situation is unfortunately generally deteriorating rather than improving. The following is a brief summary of the Std 10 mathematics results (pass rate) for the past four years: 49,5% in 1996, 46,3% in 1997, 42,1% in 1998 and a slight rise 1,3% in 1999, Government Gazette (as cited in Adler 2000:3). These are disturbing statistics, in view of the fact that mathematics is often used as a critical filter to many professions that are essential for development in any country (Burton in Lerman1994; Glencross *et al.* 2000).

The culture out of which the history of mathematics developed, has apparently led to alienation and marginalisation of those not of middle class and European origin (Gerdes 1996). The argument that mathematics is universal and therefore acultural has led to portraying it as objective. Casey (1999: 1) contends that "when we speak of universals, however it is important to recognize that often something we think of as universal is merely universal to those who share our cultural and historic perspectives". Otherwise this could lead to children of the marginalised communities developing beliefs that their people have not worked with mathematics. Shirley (1995:14) argues "If the child comes from a non-European cultural heritage this belief may be dangerously extended to I cannot work with mathematics".

Mathematics taught in school generally tends to alienate children from their out of school knowledge (Bishop 1991). Gerdes (1996) argues that students do not come to school as blank slates, but with some mathematical knowledge. However these experiences are often disregarded as inappropriate. Also (Bishop 1991) contends that the curriculum tends to favour middle class background experience. Seemingly middle class children enjoy a cultural capital advantage while others experience academic disadvantage (Gurberman 2000). Gerdes (1996) and Bishop (1994) also contend that in colonized areas in particular, such as Africa, Asia and South America, curricula were merely imported and transplanted with no contextual modification. This has led to alienation of children in accessing mathematical knowledge. Teachers therefore need to acknowledge the wealth of experience children bring to school as it has powerful influence on how they interpret and access mathematical knowledge taught at school (Gurbeman 2000).

Until recently there has been little cultural connection to the teaching of mathematics. Social constructivists advocate contextualized teaching since this affords students opportunities to construct their own knowledge. In encouraging different cultural experiences, mathematics begins to make more sense as connections to their worlds can be achieved (Zaslavsky 1998). Zaslvasky (1998:503) further contends that "...this would help students to be confident in mathematics and take pride in the contributions of their own culture and learn to appreciate the achievements of other cultures". In South Africa, in particular, such practices could hopefully help rectify past malpractices of Apartheid education such as Eurocentrism, as Ethnomathematics seeks to democratize mathematics (Visser 1991).

Bishop (1988) asserts that all cultures of the world demonstrate some mathematical practices such as counting, locating, measuring, designing, playing and explaining. This is evident in the spatial visualisation of the Navajo Tribe and the counting systems of Papua New Guinea (Bishop1988).

There is a need to seek examples of how different groups carry out their daily activities. Finding mathematical activities in other cultural settings and apply them in a classroom situation could help in accessing mathematics (Bishop 1988, Shirley 1994). Also Moll (1990:10) alludes to this view by arguing that "To make schooling significant one must go beyond the classroom walls, empty verbalisation; school knowledge grows into the analysis of the everyday". It is hoped that when students' cultural experience is acknowledged and encouraged their contribution to the formulation of mathematical meaning will be enhanced.

2.6 CONCLUSION

The need for contextualised teaching cannot be overemphasised. This calls for a paradigm shift from the meta-narratives where mathematics is portrayed as universal and acultural to mathematics as contextualised and fallible knowledge. This calls for retraining of teachers in this regard. Our teaching practices are determined by our perceptions and philosophical underpinnings i.e. worldviews. It is asserted that unless teachers see mathematics in a social and cultural context, mathematics will continue to enjoy a status of objectivity, which leads to exclusivity and inaccessibility.

This study is embedded within the ethnomathematics tenets, which I see as inextricably linked to the social constructivist paradigm. In exposing student teachers to the connection between mathematics and culture, it is an endeavour to conscientise them about problematising the neutrality of mathematics. It is envisaged that the exposure might have an impact on student teachers by challenging their worldviews about the nature of mathematics, which in turn will challenge them to value their background experience.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This study was conducted with a group of sixty four third year Senior Primary Teachers' Diploma (SPTD) student teachers at a college of education in Umtata. This is a relatively modern college, as it has the basic facilities necessary to run a college such as adequately qualified staff, new buildings and adequately equipped laboratories. All students come from the Eastern Cape, in particular Transkei and are predominantly Xhosas. Xhosas are further divided into several ethnic subgroups. They are Bacas, Pondos, Xesibes, Hlubis, Pondomises, Tembus, Bomvanas, Fingos and Gcalekas, who are usually referred to as Xhosa Proper (Costello 1990).

Students at the college are familiar with the principles of the new curriculum in South Africa, Outcomes Based Education. They have been exposed to the theory of social constructivism and its implications for teaching. A pilot study was conducted in 1999 with a group of third year Junior Primary Teachers Diploma (JPTD) student teachers. They investigated connections between number patterns and beadwork artifacts. Their findings are used to inform this study. Among those students' comments, many suggested that it would be better to investigate mathematical concepts found in beadwork generally. They felt confined and limited in just investigating number patterns. As a result they investigated beyond the required concepts and identified other concepts such as tessellation and symmetry. This year's group of students has indeed investigated connections between mathematics concepts generally and beadwork artifacts. At the time of the proposal for this study the present students of the college were already exposed to all the concepts identified by the previous group, as these were taught at years I and II.

This study was anticipated for a class of twenty eight third year students. However the Eastern Cape government had decided to close most colleges in this province at the end of 1999. Two clusters were to remain in the whole province. However, this is no longer the case as these clusters are also closing at the end of 2000. This necessarily impacted negatively on my plans as

I was suddenly faced with thirty six more students from six colleges. As a college we decided to mix these colleges heterogeneously so that every class has a fair representation of all. For SPTD final year students I ended up with two classes.

3.2 PROCESS OF RESEARCH

I am teaching this group of students for the first time, including those that originally come from this college. Since I was new to these classes, I asked them to write lists of all the topics they have done from course1. When the students were transferred, there was no hand-over done, in as far as the syllabus coverage is concerned. From the lists submitted, I discovered that there was very little common in what had been done by the colleges. None of the colleges, except for the hosting college, had studied number patterns, symmetry, tessellation, problem solving, constructivism; generally all the relatively 'new' topics. On further enquiry, in particular about these topics, the response was that they do not even know what these mean. This is a common and familiar experience when students come to college. As these topics are relatively new, they were introduced when most of these students were in high school. This necessitated brief introduction of these topics, especially tessellation, symmetry, number patterns and constructivism. These were done over a period of four weeks, which is far shorter than the usual time I take. I was pressed for time as the college started later than usual because of the registration of more colleges. Also we were soon to go for teaching practice.

Students were grouped into groups of sixes or sevens. Altogether there were ten groups. Co-operative learning principles were briefly introduced to students as I noticed that some students dominated and competition was becoming apparent. Keeping of reflective journals was also introduced. This formed part of data collection for the study. A day's lecture was given to students to share ideas on their views on how they perceive the nature of mathematics. Students reported as groups. I compiled notes of what was reported and I concur with Cohen and Manion (1994:10) when they suggest that, "the role of the researcher is to discern on-going behaviour as it occurs and make appropriate notes about its salient features".

A day's excursion was undertaken to the city museum using the college bus. A colleague and myself accompanied the students to the museum. Students came into the museum in two sessions of five groups per session. Each session lasted forty five minutes. The original plan was that it was going to be one hour per session but the students' bus got lost and went to the other museum in town, the Nelson Mandela Museum.

Before going out students were briefed about the activity. They were required to look for connections between any mathematical concepts and beadwork artifacts of their choice. They were to present at least two different mathematical concepts. In identifying such connections they were also required to find out more about the artifact; who used it and for what purpose. They were to consult with the museum staff in this regard. They were also required to account for the mathematical concepts identified and justify their claim of that particular concept (See Appendix 1). Each group prepared and presented a poster of their findings to the class. Necessary material for poster making was given to the students. My role as a researcher was to observe, question and facilitate the activity; thus a participant observer. Field notes were taken so as to "let the study tell its story" (Stake 1995:63). Some photographs were also collected.

This study generally lies within the interpretivist and in particular constructivist paradigms. Proponents of these both aim at understanding a situation from the viewpoint of those who experience it (Guba and Lincoln 1994). Cohen and Manion (1994: 29) refer to this as "direct experience taken at face value". They assert that to have a meaningful understanding of a situation one must interpret it and this is a subjective exercise. Constructivists further assert that in understanding a situation the researcher tries to get into the head of those who experience the situation (Guba and Lincoln 1994). It lies within social constructivist tenets in particular as "meanings are elicited and refined through interaction among participants" (Guba and Lincoln 1994:111). This was made apparent as students shared ideas during class discourse. Also when they took their findings home, they interacted, shared ideas on which collections to present and how to account for the mathematical concepts identified. This interaction and discourse facilitated better understanding of a situation as constructivists assert that, "there exist multiple socially constructed realities" (Guba and Lincoln 1989:86). Students were able to come to consensus as to what and how to present their findings. Notes on their presentations were made to assist in data collection.

The original idea was to focus on a group of six randomly chosen students. But since the research did not go according to plan as more colleges joined, this idea was dropped. The plan was reviewed in order to allow more ideas from different people. Semi-structured interviews were done with six groups to fill in some gaps that were noticed and to validate data collection (Le (Compte *et. al. 1992)*. The group decided on one or two volunteers to be interviewed. These interviews were not rigidly structured so as to allow further probing when a need arose (Cohen and Manion 1994). These were recorded on audiotape and transcripts were made to facilitate analysis. These interviews explored students' sense making and connections of mathematics concepts and beadwork artifacts. Students' feelings and views about the excursion were also sought.

After the excursion, students' ideas on the nature of mathematics, through discourse engagement were once more sought. This interaction was done in groups as before. It was hoped that their views had been challenged or reinforced as Guba and Lincoln (1989:90) assert that "interaction is dialectic in that it involves juxtapositions of conflicting ideas forcing reconsideration of previous positions". This interaction assists in getting subjective meanings and how these are produced. The purpose of this methodology is to explain the phenomenon Guba and Lincoln (ibid.)

This study can thus be classified as qualitative, as Guba and Lincoln (1989) suggest, as such a study be carried out in a way that exposes the constructions of all those involved. As students interact and share ideas, their meaning constructions are exposed. That leads to a better understanding of the interaction participants are engaged in. The qualitative data collected assists in providing rich insight about human behaviour, as it is useful in surfacing emic views (Denzin and Lincoln 1994). This emic component helps the researcher to describe " not only what he or she sees and hears but primarily what the members of the human community see themselves doing and hear themselves saying" (LeCompte 1993:754). Analysis is done in an inductive approach, where connections that seek emerging patterns are examined. It is a case study as it seeks to understand the connection between mathematics and culture as perceived by a particular group of students (Stake 1995). It also has elements of action research as the pilot study findings have been used to inform this study. It is therefore spiral. It also aims at improving practice in a college situation (Cohen and Manion 1994).

3.3 CONCLUSION

Since this is a qualitative analysis, the study does not seek to generalise its findings. It is based on the copnstructivist paradigm, which suggests subjectivity, understanding and interpreting the situation as it unfolds. Students' reports are analysed according to the patterns that emerged and are presented as themes.

CHAPTER FOUR

FINDINGS

4.1 INTRODUCTION

Findings are divided into three categories:

- **Students' views before the excursion**

  Notes were compiled on students' presentations on how they perceive mathematics to be. These presentations represented groups' views, as students were grouped for discussions and sharing of views in this regard.

- **Students' collections and presentations**

  Field notes were compiled on students' interaction in the museum. Interviews were conducted with students on their artifact collections.

- **Students' views after the excursion**

  Notes were also compiled on students'views after the visit to the museum. These were collected from interviews and reflective journals.

4.2 STUDENTS' VIEWS BEFORE THE EXCURSION

Before going to the museum students views were sought on their perceptions about the nature of mathematics through a class discourse. Results of that session are grouped into two categories:

- common views
- special views.

4.2.1 Common Views

Common ideas are those that came from more than five groups of the total of 10 groups from both classes. The notion that mathematics needs much rigour came through strongly. Students reported that: mathematics needs a lot of practice, needs intensive practice, a lot of exercises. One group said "it is example related; we follow the teacher's procedure by doing a lot more computations". It was also reported that it is that difficult to understand, as it is abstract and relates very little to what students know from everyday life.

It was also generally reported that it is a useful subject in that: "it provides us with skills such as accurate measurement skills, estimation". It enhances better understanding of other subjects, for example science and geography. It encourages logical thinking. Some groups reported that "it helps one to be exposed to different and prestigious careers like engineering, medical doctor, chartered accountants". When asked what they meant by prestigious, they replied "money; we mean money; paying jobs." Problem solving in mathematics was also mentioned as important. It was also reported that mathematics is mostly taught by males, especially in the senior secondary phase. Students said that in high school their teachers were mostly males from countries like India, Ghana and Uganda.

Also dominant in reports was the notion that mathematics is exclusive as it is sexist and racist. These groups reported that mathematics is predominantly a white man's subject. They argued that in South Africa for instance; there are very few Blacks in the mathematics-related professions. It is even worse for Black females. One group reported that mathematics was discovered and written by white males e.g. the Theorem of Pythagoras, the Euclid Geometry. This was further re-inforced by arguing that most, if not all, mathematics textbooks are written by Whites, "it has a racial discrimination" one group lamented.

4.2.2 Special Views

The second category responses were rather unique cases as one or two groups mentioned these. Students reported that mathematics is generally for a chosen few. At high school they have noticed that only 'bright' students do mathematics. This becomes some kind of status as these students are often regarded as special and smart. It is even more prestigious to do higher grade as those who do it look down upon those who do standard grade. They reported that from their previous schools very few students did mathematics. The majority of students did History and Geography or Biblical Studies combinations. One group reported that they see mathematics as a daily activity, for example in shopping, cooking, and building of houses. In order to have accurate corner angles certain skills are applied. This group further contended that "*our mothers are good at estimation, for example when they cook for 'umgidi' (big ceremony) they use correct amount of salt, sugar and other things without measuring*". However, a concern was raised as to why the mathematics taught at school is not related to what they do and see happening everyday.

4.3 STUDENTS' COLLECTIONS AND PRESENTATIONS

Students made their collections at the city museum. This museum was founded in 1978 but officially opened in 1982. It displays a cultural history of Xhosas, natural history (birds and animals) as well as general history (politics). Cultural history includes mainly traditional dress, linen and beads, weapons for faction fighting, mats, and eating utensils such as 'umcephe' (calabash scoop). Art and craft is used as an integral part of everyday activities of the Xhosas, such as knob kieries for easy grip (in conversation with museum staff member). Beadwork is abundant in this museum as it displays Xhosa dress generally. Xhosa dress is commonly known of its beadwork decorations.

Even before the introduction of glass beads by Arab slave traders to Southern Africa, before colonialisation, Xhosas made their own from ostrich egg shells, animal teeth and horns as well as metals. However with the rise of Christianity, beadwork became less abundant. Early missionaries regarded and confused it with paganism (Costello 1990). On the other hand beadwork did not become extinct as people in the rural areas, in particular, continued practicing it. These days with the call for African Renaissance, Xhosa traditional dress and beadwork are becoming the 'in thing'.

The museum was chosen, as it is the most accessible and economical place for us as the college. In identifying which areas still practice beadwork in abundance, would be expensive and time consuming. Also, in concentrating only on beadwork of a particular sub-group would be confining, as I preferred a more heterogeneous picture for diversity purposes The museum was thus considered appropriate for the study (see Appendix 2A).

On arrival at the museum, some students started by just drawing lines of the beadwork decorations, but later convinced one another to use dots to show actual beads and see a pattern emerging. They worked in pairs. A wide collection of items was made so as to make better-informed choices (see appendix 2B). Few students worked individually. Most interacted among each other and also consulted with the museum staff.

Altogether there were twenty eight collections made which came from the following items; 8 necklaces, 3 genital girdles, 1 teenage girdle, 5 throat bands, 2 leggings and anklets, 2 dress decorations, 2 pins, 1 grass mat, 1 man's belt, 2 beaded bottles and ladies' purse. Some of these collections were however repeated by other groups especially those from the other class. Other groups identified more than one concept from the same artifact.

These collections are classified according to the common mathematical themes. Students identified the following mathematical concepts: Symmetry, Tessellation, Number patterns as well as other geometric concepts. In this report students' real names have not been used.

4.3.1 Symmetry

This was the most common concept identified. Symmetry is divided into two main findings i.e. translational and reflectional or line symmetry.

- *Translational Symmetry*

  Three collections of throat bands were made. Tembu adults wear these specifically and Xhosas generally. Translational symmetry was identified. These throat bands are worn on occasions like weddings, ritual and customary ceremonies. They are of different designs (see Appendix 3A).

The following is an excerpt of an interview with one of the groups:

Teacher: What do you mean by translational symmetry?

Sive: *We mean that an object ...mh... an object is moved by taking a step but it does not rotate.*

- *Reflectional or Line Symmetry*

  In symmetry this was the most common mathematical concept identified in different artifacts. These are divided into vertical and horizontal line symmetry and either vertical or horizontal line symmetry as reported by students. Students' terms are used in reporting their presentations. They used words like line symmetry, reflectional symmetry , mirror image (see Appendix 3B)

- *Vertical and horizontal lines of symmetry*

  In genital girdles for Xhosa girls both lines of symmetry were identified. Also in a grass mat used as a tray (isithebe) which was decorated with beads, the same symmetry was identified.

- *Vertical or horizontal Line Symmetry*

  Horizontal line symmetry was identified in a teenage girdle of the Bomvanas and in the genital girdle of the Tembu girl. Akhona reported : This line (pointing at it) ....divides the rhombus into two triangles. Therefore the triangles are symmetrical.

Vertical line symmetry along the green beads was identified in a symbolic necklace of Xhosa man. This is usually a gift from a wife to a husband as a sign of their love. Another vertical line symmetry was identified in a genital girdle of a Tembu girl. This line of symmetry passes through the blue bead. Mirror image was identified in leggings and anklets of Xhosa youth. Reflectional symmetry was found in 'inkciyo'(genital girdle) for Xhosa girls and the hatpin of Bomvana women (refer to figure 1).

The following is part of the interview between myself and John:

Teacher:	What is this used for?
John:	It is usually worn by Xhosa girls to hide their genital organs as underwear. Inthis'inkciyo' we found a maths concept which is reflection symmetry. If you place a mirror vertically on the middle of the letter H one image on the other side of the mirror is the same as the opposite side.

Figure1: 'Inkciyo'

4.3.2 Tessellation

In this category results are classified under the tessellation of hexagons, rectangles, squares, rhombus and triangles (see Appendix 4).

- *Hexagons*

  Simple tessellation of hexagons in a beaded bottle was identified (see figure 2). Two presentations from different groups were made on the same concept using the same artifact. This bottle has no specific use. It merely shows creativity of the Xhosas and is just ornamental. The following is an excerpt from an interview with one group that presented this.

Teacher: Tell us about this beaded bottle. What concept did you find?

Themba: We noticed that, I can say ...eh ...these are hexagons and they are equal. So they are tessellating because they intersect at one point and if you add those angles you get 360 degrees

Teacher: What is the measure of each angle in a regular hexagon?

Themba: Each angle in a regular hexagon is 120 so three of these give 360 .

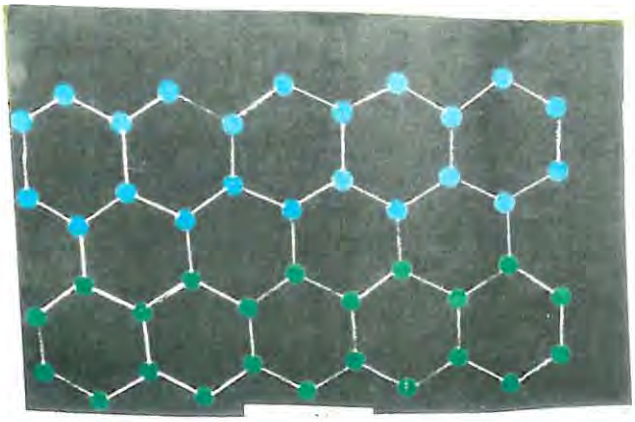


Figure 2: Beaded bottle

Also tessellation of irregular hexagons was identified in a symbolic necklace worn by Xhosa men as gifts from their wives. On asked why these tessellate, they responded just like in the case of regular hexagons

- *Rectangles*

Tessellating rectangles were identified in symbolic necklace as a love confirmation symbol among young adults (See figure 3). These are worn in 'intlombe'. The following is an excerpt from an interview between myself and Siviwe:

Teacher:	What concepts have you identified?
Siviwe:	We identified reflectional symmetry
Teacher:	In what?
Siviwe:	In traditional trays what we normally call "izithebe" and we also identified tessellation from a love confirmation emblem.
Teacher:	What tessellation is this, tessellation of what?
Siviwe:	Tessellation of rectangles
Teacher:	Why do they tessellate? What is the mathematics?
Siviwe:	They tessellate because... eh...every angle of a rectangle forms 90 degrees. When all 4 angles are combined they form 360 which is at the point of tessellation.

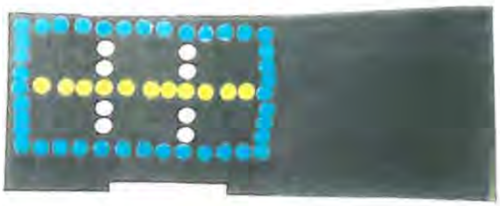


Figure 3: hatpins

Tessellating rectangles were also identified in hatpins used as broaches (refer to figure3). In both cases they gave similar account; rectangles tessellate because each angle measures 90°. Four of these meet at a point to form 360 °.

- *Rhombi*

Tessellation of rhombi was found in symbolic necklaces worn by Xhosa men (refer to figure 4). The necklace is given as a sign of love by wife to husband. It depicts the family story, such as how many wives the husband has and the number children. This group reported that since these are rhombi they have to tessellate because a rhombus is a quadrilateral. They discovered in class that all quadrilaterals tessellate.

Figure 4: Xhosa man-symbolic necklace

- *Squares*

Tessellating squares were found in leggings and anklets of Xhosa boys. These tessellated to form rectangles. Also squares were found tessellating in decorations of 'umbhaco' or braided skirts. Tessellating squares were identified in a necklace of Xhosa bride. The following is an interview with Thembi:

Teacher: And this one?

Thembi:	The second one is the art of squares, which tessellate.It is the necklace of young Xhosa women which they wear during their weddings. There are different colours that have different meanings. There is yellow that stands for fertility, green for new life.
Teacher:	New life because she's getting married?
Thembi:	Yes, blue acts as a ring and white for love. We discovered tessellating squares, that when we add different angles that is 1, 2, 3, 4 add up to 360 degrees. Each angle is 90 because it's a square.

Similar responses were given to account for tessellation of squares.

- *Triangles*

Tessellating triangles were reported in leggings and anklets of Tembu boys and girls (see figure 5). This group reported that 6 equilateral triangles tessellated to form a hexagon. The following is an excerpt of an interview with a member of the group that presented this artifact.

Teacher:	What concepts did you come up with?
Pat:	Tessellation
Teacher:	Of what?
Pat:	The first one is tessellation from the triangles, that is equilateral triangles. Each angle has 60 degrees then when you combine them to get that tessellation ...mh ,when you combine them you get 360 degrees
Teacher:	Because?
Pat:	Because each angle is 60 so now at the point where these meet you get...eh... 6 x 60 which is 360

Figure 5: Leggings and anklets

4.3.3 Number Patterns

The dominant number patterns identified were triangular numbers. These are numbers, which can be illustrated as triangles (see figure 6). Most students generalised this pattern as $n(n+1)/2$ or $n^2+n/2$ (refer to table 1 and 2). These were found in the following artifacts: genital girdle of Tembu girls, pin (same pin for line symmetry) given as a symbol of love usually on a wedding day or any other ceremony (see Appendix 5).

```
                                    0
                 0              0       0
0           0        0      0       0       0
```

Figure 6 : Triangular numbers

Number of Rows	Sum of beads
1	1
2	3
3	6
4	10
5	15
:	
n	$n(n+1)/2$

Table 1: Triangular numbers (first type)

However, there were different presentations of triangular numbers. In the Gcaleka man's belt, symbolic necklace showing man's family and in tessellating rhombus, triangular numbers were identified, by using half of the rhombus. These were represented as follows:

Number of rows	Sum of beads
1	1
2	3
3	6
4	10
5	15
:	
n	$(n^2+n)/2$

Table 2: Triangular numbers (second type)

More number patterns were identified in throat bands worn by Bomvana adults. This is the mostcommon throat band among Bomvana adults. This group presented this generalisation.

Number of Rows	Sum of beads
1	3
2	9
3	18
4	30
5	45
:	
n	$3n(3n+3)/6$

Table 3: More triangular numbers

On further probing, students could see that $3n(3n+3)/6$ is the same as $3x\ n(n+1)/2$, which is actually 3 x triangular numbers formula. They could see that this makes sense as there are triangles. On genital girdles of Tembu girls, number patterns were done in two different ways.

The first was reported as just taking a triangle. The second one was starting at the centre and moving out (see Table 4). This was verbally illustrated reported and not drawn (refer to figure7).

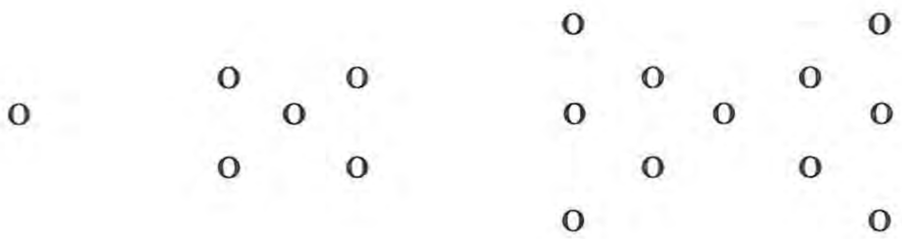


Figure 7: Genital girdle of a Tembu girl

This pattern became:

Pattern Number	Sum of beads	Level 1	Level 2
1	1		
2	5	4	2
3	11	6	2
4	19	8	2
5	29	10	2
n	n^2+n-1		

Table 4: More number patterns

In all the cases reported, students used the 'common difference method'. To find the generalisation, students looked for the difference between consecutive numbers from each level, as illustrated above (see table 4). The level on which the common difference of the sum of beads is found determines the nature of the pattern. If the difference is constant from the first level, then the pattern is linear. If the difference is constant on the second level, the generalisation is quadratic and so on. To find the exact formula, guess and check strategies were employed. This approach was actually done in class. The following is an excerpt from an interview with the group that did this pattern.

Teacher:	and, what do you have?
Namhla:	We now have this number pattern, if you look at this artifact, you'll find one bead at the centre and two more from each sides.
Teacher:	And now is it five?
Namhla:	Yes then 5+3+3 = 11 .Then we add 8 and 11 we get 19 then we add 10 and we get 29 beads.
Teacher:	Did you generalize this pattern?
Namhla:	Yes ma'am.
Teacher:	What did you find?
Namhla:	We got the formula $n^2 + n - 1$
Teacher:	Was it easy to find that formula?
Namhla:	No! We tried to get the difference between the terms. That is 5 and 1 11 and 5 and we noticed that difference between 6 &4 is... and so our common difference is 2 in our calculation.
Teacher:	In which level did you get this common difference?
Namhla:	In the second level, so this must be quadratic.

4.3.4 Other Collections

Some geometric concepts were identified in the following artifacts (see Appendix 6):

- Man's necklace of Gcalekas & Fingos;

  Vertical opposite angles and angles on a straight line were noticed.

- In a long necklace with different colours representing age groups: green for new life, blue and white for old men, geometric shapes such as cylinders were identified.

  Parallel lines in bags used by Xhosa young women, between 18 & 29 years as purses to keep their items such as tobacco, pipes, alternate angles and co-interior angles were also identified (refer to figure 8).

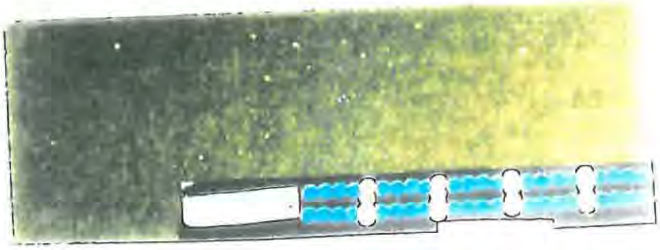


Figure 8: Xhosa lady's purse

4. 4 Students' reflections after the excursion

The third category of results is found from students' classroom discourse and presentations on their feelings and views about the excursion as well as their perceptions on the nature of mathematics. Data was collected during class presentations as well as from journals and interviews. Some journal entries are reproduced below.

About 75% of the students had never been to the museum. Students reported that they never thought there would be any connections between mathematics and the museum, including those who had been to the museum. They reported that they saw the museum as a place for leisure, or if educational at all for history, art and culture. Most students also reported that at first they were not very certain as to what to look for. Working as groups helped them to exchange views and by interaction they could see the trend. The following is an extract from a student's reflection:

Firstly I was lost but I met my group members. We worked as a group of three. We saw beautiful traditional things there. We saw symbolic necklaces which are worn by men and used as the gift from their wives. I was so suprised to find mathematical concepts in beadwork.

Most groups reported that they were happy and excited and even puzzled to see connections between mathematical concepts and their culture. One student reported "we thought it was a white men's thing but now we see it is for all people". Another student commented that she was excited to see school mathematics linked to what is done at home. Another group reported: "we feel proud that our forefathers were mathematicians also". In an interview with Athi, this is his response:

Teacher:	So how do you feel about this activity?
Athi:	I'm very proud as Black people are regarded as inferior group amongst other people of the world. It shows that mathematics can be done by people which are not well educated in the sense that they can do something which is mathematical in nature.

Another student reflected as follows in his journal:

Before I visited the museum I saw Mathematics in nature as a white mans thing and a mans things. But I after I visited the museum I realised that Mathematics is not a mans things because beadwork are done by women. Africans play an important role in Mathematics and culture. Even illiterate people apply Mathematics in real life. I realised that those people who did beadwork are critical and creative. They are so brilliant.

Two students from different classes reported that beadwork is still very actively practised from their localities. One student is from Mt Frere and the other is from Elliotdale in the Bomvana area. They both promised to bring these artifacts from their relatives. One student from the Bomvana area commented that her eyes are really opened, as she did not think there was any mathematics in beadwork. She lamented that she used to undermine beadwork activity as a 'thing of the uneducated'. She actually challenged me by arguing that we should have organised a trip to her location where we would see 'beadwork live'. On the other hand there was another student from an urban life experience who commented that he had never seen people working on beads. This was a real cultural heritage for him.

Nomsa was asked about her feelings and she responded as follows:

Teacher:	Can you explain your feelings about the excursion?
Nomsa:	I feel very happy to see mathematics is not a subject that exist in the classroom only and I'm proud that our forefathers has an idea of what is mathematics. I mean mathematics concepts already existed to them.
Teacher:	Do you think they were aware that they are doing mathematics?
Nomsa:	Mh.... They were not aware but they just did it since mathematics is a product of mankind, they just did it.
Teacher:	So you believe that mathematics is a product of mankind?
Nomsa:	Yes, I believe it because we live with mathematics and whatever thing we do we do it with mathematics.
Teacher:	Such as?
Nomsa:	Building of rondavels we tie uluthi (stick) to the rope and fix it at the centre and tie another at the other and then pull along and write – just like a compass and pencil drawing a circle.

The same idea of rondavel construction came up in the other class as one student commented that, that is why rondavels are perfectly round. One student reported that "I really felt scaffolded as Vygotsky said" and the whole class laughed because she was actually imitating my voice. She, however, qualified her claim and said: "In our homes we see rondavels decorated with triangles and symmetry patterns in mud plastering". She reported that before she did not think there was mathematics in that but now she does.

Most groups reported that they now look for mathematics all around their surroundings in whatever they come across. The following is a response of one student.

Teacher:	Can you explain your feelings about the excursion
Athi:	My feelings about the excursion make me more interested in mathematics. Sometime at home we see these beads. They decorate their clothes and necklaces. It is not the first time I see these beads but ... but now it makes me to be interested in mathematics. Mathematics has more meaning now. I know my culture take part in Mathematics.

The following is an extract from another student's journal reflection:

I enjoy mathematics much more now and I
wish these activities that we do now were
applied or done to me at the earliest stage

4.5 CONCLUSION

From the artifacts explored, students generally identified three mathematical concepts, namely: symmetry, tessellation and number patterns. Students could also account for their explorations and discovered mathematical concepts. Only two groups identified other geometric concepts such as parallel lines, alternate angles, vertical opposite angles and cylindrical shapes.

Students generally showed a shift from their previously held views about the nature of mathematics. Initially they did not see any connections between the mathematics they studied at school and their everyday activities. After their own explorations they could link mathematics to their cultural practices.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

5.1 INTRODUCTION

In this analysis results are discussed in two categories viz:

- Students' presentations on their artifact collections and mathematical connections
- students views about the nature of mathematics before and after the excursion.

It was apparent that in most groups more collections than actually presented were made so as to have a wide range from which to make their best selections. This was clear throughout students' presentations and interviews. Some reported that it was not easy to make a choice as they found collections that were equally interesting. Through negotiation by co-operation and sharing of ideas they could come to consensus as to which collections were their best choice. They were engaged in discourse in accounting for their mathematical concepts. Their interaction involved thinking strategies that enhanced problem-solving skills. There was also a review of some of the previously held ideas about the nature of mathematics.

5.2 STUDENTS' COLLECTIONS

Generally, students could link what they previously learnt in class with beadwork artifacts of their cultural heritage. In mathematics there are basically four kinds of symmetries found in a plane. These are line or reflectional symmetry, translational symmetry, rotational symmetry as well as glide symmetry, which is the combination of translational and reflectional symmetry (such as example of footsteps on sand) as mentioned in 2.4. Students could identify two of those i.e. reflectional and translational symmetries. In identifying symmetry, refectional symmetry was the most prevalent. Both vertical and horizontal or just vertical or horizontal line symmetry were found. Students used different terminology in describing this symmetry, such as reflectional, line symmetry or mirror image. This shows their proficiency in mathematical language. They were able to qualify what they meant by that. Statements like; if a mirror is placed in the middle line the same image as the reflected object will be found. Translational symmetry was also identified and was also accounted for. Statements such as; translational symmetry is a positional shift of an object without rotating, were mentioned in qualifying this concept. Thus of the four basic symmetries two were identified of which line/reflectional symmetry was dominant. This study has similar findings to that done in the Woodlands Indian beadwork (Nishimoto and Berken 1996) as mentioned earlier on in 2.4, as in both studies line symmetry is found to be dominant. However, in Ute Indian beadwork study, Barkley (1998), also mentioned in 2.4, there were also connections found in rotational symmetry. In all these studies glide symmetry could not be identified. However some groups' exploration of symmetry were rather superficial as only line symmetry was mentioned without indicating exactly which one. In some cases it was after some probing that an account was given. Misconceptions were easily identifiable as one collection of three showed some discrepancy on drawing. However, in interacting with this group they knew what translational symmetry is.

On the whole students could see connections between symmetry and beadwork artifacts. This knowledge was further extended to their home background experiences. They could connect symmetry to their home (hut) decorations. Triangles and symmetrical patterns in mud plastered house decorations were noted. Similar findings were noted in a study conducted by Gerdes (1999) of Basutu houses (as mentioned in 2.4). Also in the building of rondavels students' knowledge was extended and applied, as they linked this to the construction of a circle using a compass. In the study conducted by Gerdes (in Frankenstein and Powell 1997), similar findings were made. Properties of a rectangle were found in the construction of rectangular houses of the Mozambique people where the concept of equal diagonals is applied.

Also, with tessellations students could connect their previous knowledge with the beadwork artifacts they explored. Their classroom knowledge of tessellation was applied. They have grappled well with the fact that for polygons to tessellate the sum of angles at the point where polygons meet is 360°. This was apparent throughout. In squares and rectangles they all reported that it will be $4 \times 90^\circ = 360^\circ$; in regular hexagons it will be $3 \times 120^\circ$ and equilateral triangles $6 \times 60^\circ$. One group even further argued that rhombuses will necessarily tessellate irrespective of the nature of angles because all quadrilaterals tessellate. Before the excursion various quadrilaterals were investigated and this generalization was discovered. On the other hand one group seemingly treated all hexagons as regular as their explanation revealed, yet theirs was not a regular hexagon. The students also displayed a general understanding of what tessellation is. Connections of this mathematical concept were successfully made to out of school application.

Number patterns were the least rigorously explored mathematical concept. Almost all collections on number patterns were predominantly triangular numbers. Even when there could be another way of investigating patterns most groups opted for concentrating only on one triangle. As a result the dominant pattern was $(n^2 + n)/2$ or $n(n+1)/2$. This could probably be due to the fact that in class triangular numbers were investigated. This might have influenced students' exploration in this case. On the whole, students were able to manipulate number patterns in a different setting other than the class. All groups who explored number patterns were influenced by the common difference link, which is what was discovered in class. In finding the nature of patterns, students kept on finding the difference between consecutive numbers in different levels until they found a common difference. Depending on the common difference and the level they found, they could predict the nature of the function; whether it is linear, quadratic or cubic. For instance one group reported that if the common difference is found in the second level then that is a quadratic function.

In a small way this study has revealed that students can identify and connect mathematical concepts studied in class to real life situation, in this case beadwork found in their cultural heritage. For the relatively few cases where some misconceptions were identified, this has helped in informing me to revisit such discrepancies. Another factor that could have contributed to these misconceptions is the time constraint. The time spent introducing these concepts to the new group of students was rather short. This could have probably contributed to some of the misconceptions or less rigour. Also 80% of the groups reported that time was not sufficient for exploration in the museum. They reported that at the beginning they were anxious and uncertain of what precisely to look for. Despite all these challenges, generally, students could link their mathematical knowledge with the beadwork patterns abundant in their cultural heritage.

This has been a basis for assessing students ability to see these connections, whether this would generally improve their performance is another issue beyond this study. It has however opened a gateway to investigate that further.

5.3 STUDENTS' VIEWS

Students' initial views generally portrayed mathematics as an abstract and theoretical discipline that has very little or nothing to do with their background experiences. What is done at home has little relevance to what is done at schools. Mathematics was reported as purely an academic discipline that has no relationship to their everyday activities Mathematics was seen as acultural and absolute. Also, students portrayed mathematics as a subject that demands much rigour, to cope with. One has to exert himself or herself more in mathematics than in any other subject. It is seen as only meant for the gifted. It is therefore not meant for all, students claimed. This rigour is however associated with example related activity, thus the transmission model is still prevalent with the teaching of mathematics, where students are treated as empty vessels.

The perception about the exclusive nature of mathematics was further demonstrated as students claimed: it is a white 'man's thing'; it is a male domain and it is elitist. The view that mathematics is a product of European origin was displayed throughout students' presentations, interviews and their reflective journals. They claim mathematics was discovered and developed by Whites since theorems and textbook writing is a white man's domain. These views reinforce the stereotype notions of mathematics and Shirley (1994) contends that this kind of perception can lead to marginalisation of those whose cultural origin is non-European. It could also lead to such students developing poor self-esteem and less confidence when it comes to mathematics (Adler 2000, Strutchens 2000).

In perceiving mathematics as a predominantly man's domain, it was apparent in students' presentations that they were mainly taught by males especially in senior secondary schools. The Third International Mathematics and Science Study (TIMSS) generally reported that there were no significant differences in mathematics participation and achievement in the middle years (Beaton *et al.* 1996). In higher levels there is however, a general decline of students doing mathematics, but white male dominance still persists (Leder, Forsgaz and Brew 1998). Mathematics as a critical filter to 'prestigious paying jobs' also came up very strongly. Glencross *et al.* (2000) also allude to this view by arguing that for any country to prosper mathematics plays a crucial role as a critical filter.

However, after the excursion there was a general trend showing some students' previously held ideas on the nature of mathematics as having been challenged. Students changed their views from mathematics as a 'man's thing' as they argued that these artifacts are actually made by women in their culture, so mathematics is for all. They also showed a shift from perceiving mathematics as a sole production of Europe but rather only portrayed as such in their school experience. In their school experience they do not see textbooks written by Black mathematicians but found that in their cultural practices there are mathematical activities that called for a revision of ideas. This changed perception led to students showing interest and motivation in doing mathematics. This was eminent in their zeal to look for mathematics even outside the classroom situation especially their cultural experiences such as in huts. Students also reported that they pride themselves on their cultural heritage, to see some mathematical connections. This has an embedded feeling of ownership and less marginalization. Similar findings were noted in a study by Laridon (2000) where students' linkages of their cultural practices and mathematics were found. In this study students became motivated to see connections between mathematics and culture but no significant achievement was registered.

Constructivists argue that true learning takes place when the teacher asks questions that reveal what happens in the child's mind (Cobb, 1998). Intervention carried should elicit responses that reveal conflicts and shortcomings (Underhill 1991). Von Glasersfeld (as cited in Janvier 1987:14) further contends that " the child is unlikely to modify a conceptual structure unless there is an experience of failure or at least surprise at something not working in the expected fashion. Such failure or surprise however can be experienced if there was an expectation". It would seem that students' shift is due to their hands-on experience which challenged their previously held views.

5.4 CONCLUSION

On the whole, in this study, students could connect mathematical practices of their culture to the mathematics practised in the classroom. This has led to challenging some of their previously held ideas about the nature of mathematics. They now see mathematics as embedded in everyday activities. They could also identify their cultural practices with school mathematics. Mathematics is therefore perceived as a socio-cultural activity.

In a small way this has led to the development of a positive attitude in the students in seeing mathematics contextualised within their own culture. Students also showed an interest in mathematics taught in the ethnomathematical approach. They also pride themselves of their cultural heritage connections to mathematical concepts.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The dominant view underpinned by the scientific paradigm has portrayed mathematics as having little or nothing to do with socio-cultural issues. Mathematics has often been presented as absolute, abstract, pure and universally the same. This has led to teaching it as devoid of social, cultural, and political connotations. Yet, from its formal inception in Europe it was designed for different social classes. There was mathematics for middle class as well as mathematics for the working class, hence the two parallel strands of mathematics referred to in 2.. During the colonization period the general mathematics curriculum was also imported and transplanted with little or no modifications. Context was not regarded as important. This naïve approach led to the marginalisation of those learners whose background experiences were inconsistent with those of the colonialists.

The rise of the newer perspectives has led to the perception that mathematics is a human endeavour, and therefore fallible and context-bound. Mathematics is seen as a universal human activity. However, universality is articulated differently from the absolutists' perception. As much as all cultures practise mathematics, their socio-cultural context is regarded as crucial in knowledge formation. Experiences are embedded in this context. There are indisputable commonalties in mathematics practiced everywhere in the world, however there are also differences. This gave rise to the emergence of ethnomathematics. Students' background experience is regarded as crucial in accessing new knowledge. For students to grapple with new mathematical concepts they have to access it through language and background experiences. This study is informed by these philosophical underpinnings.

6.2 SOME REFLECTIONS AND LIMITATIONS OF THE STUDY

In exposing student teachers to familiar artifacts like their cultural dress, they were able to connect their mathematical knowledge to these. Mathematical concepts identified were all patterns. These patterns are symmetry, tessellation and number patterns. Students were surprised at the results of own their explorations and excited about their discoveries. They showed a shift from their previously held views about the nature of mathematics. They initially saw mathematics as having little to do with everyday activities. They also claimed that mathematics is the white man's domain and has nothing to do with their cultural practices. However, after their explorations, they preferred to see mathematics as a cultural product practised by all cultures. Generally, students showed a positive attitude and motivation in seeing mathematics in their own cultural practices. They pride themselves on their forefathers' engagement in mathematical practices and felt included in mathematics activities. Thus, a general sense of ownership was experienced.

In this study there were, however, some limitations.

- Due to the new intake of students at the college, there was a need for orientation to the underlying topics, which emerged from the pilot study. Time for such orientation was too little.
- The period of research was not extensive enough. As Taole (2000) suggests there is a need for more longitudinal studies in South Africa.
- Combining a visit to a beadwork practising location with the museum visit would have facilitated even better insight into mathematics and cultural practices
- There was too much data collected, such that this project could have been easily extended into a half thesis.

6.3 FURTHER RESEARCH AND RECOMMENDATIONS

This project could lead to more studies, which investigate the relationship between motivation and attitude in an ethnomathematical context. This would inform research investigating the role

Bishop, A. J. (1991). Cultural Aspects of mathematics education. *Science Education Newsletter.* 99, 1-3.

Bishop, A. J. (1996). Western mathematics: The secret weapon of cultural imperialisation. In Rogers, M.F. (Ed.), *Multicultural experiences, multicultural theories* (pp.122-134). New York: McGraw Hill.

Burton, L. (1994). Whose culture includes mathematics? In S. Lerman, (Ed.). *Cultural perspectives on the mathematics classroom* (pp. 69-84). London: Kluwer.

Brombacher, A. (2000). Mathematics top- education priority- Asmal. *AMESA NEWS.* 20, 14.

Casey, N. (1999). Article on ethnomathematics: summary, Retrieved on 22 September 1999, from the World Wide Web: http://www.teacherlink.usu.edu/Tlresources/1999-06b/ethnomath.html.

Cobb, P. (1998). *Analysing the mathematical learning of the classroom community: The case of statistical data analysis.* In A. Olivier, & K. Newstead (Eds.), Proceedings of the 22nd international Group for the Psychology of Mathematics Education conference (pp.133-147). Stellenbosch: PME.

Cobern, W.W., & Aikenhead, G.S. (1998). Cultural aspects of learning science. In B.J. Fraser, & K.G.Tobin (Eds.), *International Handbook of Science education* (pp. 39-54). Dordrecht: Kluwer.

Cohen, L. & Manion, L. (1994). *Research methods in education* (4th ed.). London: Routledge.

Costello, D. (1990). *Not only for its beauty: Beadwork and its cultural significance among the Xhosa speaking peoples*. Pretoria: UNISA.

RHODES UNIVERSITY LIBRARY

that motivation plays in the achievement in mathematics. Also recommended for a further study is an investigation of museum utilisation in accessing mathematical knowledge. I would concur with (Ngcoza 2000) when he laments that museums in the Eastern Cape, in particular, are generally under-utilised for Science studies. Further there is a need for more classroom-based research which links everyday students' experience with mathematical activities. As a direct result of this study, my second project will focus on in-service teachers' understandings of the relationship between mathematics and culture as expounded in the new South African curriculum.

6.4 CONCLUDING REMARKS

This study has reinforced that contextualised teaching, with particular emphasis to ethnomathematical approach, motivate students. The learning process that the students were involved in has scaffolded them to link their findings with their cultural backgrounds. Also, students' initial ideas were challenged. Through reflection and evaluation of their previously held ideas, new understanding and knowledge was facilitated. These students now see mathematics as an activity practised by all cultures.

This study was enriching and fulfilling in many ways, both to students and myself. To see theories unfolding right under my eyes, is a very exciting experience. Linking theory to practice in the teaching of mathematics is very crucial. Introducing perspectives, in which socio-cultural issues are considered important, influenced students'worldviews and epistemological underpinnings. The central notion of mathematics being a human endeavour was re-inforced by the hands-on approach of the project. It is hoped that this project has contributed to love and ownership of mathematics thereby making it a more accessible and inclusive activity.

REFERENCES

Abreu, G. (1998). *Reflecting on mathematics learning in and out of school from a cultural psychology perspective*. In A. Olivier, & K. Newstead. (Eds.), Proceedings of the 22nd International Group for the Psychology of Mathematics Education Conference (pp.115-130). Stellenbosch: PME.

Adler, J. (1991). Vision and constraint: Politics and mathematics national curriculum in South Africa. In D. Pimm, & E. Love (Eds.), *Teaching and learning school mathematics* (pp. 153-171). London: Hodder & Stoughton.

Adler, J., Brombacher, A., & Shan, S. (2000). Submission by the mathematics education community to the Council of Education Ministers (CEM). *AMESA NEWS*, 20, 3-5.

Almeida, D.A. (2000). *Countering prejudice against American Indians and Alaska natives through antibias curriculum and instruction.* Retrieved on 28 April 2000, from the World Wide Web: http://www.ed.gov/databases/ERIC_ Digests/ed380295.html.

Barkley, C. A. (1998). Symmetry patterns of Ute beadwork. *International Study Group on Ethnomathematics (ISGEm) Newsletter*, 13 (2), 5-9.

Barta, J. (1995). Reconnecting mathematics and culture in the classroom. *Mathematics in School,* March, 12-13.

Beaton, A. E., Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., Kelly, K.L., & Smith, T.A. (1996). *Mathematics achievement in the middle years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: TIMSS International study Center, Boston College.

Bishop, A. J. (Ed.) (1988). *Mathematics education and culture*. London: Kluwer.

Bishop, A. J. (1991). Cultural Aspects of mathematics education. *Science Education Newsletter*. 99, 1-3.

Bishop, A. J. (1996). Western mathematics: The secret weapon of cultural imperialisation. In Rogers, M.F. (Ed.), *Multicultural experiences, multicultural theories* (pp.122-134). New York: McGraw Hill.

Burton, L. (1994). Whose culture includes mathematics? In S. Lerman, (Ed.). *Cultural perspectives on the mathematics classroom* (pp. 69-84). London: Kluwer.

Brombacher, A. (2000). Mathematics top- education priority- Asmal. *AMESA NEWS*. 20, 14.

Casey, N. (1999). Article on ethnomathematics: summary, Retrieved on 22 September 1999, from the World Wide Web: http://www.teacherlink.usu.edu/Tlresources/1999-06b/ethnomath.html.

Cobb, P. (1998). *Analysing the mathematical learning of the classroom community: The case of statistical data analysis.* In A. Olivier, & K. Newstead (Eds.), Proceedings of the 22nd international Group for the Psychology of Mathematics Education conference (pp.133-147). Stellenbosch: PME.

Cobern, W.W., & Aikenhead, G.S. (1998). Cultural aspects of learning science. In B.J. Fraser, & K.G.Tobin (Eds.), *International Handbook of Science education* (pp. 39-54). Dordrecht: Kluwer.

Cohen, L. & Manion, L. (1994). *Research methods in education* (4th ed.). London: Routledge.

Costello, D. (1990). *Not only for its beauty: Beadwork and its cultural significance among the Xhosa speaking peoples*. Pretoria: UNISA.

RHODES UNIVERSITY LIBRARY

D'Ambrasio, U. (1985). *Ethnomathematics and its place in the History and Pedagogy of mathematics*. Retrieved on 22 September1999, from the World Wide Web: http://www.enc.org/equity/eqtyres/erg/111552/1552.htm.

Denzin N.K. & Lincoln Y.S. (Eds.) (1994). *Handbook of Qualitative Research.* London: Sage

Ernest, P. (1991). *The philosophy of mathematics education*. London: Falmer Press.

Gaganakis, M. (1992). Language and ethnic group relations in non-racial schools. *The English Review,* 9, 46-55.

Gerdes, P. (1996). Ethnomathematics and mathematics education. In A.J. Bishop (Ed.), *International Handbook of Mathematics Education* (pp. 909-943). Dordrecht: Kluwer.

Gerdes, P. (1997). On culture, geometrical thinking and mathematics education. In A.B. Powell, & M. Frankenstein (Eds.), *Challenging Eurocentrism in mathematics education* (pp.234-248). New York: New York Press.

Gerdes, P. (1999). *Geometry from Africa: Mathematical and educational explorations*. Washington DC: The Mathematics Association of America.

Getz, C.G.L. (1999). Computer generation of geometric designs woven into izimbenge using algorithmic processes developed in the field of fractal geometry. *South African Journal of Science Education,* 95 (10), 434-439.

Gilmer, G. (2000). *Using technology to explore mathematical patterns in African American hairstyles.* Retrieved on 25 February 2000, from the World Wide Web: http://www.math.bufallo.edu/mad/special/gilmer-gloria_HAIRSTYLES.html.

Glencross, M. J., Kulubya, M.M., Mji, A., Njisane, R.M., Dabula, N.P., & Qwele, B.N. (2000). *Critical variables that influence first year university students in the Eastern Cape to study* *mathematics*. Proceedings of the 8th Annual Conference of the Southern African Association for research in Mathematics and Science Education (pp146-151). Port Elizabeth: SAARMSE.

Guba E.G. & Lincoln, Y.S. (1994). Competing paradigms in qualitative research. In N.K Denzin, & Y.S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp.105-117): London Sage.

Guba, E.G. & Lincoln, Y.S. (1989). *Fourth generation evaluation*. NewburyPark: Sage

Guberman, S.R. (2000). *Cultural aspects of young children's' mathematics knowledge.*Retrieved on 10 April 2000, from the World Wide Web:
http://www.spot.colorado.edu/~gubermas/NCTM_pap.htm.

Janvier, C. (Ed.). (1987). *Problems of representation in the teaching and learning of mathematics*. Erlbaun: Hilldale.

Joseph, G.G. (1991). *The crest of the peacock: Non-European roots of mathematics*. New York: Penguin.

Knijnik, G. (2000). *Ethnomathematics and postmodern thinking: Conver/Divergences*. Retrieved on10 April 2000, from World Wide Web:
http://www.enc.org/equity/eqtyres/erg/111552/1552.html.

Kuiper, J. (1999). Science and culture: The art of balancing. *JOSAARMSE*, 2 (1) 21-32.

Laridon, P. (2000). *Ethnomathematics and performance in school mathematics*. Proceedings of the 8th Annual Conference of the South African Association for Research in Mathematics and Science Education (pp. 247-252). Port Elizabeth: SAARMSE.

Le Compte, M.D. & Preissle, J. (1993). *Ethnography and qualitative design in mathematics educational research*. New York: Academic Press.

Mogari, D. (2000). *Problems associated with the use of ethnomathematical approach.* Proceedings of the 8th Annual Conference of the Southern African Association for Research in Mathematics and Science Education (pp.329- 335). Port Elizabeth: SAARMSE.

Moll, L.C. (Ed.). (1990). *Vygotsky and education: Instructional implications and applications of sociohistoric psychology.* New York: Cambridge.

Moore, B. (1994). Multicultural education in South Africa: Some theoretical and political issues. *Perspectives in Education.* 15 (2), 237-267.

Mosemege, M. (1999). *A culturally specific game as a resource: An example of analysis, design of worksheets and Implementation in the mathematics classroom.* Proceedings of the 7th Southern African Association for Research in Mathematics and Science Education Conference (pp. 294-299). Harare: SAARMSE.

Ngcoza, K. (2000). Promoting learning in science: a case study on the benefits of using the museum's science programmes. Unpublished master's thesis, Rhodes University, Grahamstown.

Nishimoto, K. & Berken, B. (1996). Symmetry patterns of the Wisconsin Woodland Indians. *International Study Group on Ethnomathematics Newsletter* 12 (1), 7-13.

Powell, B., Knijnik, G., Gilmer, G., & Frankenstein, M. (2000). *Ethnomathematics and critical mathematics.* Retrieved on 10 April 2000, from World Wide Web: http.//www.nottingham.ac.uk/csme/meas/symposia/ethno.htm.

Saxe, G.B. (1988). Candy selling and math learning. *Educational Researcher*, 17(6), 14-21.

Shirley, L. (1995). Using ethnomathematics to find multicultural connections. In NCTM (Ed.) *Yearbook connecting mathematics across curriculum.* Virginia: NCTM.

Stake, R.E. (1995). The art of the case study research. London: Sage.

Strutchens, M. (2000). *Multicultural mathematics: A more inclusive mathematics.* Retrieved on 28 April 2000, from the World Wide Web: http://www.edu.gov/databases/ERIC_Digests/ed380295.html

Taole, K. (2000). *Calling for a shift in the existing research culture.* Proceedings of the 8th Annual Conference of the Southern African Association for Research in Mathematics and Science Education (pp. 37-47). Port Elizabeth: SAARMSE.

Vithal, R. (1993). *Ethnomathematics: Research directions and some implications for curriculum.* Proceedings of the 1st Annual Conference of the Southern African Association for Research in Mathematics and Science Education (pp 275-291). Johannesburg: SAARMSE.

Vithal, R. & Skovsmose, O. (1997). The end of innocence: A critique of ethnomathematics. *Educational Studies in Mathematics*, 34 (2), 131-157.

Visser, K. (1999). Overcoming Eurocentrism in school mathematics. *MATHLASEDI,* November, 40-41.

Volmink, J. (1994). Mathematics for all. In S, Lerman (Ed.), *Cultural perspectives on the mathematics classroom* (pp. 51- 68). London: Kluwer.

Von Glasersfeld, E. (Ed.). (1991). *Radical constructivism in mathematics education.* Dordrecht: Kluwer.

Welch, A. (1998). The end of certainty? The academic profession and the challenge of change. *Comparative Education Journal*, 42 (1), 1-14.

Zaslavsky, C. (1973). *Africa counts: Number and pattern in African culture.* New York: Lawrence Hill.

Zaslavsky, C. (1998). Ethnomathematics and multicultural mathematics education. *Teaching Children Mathematics*, 5(5), 502-503.

APPENDIX 1

CITY MUSEUM VISIT-23 FEBRUARY 2000

SPTD 111's

1. As a group investigate any mathematics concepts that you can identify in beadwork artefacts you find in the museum.

2. Choose items/artefacts that will enable you to identify at least two different mathematical concepts.

3. Account for strategies employed in identifying those concepts

4. Prepare a poster for class presentation.

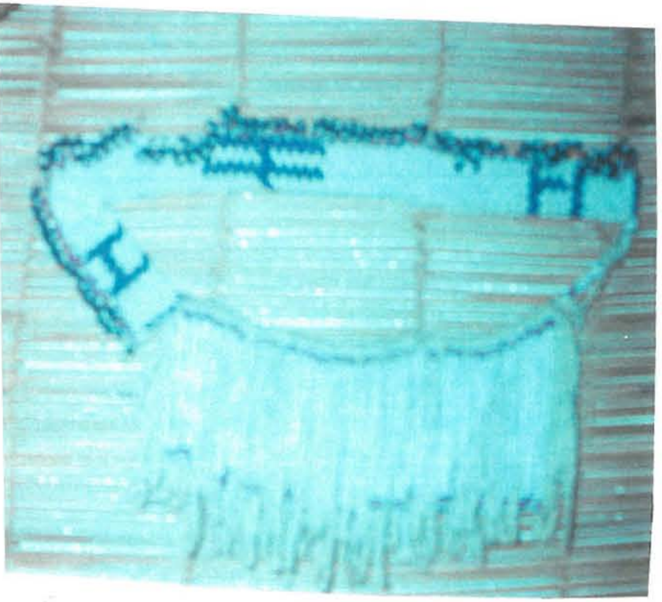
Note: You can consult the museum staff and find out more information about the artifact chosen.

STUDENTS IN THE MUSEUM

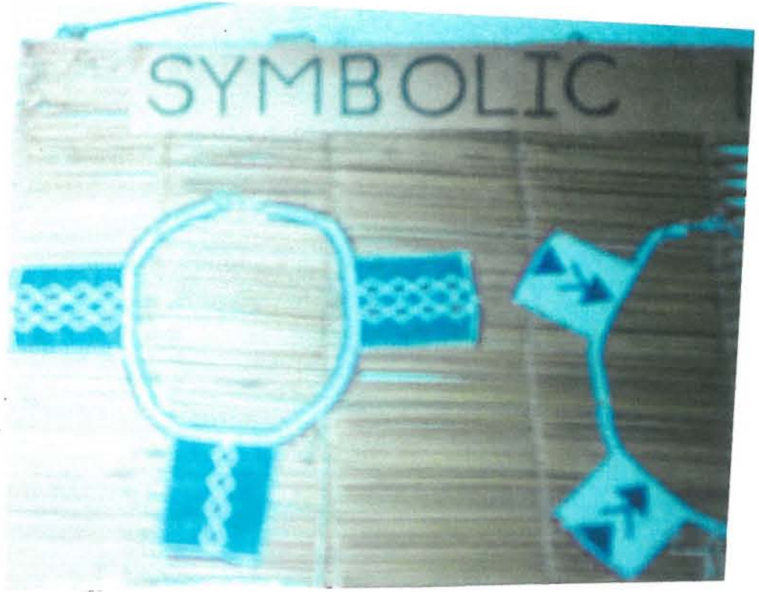
APPENDIX 2A

COLLECTION OF SOME ARTIFACTS

APPENDIX 2B



GENITAL GIRDLE

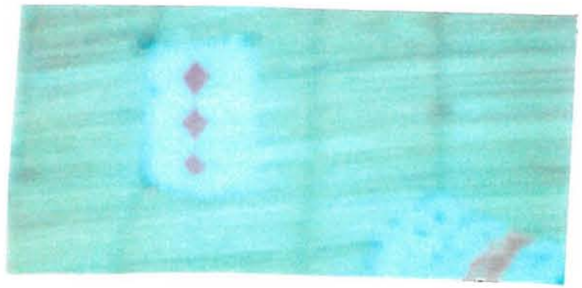


SYMBOLIC NECKLACES

ORNAMENTAL BOTTLES

SYMBOLIC NECKLACES

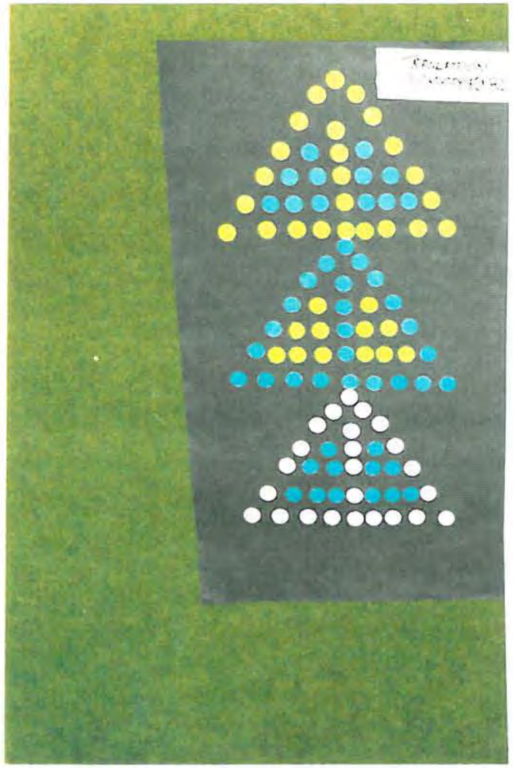
GENITAL GIRDLE

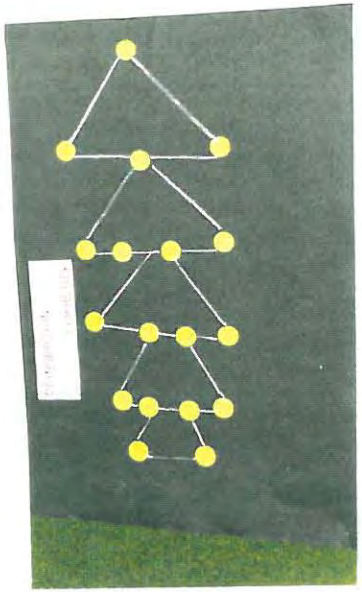


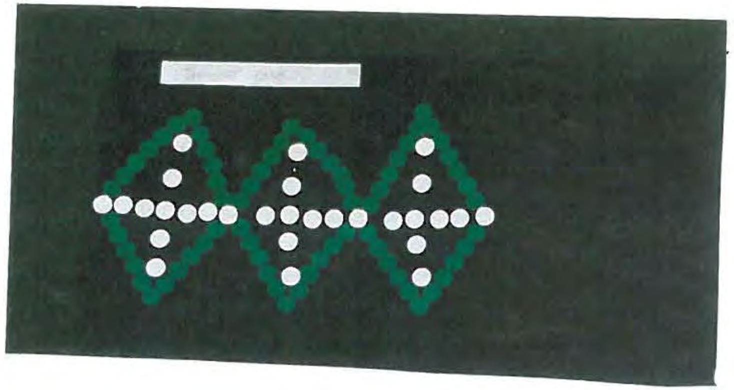
PIN

TRANSLATIONAL SYMMETRY

APPENDIX 3A



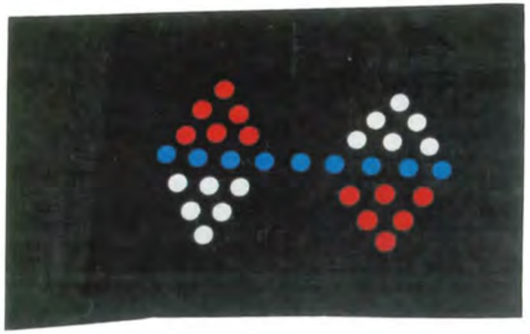




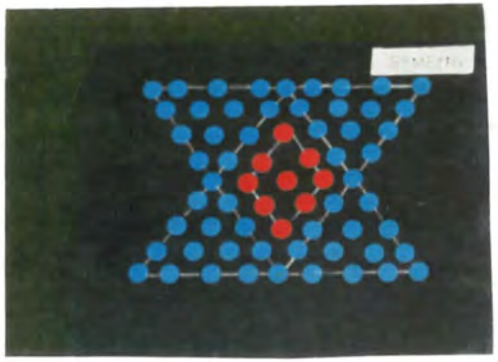
THROAT BANDS

REFLECTIONAL SYMMETRY

APPENDIX 3B

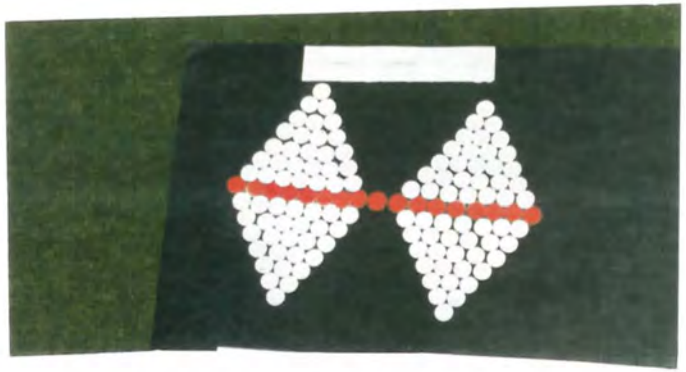


TEMBU GENITAL GIRDLE

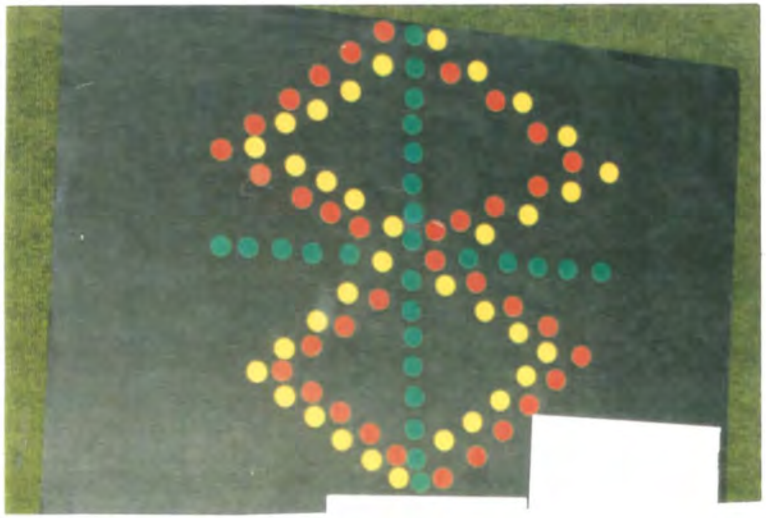


LEGGINGS AND ANKLETS

SYMBOLIC NECKLACE

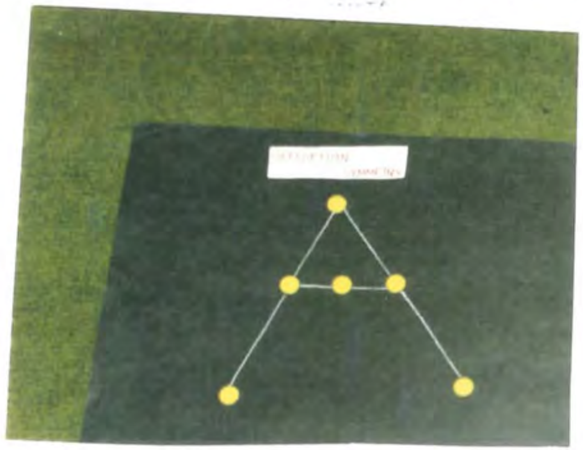


BOMVANA TEENAGE GIRDLE



GRASS MAT

'INKCIYO'

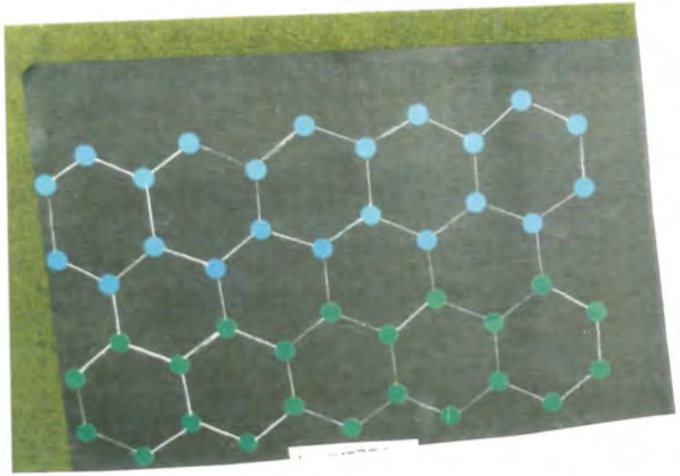


HAT PIN

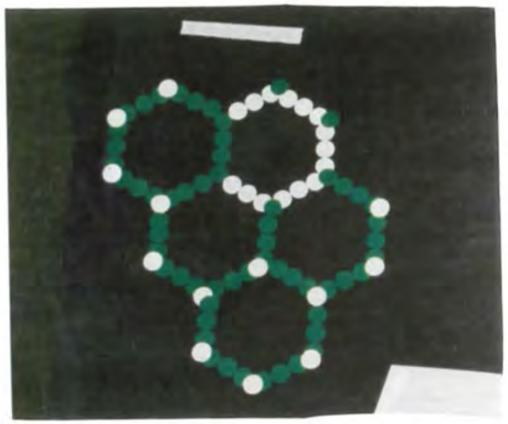
TESSELLATION

APPENDIX 4

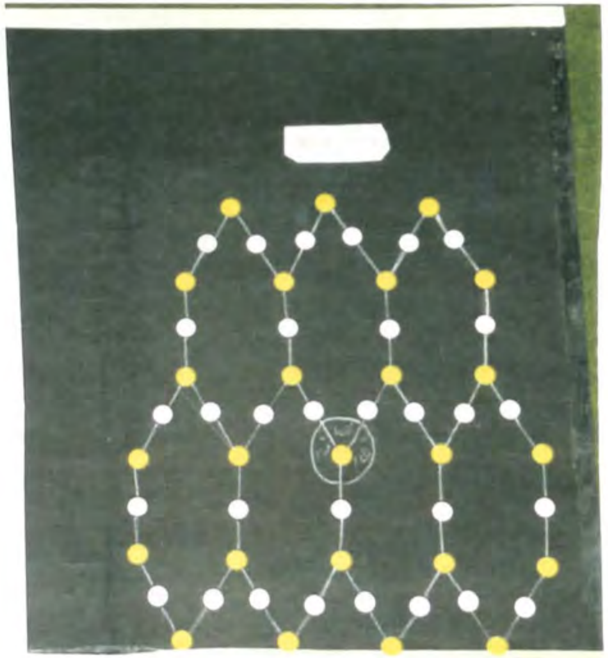
HEXAGONS



BEADED BOTTLE



BEADED BOTTLE



SYMBOLIC NECKLACE

RHOMBI

SYMBOLIC NECKLACE

TRIANGLES

SYMBOLIC NECKLACE

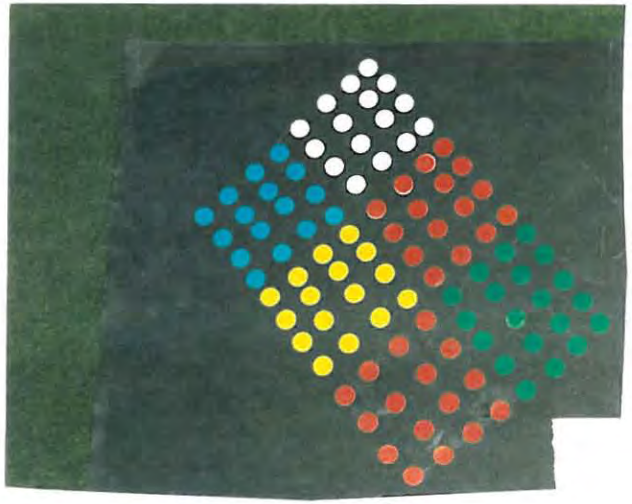
LEGGINGS AND ANKLETS

TESSELLATION

APPENDIX 4

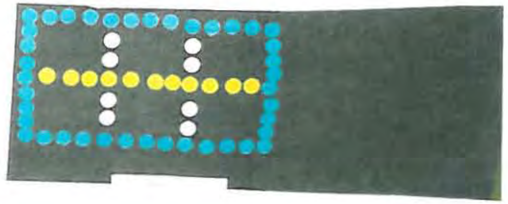
SQUARES

'UMBHACO'



LEGGINGS AND ANKLETS

RECTANGLES

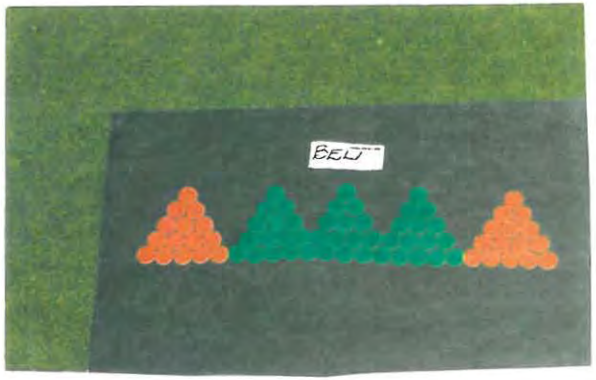


HAT PIN

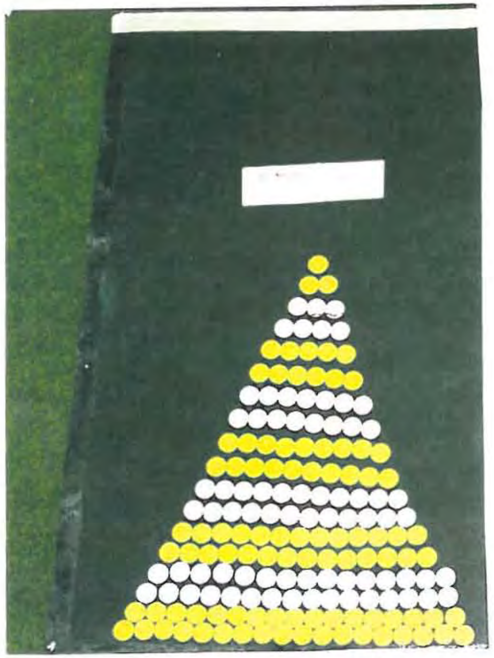
SYBBOLIC NECKLACE

NUMBER PATTERNS

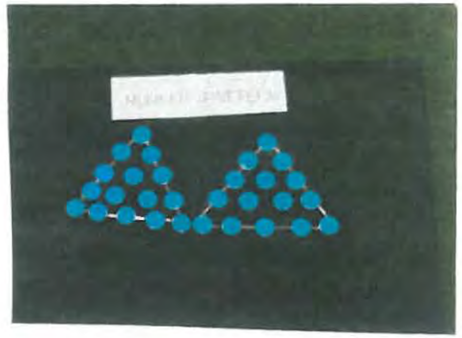
APPENDIX 5



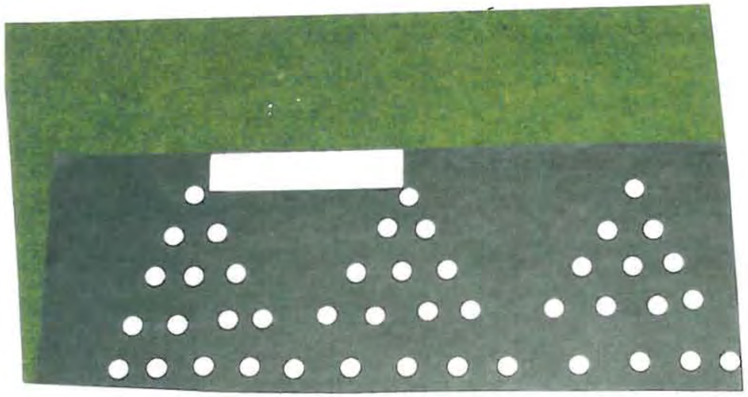
XHOSA MAN'S BELT



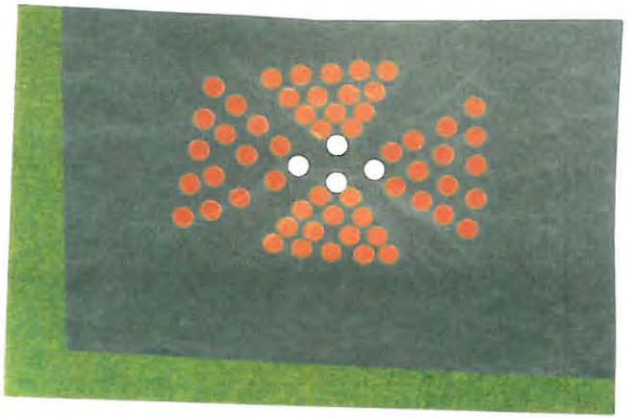
SYMBOLIC NECKLACE



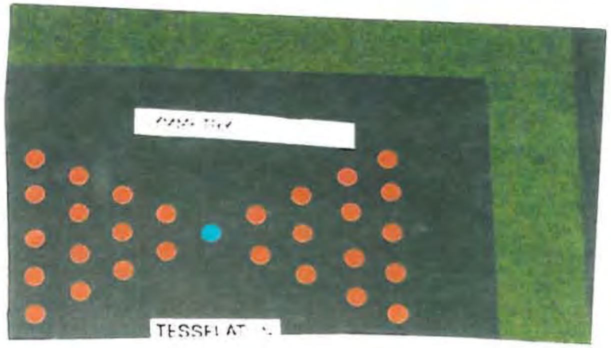
SYMBOLIC NECKLACE



BOMVANA THROAT BAND



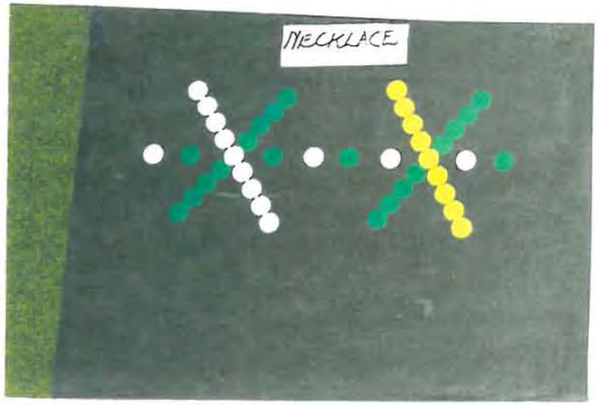
GENITAL GIRDLE



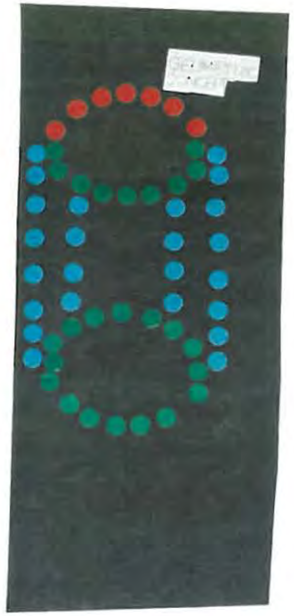
GENITAL GIRDLE

APPENDIX 6

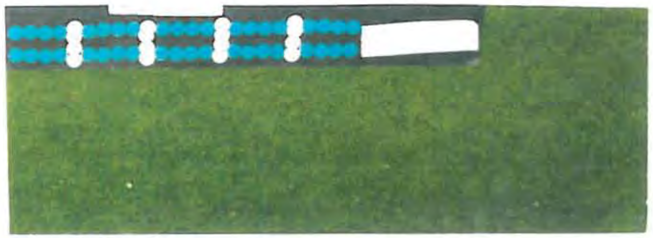
OTHER GEOMETRIC CONCEPTS



GCALEKA MAN' NECKLACE



LONG NECKLACE



XHOSA YOUNG WOMANS BAG

PROJECT 2

IN-SERVICE TEACHERS' CONCEPTIONS OF CULTURE-RELATED OUTCOMES IN MATHEMATICS WITHIN THE NEW CURRICULUM IN SOUTH AFRICA

ABSTRACT

The new mathematics curriculum in South Africa calls for a paradigm shift in the way mathematics has been taught. It portrays mathematics as a socially situated human activity. This kind of thinking is underpinned by a Post-modern paradigm. Knowledge formation of all cultures is considered important if mathematics is to be inclusive of all. About a third of the specific outcomes for the new mathematics curriculum reflect this perspective.

This survey investigated teachers' ability to identify the specific outcomes that relate mathematics to socio-cultural issues as well as the implementation of such in their classroom situations. The study was conducted among in-service teachers who are currently implementing the new curriculum as well as those that will implement it in 2001. This study was conducted around Umtata in the Eastern Cape. Questionnaires were used to collect both quantitative and qualitative data.

It was generally found that only a few teachers could identify the relevant specific outcomes. Language inaccessibility in policy documents was found as the inhibiting factor in understanding the specific outcomes. Although the participating teachers generally identified with the need to include socio-cultural issues in mathematics teaching, the implementation of these outcomes revealed a different story.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

This study arose from research I conducted recently with a group of pre-service teachers. This group of student- teachers explored beadwork artifacts from a museum in Umtata, in order to establish various mathematical connections with their traditional cultural practices. Their previously held perception, that mathematics was culture-free, absolute and objective, was seriously challenged. As a result of their exploration, a shift in their perception took place. They appreciated the notion that mathematics is a context-bound human activity that is practised in our everyday settings (See Project 1).

This personally challenged me to look further into in-service teachers and conduct a survey on teachers' views about the relationship between mathematics and socio-cultural issues as expounded in the new curriculum. Since students come to college of education with vast experiences from school, I wanted to investigate how teachers at school connect mathematics and culture in their teaching practices.

Also, since the new mathematics curriculum in South Africa incorporates some socio-cultural issues, I felt there was a need to explore teachers' conceptions and views on this approach. The introduction of the new curriculum in South Africa calls for change in the way mathematics is taught. This inevitably also challenges the teachers' mindset as to what constitutes knowledge and how knowledge is constructed.

The sudden introduction of the new curriculum has resulted in numerous concerns. It is generally documented that one of the major pitfalls in the implementation of the new curriculum is that teachers have not been adequately oriented and trained into the new paradigm. This has led to misconceptions, confusion and sometimes, outright rejection of the proposals in the new curriculum (Jansen 1999; Taylor and Vinjevold 1999). As a result of such factors, teachers have just reverted to their old ways of teaching. That is, they tend to teach the way they were taught during their years of training, thereby defeating the whole purpose of transformation (Lukhele 2000; Vacc and Bright 1999).

1.2 GOALS OF THE RESEARCH

This study aims at investigating the following:

- What are practising teachers' views concerning the relationship between mathematics and socio-cultural issue?
- What do teachers understand by the three culture-related specific outcomes in the learning area of Mathematics Literacy, Mathematics & Mathematical Sciences (MLMMS)?
- How do teachers incorporate these outcomes into their classroom practices?

1.3 FRAMEWORK OF THE STUDY

My concern as a mathematics educator about how teachers at school view the connections between mathematics and socio-cultural practices informed the background of this study. It is my belief that there is a cyclical relationship between teachers' ontological-epistemological perceptions and classroom practices. If the pre-service teachers referred to above showed such surprise at their own explorations, how do practising teachers view culture and mathematics? I felt that a small-scale survey could shed a light on cultural perceptions inherent in teachers.

My concern also stems from the reports we receive about problems associated with the implementation of Outcomes Based Education (OBE). These reports, amongst others, intimate inaccessibility of OBE in terms of its terminology. Teachers often find the terminology vague confusing and too academic.

Chapter two looks into the context of the study. It discusses socio-cultural issues embedded in the new curriculum. It also analyses factors that have led to curriculum transformation in South Africa.

Chapter three deals with the research methodology used in this study.

Chapter four reports findings of the study with particular emphasis on:

- teachers' views and conceptions of culture
- teachers' conceptions on the relationship between mathematics and socio-cultural issues
- teachers' unpacking of specific outcomes related to socio-cultural issues in mathematics
- applications of these outcomes in their classroom practices

Chapter five analyses and discusses the findings.

Chapter six draws conclusions of the study and recommendations for further research are suggested.

CHAPTER TWO

CONTEXT OF THE STUDY

2.1 INTRODUCTION

Global trends have been marked by various curriculum reforms that tend to favour learner-centred approaches (Welch 1998). This, inter alia, calls for the incorporation of students background experiences. Consistent with those global trends, South Africa developed its curriculum embedded within these narratives. However, the South African curriculum is also fused with the concept of an outcomes or competency- based model (Taylor and Vinjevold 1999). The new curriculum has been received with different views. Some educators are positive and passionate about it, whereas others are critical towards it.

As a result of the rushed implementation of the new curriculum many misconceptions and misunderstandings have arisen. For example, it is generally documented that the language used in the curriculum documents is not easy to understand (Jansen 1999; Tayler and Vingevold 1999; Chisholm *et al.* 2000). Furthermore, the new curriculum calls for a paradigm shift, as it challenges the old views and practices. In my understanding, social constructivism is an underpinning philosophy of the new curriculum, which advocates contextualised knowledge. This inevitably includes socio-cultural issues as a necessary ingredient for this kind of approach (Ernest 1991, Zaslavsky 1998). In this study the concept of culture and socio-cultural issues will be interchangeably used.

Traditionally, in mathematics the concept of culture has often not been regarded as an issue. Yet, mathematics developed within cultural contexts that have shaped what we see in many of our classrooms today (Zaslavsky 1973; Joseph 1991; Gerdes 1994). Various cultures have contributed to the mathematics practised in schools. However, it is with regret that this history is often disregarded as if mathematics just came from on high in a neat and orderly fashion (D'Ambrasio 1985); (Gerdes 1998); (Knijnik 2000) and (Zaslavsky 1973) lament.

2.2 SOCIO-CULTURAL-ISSUES EMBEDDED IN THE NEW CURRICULUM

As mentioned above, social constructivism advocates contextualized knowledge. This knowledge is situated within social-cultural contexts of peoples' lives. People have different patterns of lifestyles and practices. These practices are part and parcel of their daily lives, which differ from one group of people to another.

Bernnet (as cited in Gaganakis 1994:48) defines culture as "the level which social groups develop distinct patterns of life and give expressive form to their social and material experiences ...[it] includes the maps of meaning which make things intelligible to its members". That is, culture is shared experiences among a group of people. D'Ambrasio (1985) further illustrates culture in mathematics as that mathematics which is practised among identifiable social groups that share some common practices including own jargon, code of behaviour, symbols, and their own way of reason. In this context, culture is construed beyond the traditional perspective of ethnic or geographic locations. This social group, for example, could consist of children of a certain age bracket or a group of professionals. Knain (1999:5) concurs with this view and argues that "in the same way mathematics/science has its own norms and values, beliefs, expectations and conventions that are generally shared by communities of scientists, so it constitute a culture of its own". So the concept of culture is not necessarily ethnicity-bound. It is a contested terrain as various conceptions are given to it. Some confine it to ethnic social groups, which makes it to be interlocked within racial discourse; others see it beyond such confinements but still a phenomenon to reckon with.

Within the South African context there are basically two schools of thought that emerged as Moore (1994) conducted a study on multiculturalism in South Africa. There are those who see culture from a realist perspective and those who see it from the constructionist point of view. The realist perception sees culture as a fact and a reality out there. They argue that even Apartheid did not create culture, but rather distorted it (Moore 1994). In support of the realist perspective, those who uphold this view assert that there is a need to work with the reality of culture and cultural differences, in a way that does not reproduce racist differences of Apartheid (Moore

1994: 248). There is a need to deal with culture in a constructive way that acknowledges and respects cultural diversity on an equal basis. Korodia as cited in Moore (1994: 246) advocates that "culture needs to be understood at a range of different levels", from family to community. People are free to discard or assimilate their cultural practices. Multiculturalism is about "understanding the dynamics of difference as it plays itself out in the interaction of individuals with rich variety of community histories at a range of different levels" Neville (as cited in Moore 1994:247) contends.

The constructionist perspective on the other hand sees culture as a social construct and not a natural phenomenon (Moore 1994). Moore (1994) argues that given the history of South Africa there is a need to construct a new culture, which gives people identity; that which humanizes. In alluding to this view Coutts (as cited in Moore 1994:254), argues that cultures are dynamic and are currently changing; "they change as people use their cultural heritage in a vast variety of ways to negotiate situations, which confront them". Gilroy and Smith (1999) argue that it would be partisanist to propagate people to maintain their traditional cultural practices, just like it would be assimilationist for people to abandon all their cultural practices in favour of some better or new ways. Thus, Gilroy and Smith (1999) argue from a constructionist perspective, albeit with caution.

In South Africa it would be unfortunate, in my view, if we opt for strong adherence to our cultural groups, as this would perpetuate apartheid and racial or ethnic divisions. Equally not wise would be to opt for the concept of assimilation and forget and abandon our entire cultural heritage. Gilroy and Smith (1999) caution against this as he calls it cultural imperialism that exists within certain countries. This is aimed at assimilating minority groups into dominant cultures. Diversity in schools is ignored and we "continue to prepare teachers for some mythical homogenous society where everyone shares the characteristics of the dominant cultural group" Gilroy & Smith (1999:4) contest. Opting for diversity by including all cultural groups results in fair representation and will avoid domination or assimilation of one group by others. This model, in my view, would suit South Africa best.

2.3 FACTORS THAT LED TO CURRICULUM TRANSFORMATION IN SOUTH AFRICA

South Africa has a history of racially segregated education, which under the Apartheid regime was underpinned by Christian National Education principles. This led to inferior and subversive education for most Black people. In one of his notorious speeches Dr H. Verwoed suggested:

> We should not give the natives an academic education, as some people are prone to do. If we do this we shall later be burdened with a number of academically trained Europeans and non-Europeans and who is going to do the manual labour in this country ... I am in thorough agreement with the view that we should so conduct our schools that the native who attends school will know that to a great extent, he must be the labourer in this country.
> Christie & Collins cited in (Naicker 1999: 75).

Thus, the system of education was deliberately divisive and re-inforced socio-economic differences based on colour. This was perpetuated by upholding the principle of white supremacy, hence, racism was apparent in most forms of educational practices in South Africa.

This system of education was propagated through the Calvinistic views; which sees the child as born in original sin, and therefore deficient. The child needed to be guided from a point of deficiency and moulded into adulthood. Certain values are to be inculcated into making this child a normal adult (Naicker (1999). This filtered down into the school or classroom situation through the principle of fundamental pedagogics, which equally perceived the child as an empty vessel that needed to be shaped into adulthood. Naicker (1999) contend that fundamental pedagogics is embedded within the Modernism paradigm and is generally practised epistemologically as behaviourism. In this paradigm, knowledge is transmitted from the knowing (the teacher) to the ignorant (the child).

The modernistic curriculum is based on Newtonian ideas where the curriculum is presented as orderly and cumulative. It is entrenched within the reductionist's principle where a whole is seen as not bigger than the parts that form it. Information is to be presented in chunks until a bigger whole is formed (Doll 1989). Curriculum is presented as neutral, objective, and prediction and control are crucial. It is evolutionary in nature rather than transformative (Naicker 1999).

This kind of curriculum is teacher-centred as the teacher is taken as the one who is all-knowing and the child as the ignorant one. As a result, the curriculum was content-laden but deficient in life-skills. This content was also disconnected and compartmentalised. Knowledge acquired outside formal education was not regarded as reputable knowledge.

With the introduction of the new curriculum there was a need to recognise experience and knowledge acquired outside the classroom situation and the National Qualification Framework was put in place as an enabling framework for such. It recognizes both formal and non-formal knowledge as important.

2.4 THE NEW CURRICULUM - WHAT DRIVES IT?

The new curriculum in South Africa is underpinned by philosophical assumptions that are different from the old one. These include post-modernism, social constructivism and an outcomes based model. Although these are discussed separately they are, however, inextricably interlinked.

2.4.1 Post-Modernism as a paradigm shift

When major changes are globally experienced from every direction of life a new era is born; a new paradigm is emerging. It permeates and affects people's thought from all walks of life, (Vorster, 1999). Froneman (1999) regards post modernism as an open system where change is transformational, complex and cyclic. It is some kind of flux and questions the old order like never before. Education in turn could not escape this global turbulence (Knijnik 1999).

The South African curriculum is driven by this global move away from the modernistic way of doing things. The National Education Department (RSA 1997:1) argues as follows:

"A paradigm shift therefore entails moving away from that which perpetuate race, class, gender, ethnic divisions and has emphasised separateness rather than common citizenship and nationhood". The new curriculum calls for incorporation of all, equity and redress of the previous order. It is an inclusive, unitary system of education based on democratic principles where everyone has a right to education This approach advocates change and is committed to non-racist, non-sexist and non-disabilitist society (Naicker 1999).

In order to change educators mindset and all those concerned with education, radical structuralist and radical humanist approaches are evident as they drive the curriculum change in South Africa (Naicker 1999). Naicker (1999) differentiates between the two; radical humanists are mainly concerned with ideological structures and personal consciousness whereas radical structuralist focus their critique mainly on material structures and are concerned with consciousness of social group constituted in terms of class, race and gender. For real transformation to take place, the old order has to be challenged and reviewed. Thus, a new paradigm shift is necessary.

The issues discussed above underpin and drive the postmodern thinking in South Africa. Bernett and Morgan cited in Naicker (1999: 73) contend that "change in a society must be accompanied by change in structures of the society." For effective change to be meaningful, it has to affect the whole system. Spady as cited in Naicker (1999:14) suggests that "systemic paradigm shifts are inherently transformational- that is they change the fundamental nature of everything done previously." At a micro level such as a school, change has equally to be systemic; where everybody shares the vision of that system (Wilkinson 1998). It is collaborative in approach as peoples' ideas and input are welcomed. In this approach no previous knowledge is assumed as absolute. It is asserted that there are more than one 'truths' (Vorster 1999).

To me, I see post-modern thinking as directly linked to social constructivism tenets. These challenge the way educational practices have been implemented. Then, how does social constructivism drive the new curriculum in South Africa?

2.4.2 Social constructivism as an epistemological assumption

In my view, social constructivism can be seen to underpin the new curriculum in South Africa. Proponents of this paradigm assert that learning is a social construct (Ernest 1991). Educators need to acknowledge and incorporate students' background experiences into their lessons in order to access meaningful learning (see project 1). Students' background experiences are embedded in their contextual settings. Thus the new curriculum advocates contextualised learning and teaching. Doll cited in (Froneman 1999:10) asserts that "learning should be an adventure in the construction of meaning and for this historical and cultural context is of importance." Students' personal experiences are regarded as crucial in knowledge construction. Froneman (1999) further argues that this leads to humanification of the subject including the so-called 'hard sciences'. With the inclusion of journals and portfolios this encourages learners' expression of their thoughts and feelings. This humanizes knowledge. This approach therefore contends that teaching has to be learner-centred. The role of the teacher therefore, is to facilitate learning.

2.4.3 Outcomes Based Model underpinning the new curriculum in South Africa

Spady (1994:1) defines OBE as "clearly focussing everything in an educational system around what is essential for all students to be able to do successfully at the end of the learning experience". This implies clearly defining what learners should be able to do and then organising teaching and assessment around those outcomes to ensure effective learning. In Spady's view 'what and whether' learning is happening successfully is the crux of OBE rather than 'when and how' it happens. Spady (1994:2) further defines outcomes as "actions and performances that embody and reflect learner competence in using content, information, ideas, and tools successfully". These, to me, sound more like behavioural objectives as they emphasise that which is observable and can be measured. However, in the South African OBE values and attitudes are also regarded crucial. Also embedded in the outcomes based model is the notion that all students can succeed but not necessarily on the same day.

South Africa has opted for transformational OBE, which happens to be the most radical form of an integrated curriculum. It is driven by seven critical outcomes that are generic in all the bands i.e. foundation (grade 1-3), intermediate (grade 4-6), senior (grade 7-9) further education and training (grade 10-12) as well as the higher education and training band. These outcomes articulate that "learners gain the skills, knowledge and values that will allow them to contribute to their own success as well to the success of their family, community and the nation as a whole" (RSA 1997:15). The curriculum has eight learning areas, which are clustered subjects according to some similarities. Each learning area has its own prescribed specific outcomes, which act as guiding precepts for both content and methodology. The Mathematics Literacy, Mathematics and Mathematical Sciences (MLMMS) learning area, has ten such specific outcomes. (The bolded outcomes relate mathematics to socio-cultural issues, envisaged to be identified by the teachers in this study). These are:

1. Demonstrate understanding about ways of working with numbers.
2. Manipulate number patterns in different ways.
3. **Demonstrate understanding of the historical development of mathematics in various social and cultural contexts.**
4. **Critically analyse how mathematical relationships are used in social, political and economic relations.**
5. Measure with competence and confidence in a variety of contexts.
6. Use data from various contexts to make informed judgements.
7. Describe and represent experiences with space, time and notion, using all available senses.
8. **Analyse natural forms, cultural products and processes and representations of shape, space and time.**
9. Use mathematical language to communicate mathematical ideas, concepts, generalizations and thought processes.
10. Use various logical processes to formulate, test and justify conjectures. (RSA 1997:13).

The South African OBE is based on the competency model as it is linked to learner-centred approaches "based on emanicipatory vision in which learners take control of their own learning. Learners are active, creative and self-regulatory" (Taylor & Vingevold 1999:108). In particular the South African OBE falls within the progressive competence mode where learners are supposed to be independent, innovative, critical thinkers and be able to apply knowledge to different settings (Taylor and Vinjevold 1999).

This approach recognises the value of everyday experience as it is regarded as crucial in "defining the identity of individuals, building of self-confidence of citizens who value their own heritage, but also respect the difference exhibited by others"(Taylor and Vinjevold 1999:113). Taylor and Vinjevold (1999), however argue that most discussions in the competence model tend to over-emphasise contextualisation as the main source of abstraction. Taylor (2000) further argue that, the curriculum, Mathematics in particular, tends to over-emphasise one kind of logical thinking, which is inductive reasoning. Deductive reasoning is not sufficiently represented within the existing specific outcomes in this learning learning area. There are other abstractions and concepts that do not necessarily relate to the concrete world. A need for a more balanced mathematical curriculum that caters for all forms of reasoning is recommended (Taylor 2000).

I concur with this view, as proof in mathematics tends to favour more deductive thinking. This balance enhances a more holistic approach to mathematics thinking. However, to arrive at abstractions I would argue that, contextualised knowledge helps in scaffolding the learners understanding. This acts as a springboard to the abstract thought. My contention therefore is that as long as contextualised teaching is done in order to ultimately access abstraction then I see it as a good base. In other words it should not be done without a goal of reaching the 'universal' concepts.

Bernstein cited in Taylor & Vinjevold (1999:116) cautions that "a competence curriculum is likely to require high teacher training costs because of the sophisticated theoretical base of competence pedagogies". It definitely calls for a new mindset; but change is a process. In the South African context, the complicated language used in the policy documents aggravates the situation and that impedes on classroom implementation (Jansen 1999). It is argued that only the highly competent and knowledgeable teacher would be able to tease out concepts and develop them from real life settings incorporating students' experiences (Taylor and Vinjevold 1999). In mathematics, in particular, "the subtle concepts in higher order learning providing space for all teachers' interpretation is very difficult to achieve... the pedagogical and performance statements are characterised by high level of generality and level of complexity is vague" Taylor and Vinjevold (1999: 123) contend. They further argue that the new curriculum is generally prescriptive enough as far as the policy and methodology are concerned, but rather vague with regard to content. Yet, from the majority of countries that took part in the Third International Mathematics and Science Study (TIMSS), it was noticed that their curriculum guides were quite explicit and prescriptive on content and showed a high degree of micro-management, Taylor and Vinjevold (1999: 124) argue.

Nekhwevha (2000:1) on the other hand, contests that "the underpinning philosophy both to Namibian and South African curriculae lack the cultural capital of the indigenous ingredient". Bantenyerga as cited in Nekhwevha (*ibid.*) equally contests that " the so-called modern education is not satisfactorily addressing the problems of Africa to meet the needs and aspirations of the African people". Nekhwevha (2000) calls for a more indigenized curriculum, which does not undermine African knowledge. He strongly objects to the notion that South African OBE is inclusive and calls it a 'emancipatory rhetoric', as he feels that education and economics are inextricably interwoven. Nekhwevha (2000) further cautions that we might end up with a skilled populace, but fundamentally alienated in terms of African culture, language, ideas and values. Nzimande cited in (Nekhwevha 2000:7) also concurs with this view and argues that "globalization is a term used to describe the process of transforming the world into a single world market dominated by interests of big multinationals". There is a strong contention in this view, that even curriculum reforms are actually driven by the dictates of such multinationals including the World Bank and International Monetary Fund (IMF). They, therefore, call for a more Afro-centric approach to curriculum reform.

Seemingly, there are those who see the curriculum as overloaded with socio-cultural or contextualized knowledge as well as those who see it lacking in such. I would therefore contend that in any curriculum a need for a balance of all forms of knowledge is desirable. Localised and indigenous knowledge should be incorporated but not to the detriment of global knowledge. We live in an era of globalised communication. If we over-emphasise local we might be alienated to the global trends. In the same vein, I want to reiterate that being part of the global world should not alienate us from our roots and contexts. I therefore, concur with Kuiper (1998) when he calls for a need for a balance between contextualised and universal knowledge.

2.5 CONCLUSION

From the presentation above it can be concluded that the notion of culture is a contested one. People have different perceptions about it. There are those who view culture as a static phenomenon that is transmitted from generation to generation. Others see it as dynamic and therefore constructed and shaped by people to meet their needs as situations demand. Also, culture is not only confined to ethnic situations, but is also extended to include other groups within a society, such as mathematicians and mathematics educators.

Traditionally mathematics education, in particular, has been presented as culture-free objective truth. Teacher training programs have presented mathematics as such. With the rise of the newer perspectives underpinned by constructivism and post modernism thinking this notion has been challenged as naive. Mathematics knowledge is viewed as embedded within social, cultural and political influences. These are newer perspectives that underpin the new South African curriculum. This calls for intensive in-service teacher training programs to ensure that teachers are on par with current thinking trends in order to cope with these daunting changes

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This research project involved a group of thirty-one in-service teachers from schools around Umtata, in the Eastern Cape. As mentioned in 1.2, this study aims at investigating teachers' views about the relationship between mathematics and socio-cultural issues. It seeks to unpack teachers' conceptions of the specific outcomes as expounded in the new curriculum as well as teachers' implementation of such.

The study concentrated on grade 1-3, (foundation phase), and grade 7 teachers. They are already in the process of implementing the new curriculum. Grade 4 and grade 8 were also included as it is envisaged that this group will start implementing the new curriculum in 2001.

3.2 METHODS AND PARADIGMS

Data was collected by means of a survey. Although forty-five questionnaires were issued, only thirty-four were returned, three of which were disqualified as they had too many blank spaces.

Surveys are generally used to reach a large population where a sample is needed. Findings are then generalised. However, there are also small-scale surveys that consider a particular case. These do not have to generalise (Irwin 1999). Cohen & Manion (1994:83) describe a survey as:

> Typically surveys gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared or determining the relationships that exist between specific events. Thus surveys may vary in their levels of complexity from those which provide simple frequency counts to those, which provide relational analysis.

This study attempts to describe the nature of an existing condition; i.e. teachers' views about the relationship between mathematics and culture. The analysis of this study mainly falls within the interpretive paradigm, although there are also some elements of quantitative analysis. Guba & Lincoln (1989) argue that paradigms are distinguishable at the level of methods as different tools and techniques are employed. Schwandt cited in Guba & Lincoln (1994:157) contend:

> A third and more recent counter- argument is to assert that while there might be quite meaningful differences at the ontological and epistemological levels, these differences do not matter in the day to day conduct of inquiry because methods and paradigms are interdependent. At the level of practice inquirers find it impossible to choose between the two or more paradigms, instead they blend them as a problem or situation requires.

This study falls within the articulations of the above statement. The analysis takes an eclectic approach. Also, Cook & Reichard as cited in Guba & Lincoln *(ibid.)* suggest "evaluators should feel free to change their paradigmatic stance as the need arises". Poulton cited in Guba & Lincoln (*ibid.*) also concurs with this view and argues that "the mind shifts back and forth between paradigms even within a single particular investigation".

This is also a case study as it is concerned with the uniqueness of a particular case (Stake 1995). It is about the complex functioning of the situation, in this case teachers' views around Umtata. It has also phenomenological dimension as Merriam cited in (Schäfer 1999:10) suggests; "it focuses on the essence or structure of an experience". It therefore lies mainly within interpretive domain as it seeks to find subjective consciousness of teachers' views on mathematics and socio-cultural connections. Views are subjective and cannot be measured to precision.

Questionnaires were issued to teachers in order to collect data. It was a non-participant exercise as subject advisers concerned with these groups administered these questionnaires. These questionnaires comprised "a series of questions on a paper that ... focussed on an area of interest" (Irwin 1999:4). In the questionnaires empirical data such as teachers' profile on their experience, qualifications, workshops attended were also included (See Appendix1). Closed-ended questions had some elements of nominal questions such as identifying whether the respondent is male or female. There were also ordinance and interval questions that sought teachers' experience for instance. Validating questions were also included where "similar answers were sought in different categories in order to increase validity and reliability" (Irwin 2000:17).

Open-ended questions were also used and this is where the respondents had all the freedom to express their views without being confined. A variety of responses were given to the same question. Subjective views and feelings can be detected in this category. This helps in facilitating qualitative data analysis.

3.3 CONCLUSION

This study is a survey that adopts an eclectic approach. It predominantly lies within an interpretive paradigm but has elements of quantitative analysis. Teachers'profile and general teaching experience as well as OBE workshops exposure are quantitatively analysed. Teachers' views on the culture, relationship between socio-cultural issues and mathematics, unpacking of mathematics outcomes that relate to socio-cultural issues and application of such in their classroom practices are qualitatively analysed.

CHAPTER FOUR

FINDINGS

4.1 INTRODUCTION

Altogether thirty-four out of forty five questionnaires were returned. I struggled to collect them as subject advisers administered these on my behalf. Some were returned almost blank and these were disqualified. Eleven could not be returned altogether. Findings are divided into the following categories:

- Teachers' profile
- Teachers' use of the policy documents
- Teachers' understandings of culture
- Teachers' conceptions of the relation between mathematics and socio-cultural issues
- Unpacking the mathematics specific outcomes (SOs) related to mathematics
- Application of such SOs in teachers' classroom practice

This chapter provides the responses to the questionnaire. I will discuss and interpret these findings in chapter 5.

4.2 TEACHERS' PROFILE

General teachers' profile is reported according to the following themes:

- Gender
- Levels taught
- Teacher' qualification
- Teachers' last qualification
- General teaching experience
- Mathematics teaching experience
- Number of students taught

Gender

77,5% of the respondents were females. This is the case because generally in this region all foundation phase teachers are females. Also, teachers in the primary level are predominantly females.

Levels taught

Table1 illustrates the breakdown of grades taught by the sample teachers.

LEVEL TAUGHT	PERCENTAGE
Foundation phase	56,6
Grade 4	16,1
Grade 7	12,9
Grade 8	9,4

Table 1: Levels taught

Thus 64,5% of the respondents already implement the new curriculum i.e. Foundation phase and grade 7.The rest will be implementing it in 2001.

Teachers' Qualifications

Figure 1 provides a breakdown of teachers' qualifications in percentages. The qualifications are as follows:

- M+2 - matric and two year teacher's certificate
- M+3 - matric and three year teacher's diploma
- M+4- matric and four year teacher's diploma or degree and teacher's certificate or diploma
- M+5- Senior degree and teacher's certificate or diploma

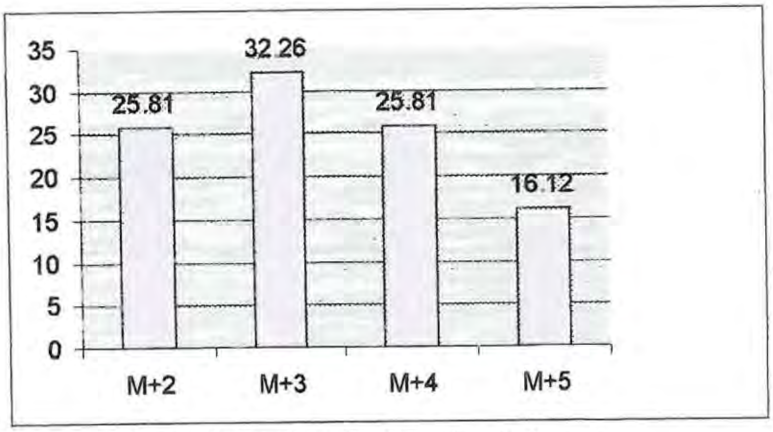


Figure 1: Teachers' Qualifications in Percentage

Teachers' most recent qualifications were sought and the highest number of recent qualification was among those who qualified about 3 years ago, followed by those who qualified over 8 years ago. Table 2 shows the distribution.

Last Qualification Obtained	Percentage
2 years ago	16,1
3 years ago	38,7
5years ago	12,9
8 years ago	9,7
More than 8 years ago	22,6

Table 2:Teachers' Last Qualification

General teaching experience

The sample is generally represented by well experienced teachers as the majority (64,6%) has more than 15 years teaching experience. 22,5% have taught for five to ten years. Only 3,22% teachers have been teaching for less than 5years.

Mathematics Teaching experience

The table 3 represents the teachers' experience in the teaching of mathematics:

Maths Teaching Experience (in yrs)	Percentage
Less than 5	12,9
Between 5 and 10	25,8
Between 10 and 15	16,1
Between 15 and 20	19,4
More than 20	25,8

Table 3: Mathematics Teaching Experience

Number of students taught

Table 4 shows teachers' responses with regard to the number of students they currently teach. All teachers reported that they taught more than 40 students. Most teachers teach between 40 and 60 students.

No. of Students taught	Percentage
Less than 40	0
Between 40 and 60	51,16
Between 60 and 80	16,19
Between 80 and 100	6,5
Between 100 and 120	6,5
More than 120	9,5

Table 4: Number of students taught

4.3 TEACHERS' RESPONSES

Teachers' responses are categorised into the following:

- Teachers' rate of using policy documents
- Teachers' understanding of culture
- Unpacking specific outcomes related to culture
- Relation between mathematics and culture
- Feelings on incorporation socio-cultural issues in the mathematics curriculum
- Exposure to OBE-related workshops

4.3.1 Teachers' rate of using policy documents

Table 6 shows the teachers' responses in using the OBE policy documents. Their responses varied as shown below:

RATE OF POLICY DOCUMENTS USE	PERCENTAGE
Always	32,25
Sometimes	48,38
Rarely	6,45
Never	12,92

Table 5: Rate of policy documents use

The following responses were also made. All teachers implementing curriculum 2005 reported that they have a copy of specific outcomes for MLMMS. 48% of the teachers who will be implementing in 2001 reported that they do not have a copy of these outcomes. A follow-up question was asked on why the policy documents were not used. These were some of their responses:

- It is difficult to understand (the commonest response)
- I never attended the course/ not yet trained for OBE (teaching Gr4)
- Not very clear on how to use it, it has no pages.
- Terms used are unfamiliar.
- Never seen any policy document for this curriculum.

4.3.2 Teachers' understanding of culture

The concept of culture was sought in order to have a picture of teachers' conceptions of it. The following are some of their responses grouped in common themes:

- It is understanding norms , values and attitudes, beliefs of a society (65% responses)

  Teaching they get at home as to how to behave.

  It is a way of life, which includes inherited ideas, beliefs knowledge and social activities

  It is a way of living in a particular society.

  Culture is a socially transmitted behaviour patterns lifestyles, heritage, knowledge, and belief systems arts, customs, attitudes, values, ideas, and other products, of human work, and thought characteristics of that particular community or population. It is transmitted from generation to generation.

  It concerns lifestyles, behaviour patterns and societal organization. Anything that draws our attention to the places we live in and neighbouring countries.

- It is background habits (6% responses)
- It is understanding of literature or environmental affairs or customs and traditions in art and music.

4.3.3 Unpacking mathematics specific outcomes related to culture

On asking whether there are specific outcomes that relate mathematics to culture, 90,32% responded that there are such outcomes. Those who disagreed were mainly grade 4 teachers. When asked to identify such specific outcomes (See 2.3.3), the following are the results:

- All SOs except 9 and 10 were found in various combinations.
- SO3 was the most common (found in 70,96 of the various combinations)
- SO 8 was identified in 45,16% of combinations

- SO4 was identified in 41,93% of the combinations
- SOs 3,4,and 8 were found in 22,58% of the combinations
- SOs 3 and 4 were found in 35,48 of the combinations

A further probing question was asked on what do teachers understand by the outcomes they have chosen. 25 % of the responses were completely irrelevant and gave responses like: they all integrate, they correlate between critical outcomes, show understanding of historical maths.

The following are the teachers' various responses given in themes:

- ***Measurement***

  We measure when building houses

  How measurement was done in the olden days e.g. using part of our bodies

  History of the development of maths, presently using metric system

- ***Shapes***

  Learners should be able to make analysis of cultural products such as huts made in grass in relation to shapes. Our culture has culture full of shape

  Ancient buildings and present day buildings

  Make shapes e.g. rondavel, going round to identify shapes in the environment, pictures used in wall paintings

- ***Counting and Pattern***

  Singing and dancing, different patterns are made

  Even in economy and politics maths and culture are involved

  For social, political and economic reasons people are usually counted

  Number patterns, counting in Roman figures

- ***Design***

  African design e.g. Ndebele design beadwork, women jewelry

  In beadwork use, understanding of culture in dancing and knitting

- ***Unique response***

History of mathematics can be traced to what happened in the past. We see maths in children's plays or games, in house decorations, many other things. This shows that maths has been around since time immemorial.

- ***General and irrelevant responses***

  Other responses were not explicit enough such as: learners can apply what they have learnt from school to their community, demonstration of how technology or its lack can influence the quality of humanity.

A few of respondents did not fill in this part. Also some responses did not match with the specific outcomes chosen.

4.3.4 Relationship between mathematics and culture

Teachers generally (83,87%) agree that issues related to culture do belong in a mathematics curriculum. However, many did not qualify this assertion. In justifying this claim one responded by saying, " 'Intonjane' has nothing to do with mathematics curriculum". 'Intonjane' is a ritual ceremony for girls as they graduate into adulthood (some kind of 21st birthday in the Western culture). Some responses were not that clear.

Responses on mathematics as an everyday activity

- Because at home and in the community learners use mathematics
- If you cannot count when mixing the Xhosa beer it will not be right
- Shapes which are used in maths are also abundant in our culture
- Working with numbers is part of our daily lives e.g. how much, how many, how long, how big?
- Patchwork as art of sewn design has something to do with our way of beautifying our clothing. The designs in patchwork are shapes geometry
- It is of great importance to know your cultural values and events i.e. particular year or month. It is important to cultural values, events and time

Responses on moving from concrete to abstract

- Children understand easily when taught something related to their culture because it is something they see everyday i.e. familiar with
- Learners start from the known to the unknown
- In most cases pupils must be taught from concrete to abstract
- What pupils know is from their cultural background so it is important to integrate what they know to present mathematics

4.3.5 Application of these in classroom practices

When teachers were asked whether they personally incorporate socio-cultural issues in their mathematics teaching, 80% responded that they do. A follow up question required them to explain what they meant. The following were their responses:

- ***Shapes as a concept***

  When teaching shapes, drawing of houses

  When teaching shapes, drawing of houses of the olden days and now

  Students use their own materials i.e. what is available like objects in the classroom to form up shapes

  For example when teaching fractions I use things like bread which is what is what they are all familiar with instead of teaching them about cake and other things that are rare in their environment.

- ***Other responses***

  At home they count sheep herds of cattle etc., they use the information in the classroom when doing maths games.

  Three legged pots, which are, used in our culture shows a number of legs, which a learner can relate to Mathematics

  I also teach the learners how to calculate profit and loss when they sell some things to raise funds

- ***Vague responses***

  Some responses were not so easy to understand, such as:

  This learning area will promote all aspects of technology, planning and manufacturing.

  Team teaching for problem- solving where a tape measure, metre stick or scale will be used.

  When pupils use their body parts

From the responses of those who do not see mathematics and socio-cultural issues related argued that it is not relevant in their grades but taught in the upper grades or OBE will be introduced in 2001 in their classes. About 17% of the respondents left this part blank.

4.3.6 Feelings on incorporation of such issues in the mathematics curriculum

Responses on how teachers felt about incorporation of socio-cultural into the new curriculum were generally positive, as some reported they felt proud or good and it will help learners become creative workers. One teacher responded as follows, "*Our new curriculum must accommodate the socio- cultural issues because this facilitates much comprehension in different areas of culture*". Another responded that mathematics has a tendency of cutting across many learning areas it must therefore include socio- cultural issues. Some felt such issues should be included since they " *are part and parcel of each person's well being*". One responded that this learning area would equip learners to cope with the rapidly changing technological environment.

There was a general feeling that they welcome the fact that socio-cultural issues are included in the new curriculum. About 19% did not respond to this question.

4.3.7 Exposure to OBE-related workshops

About 80,65% reported that they have at least attended one OBE workshop between 1998 and 2000. The number of workshops attended varied between one and eight. Figure 2 shows the percentage of teachers who attended these workshops. (The number of workshops is represented in different colours.)

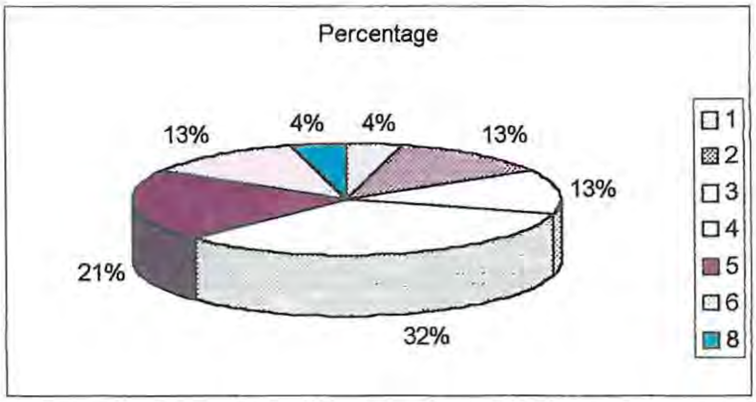


Figure2: Percentage of teachers who attended at least one OBE workshop

From those who have attended workshops, 61,29% reported that they have been exposed to workshops that relate mathematics to socio-cultural issues. Amongst those who attended socio-cultural related mathematics workshops, some identified concepts like: beadwork, shapes in mats, activities dealing with olden ways of measuring such as Roman figures. One teacher wrote:

> The last I attended for example was dealing with different types of transport e.g. airplanes, busses, cars, horses etc. The theme automatically changed into mathematics as we had to look at the fastest, i.e. speed, time taken, the biggest, capacity, slowest and the expenditure on fuel.

Another responded that she is new in this, sometimes even workshop facilitators are themselves not sure of such issues and give unsatisfactorily answers.

There were also irrelevant or confusing responses such as: Each specific outcome seem related to each other, so mathematics is a language based on culture, so knowledge skills and values are also there

When asked whether they think they have benefited from such workshops, 51,85% responded positive. When asked to justify what they meant by gaining a better insight. They responded as follows:

- ***Economy and accounting related***

  Budgeting

  Pupils can economise at their homes

  In our culture there is 'lobola' which needs counting skills

- ***Design and technology related***

  Use of different styles when building houses

  Use of different angles when building houses

  You measure the space in between when making mats

  You count the colour of beads made when making a pattern

- ***Unique response***: I started understanding the world as a set of related systems with its activities overlapping to one another

10% did not respond and left blank spaces.

4.4 CONCLUSION

Teachers' profile generally shows that they are well qualified for the classes they teach. These teachers are well experienced as only a few have less than five years teaching experience. Teachers generally attend workshops but differ in the rate of attendance. It was apparent that teachers do not regularly use the policy documents due to the inaccessible academic language used in them. As a result, identifying, unpacking and implementation of the culture related mathematics specific outcomes was not easy to do as some left blank spaces or superficially responded to these questions.

Teachers generally displayed a realist view of understanding culture as they see it as transmitted from generation to generation. On the whole, an overwhelming majority sees the need to incorporate socio-cultural in the mathematics curriculum, although justifying such assertions was superficially done.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

5.1 INTRODUCTION

This chapter discusses the findings obtained from the themes that guided the study. These are:

- Teachers' profile
- OBE policy documents and workshops
- Views on culture and its relationship to mathematics
- Unpacking culture related mathematics SOs and classroom application thereof

5.2 TEACHERS' PROFILE

This group of teachers is generally well qualified since only 25,1% are under-qualified i.e. matric+ 2 year professional certificate. All those in this category were found to be in the foundation phase and among the older teachers. This was evident from their teaching experience, which is generally over twenty years. The overwhelming majority of teachers are well experienced, as generally have been teaching for more than five years. Also, teaching experience in mathematics is generally more than five years. All teachers reported that they teach more than forty pupils. This is, however, detrimental to what is envisaged in implementing the new curriculum, as the current official pupil-teacher ratio reads 1:40. It was found that most teachers, across all grades, teach between 40 and 60 pupils in a class. Those who teach more than one hundred and twenty pupils are predominantly teachers of the upper grades i.e. grade7 and 8. This is possible, since at this level, subject teaching is practised.

A question about teachers' recent qualifications was included in order to find out whether teachers upgrade themselves in order to keep abreast with the changes. The majority of teachers have recently, within the last eight years, acquired a new qualification. Very few teachers have their teaching experience less than ten years. So, the difference must be due to newly acquired qualifications. Thus, these teachers are upgrading their qualification at a significant rate. This is in line with what is purported by the Departrment of Education in the policy document for Norms and Standards for Educators. In the document, (RSA 1998), it is outlined that teacher education will equip teachers in order to cope well with new curriculum activities. Also in line with the principle of life long learning, teachers will need to keep abreast of the changes by attending in-service courses and through self-study. So, these teachers have seized that opportunity.

5.3 OBE POLICY DOCUMENTS AND WORKSHOPS

In seeking teachers' exposure to in-service courses, especially OBE related workshops, the study found that an overwhelming majority has at least attended one such workshop. Among those who have attended workshops, 61,29% have been exposed to at least one workshop related to socio-cultural issues in mathematics. The questions on upgrading and in-service workshops were specifically included to establish whether teachers have been exposed to the new ways of thinking. It is of course recognised that teaching styles take time to change as teachers have a tendency to teach the way they were taught (Vacc and Bright 1999). Exposure to workshops and upgrading one's qualification can lead to a new mindset though. Change comes as a result of challenge, and "if teachers' beliefs are compatible with the underlying philosophy and materials of a curriculum, there is greater likelihood that the curriculum will be fully implemented" Hollingsworth; Richardson cited in (Vacc & Bright 1999:91).

From the workshops attended, about half responded that they did benefit. However, some reported that they did not benefit much as workshop facilitators sometimes themselves had problems in unpacking certain things. This is well articulated in Taylor and Vingevold (1999) when they argue for a need for intensive training of everyone involved with education including district officers. Wilkinson (1999) also concurs with this view and advocates systemic change for any real change to permeate all those involved.

When teachers were asked to justify their claims about benefiting in workshops, reasons forwarded were far-fetched and often superficial. Their responses generally related to what pupils do and what is generally enhanced by mathematics application in socio-cultural contexts. Few responded about how the workshops have affected them personally. For example one Grade 7 teacher responded as follows: "I started to understand the world as a set of related systems with its activities overlapping to one another." Generally, there was no evidence of a philosophical shift. The responses focussed only on tools and techniques. This is cause for concern, as teachers could use these tools, but still remain behaviouristic in their approach. I would argue that this is a shallow understanding or display of a paradigm shift and further concur with Doll (1989) when he argues that changing over from modernism to post-modernism will not be easy, as modernism is well entrenched in peoples' daily lives.

All teachers reported that at their respective schools they all have policy documents. However, unpacking the issues in the documents was seemingly a problem as the language is not user-friendly. They generally reported that the document is difficult to understand. As a result only a few regularly consult the document. On asking why they do not use the documents, some responded that it has unfamiliar language, it is unclear and pages are not numbered. All these factors point to the concern that the OBE documents have meaningless jargon and vague ambiguous language (Chisholm *et al.* 2000; Jansen 1999). Taylor and Vingevold (1998) equally complain that the language used in these voluminous documents is inaccessible to the teacher in the classroom. It seems the complicated language deters teachers from perusing and unpacking the philosophical issues embedded in the new curriculum. The possible option would be for the teachers to revert back to their comfort zone, thus teach the way they have been teaching.

5.4 VIEWS ON CULTURE AND ITS RELATIONSHIP TO MATHEMATICS

The study also required teachers to unpack their understanding of culture as a concept. A common trend was that the teachers' conception of culture is consistent with that of the realist perspective. They generally portrayed culture as a static phenomenon and one teacher reported "It is transmitted from generation to generation". It is perceived as something that cannot be challenged but is ordained from 'above'. The majority perceives culture mainly from the values, beliefs and behaviour standpoint. This kind of perception is embedded within the modernist paradigm. It seeks order and maintains that there is one truth. This naively leads to taking things for granted as change is often seen as a threat to disrupting the existing order. Constructionists, however, perceive culture as a dynamic social construction that continually changes and responds to the needs of the people at any point in time (Moore 1994). The post-modem thinking seems to underpin this perception. This paradigm calls for various cultures and sub-structures within structures to be included. Its underlying tenet is that there are many truths (Doll 1989). In mathematics for example the thinking modes of females and marginalised cultures have been excluded. It has been assumed as natural for men and western cultures to dominate such fields of study. Also, portraying culture as referring only to ethnicity is in contradiction to what underpins ethnomathematical thinking. As a narrative, ethnomathematics sees culture beyond the ethnic and geographical locations (D'Ambrasio 1985). If teachers have little or no underlying theory to interpret the philosophical underpinnings of the new curriculum, true transformation could remain a pie in the sky.

Though teachers' understanding of culture is rather conservative, their views on the relationship between mathematics and culture showed diversity. Some argued that there are no linkages at all between the two. Others portrayed mathematics as integrated in our daily activities. This group of teachers advocates contextualised teaching. The popular view among the responses reported is that this enhances better understanding as pupils learn better from the concrete to the abstract. However, there were a few who promoted the teaching of mathematics with strong ethnic undertones. This would be detrimental to the teaching of mathematics as this could promote ethnicity and racial segregation as opposed to ethnomathematical approach, which calls for diversity of cultures (Zaslavsky 1998).

5.5 UNPACKING CULTURE RELATED SOs AND CLASSROOM APPLICATION THEREOF

The overwhelming majority agreed that there are specific outcomes that relate mathematics to culture, however unpacking the underlying meanings of such SOs revealed a different story. From the combinations of SOs identified all except 9 and 10 were mentioned. Of those combinations only 22,5% identified the correct combination i.e. SOs 3, 4 and 8.

The policy document (RSA1997:) unpacks these culture-related outcomes as follows:

SO3: Demonstrate an understanding of historical development of mathematics in various social and cultural contexts: Mathematics is a human – activity. All people of the world have contributed to the development of mathematics. The notion that mathematics is a European product must be challenged. Learners must be able to understand the historical background of their communities by use of mathematics.

SO4: Critically analyse how numerical relationships are used in social, political and economic relations: Mathematics is used as an instrument to express ideas from a wide range of other fields. The use of mathematics in these fields often creates problems. This outcome aims to foster a critical outlook to enable learners to engage with issues that concern their lives individually, in their communities and beyond. A critical mathematics curriculum should develop critical thinking including how social inequalities particularly concerning race, gender and class are created and perpetuated.

SO8: Analyse natural forms, cultural products and processes as representations of shape, space and time: Mathematical forms, relationships and processes embedded in the natural world and in cultural representations are often unrecognised or suppressed. Learners should be able to unravel, critically analyse and make sense of these forms, relationships and processes.

From the outcomes above it can be deduced that, ethnomathematical and critical mathematics philosophies underpin these, where social, cultural and political influences are seen as crucial in shaping mathematics. Out of ten outcomes, three relate to socio-cultural issues. This shows that the new curriculum in mathematics is committed to incorporating such issues. This is actually confirmed in Taylor and Vinjevold (1999) when they argue that C2005 tend to over- emphasise contextual knowledge.

In unpacking the underlying meanings of the culture-related outcomes in mathematics, teachers identified concepts such as: measurement, shapes, counting and pattern. The following were also identified and well articulated: history of the development of mathematics, measurement in the olden days using body parts, measurement in building houses. Shapes were the most commonly identified concept and, predominantly came from the foundation phase teachers. Design in beads and Ndebele design was also mentioned, however, the unraveling of such concepts was not clear.

Generally the culture-related specific outcomes were well articulated by the few that could identify them. Most teachers however, responded in a simplistic and superficial manner. Examples were just given instead of perhaps illustrating a concept. I noticed that few teachers exerted themselves in explaining their understandings. Some teachers did not qualify their claims and in some cases unpacking did not match the chosen correct outcome. It was found that for those who have attended more than four workshops, there was better unpacking of the outcomes. This was mainly from the foundation phase teachers. Qualifications did not seem to help one to understand these better. The advantage perhaps of the foundation teachers over others could be because this is their third year of OBE implementation. It was found that for those teachers who will start their implementation in 2001 there is virtually no orientation as yet.

Thus, it can be deduced that the more intensive the training on OBE issues, the better will be the understanding. Chisholm *et al.* (2000) report that although teachers show a poor understanding on the substance of OBE, however, they are generally positive about it. There is therefore a need to capitalise on such an attitude. The foundation phase teachers were the keenest group. I concur with Chisholm *et al.* (2000) when they further recommend a need for intensive training of the quality of trainers that has classroom based support component.

Due to the complicated language used in the policy documents, much time has been wasted on unpacking terminology. These documents are not only many, but voluminous as well. This has led to a shallow understanding of the essence of OBE issues. It is in the light of these concerns that Chisholm *et al.* (2000: 22) have recommended the dropping of the specific outcomes and rather promote " conceptual coherence by specifying learning outcomes and assessment standards by grade".

In applying socio-cultural issues in their classroom practices, teachers showed a strong connection with how they interpret the specific outcomes. Those who had a better insight of the socio-cultural specific outcomes better articulated their classroom application of such. This shows that unless teachers have a clear understanding of underpinning philosophies to mathematics teaching, it will not be easy to implement the new curriculum.

5.6 CONCLUSION

The language used in the policy documents of the new curriculum is not easy to unpack. Teachers generally display problems in understanding the specific outcomes that relate mathematics to socio-cultural issues. This problem is apparent across all teachers irrespective of qualifications and gender. However, with more exposure to workshops there is a slight change towards better insight. Thus the more the exposure and the longer the period of implementing OBE, the better the chances for change.

Also, apparent in the study are teachers' beliefs and the actual implementation of such. There was a gross disproportion between what teachers believe and their classroom practices. All respondents saw the need for the inclusion of socio-cultural issues in the teaching of mathematics but their own teaching styles did not confirm this belief. There is, therefore, a need to assist teachers to close this gap.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

Education in South Africa, in the past has been marked by racial segregation. With the introduction of democracy there was a need for an education system that is inclusive of all. A new curriculum that upholds democratic principles was put in place. South Africa opted for transformational OBE that is dovetailed with social constructivist principles. This calls for a new mindset. Teachers have, however, been taught in a behaviouristic paradigm where mathematics in particular is perceived as acultural. The new approach, however, perceives mathematics knowledge as intertwined within social and cultural influences. As a result, about a third of the outcomes for mathematics portray it as such. The concern is whether practising teachers are aware of this, and if so, how do they interpret and apply these in their classroom practices.

The introduction of the new curriculum has been rather hurriedly done. There has been a general outcry about inadequate time in orientating and training teachers for the new curriculum. This has led to confusion and misunderstanding of the essence of OBE and its underpinning philosophy. The complicated language used in the documents has aggravated the situation.

6.2 REFLECTIONS AND LIMITATIONS

In this study, the problem of the inaccessible language of the policy documents came up strongly. Few teachers seem to consult these documents, as the complicated jargon and terminology deterred them. This was evident in teachers' understandings of the socio-cultural outcomes as expounded in the MLMMS learning area. These were poorly identified as only a few could get a correct combination of all three such specific outcomes. Furthermore, unpacking the underlying meanings embedded in those outcomes was superficially done. Most teachers merely used examples to illustrate their interpretation. There was generally little understanding of the underpinning philosophy to these outcomes. This actually re-inforces what Taylor & Vinjevold (1999) are concerned about; understanding the very heart of OBE. I am equally concerned about this shallow understanding of the basic tenets to the new curriculum as this could lead to using social constructivist's tools and techniques in a behaviouristic way.

Teachers' concept of culture is more consistent with the traditional view, and mostly confined to ethnicity. Although there was a general feeling that cultural practices do relate to mathematics, there was a shallow explanation of what teachers meant. There was a strong link between the teachers' understandings of the relationship between mathematics and culture and their classroom practices.

This study has some limitations, which include:

- Follow up interviews could have better triangulated some of the teachers' responses
- Another questionnaire or interview with the subject advisers could have helped in having a clearer picture of the workshops conducted
- A better method of administering questionnaires could have helped eliminate the gaps that were left. If I were personally administering these I would have seen to it that there were no blank spaces.

6.3 FURTHER RESEARCH AND RECOMMENDATIONS

This project could be further explored on a larger scale. A survey would be conducted to include a bigger population of teachers since this one cannot be generalised beyond the case it was involved with. This would help in planning workshops that meet the needs of the teachers. Teaching mathematics with contextualised knowledge is a global trend and underpins the South African curriculum.

As a survey, this study has shown a mere glimpse of the situation. Another study would be to make follow-up visits and investigate how teachers implement these issues in their classroom practices. This would require a more qualitative analysis and be more participatory in approach.

There is a need to have intensive orientation and training in a more holistic way, where both theory and practice will be integrated, so as to challenge teachers' worldviews. These should be followed by classroom support so as to assist teachers in unpacking these issues at grass root level. Training for the next grades has to be done quite in time. I also concur with the many researchers on the need to make OBE language more accessible (Jansen 1994; Taylor & Vinjevold 2000; Chisholm *et al. 2000)*

6.4 CONCLUDING REMARKS

This study has confirmed the general outcry on the implications of the rushed implementation of the new curriculum in South Africa. Teachers generally show a shallow understanding of the implications and the essence of the new paradigm shift as entailed in the new curriculum. Language used in the policy documents has a negative effect in accessing what is expounded in these documents. There is a dire need to assist teachers to access OBE in a holistic way and not just focus on the techniques.

Although an overwhelming majority of teachers agreed that there are connections between culture and the specific outcomes in Mathematics learning area, however, teasing out such connections was rather shallow. Teachers had problems in identifying the relevant specific outcomes and this merely became rhetoric. So, what teachers claim to believe is not always what they do.

REFERENCES

Chisholm, L., Volmink, J., Potenza, E., Muller, J., Vinjevold, P., Ndlovu, T., Mahomed, H., Lubisi, C., Ngozi, L., & Mphahlele, L. (2000). *South African curriculum for the twenty first century: Report of the Review Committee on Curriculum 2005*. Pretoria: Government Printer.

Cohen, L., & Manion, L. (1994). *Research methods in education* (4th ed.). London: Routledge.

D'Ambrasio, U. (1985). *Ethnomathematics and its place in the history and pedagogy of mathematics*. Retrieved on 22 September 1999, from the World Wide Web:

http://www.enc.org/equity/eqtyres/erg/111552/1552.htm.

Doll, W. E. (1989). Foundations for a Post-modern curriculum. *Journal for Curriculum Studies*, 21 (3), 243-253.

Ernest, P. (1991). *The philosophy of mathematics education*. London: Falmer Press.

Froneman, S. (1999). *The paradigm shift to postmodernism as rationale for Outcomes Based Education*. Proceedings of the fifth national congress of The Association for Mathematics Education of South Africa (pp. 96-105). Port Elizabeth: AMESA.

Gaganakis, M. (1992). Language and ethnic group relations in non-racial schools. *The English Review*, 9, 46-55.

Gerdes, P. (1996). Ethnomathematics and mathematics education. In A. J. Bishop (Ed.), *International Handbook of Mathematics Education* (pp. 909-943). Dordrecht: Kluwer.

Gilroy, P., & Smith, M. (1999). Teacher education as cultural imperialism. *International Analysis of Teacher Education for Teaching*, 19 (4&5), 1-7.

Guba E.G., & Lincoln, Y.S. (1994). Competing paradigms in qualitative research. In Denzin, N.K. & Lincoln Y.S. (Eds.), *Handbook of Qualitative Research* (pp.105-117): London Sage.

Guba, E.G., & Lincoln, Y.S. (1989). *Fourth generation evaluation.* NewburyPark: Sage.

Irwin, P. (1999). (An introduction to conducting surveys and to the use of questionnaires). MEd. lecture notes, Education Department, Rhodes University, Grahamstown.

Jansen, J., (1999). Why Outcomes-based Education will fail: An elaboration. In J. Jansen, & P. Christie (Eds.) *Changing curriculum on Outcomes-based Education in South Africa* (pp.145-156). Cape Town: Juta.

Joseph, G. G. (1991). *The crest of the peacock: Non-European roots of mathematics.* New York: Penguin.

Knain, E. (1999). Sense and sensibility in science education: Developing rationale beliefs through cultural approaches. *Studies in Science Education*, 33, 1-29.

Knijnik, G. (2000). *Ethnomathematics and postmodern thinking: Conver/Divergences.* Retrieved on 10 April 2000, from the World Wide Web:
http://www.enc.org/equity/eqtyres/erg/111552/1552.html.

Kuiper, J. (1999). Science and culture: The art of balancing. *Journal of Southern African Association for Research in Mathematics and Science Education*, 2 (1) 21-32.

Lukhele, B. (2000). *In-service teachers' conceptions of C2005 and the implementation thereof.* Proceedings of the sixth national congress of The Association for Mathematics Education of South Africa (pp. 189-194). Bloemfontein: AMESA.

Moore, B. (1994). Multicultural education in South Africa: Some theoretical and political issues. *Perspectives in Education*, 15 (2), 237-267.

Naicker, S. R. (1999). *C2005 A space for all: An introduction to inclusive education.* Cape Town: Tafelberg

Nekwevha, P. (2000). *No matter how long the night, the day is sure to come: Culture and educational transformation in post colonial Namibia and Post- Apartheid South Africa.* Retrieved on 20 July 2000, from the World World Web: http://www.uct.ac.za/education/wc ces/papers/nekhwe.htm.

South Africa (Republic). (1997). *Policy Document: Senior Phase.* Pretoria: Government Printer.

South Africa (Republic). (1998). *Norms and Standards for Educators.* Pretoria: Government Printer.

Schäfer, M. (1999). *Designing and making a difference: An exploration of technology education for rural school teachers.* Unpublished master's thesis, Rhodes University, Grahamstown.

Spady, W.G. (1994). *Outcome-Based Education: Critical issues and answers.* Virginia: American Association of School Administrators.

Stake, R.E. (1995). *The art of the case study research.* London: Sage.

Taylor, N. (2000). Mathematics in Curriculum 2005: Submission to the ministerial Review Committee. *Pythagoras*, 50, 8-9.

Taylor, N., & Vinjevold, P. (Eds.). (1999). *Getting Learning Right: Report of the President's Education Initiative Research Project.* Johannesburg: Joint Education Trust.

Vacc, N. N., & Bright, G.W. (1999). Elementary pre-service teachers' changing beliefs and instructional use of children's mathematical thinking. Journal for Research in Mathematics Education, 30 (1), 89-110.

Vorster, J.A. (1999). *A perspective on postmodernity as key to understanding curriculum 2005.* Proceedings of the fifth national congress of The Association for Mathematics Education of South Africa (pp.351-364). Port Elizabeth: AMESA.

Welch, A. (1998). The end of certainty? The academic profession and the challenge of change. *Comparative Education Journal*, 42 (1), 1-14.

Wilkinson W.G. (1998). *Investigating systemic factors affecting Science learning in curriculum 2005: Case studies of two schools.* Unpublished master's thesis, Rhodes University, Grahamstown.

Zaslavsky, C. (1973). *Africa counts: Number and pattern in African culture.* New York: Lawrence Hill.

Zaslavsky, C. (1998). Ethnomathematics and multicultural mathematics education. *Teaching Children Mathematics*, 5 (5), 502-503.

APPENDIX 1

The following is a questionnaire seeking to investigate teachers' views on the relationship between Mathematics and culture. Your voluntary co-operation in completing the questionnaire is highly appreciated. You are requested to answer each question as truly as you can as these will be treated with utmost confidentiality.

SECTION A
Please circle your response to the following:

1 Grade taught: A.1 B.2 C.3 D.4 F.7 E. 8

2. Sex: A. Male B. Female

3. Qualifications
A.matric+ 2 year teachers's certificate B. matric + 3 year teacher's diploma
C. Bachelor's degree+ professional certificate/diploma D. senior degree + professional cert/diploma E. Other (specify)......................................

4. Teaching experience (in years)
A. less than 5 B. between 5 and 10 C. between 10 and 15
D. between 15 and 20 E. more than 20

5. Teaching experience in Mathematics
A. less than 5 B. between 5 and 10 C. between 10 and 15
D. between 15 and 20 E. more than 20

6. Number of students taught this year
A. less than 40 B. between 40 and 60 C. between 60 and 80
D. between 80 and 100 E. between 100 and 120 F. more than 120

7. Last qualification obtained
A.between 1999 and 2000 B. over 3 years ago C. 5 years ago
D. 8 years ago E. over 8 years ago

SECTION B

8. In your school do you have policy documents for curriculum 2005?
A. Yes B. No

9. Do you use it: A. Always B. Sometimes C Rarely D Never

10. If your response is C or D, why?
....
....
....
....

12. Do you own a copy of specific outcomes(SO's) for MLMMS: A. Yes B. No

13.What do you understand by the concept of culture?

....
....
....
....

14. In your views are there any SO's that relate mathematics to culture?
A.Yes B. No

15. If yes state which ones, specify only their numbers, eg 1or 2....

....

16. In your own words what do you understand by each you have identified

....
....
....
....
....
....
....
....
....
....
....

17. Do you think issues related to culture belong in the mathematics curriculum?
A. Yes B. No

18. Why?..
....
....
....
....

19. Do you personally teach such issues?
A. Yes B. No

20 Please explain

....
....
....
....

21 The new curriculum identifies socio-cultural issues as important in mathematics curriculum, how do you feel about this?

....
....
....
....
....
....

SECTION C

22. Have you attended any OBE workshops between 1998 and now?
    A. Yes B. No

23. If yes, how many?……

24. Did any of the workshops attended relate mathematics to socio-cultural issues?
    A. Yes B. No

25. If yes, provide details
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………

26 Did these workshops assist you in understanding the relationship between mathematics and socio- cultural issues?
    A. Yes B. No

27. In what way, please explain.
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

THANK YOU FOR YOUR HELP

PROJECT 3

FACELIFTING THE IMAGE OF MATHEMATICS: WHITHERTO SOUTH AFRICA?

ABSTRACT

Mathematics in South Africa is in crisis. This has resulted in the national minister of Education declaring it as a priority of priorities. South Africa was rated the last achiever in the recently conducted Third International Mathematics and Science Study. Matric results in mathematics continue to be poor. Various causes have contributed to this state of affairs in South African mathematics. Amongst others, it is asserted that this bleak picture can be traced to the behaviouristic epistemology which has underpinned the way mathematics has been taught in South Africa. As a result, the majority of the public hold a negative image of mathematics. This stems mainly from their school experience as students of mathematics.

This literature review addresses the crises faced by South Africa in mathematics and mathematics education. The way the public views mathematics needs to be seen as a priority issue. The 21^{st} century has daunting challenges which require effective mathematics literacy and competency. There is a need to recognize and reinforce the role played by mathematics in our daily lives, as this is often hidden.

In South Africa there is a serious shortage of mathematicians and mathematics educators. They are often attracted to other countries with better working conditions and more attractive financial packages. There is therefore a need to attract more students into the 'endangered' mathematics field. There is equally an urgency to attract and retain good mathematics educators to assist in re-establishing a more positive image of mathematics. Attractive incentives should be devised to keep such people within this crucial yet, obscure field. The role played by mathematics in other fields of study should be brought to the fore. In a small way this literature review interacts with these burning issues.

FACELIFTING THE IMAGE OF MATHEMATICS: WHITHERTO SOUTH AFRICA?

1. INTRODUCTION

A common trend in many countries is that the number of students who pursue mathematics beyond the compulsory classes and tertiary level is fast decreasing. This puts the future of mathematics in a predicament (Leder *et al.* 1998). Not only will mathematics as a subject suffer, but also all those other fields that enjoy the fruits of mathematics. It is often perceived that mathematics is the bedrock of all sciences, yet its role is rather covert to most people (Hansen 2000; Steen 2000). Although the public often realizes the importance of other sciences, especially natural sciences, economic/business sciences as well as technology, it fails to realize the contribution made by mathematics to such disciplines. There is a need to unravel the important role that mathematics plays in these fields, both to the general public and the students. It is hoped that such a move would help in publicizing and popularizing mathematics.

Because of this pressing need, the International Mathematics Union on the 6th May 1992 in Rio de Janeiro, declared 2000 as the World Year of Mathematics. This declaration targets the following:

- The great challenges of the 21st century
- Mathematics as the key for development
- The image of mathematics
  (International Mathematics Union 2000:1)

This paper interacts with these challenges. In the dawn of the new millennium there are daunting challenges as to the role played by mathematics in facilitating development in South Africa. The way the general public view mathematics has an impact on the participation of students in mathematics, since they are also influenced by the same views that the general public holds about mathematics.

In South Africa we are faced with a crisis in mathematics education. This country was rated the lowest achiever in science and mathematics in the Third International Mathematics and Science Study (TIMSS) (Howie and Hughes 1998). The country is also faced with enormous problems in matric mathematics results. For the past four years, the pass rate has generally been less than 50%. Unfortunately the situation seems to persist. Moreover, the country is faced with the emigration of many skilled people, including good mathematics teachers (Adler *et al.* 2000). These teachers often leave for countries like Australia, England, United States of America, New Zealand Saudi Arabia and many others with generally far better working conditions than those of South Africa. Also, some mathematics educators redirect their careers into becoming chartered accountants or Information Technology specialists. These are attractive careers in as far as salaries are concerned. Young mathematicians therefore, have these other attractions and numbers in mathematics participation are gradually becoming less and less. Unless drastic measures are put in place, we are faced with a depleting mathematics community.

Popularizing mathematics and changing its current image is a matter of urgency. There is a need to attract good mathematics teachers who will instil a love of and a positive attitude towards mathematics in their students. Otherwise, where will future mathematicians and mathematics educators be generated? Mathematics is often regarded as the critical filter for the development of the country (Leder *et al.* 1998). Where would we get the personnel to engineer such development? Equally important is the need to seek good students from all corners of South Africa and search for talent and nurture that talent to remain within this very important field.

This literature review looks into the causes of the negative image often held by the public. It also looks at the changing face of mathematics and suggests ways of popularising mathematics. The negative image in my view can be attributed to the absolutist perspective of the nature of mathematics. The classroom practices and teachers' attitudes as well as the curriculum within this philosophy are discussed as having a direct impact on the public perceptions. The newer perspectives are discussed with an aim of bringing back an improved image of the 'defaced' mathematics. In targeting the public and students, a move towards contextualised knowledge and people oriented mathematics is advocated. The role played by mathematics in driving the development of a country is also discussed. This role should be brought to the fore so as to show that mathematics and the country's development are inextricably interlocked. The challenge of the 21^{st} century for all to be numerate is also discussed.

2. SOME CAUSES OF THE CURRENT PUBLIC IMAGE OF MATHEMATICS

2.1 Introduction

The public often views mathematics as a difficult subject that is reserved for the limited gifted few. People generally display a negative attitude towards mathematics and do not regard it as relating to their personal lives, as it is abstract and not easily accessible (Volmink 1994). This negative image emanates mainly from classroom experiences that people gather as students of mathematics. The classroom milieu plays a very crucial role in shaping peoples' feelings and attitudes towards mathematics. The nature of mathematics, its philosophy, the way it is taught, teachers' general attitude to the subject as well as children's own performances all add up to an internalized view of what mathematics is all about (Ernest 1996). These attitudes are further replicated into society. As children grow and become adults, their stereotypical images about mathematics are in a subtle way, transferred to their own children by way of negative comments and outright distaste of the subject.

2.2 The traditional view of mathematics

Traditionally, the 'Scientific Model' has shaped the nature of mathematics. This paradigm underpins the 'Absolutist' and 'Dualism perspectives' (Ernest 1996). The Absolutist philosophy portrays mathematics as neutral, taught in a way that disregards socio-cultural contexts and meanings. Mathematics is presented as an objective, certain and abstract body of knowledge (Zaslavsky 1973; Joseph 1991; Visser 1991; Gerdes 1994; Ernest 1991). Ernest (1996) describes these perspectives as portraying mathematics knowledge as timeless, superhuman, and not concerned about history as it is felt that it is irrelevant in justifying mathematics knowledge. Mathematics is regarded as "pure isolated knowledge, which happens to be useful because of its universal validity; is value free for the same reason" (Ernest 1996:805).

The nature of mathematics is also based on a Dualism philosophy. This philosophy portrays mathematics as a fixed body of knowledge that is exclusive to the experts. Its practice is precise and relies heavily on rules and algorithms in its computations. Its foundations are regarded as permanent and infallible. Ernest (1996:806) argues that "this perspective envisaged the building of indubitable structures of thought based on a logical masterplan, the Euclidean, masterplan. This is the ancient Greek model for an axiomatic theory as the true science and it became a model for all science, reasoning and rationality". Mathematics has been founded on such assumptions. These narratives filter down through the curriculum as well as to the pedagogy.

The scientific paradigm assumes that "only certain privileged individuals are competent enough to enter into higher echelons of mathematics since they are intrinsically equipped for the mathematical study", Visser (1991:39) argues. Also, (Burton 1994:72) argues that this "reinforces a social view of mathematics as belonging only to a very particular set of people, a closed club who subscribe to the same rules and speak the same language." This perspective, thus, portrays mathematics as elitist and exclusive knowledge specially created by mathematicians. The curriculum is usually designed with a few such special people in mind, for this kind of knowledge is not for all. It is academic in nature.

This kind of thinking permeates many levels of education, often influencing the classroom situation. It is often argued that this perception is responsible for the negative view the public has towards mathematics.

2.3 School experience

Generally, in mathematics classrooms the teacher is the sole source of information and students merely follow the teacher's methods. Teachers are mainly concerned with algorithms and proof of their correctness. Hansen (2000:1) describes an algorithm as "a precise description of a method of calculation". This is the kind of experience some of us personally went through. Whenever I did not understand a method or a theorem I just 'punched it into the computer (memory)', as we commonly used to say during our school days. In this approach, teaching methods predominantly involve transmission of information to learners and generally encourage rote learning.

Generally in my view, mathematics taught in schools is often devoid of everyday experiences. This sends a subtle message that what is taught in school has nothing to do with life generally, and work situations in particular. Schools have a tendency to advocate only formal and abstract mathematics as the mathematics. Street mathematics, recreational and ethnomathematics are not considered as mathematics (Visser 1991, Shirley 1994). Burton (1994:81) contends that mathematics should be taught such that it is person-related and culturally embedded for it to be accessible to most students. The history and the human side of mathematics are not considered as part of mathematics teaching. It is unfortunate though, because this kind of history reveals a broader picture of the nature of mathematics; that of mathematics as a human activity. It has developed with the contribution of various cultures, (Joseph 1991, Zaslavsky 1993, Gerdes 1998). Mathematics is not a sole production of European cultures, though its content tends to promote European thinking modes; i.e. axiomatic theory. However, "for technical and other reasons it is not possible to formally axiomatize all mathematical knowledge, nor to gain absolute certainty even for large parts of mathematics" Tiles, Tymoczko (as cited in Ernest 1996:807), contend.

Presenting mathematics as devoid of everyday experiences portrays mathematics as not relevant to life outside the classroom. Schools therefore need to prepare students for both work and post-school education (Steen 2000). Burton (1994:69) argues that " there is evidence that the mathematics which is actually used in the workplace, and is more usually generated 'on the job', does not directly resemble the formal mathematics taught in the classroom". The lack of such diversity results in students regarding mathematics as irrelevant. They develop negative attitudes towards it and thus drop it as soon as they can. Most curricula tend to be lacking in preparing students for more advanced studies, and therefore disadvantage some students. This is also evident in the constant decrease of the number of students who persist with mathematics beyond the compulsory stage, Miller (1996) argues. Schoenfeld (1992) reports that in the United States of America (USA), for example, mathematics drop-out rate is about half of the students pool doing mathematics beyond grade 8. These are mainly are women and minority group students. The teaching of mathematics has to address these concerns.

Students' own performance in mathematics is another contributing factor to the negative image the public holds about mathematics. In South Africa, for instance, Kahn (National Minister of Education adviser) (as cited in Brombacher 2000:14), reported that "for every fifty whites one black pupil passes matric higher grade physical science and mathematics". Student's performance acts as a reflection of his/her own incapabilities. When a student performs well, he/she is re-inforced to do better. But if a student constantly performs poorly, he/she develops negative feelings and begins to dislike the subject. This in turn impacts negatively on his/her self-concept and confidence generally. The teacher's role is very crucial in this regard to ensure that encouragement and help are offered to such a student. The classroom situation should be such that it is non-threatening and reassuring to students, otherwise students develop fear of both the teacher and the subject. Unfortunately mathematics teachers are, in my own experience, often regarded as cold, aloof, indifferent and rather lacking some social flair. Some teachers have an arrogant attitude and are intolerant to mistakes and failure. Students fear ridicule or intimidation and develop a tendency of keeping to themselves. Howson and Kahane (as cited in Ernest 1996:804) alludes to this view by arguing that:

> At times, even if the image is positive it is usually based on wrong assumptions. Mathematics is always correct providing absolute truth, solid and static. The image of mathematicians are still worse: arrogant, elitist, middle class, eccentric, male social misfits. They lack social antennae, common sense and a sense of humor.

This public image of mathematics reminds me of my own personal experience. A fellow student in the Faculty of Arts once asked me what my intended majors were. I told her that they were Mathematics and Psychology. Her response was "you will soon go mad, those kind of people are abnormal and antisocial. Psychologists are not quite 'normal' and mathematicians too. In your case it will be worse, combining both! We will soon find you in a 'mental hospital'." This example illustrates that people draw their own stereotype conclusions about mathematics and people that participate in it. Unfortunately, this image happens to be negative and discouraging, especially to someone who is not quite committed to pursuing mathematics. These social stereotypes are perpetuated from generation to generation.

Also many schools portray mathematics as a predominantly male domain. Mathematics in secondary and especially tertiary levels in usually taught by males. The image of mathematics as a white middle class male domain still persists (Glencross *et al.* 2000). This is not only particular to South Africa but is still prevalent in most countries. The National Center of Educational Statistics (as cited in Schoenfeld 1992:5) argues that in U.S.A, for instance, "the educational and technological requirements for the work force are increasing, while prospects for more students in mathematics-based areas are not good". He further contends that only 8% of labour force is scientists or engineers of which the overwhelming majority are white males. Australia, however, seems to be succeeding in attracting mature and female students into the mathematics field (Leder *et al.* 1998). Also, the only region that has proved otherwise, where females dominate in mathematics and Science fields, is Latin America. There are five times more females than males that are within this field (Ernest 1996).

This shows that there are several factors that contribute to the negative view that the public holds about mathematics. The list cannot be exhausted, but some people's experiences as students of mathematics and the traditional view of mathematics seem to play a dominant role. Students' experiences are internalized and form attitudes, which then determine whether a student remains or opts out of mathematics.

3. CHALLENGING THE TRADITIONAL VIEW OF MATHEMATICS

There is a group of philosophies of mathematics that challenge the notion that mathematics is absolute and detached from every day practices. They advocate contextualizing mathematics and making it accessible to all. In this perspective, mathematics is seen as a human activity embedded in socio-cultural contexts and meanings. It is not just a fixed body of knowledge. Its 'truths' are always open to revision. Mathematics can be perceived as fallible (Ernest 1991; Bishop 1999). These narratives further contend that the development of mathematics is not linear, i.e. only a European product, but is a contribution of many cultures. Mathematics has a cultural history (Joseph 1991, Ernest 1991, Zaslavsky 1994). Burton in Lerman (1994:69) contests that " we can no longer shelter behind a pretence that the subject is universal, objective and unrelated to social conditions within which it is developed and practised". The mathematics is seemingly responding to such calls. This is evident in the activities held in celebrating the contribution of mathematics to the development of humankind in the past century. Contributions from various cultures in the development of mathematics are acknowledged, as many conferences have been held under the banner of World Mathematics Year 2000 (WMY2000). The main aim of these conferences "is to make visible to the general public that mathematics bridges gaps in culture, science and technology" (Hansen 2000:1). Amongst others, these conferences focus on the early mathematical works from cultures such as China, India Arabic World as well as late Middle Ages in Europe. There is therefore, a set of philosophies that oppose the absolutist perspective of mathematics. These are underpinned by Post-modern thinking (see project 2). Ernest (1996:808) asserts that:

> Post modernism is committed to a multidisciplinary account of mathematics as a set of socially distributed practices. It embraces the practices of mathematicians, the history and applications of mathematics, and the place of mathematics in human culture, including the issue of values and education. In short Post modernism fully admits the human face and basis of mathematics as a legitimate philosophical concern.

This approach is dovetailed with the principle of relativism, which portrays mathematics as a dynamic human creation. Mathematics is a tool used to solve problems encountered in day to day living (Bishop 1988). Shirley (1996) alludes to this view by arguing that mathematics should not only be confined within classroom walls, but all forms of mathematical thinking should be such that, it equips students with lifeskills to interact with the world. Miller (1996) concurs by saying that the curriculum should enhance understanding mathematical concepts from contexts; thereby making it accessible to all. It should further emphasize the vital role played by mathematics in other disciplines.

The role played by mathematics in other fields needs to be teased out, as it is not immediately obvious. The teaching of mathematics is often done in a way that does not connect it to other subjects. Yet, interaction between mathematics and real life settings cannot be overemphasized.

Students could be made to experience mathematics outside the classroom and go into the world where things are happening. For example students could be taken out to stock exchange centers, engineering industries or business firms, street vendors and cultural artifact designers, where they are required to bring out the hidden mathematics in those fields. Linking theory and practical experience of mathematics in other fields would challenge students' perception about mathematics. Students should be encouraged to bring to the fore mathematics in their interaction with real life situations (See project 1). Experts from other fields could also be consulted to address students and explain the role played by mathematics in their fields of specialization. Such exposure would challenge students to view mathematics with a positive attitude.

Visser (1991:40) argues that mathematical skills and concepts cannot be divorced from the contexts in which they are taught. She contends that:

> Ethnomathematics is an attempt to bridge the gap between cultural and societal values and the demands of the modern science and technological advancement into the classroom and at the same time allows for an appreciation and respect of Mathematical practices of different cultures and societies.

This would be more encompassing as a sense of ownership is instilled and reinforced; thus students feel included. Steen (2000:9) also argues that the way mathematics is taught alienate many. He argues that "you change the way mathematics is taught; you will be surprised who will learn mathematics."

The newer perspectives, therefore, argue for a more positive picture of mathematics that includes all. This calls for a shift from the traditional view that mathematics is essentially devoid of socio-cultural meanings. Mathematics is viewed as a human activity and is used as a tool to solve problems. Therefore mathematics is inextricably interwoven with everyday practices, albeit in a way that is often not obvious to the general public. It needs a dynamic curriculum that will bring to the fore the vital role played by mathematics in other fields. This would hopefully change the negative image that the public holds about mathematics. But, how do we go out to the public and market a positive image of mathematics? How do we change the wrinkled face of mathematics so that it becomes more attractive both to the young and old?

4. CHANGING THE FACE OF MATHEMATICS

In changing the image of mathematics I want to target mainly two themes. In my argument earlier on, I mentioned that the negative image that the public generally holds of mathematics, mainly originates from their school days as students of mathematics. I will therefore concentrate on the following themes:

- The school setting
- Popularising mathematics to the public

4.1 The School Setting

In this theme I want to confine myself to the following:

- teachers and their teaching methods
- The role played by mathematics in other fields

4.1.1 *Teachers and their teaching methods*

In South Africa there is a need to improve teachers' level of content competency in mathematics. It is generally documented that some teachers' level of understanding of content is found wanting (Adler *et al.* 2000; Glover *et al.* 2000). The tendency is that if a teacher is not competent enough in certain concepts, he/she will simply not teach such concepts. This inevitably impacts on students' general competence in the subject.

Also the way mathematics is taught in some schools leaves much to be desired. Teaching methods tend to be teacher-centred and emphasise the transmission model (see project 2). Teachers often use the 'chalk and talk' methods and these inherently encourage rote learning.

Among other causes of such practices is the fact that traditionally teacher-training has been based on a behaviourist paradigm (see project 2). The tendency therefore is to teach the way they were taught (Vacc and Bright 1999). Mathematics is taught in a boring and highly abstract way. The situation becomes even worse at tertiary level, as students experience more problems in adjusting to the way university mathematics is presented (Glencross *et al.* 2000). Teachers need to prepare their students for mathematics beyond the secondary level.

Teaching methods should incorporate strategies that make mathematics more accessible. Students should be encouraged to take an active role in mathematics activities, which could include compiling of mathematics bulletins, making of journal entries as well as taking part in debates on mathematical issues. I have practised this with my college students. Students made their own mathematical magazines and worked in groups. Each group researched a prominent figure in mathematics such as Euclid, Pythagoras, Euler, Gauss and Newton and named themselves after that leader. A comprehensive history about the chosen person and his contribution in mathematics was given. I wanted them to relate mathematics to people, read about their struggles and triumphs in mathematical discoveries. That helped them to see that mathematics has a human face in which history plays a prominent role. Sometimes I made my student get engaged in a mathematical debate. One student once commented in his journal entry as follows: "I never thought debates belong to mathematics class. I only knew them from my English class, nevertheless I enjoyed this exposure."

The environment in a mathematics class should be such that students are encouraged to engage in meaningful discourse, which is conducive to learning. Mistakes and failures should be taken as part of the growing process. The environment should not be threatening or intimidating. The tendency, however, is that mathematics is taught in such a way that it is infallible. This includes the people who participate in it. Students are often not told that it took years or even decades before some concepts and theorems were accepted into true mathematical argument. This would hopefully help students to realize that their 'crude' ways of thinking are stepping stones towards true mathematical argumentation and proof. These would also help students realize that to err is human and forms part of the growing process. This hopefully would promote "the changing views on the nature of mathematics and the controversy over the foundations of its knowledge and theories in relation to culture, history and society" (Ernest 1996:786).

In making mathematics accessible to students, problem-solving should be encouraged as an integral part of mathematics teaching. The new curriculum in South Africa advocates this kind of approach, but in most mathematics classrooms this is merely rhetoric (Taylor and Vingevold 1999; Chilsholm 2000). For teachers to develop confidence and competence in this approach collaboration would help. This is relatively new to most South Africans. They can work together within the same schools and with neighbouring schools by sharing ideas and resources. In this way students will develop an attitude that the teacher is not a "Mr know all" of some kind, but people need to adopt a collaborative approach so as to complement one another. These kinds of activities could help to change the attitude that "students generally experience mathematics as an algorithmic; mechanical and stereotyped subject" Ernest (1996:805) contends. Students should experience mathematics as part of their daily lives and not just as something out there.

In challenging the way mathematics is presented, D'Ambrassio (1997:15) argues that "we cannot accept a kind of grand tautology, saying that things are the way they are because this is the way they have to be, because this is normal. Normopathy is the most serious threat to survival!" Mathematics teaching has to be centred around the learner and incorporate his/her background experiences. This calls for a complete shift from the traditional way of presenting mathematics.

4.1.2 *The role played by mathematics in other fields*

In enhancing the value of mathematics in life generally, the role played by mathematics in other fields in solving problems should form part of classroom activities. For example, school textbooks could have a brief historical development of a concept as an introduction. This could include the pioneers of that concept and a history behind it, such as the cultures that developed the idea. Also included in this introduction could be the practical application of the concept in other fields. The grade 12 textbooks, for instance, include a concept of compound increase and decrease. This would help students to value the contribution of mathematics in the business world as well as their own personal lives; to know the effects of loans, mortgage bonds and hire purchase. This enables personal values to make more informed decisions on such issues. This reminds me of a very pathetic story I was told by a lady teacher who once borrowed R8 000,00 from the 'short loans' people. Over the three years she found that she had paid altogether R22 000,00. I thought to myself, if only mathematics literacy could include such life skills, so as to influence people's decision-making. They would not drain themselves in these kinds of activities. Mathematics must be taught such that it relates to us, and we relate to it. It is for such reasons, amongst others, that Ernest (1996:806) asserts that:

> Many adults leave full time education having not been empowered by their mathematics education as mathematical literate citizens, who are able to exercise independent critical judgements with regard to underpinnings of democratic modern society and its crucial process of social, political decision making.

Teaching mathematics with these ideas in mind would give rise to generally numerate communities. However, in South Africa illiteracy is prevalent among the majority of the people. There are some programs in place to address these, but there is still a long way to go. The debate about whether the year 2000 marks the beginning of a new millennium or the end of an old one was a signal enough on the way the public and the mathematicians understand mathematics. Interestingly enough, the public perception became the popular world-view.

Mathematics plays a prominent role in the development of a country. It forms the cornerstone of the many different areas in life generally. This is unfortunately not obvious. Many mathematical concepts and algorithms underpin a lot of aspects of our daily lives. Mathematics drives the industrial society "providing the basis for science, technology and information revolution", Ernest (1996:812) contends. He further argues that in life we generally want the best solutions and mathematics plays the crucial role in optimizing such solutions. It makes life a lot easier.

Hansen (2000 :1) asserts that the whole field of Engineering Science would collapse without mathematics. For example, "the mathematics of airflow is essential in designing planes and water flow in designing ships and boats". In computers, mathematics algorithms are used to deal with fast, accurate and advanced calculations. Calculations on weather predictions are made from mathematical concepts of airflow and partial differential equations, Hansen (*ibid.*) contends. Signals sent from space use error correcting codes developed by mathematics to probe Voyager II. (Hansen 2000; Rodrigues 2000). Also, in a conference held at Macau in 2000, mathematicians gathered to celebrate the contribution of mathematics as a driving force in the general welfare of people as well as human progress. The themes that were handled, amongst others, as reported by Rodrigues (2000:1) included the following:

- the theory of partial differential equations over the past century, highlighted the close interaction with Physics and technology
- importance of mathematical models in life sciences with the example of analysis of cardiovascular diseases
- fundamental data structures and data base algorithms
- computational geometry and number theory and how these are used in the modeling of technological processes
- the role of mathematics in technological processes, the impact of mathematical logic in computer science

All these examples are just a glimpse of the role played by mathematics in other fields. Students of mathematics are generally not exposed to this kind of knowledge. As a result of this covert nature of mathematics in these fields, students do not see mathematics as appealing to their lives. I therefore strongly argue that students must be made aware of such a vital role played by mathematics.

There is therefore a pressing need to portray a more positive image of mathematics, so as to attract young people to specialize in this field. There is a need to catch them young, otherwise, there will soon be very few mathematicians and mathematics educators to cope with the demands of the 21st century. Equally important is the need to instil the love of mathematics to the younger generation. This would help attract more into the mathematics field so as to minimize the downward trend experienced in mathematics. Unless, as educators, we instil this kind of attitude, we will continue to experience high drop-out rate in this field. The role of the teacher, therefore, is very crucial. But, the question is how to keep and attract teachers within this field, especially young mathematics graduates?

There is a serious challenge facing academics in mathematics and mathematics education. The pool from which to draw more and potential mathematicians is fast becoming dry. In South Africa there are programmes in place that recruit young mathematics graduates and redirect them into becoming chartered accountants or computer programmers. These have quite attractive financial packages. The challenge facing South Africa is how to keep young mathematics graduates in this 'noble profession', when they have such attractive alternative offers.

I would then argue that, if South Africa is really committed to declaring mathematics the "priority of priorities" as national Minister of Education, Professor Kader Asmal cited in Singh (2000: 14) announced, mechanisms of attracting mathematicians and mathematics educators should be sought. Mathematics as the engine of a nation's development, must be given preferential treatment. That should not just remain rhetoric. I feel there is a need to attract able personnel to keep mathematics alive and vibrant. Incentives to attract and keep such people should be offered in order that the goose continues to lay the golden eggs. People enjoy the eggs but do not seem to recognize the value of the goose. If it is not properly fed, it will soon die, and where will the eggs come from?

4.2 Popularising mathematics to the public

The current trend is that nations emphasize the use of mathematics in the everyday life. Some stress its applications to other subjects, its utility in employment, power to reason and valuing the subject for what it is. This is, however, not obvious to everyone. As a result, the public generally holds a different view of mathematics. They see it as irrelevant to their daily applications and merely a scheme to sort out students (Ernest 1996). This view sends negative signals to those who aspire to remain in this field.

The adult world needs mathematics/science literacy to cope with the demands of the 21st century. Presently there is, however, very little understanding of basic mathematical concepts that students have by the time they leave school. This results in failing to apply mathematical knowledge in real life situations as adults. This is danger to a mathematically illiterate society as information becomes more quantitative. As the society relies more on computers and the data they produce, an innumerate citizen becomes even more vulnerable Steen (2000) argues.

There is therefore a need to promote a public understanding of mathematics. Durant cited in (Miller 1996:9) presents five crucial arguments to this effect, which are:

- The Economic Argument
- The Utility Argument
- The Democratic Argument
- The Social Argument
- The Culture Argument

All these arguments encapsulate the need to promote mathematics literacy in the information age we live in.

4.2.1 The Economic Argument

There seems to be a trend showing a correlation between the nation's development and its public understanding of mathematics and the economic stability of that country, Steen (2000) argues. This is a reciprocal process in the sense that the nation that understands the value and the role played by mathematics for its development will invest in such fields. It is hoped that more students will want to engage themselves in mathematics and become motivated to remain within these fields. As they become adults and hold responsible posts, they are able to motivate for more investments into research that promote the development in the technological advances, (Miller 1996). The country will therefore, need to invest in its education for economic development to advance its technological infrastructure. The converse also holds i.e. if the public does not see the value of mathematics, children will not be motivated to do mathematics.

4.2.2 The Utility Argument

Science and mathematics are useful for all living in the scientifically sophisticated society we find ourselves in (Miller 1996). Everyday activities call for the general public to be mathematics/ science literate in order to cope efficiently with the demands of the 21st century. The better equipped the people are in this kind of literacy, the wiser the decisions they will make, as they are based on sound knowledge. These include such things as, diet, safety and lottery. In South Africa there is this craze about the national lottery, Lotto (Tata ma chance tata ma million) as its slogan, meaning take chances, take millions. The concept of probability is embedded in these kinds of activities. But, because people generally lack this basic knowledge they always have high hopes that they will win those millions. Few know that such chances exist only in approximately 1out of 14 million cases (Sproule 2000: 47). Some put a lot of money in these games and when they do not win they become frustrated and lead miserable lives. If people knew the basic principles applied in gambling games they might play reasonably.

4.2.3 The Democratic Argument

For the public to engage meaningfully and effectively in crucial issues pertaining to the welfare of their societies, the need for mathematics/science literacy is very crucial. The public needs to make effective contributions for their civic rights and values. Worthwhile contributions in debates, discussions and deciding on issues that concern mathematics/science fields can be made by those who understand such issues well (Miller 1996). The world generally is getting to grips with the vicious attack by HIV/AIDS. South Africa, in particular, as of late, is among the hardest hit country (Panafrican News agency 2000). This calls for sound arguments on the causes and effects of this epidemic. Big numbers are often reported, which require sound understanding of basic mathematical concepts. Projections made have to be unpacked mathematically, graph illustrations also need numerate people to grapple with the effects of this killer disease. If the public is not well developed numerically they might remain naïve about the situation.

Also in issues concerning environmental affairs, where the public is involved in making decisions about whether to apply, for example, knowledge on energy, policy, testing and treatments. The public should be able to account for such issues, Miller (1996) argues.

4.2.4 The Social Argument

The social argument holds the view that mathematics literacy helps in maintaining links between mathematics and society. A better public understanding leads to better support for science and technology. The image about mathematics will be improved and a scientific literate society will be born (Miller 1996).

The rise of the technological era with its demands for quantitative informative literacy "calls for the change of not only the environment but also the culture framework of civic life" (Steen 2000:2?) Media often report on deficit projections and unemployment figures, news on market trends and health care generally. Steen (*ibid.*) further argues that "behind the sciences the mechanisms of everyday life depend increasingly on digital technology from cellular phones to ATM machines, from bar codes to the World Wide Web. How many people understand about the Dow Jones implications?" It is indeed very crucial that people are able to interpret and make sense of these concepts. Literacy courses therefore should take cognizance of such issues in addressing this concern.

There is a need to have quantitatively literate and informed members of the society. To empower the general public in these fields is an urgent need. Price cited in (Steen 2000:4) contends that "logical thinking, analysis of evidence and statistical reasoning are far more important for engaged citizenship in the 21st century than the traditional algebraic and mathematical skills." This would lead to an informed society, and an informed society is an empowered society.

4.2.5 The Culture Argument

Mathematics is regarded as a cultural product. All cultures demonstrate some mathematical practices (Bishop 1988). It is therefore necessary that this cultural heritage should be celebrated. In celebrating a major break-through in the cultural history of mathematics, the public will begin to value their heritage. As an informed society they can function effectively and more meaningfully.

All these arguments support the notion that there is a need for mathematics/science literate communities. Otherwise it will soon be hard to cope with life. Literacy is about reading and writing, reasoning and calculating, thus meaning-making from the background knowledge one has. It involves solving problems in our everyday settings. Steen (1996:100) asserts that "Numbers count because ideas count. The ubiquity of computers make it possible for many people to calculate and communicate numbers, they do not understand". If one is limited in such literacy he/she can never be able to contribute effectively to his own community. The role played by mathematics is apparently not so obvious and remains totally hidden within scientific and technological advancements. It is therefore the duty of mathematicians and scientists to help in explaining the vital role played by mathematics. Even politicians might not be so articulate about this role. It is, therefore, necessary that those who know enlighten those who do not.

In a study carried out by Ernest and Sam (1998), there was however a slight improvement on the traditional negative view often held by the public on mathematics. The sample in the United Kingdom (UK) showed that 52,9% was reported as liking mathematics and only one third disliked it. These results challenge the widespread view about the public perception on mathematics. However, this study still found youth between 17 and 20 years (non-maths students) generally showing dislike of mathematics. Ernest and Sam (1998) register concern about the latter findings, as there is already a general trend towards decline in mathematics participation by young people in higher education.

There is hope therefore that the public view in mathematics can be changed. By having many programs that portray a positive view of mathematics, could lead to people perceiving mathematics differently. Countries like U.K. have embarked on numerous strategies to popularize mathematics. It could be that the dividends are beginning to pay.

Celebrating mathematics days, important discoveries in Mathematics/science and involving parents in school programs, including projects like Family Mathematics and Science festivals, will gradually help in changing the face of mathematics. There are few such programs in South Africa. There is still a need for more engagement with the public in this regard. South Africa is predominantly rural. I would think that, taking these activities to where ignorance is dominant and valuing the indigenous knowledge that links mathematics to the people's socio-cultural practices would hopefully alleviate the situation. The role of mathematics is often hidden even in such rural activities. Yet, Gerdes (1994) argues that the sub- Saharan region is rich in artifacts with mathematical concepts. This region is renowned for its mathematical fractals, for example.

It is envisaged that unraveling the hidden mathematics from people's everyday activities, will change the face of mathematics in South Africa. I would therefore argue for bringing out mathematics to the fore in a manner that will be meaningful to the people's lives and contribute to better living. For when people's mental capabilities are challenged through logical thinking, their ability to analyze, synthesis, and evaluate is enhanced. This in turn will result in a better engaging society, that will be able to solve its problems as individuals first and also as a community.

5. CONCLUSION

Technological advances are at the heart of the information age we live in. Technology, like all sciences is underpinned by mathematical reasoning. However, mathematical concepts are largely hidden to the majority, except the few experts. This is mainly due to the fact that, traditionally mathematics has been portrayed as having very little to do with everyday activities.

The public has developed a negative attitude towards mathematics because, amongst other reasons, of their own school experiences as students of mathematics. It is often taught as abstract, pure and divorced from contextual meanings. Mathematics educators are generally reported as intolerant to mistakes made by students. Unfortunately most students do not perform well in mathematics. All these experiences contribute to the negative attitude that students form about mathematics. As a result, some of them opt out of mathematics as soon as they possibly can. As adults they have internalised these ill feelings and become really negative towards the subject. Since there are many people who drop mathematics after the compulsory classes, the majority of the people thus hold a negative view of mathematics.

There is a current trend of decreasing numbers of students who persist with mathematics and science at higher levels. This is a real concern in view of the fact that mathematics is a critical filter for various careers and the prosperity of the country. There is therefore a need not only to attract young mathematicians but also to retain those already in this field. For if we do not, the country will suffer as mathematics is the driving force behind all sciences. There is a strong attraction for mathematicians, as they are often recruited into other alternative fields such as industries with far better financial awards. Also, South African mathematicians and mathematics educators are fast joining other countries with better working conditions. There is currently a shortage of mathematics educators. This is highly likely to become even worse, unless drastic steps are taken to remedy the situation. I would recommend that there be some incentives in place to attract more personnel into this field.

The public view of mathematics as bad and not relevant to their daily activities has to be addressed. The role of mathematics in other fields should be brought to the fore for all to see its value. Mathematics has to be portrayed as an economic, utility, democratic, social and cultural value to the people. Unless people are made to see the role played by mathematics in contributing to the development of their country, they will continue to see it as irrelevant to their lives.

In this information age the public is challenged to be mathematically and scientifically literate. The daunting challenges are such that coping with this era is almost impossible without this kind of literacy. In order to engage meaningfully in debates concerning one's welfare, this kind of knowledge is very crucial. A numerate society can interact well with numbers and make informed decisions and thus be efficient members of their communities. The need for such communities is a matter of urgency in South Africa.

REFERENCES

Adler, J., Brombacher, A., & Shan, S. (2000). Submission by the Mathematics Education Community to the Council of Education Ministers (CEM). *AMESA NEWS*, 20, 3-5.

Bishop, A. J. (Ed.) (1988). *Mathematics education and culture*. London: Kluwer.

Brombacher, A. (2000).Business Day Tuesday 28 March 2000. *AMESA NEWS*, 20, 14

Burton, L. (1994). Whose culture includes mathematics? In S. Lerman, (Ed.). *Cultural perspectives on the mathematics classroom* (pp. 69-84). London: Kluwer.

Chisholm, L., Volmink, J., Potenza, E., Muller, J., Vinjevold, P., Ndlovu, T., Mahomed, H., Lubisi, C., Ngozi, L., & Mphahlele, L. (2000). *South African curriculum for the twenty first century: Report of the Review Committee on Curriculum 2005*. Pretoria: Government Printer.

D'Ambrasio, U. (1997). Where does ethnomathematics stand nowadays? *For the Learning of Mathematics*, 17(2), 13-17.

Ernest, P. (1991). *The philosophy of mathematics education*. London: Falmer Press.

Ernest, P. (1996). Popularization: Myths, Massmedia and Modernism. In A.J. Bishop (Ed.). *International Handbook of Mathematics Education* (pp.785- 817). Dordrecht: Kluwer.

Ernest, P., & Chap Sam, L. (1998). *Public attitudes towards mathematics*. In A. Olivier, & K. Newstead (Eds.), Proceedings of the 22nd international Group for the Psychology of Mathematics Education conference Vol 4 (pp.251). Stellenbosch: PME.

Gerdes, P. (1996). Ethnomathematics and mathematics education. In A.J. Bishop (Ed.), *International Handbook of Mathematics Education* (pp. 909-943). Dordrecht: Kluwer.

Glencross, M. J., Kulubya, M. M., Mji, A., Njisane, R. M., Dabula, N. P., & Qwele, B. N. (2000). *Critical variables that influence first year university students in the Eastern Cape to study mathematics*. Proceedings of the 8th Annual Conference of the Southern African Association for research in Mathematics and Science Education (pp.146-151). Port Elizabeth: SAARMSE.

Glover,H., & King, L. (2000). *An analysis of the algebraic misconceptions held by a group of Eastern Cape intermediate phase teachers.* Proceedings of the 8th Annual Conference of the Southern African Association for research in Mathematics and Science Education (pp.152-157). Port Elizabeth: SAARMSE.

Hansen, V.L. (2000). *Raising the public awareness of mathematics*. Retrieved on 4 November 2000, from the World Wide Web: http://www.bangor.ac.uk/cpm/rpamath/cdroms/knots2.html

Howie, S.J., & Hughes C.A. (1998). *Mathematics and Science literacy of final-year school students in South Africa :TIMSS South Africa.* Pretoria: Human Sciences Research Council.

International Mathematical Union (2000). World Mathematics Year. Retrieved 2 December 2000, from the World Wide Web:http://wmy2000.math.jussieu.fr/.

Joseph, G.G. (1991). *The crest of the peacock: Non-European roots of mathematics*. New York: Penguin.

Miller, R. (1996). Towards a science curriculum for public understanding. *School Science Review.* 77(280), 7-18.

Panafrican News Agency. (28 June 2000). Over 24 million people living with HIV/AIDS in Africa. Retrieved on 5 September 2000, from the World Wide Web: http://retaildirect.realmedia.com.

Rodrigues, J.F. (2000). Mathematics and its role in civilisation. Retrieved 2 December 2000, from the World Wide Web: http://wmy2000.math.jussieu.fr/9macao.htm

Schoenfeld, A.H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. Retrieved on 6 November 2000, from the World Wide Web: http://www.gse.berkeley.edu/faculty/aschoenfeld/LearningToThink/LearningtothinkMath.html.

Shirley, L. (1995). Using ethnomathematics to find multicultural connections. In NCTM (Ed.) *Yearbook connecting mathematics across curriculum.* Virginia: NCTM.

Singh, P. (2000).Maths top education priority –Asmal. *AMESA NEWS*, 20, 14.

Sproule, S. (2000). Activity : The mathematics of the lottery-probability. *Pythagoras,* 52 ,47-56.

Steen, A.L.(Ed.) (2000). *Why numbers count: Quantitative literacy for tomorrow's America.* Retrieved on 5 November 2000, from the World Wide Web: http://www.collegeboard.org/frstlook/wnc/html/wnc_toc.html.

Taylor, N., & Vinjevold, P. (1999). Getting Learning Right: Report of the President's Education Initiative Research Project. Johannesburg: Joint Education Trust.

Vacc, N. N., & Bright, G.W. (1999). Elementary pre-service teachers' changing beliefs and instructional use of children's mathematical thinking. Journal for Research in Mathematics Education, 30 (1), 89-110.

Visser, K. (1999). Overcoming Eurocentrism in school mathematics. *MATHLASEDI,* November, 40-41.

Volmink, J. (1994). Mathematics for all. In S. Lerman (Ed.). *Cultural perspectives on the mathematics classroom* (pp.51-68) London: Kluwer.

Zaslavsky, C. (1973). *Africa counts: Number and pattern in African culture*. New York: Lawrence Hill.

Zaslavsky, C. (1994). Africa Counts and ethnomathematics. *For the Learning of Mathematics*. 14 (2), 3-7.

RHODES UNIVERSITY LIBRARY