

**The teaching of mathematics to intermediate phase learners, in
Itsoseng circuit**

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degree of Master of Education (Mathematics Education) at Mafikeng
Campus North West University*

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TABLE OF CONTENTS

Declaration	i
Acknowledgements	ii
Dedication	iii
Abstract	vi
List of tables and figures	vii
List of acronyms and abbreviations	viii

CHAPTER ONE: ORIENTATION

1.1	Introduction	1
1.2	Background of the study	2
1.3	The research problem	4
	1.3.1 Statement of the problem	6
1.4	Research Questions	6
1.5	Purpose of the study	6
1.6	Significance of the study	7
1.7	Limitations of the study	7
1.8	Definition of terms	9
1.9	Chapter Organization	10

CHAPTER 2: REVIEW OF RELATED LITERATURE

2.1	Introduction	11
2.2	OBE and curriculum framework	13
2.3	OBE principles	14
2.4	Role of educators and learners in OBE classroom	16
2.5	Purpose of teaching and learning mathematics	17
2.6	Nature of mathematics instruction as envisaged in OBE	18

2.6.1	Minds-on activities	20
2.6.2	Active questioning	22
2.6.3	Building on learner's prior knowledge	25
2.6.4	Group work	28
2.6.5	Hands-on activities	29
2.6.6	Authentic tasks	34
2.6.7	Problem solving in mathematics teaching and learning	36
2.7	Inclusive education in mathematics classroom	37
2.8	Nature of assessment in mathematics	38
2.8.1	Purpose of assessment in mathematics	39
2.8.2	Alternative assessment	41
2.8.2.1	Different types of alternative assessment	42
2.9	Conclusion	45

CHAPTER 3: RESEARCH METHODOLOGY

3.1	Introduction	47
3.2	Research design	47
3.3	Research methods	48
3.4	Population and sampling	49
3.4.1	Population	49
3.4.2	Sample and sampling procedure	49
3.5	Research instruments	50
3.5.1	Questionnaire	50
3.5.1.1	Structure of the questionnaire	50
3.5.2	Interview	51
3.5.2.1	Types of interview used in the study	52
3.5.2.2	Recording of interview	53
3.5.3	Observation	54

3.5.3.1	Types of observation used in the study	54
3.5.3.2	Recording of classroom observation	55
3.6	Enhancing validity through triangulation	55
3.7	Administration of instruments	56
3.8	Data analysis	57

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1	Introduction	58
4.2	Analysis of educators' questionnaire	58
4.3	Analysis of educators' interview	70
4.4	Analysis of classroom observation	73
4.5	Questionnaire, interview, classroom observation cross analysis	75

CHAPTER FIVE: DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

5.1	Discussions	80
5.2	Conclusion	83
5.3	Recommendations	84

REFERENCE LIST	86
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APPENDICES	94
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DECLARATION

I declare that the mini-dissertation for the degree of Masters in Mathematics Education at the North-West University hereby submitted, has not been submitted by me for a degree at this or any other university, that it is my own design and execution, and that all material contained herein has been duly acknowledged.



.....
N.M. Diale

Date 20/09/2006.....

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DEDICATION

I dedicate this study to my loving husband and my children, Reamogetse and Kopano, who rendered me support and persevered while I was working on this research.

ABSTRACT

This study investigated the teaching of mathematics in the Intermediate phase, in Itsoseng circuit.

The study adopted a survey as its research design. Data was drawn from a sample size of 14 mathematics educators from 5 primary schools, which were selected from 9 Itsoseng primary schools.

Questionnaires, interviews and observation were used to elicit data on classroom practices during the teaching and learning of mathematics. Lesson observation was used to triangulate the information collected through questionnaire and interviews.

The investigation indicated that Itsoseng primary mathematics educators are still using traditional methods used in the apartheid education system to teach mathematics. The conclusion drawn from the study is that there is a need for professional development of educators to broaden their knowledge on the teaching strategies that could be used to teach mathematics in the Outcomes Based Education (OBE) context.

LIST OF FIGURES AND TABLES

FIGURES

Figure 1: Concept map of 2-dimensional shapes	27
Figure 2: Tablemat constructed by weaving	32
Figure 3: patterns identified from tablemat	32
Figure 4: patterns formed using matchsticks	34

TABLES

Table: 4.1 Teaching strategies used in mathematics	59
Table: 4.2 Engaging learners in mathematics lessons	60
Table: 4.3 Using problem solving in mathematics teaching to develop reasoning ability in learners	61
Table: 4.4 Linking mathematics teaching to everyday life situations	62
Table: 4.5 Encouraging learners to construct their own knowledge	63
Table: 4.6 Assessment strategies in mathematics	64
Table: 4.7 Level of questions used in mathematics assessment	65
Table: 4.8 Assessment tools in mathematics	66
Table: 4.9 Mathematics resource centres	67
Table 4.10: Teaching and learning material used in the teaching and learning of mathematics	68
Table: 4.11 Work-shops on mathematics teaching	69

LIST OF ACRONYMS AND ABBREVIATIONS

Acronyms

1. DoE – Department of Education
2. OBE - Outcomes Based Education

Abbreviations

1. Hi-tech - High technology

CHAPTER ONE: ORIENTATION

1.1 Introduction

According to O'Brien (2002), the world is becoming more scientific and technological. Setati (2004) also said that mathematics forms the basis of scientific and technological advancement. The Department of Education [DoE] (2002) argues that being mathematically literate enables persons to contribute to and participate with confidence in society. Access to mathematics is, therefore, a human right. According to Selinger (1994) mathematics is a language of patterns in our thinking and our interpretation of the world around us, be it the growth of trees or motion of planets. The logic of mathematics offers the most powerful way of making sense of the world, whether social, cultural, political or economic.

Even though mathematics is such a crucial subject, according to Setati (2002) many people view mathematics as a difficult subject, and South African people boldly declare that they are not good in mathematics and they could never do it at school. In contrast to the shame associated with illiteracy, inability in mathematics is almost a matter of pride amongst many people in South Africa. DoE (2001) argues that the vast majority of Blacks are severely crippled by the *apartheid* education system. Disparity between Blacks and Whites in accessing educational opportunities was much greater in the learning of mathematics, science and technology than in other areas. This system ensured failure in mathematics performance to keep the majority of Black South Africans away from careers in natural and applied science careers.

The architect of *Bantu Education* Dr Hendrick Verwoerd complements DoE (2001) by stating that: "Natives will be taught from childhood to realize that equality with Europeans is not for them." ... (Republic of South Africa, 1953/54).

The Bantu Education Act of 1953 passed by the then National Party Government was really meant to make Blacks inferior to their Whites counterparts. Education and training under *apartheid* were characterized by the underdevelopment of human potential, particularly that of Blacks. Blacks were given inadequate education sufficient only to equip them for "peanut-paying" jobs like domestic work, mine digging and farm work.

Fortunately, in 1995 one of the issues the first democratic government in South Africa had to tackle was to transform the unequal, worn-out, racially based education system of *apartheid* to redress problems and bridge the division of the past. The Government of National Unity decided that the best way to realise the goal of the new society was to organize a curriculum underpinned by Outcomes-Based Education (OBE), which is a teaching approach that is learner-centred, premised on the belief that all individuals can learn (DoE, 1997).

1.2 Background of the study

Mathematics teaching during the *apartheid* era was counter productive as Lubisi *et al.* (1997) state that the education system in the *apartheid* era encouraged passiveness of learners, rote learning and obedience to authority, and discouraged intellectual risk taking, curiosity or independence of thought. Gunter (1974) cited by Khuzwayo (2005) indicated that educators in the *apartheid* system were invested with authority which gave them the right to prescribe to the learners what they must do and how or what they must not do, while the learners had to respond by accepting instruction without questioning their educators. This situation led to memorisation of theorems, formulae and sums that were mostly repeated in previous examination papers. According to Wilensky (1997), lack of connection to previous knowledge, a focus on a single correct answer, fear of expressing half-formed understanding and lack of connection to real life situations are the features which characterised

mathematics teaching during the *apartheid* era. These features clearly indicate that the *apartheid* era curriculum did not relate to learners' real life and experiences, and there was no meaningful learning.

Doll (1993) argues that we are living in a society that is complex, dynamic and technologically sophisticated therefore, a curriculum that is flexible and able to prepare adaptable learners is necessary. The Department of Education realised the role of mathematics education in promoting a technologically literate work force, and thus embarked on reforming the teaching and learning of mathematics in schools (DoE, 2001). The change in mathematics education is a reaction to the sad fact that much of *apartheid* mathematics curriculum had little relevance to the lives of learners. Therefore, through the introduction of curriculum 2005 underpinned by OBE the Department of Education aimed at affording learners the opportunity to learn mathematics in a critical, active manner to develop relevant, real life skills (DoE 1997).

Educators, under curriculum 2005 and the Revised National Curriculum Statement, are held accountable for the success of their learners. Educators have to provide learners with the opportunities to develop abilities that they could use in a variety of situations. This implies that learners are to be involved in activities that need critical thinking processes. Learners are to be given opportunities to explore, discover, discuss and meaningfully construct mathematical concepts and relationships in contexts that involve real life situations.

This study is based on an expectation that educators should make a deliberate and conscious attempt to teach mathematics in the OBE context. However, a concern is that educators were not adequately trained and prepared for the teaching approaches outlined in the OBE curriculum. In preparing educators for the implementation of an OBE curriculum, the Department of Education organised workshops for the training of

educators in new methods and strategies, even though such workshops were insufficient for the purpose. It is these same educators who are teaching mathematics in the schools. One wonders therefore if they are teaching mathematics the way it should be taught. Thus the intention of this research was to find out how effectively educators taught mathematics to intermediate learners.

1.3 The research problem

According to Lubisi *et al.* (1997) and Kramer (1999) the *apartheid* education system in South Africa propagated simplicity and used teacher-centred approach that did not promote the idea that people should think analytically in order to be critical and creative thinkers. Lubisi *et al.* (1997) state that South Africa's *apartheid* education system was underpinned by behaviourism, who was regarded as a learning theory that was viewed to be authoritative in nature. Behaviourism perceived educators as the only source of information, which transmitted predetermined factual information to learners. These educators questioned, and reinforced the answers to let the learners recall the facts as presented. Behaviourists believed that learning could be controlled to produce desired effects (Johnson, 2003). This is what led Johnson (2003) to conclude that, good learners could only do as they were told and conform to accepted norms.

Doll (1989, 1993) brings a sharp contrast to simplicity by stating that learning is complex and chaotic. Saundes (1992) affirms Doll's view, by explaining that learning does not simply mean receiving and remembering a transmitted message, instead learners learn mathematics well only when they construct their own mathematical understanding. Prigogine as cited by Doll (1989), states that complex constructivist theory rejected simplicity and acknowledged that the educator is not a transmitter of knowledge but rather a facilitator and provider of experiences from which learners will learn. Similarly, learners are not passive absorbers of

knowledge but rather active participants in constructing their own meaning based on strongly held preconceptions. According to O'Brien (2002) learners construct knowledge for themselves and filter it through their existing knowledge. This notion has implications about how educators teach and monitor the learning process.

The Department of Education aligned itself with the ideas of Doll (1989, 1993), Saundes (1992) and Kramer (1999) on open systems of education and the development of critical and reflective thinking in individuals by introducing OBE, which is underpinned by Constructivism. The shift from the *apartheid* curriculum to an OBE curriculum challenged educators to change their teaching, from teacher centred to learner centred education.

Even though it was the hope of the Department of Education that the introduction of OBE would help to improve the internal efficiency of the education system (DoE, 1997, 2001 & 2002), studies indicated that the performance of primary learners in mathematics remained poor (Pretorius, 2000). Pretorius (2000) reported that South African learners performed poorly in an international comparison of achievements in mathematics. In an International Systemic Study conducted to find the mathematics readiness of grade 4 learners, of the more than 10 000 South African grade 4 learners who participated, an average of only 30% was scored compared to 51% from Botswana, 49% from Uganda and 36% from Zambia. A larger proportion of South African grade 4 learners scored below 25%, while only 2% obtained scores in the 75%-100% range.

The Department of Education (2006) also conducted a grade 6 systemic evaluation in all the nine provinces of South Africa. The result indicated that 80% of learners scored 1% - 39%, 7% scored 40% - 49%, 8% scored 50% - 69% and only 4% scored 70% - 100%. This means that 80% of the learners had not met the expectation set for grade six mathematics. The report states that questions level of complexity was from grade three to

grade six, and therefore grade six learners mathematical competency developed only up to grade 2 level, and some had not developed any mathematical knowledge. Looking at the results of these studies one wonders if the educators are able to teach to bring out the expectations outlined by the Department of Education (DoE, 2002).

1.3.1 Statement of the problem

The problem investigated in this study was to establish how effectively educators taught mathematics in the OBE context to intermediate phase learners.

1.4 Research questions

In view of the above the research sought to answer the following questions:

- Do educators use learner centred approaches in the teaching and learning of mathematics?
- What Outcomes Based Education strategies do educators use to promote critical and creative thinking in intermediate phase mathematics learners?
- Do educators use Outcomes Based Education alternative assessment to maintain quality teaching and learning of intermediate phase mathematics?

1.5 Purpose of the study

Critical and learning outcomes of mathematics describe an explicit promotion of critical and creative thinking that requires a different teaching style from the authoritarian and rote learning styles of the *apartheid* years. Educators need to take into consideration the fact that learners learn

mathematics in a way that makes sense to them; they must be actively engaged in making sense of mathematics (DoE, 2002).

Thus, the study intended to investigate classroom practices in the teaching of mathematics. Specifically, the study sought to gain an understanding of the extent to which educators used various teaching strategies that are learner-centered to actively engage learners in a creative way, and alternative assessment methods and tools to teach mathematics.

1.6 Significance of the study

The study intended to benefit primary mathematics educators in schools on how to teach mathematics effectively. Information generated from the results would add to the literature that educators could use to extend their understanding of strategies that could be used to actively involve learners in the teaching and learning of mathematics. The study also intended to inform educators on strategies that promote learners' critical thinking. A further aim of the study is to identify difficulties that educators' encountered during the teaching and learning of mathematics, and to suggest ways that could be used to support educators during the teaching and learning of mathematics. Departmental subject advisors could also use findings of the study to provide support that would help educators to teach mathematics effectively and add to their knowledge on how to teach mathematics. Recommendations could stimulate educators to find out more on how they could effectively teach mathematics in an OBE context.

1.7 Limitations of the study

Some educators thought that intentions of the research were to find faults; hence they were reluctant to answer questionnaires. Some took long to

complete and return the questionnaire; because of this I was unable to work according to my planned programme.

I intended to interview six educators from the fourteen sampled educators. However the number of educators that I could interview was limited by the time available. Thus due to time constraints the number was reduced to three. The other constraint was to interview educators during the teaching time since they could not leave learners alone in the classroom. It was not easy for educators to accept to be interviewed in their own time.

I did not intend to observe educators who were not interviewed. However two of the three interviewed educators were not willing to be observed in their classrooms. According to Grimmatt and Crehan (1992) educators' preference for classroom privacy has been noted by many researchers. Therefore I struggled to convince them to accept to be observed during the teaching their process. Observation duration was also a contributing factor to the limitations of the research study. It was my wish to observe each educator for a period of four to five days, to be able to see and understand classroom practices during the teaching of mathematics as lessons unfold. But due to lack of time I was only able to spend one day in each of the educators' classroom. Conducting interviews and classroom observation was my first experience, thus lack of experience had an impact on the conducting of research.

The sample drawn was from a single geographic area (Itsoseng circuit) and thus represented a relatively restricted community. Future research should include a larger sample. Additional research including other clusters in Lichtenburg district would help to eliminate the generalising of these findings.

1.8 DEFINITION OF TERMS

1.7.1 Assessment: is the process of identifying, gathering and interpreting information about a learner's achievements in order to assist the learner's development and process of learning and teaching (DoE, 2002).

1.7.2 Assessment standards: describe the level at which learners should demonstrate their achievement of the learning outcomes and the ways of demonstrating their achievements. They give specific and show how conceptual progression occurs in a learning area (DoE, 2002).

1.7.3 Critical and developmental out-comes: are a list of very broad generic cross-curricular outcomes that describe the kind of skills and understanding that all citizens of South Africa should develop through the education and training system. Critical outcomes emphasise the competencies necessary for a vibrant democracy and economic development, and include problem solving, critical thinking, working as a team, communicating, and using science and technology, while developmental outcomes are defined in order to contribute to the full personal development of each learner as well as social development (DoE, 2002)

1.7.4 Intermediate phase: is an educational level within the General Education and Training Band consisting of Grade 4 - 6. Learners in this phase are in the approximate age group 10 - 12.

1.7.5 Learning outcomes: are derived from the critical and developmental outcomes. They are the description of what learners should know, demonstrate and be able to do at the end of the phase (DoE, 2002).

1.9 Chapter organisation

The research study is organised into the following chapters:

Chapter one: Orientation

This chapter gives an introduction to the research. The background and problem statement are explained. It also provides research questions, purpose and importance of the study.

Chapter two: Review of related literature

A literature review is presented to provide a clear understanding of the nature of mathematics teaching.

Chapter three: Research Methodology

This chapter provides a description of research methods that were used in conducting the study. Study design is outlined focusing on the population and sample chosen and the research instrument that was employed to collect data.

Chapter four: Data Analysis

This chapter portrays the results of analysis of the data collected on teaching of mathematics.

Chapter five: Discussions conclusion and recommendations

Discussion of the findings is presented based on the information provided by respondents and data analysis. Conclusion and recommendations of the research are also presented in this chapter.

CHAPTER 2: REVIEW OF RELATED LITERATURE

2.1 Introduction

According to Setati (2002) Mathematics has a widespread public image as being difficult, cold, abstract, theoretical, ultra-rational but important. It also has an image of being remote and inaccessible to all but a few super-intelligent human beings with mathematical minds. Setati (2004) suggests that this view is the result of how mathematics is taught. Wilensky (1997) terms this fear of mathematics "epistemological anxiety", which is caused by the inability of learners to access mathematics meaningfully. Julie (1998) argues that the fear of mathematics resulted from the approach that was used during the *apartheid* education system in South Africa. This is because the syllabus was often superficially rushed through and no deep understanding was developed. Rote learning was the order of the day and teachers and text books were the only source of information to which learners could refer and this approach gave rise to a rigidity of learner's thinking. Lubisi *et al* (1997) assert that the educator's focus was on extensive content coverage, hence learning was not meaningful and the learner's mathematical power was not developed.

Therefore OBE, underpinned by constructivism, was introduced as indicated in chapter one, to redress the imbalances of the *apartheid* education system. Constructivism fully takes on board the concept of the learner-centred approach. Constructivism posits that learners actually create their ideas, rejects the transfer view of learning and oppose the notion that learning is the filling of empty minds. Constructivism views learning as an active process, it emphasises that learners should fully participate both mentally and physically for learning to be meaningful (Shiland 1999). According to Nodding (1990) constructivism suggests that mathematics learning results from people forming models in their minds in response to the questions and challenges that come from actively engaging in mathematical problems and environment.

Learning, according to constructivism does not come from simply receiving information or blossoming of an innate gift.

O'Brien (2001) supports the constructivist view by stating that an idea should be born in learner's mind and the educator should just act as a midwife. The idea should be born in the learners mind naturally and the midwife should intervene. That is, the learner learns by his own actions. The most important action of learning is to discover ideas. The challenge in the teaching of mathematics is to create experiences that engage learners and support their own explanation, evaluation, communication and application of the mathematical models needed to make sense of these experiences. Constructivism emerges from the post-modernist view and its model of education is characterized by ideas and metaphors from the new sciences of complexity, open-system, process and transformation (Doll, 1993).

The pre-conception of the *apartheid* education system about the nature of teaching and learning practices were in stark contrast to the demands of constructivism. The *apartheid* education system was underpinned by the modernists' view that is grounded in a mechanistic scientific world. Its model of education was based on behaviourist psychology, characterised by a closed system that was tightly controlled. Knowledge in this model of education was viewed in terms of simple, order, linear and uniformity concepts. The curriculum consists of bit of information, which are arranged in a linear order and transmitted to the learner. Learning was defined in terms of the number of units covered, mastered and accumulated (Doll,1993; Slattery,1995; Lubisi *et al.* 1997).

South Africa's education system from 1994 was in a transformation process, and through the introduction of OBE, post-modern philosophies and constructivists theories were infiltrating the country's education system, causing many in the system to re-examine their position about trends of assessment and instruction in the classroom.

Change and improvement in the teaching and learning of mathematics were certainly one of the major national concerns. The momentum of these changes posed enormous challenges to educators to re-evaluate and restructure the ways of teaching mathematics. O'Brien (2002) argues that to develop the mathematical knowledge which learners need, educators need to create and implement a comprehensive plan for the improvement of mathematics education.

2.2 OBE and the curriculum framework

Outcomes based education (OBE) is a process that involves the restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of high order learning and mastery rather than the accumulation of subjects credits (Tucker, 2004). Therefore the primary aim of OBE is to facilitate desired changes within the learners, by increasing knowledge, developing skills and/or positively influencing attitudes, values and judgment, and this implies that educators need to expand learning opportunities for all learners.

There are three levels of OBE, that is traditional OBE, transitional OBE and transformational OBE (Maree and Frasers, 2004). According to Spady (1994) the traditional OBE is guided by the curriculum-based objectives, whereas the transformational OBE focuses on the role performances, which are essential for the hi-tech and competitive future life of the learner (Spady, 1994). The transitional OBE, a twilight zone between the other two OBEs, incorporates traditional OBE for planning the curriculum and transformational OBE for orienting the learner towards their future role. Spady clearly favours the transformational approach to OBE in which outcomes are "high-quality, culminating demonstrations of significant learning in context" (Spady, 1994:18). For Spady (1994), learning is not significant unless the outcomes reflect the complexities of real life and give prominence to the life-roles that learners will face after they have finished their formal education. This notion

of orienting education to the future needs of learners, and of society in general is the underlying principle of the key competencies in South Africa (DoE, 2002).

OBE can be regarded as a theory (or a philosophy) of education (Killen, 2000). Within OBE there are a certain set of beliefs and assumptions about learning, teaching and the systemic structures within which activities take place. Spady (1994:9) proposed three basic assumptions:

- all learners can learn and succeed; but not in the same time or in the same way,
- successful learning promotes even more successful learning,
- schools control the conditions of success (Spady, 1994:9).

These assumptions imply that educators need to determine what things are "essential for all learners to be able to do", and that it is possible to achieve these things through an appropriate organisation of the education system and through appropriate classroom practices.

From his three premises, Spady developed four essential principles of OBE.

- clarity of focus.
- designing down
- high expectations for all learners.
- expanded opportunities for all learners (Maree and Fraser, 2004:5)

2.3 OBE principles

Maree and Fraser (2004) stated that there was no model for OBE, but according to Spady (1994) cited in Maree and Fraser (2004:4) "OBE's purpose will be achieved if educators apply four OBE principles consistently, systematically, creatively and simultaneously".

According to Spady (1994) the basic principle of OBE is the clarity of the focus. This principle infers that curriculum development, implementation and evaluation should be geared by the outcomes which are expected as the culminating demonstrations of the learners. The principle clearly describes that the articulation of the desired end point is essential for successful outcomes (Willis & Kissane, 1997). Based on Spady's idea, the DoE (1997,2002) developed critical outcomes which all learners need to attain in order to be lifelong learners, achieve their potential in their personal and working lives and play an active part in civic and economic life. These critical outcomes apply across all learning area and are the responsibility of all educators (DoE, 1997, 2002).

Educators have to identify a clear focus on what they want learners to be able to demonstrate at the end of significant learning time. Once these outcomes have been identified, the curriculum is constructed by backward mapping of knowledge and skills. The design down principle infers that all curricular and educational activities should be designed back from the point where the "exit outcomes" are expected to happen. In the South African context, critical outcomes are the exit outcomes. They were derived from the constitution of South Africa and describe the type of society envisaged by this country.

Another OBE principle is that educators should have high expectations for all learners. Educators must establish high, challenging standards of performance in order to encourage learners to engage deeply with the issues about which they are learning. Helping learners to achieve high standards is linked very closely with the idea that successful learning promotes more successful learning (Spady, 1994). When learners experience success, it reinforces their learning, builds their confidence and encourages them to accept further learning challenges. One of the most important reasons for using OBE is that it can help all learners to do difficult things well.

Intellectual quality is not something reserved for a few learners, it is something that should be expected of all learners, and this is the link to the fourth principle that educators must strive to provide expanded opportunities for all learners. This principle is based on the idea that not all learners can learn the same thing in the same way and in the same time (Spady, 1994). However, most learners can achieve high standards if they are given appropriate opportunities. traditional ways of organising school do not make it easy for educators to provide expanded opportunities for all learners. However, the practical difficulties of providing expanded opportunities must be weighed against the long-term benefits of enabling all learners to be successful.

Though the importance of using the four principles together to strengthen the conditions for both learner and educator success was emphasised, the intention of this study is to focus on how intermediate mathematics educators use the concept of high expectations and expanded opportunities in their classrooms. Spady (2001) argued that OBE provides educators and learners with expanded opportunities for achieving success. This allows for a flexible approach in time and instructional method for learners learning needs and more than one opportunity such as resources or learning opportunities to succeed. Hence OBE is not time based or curriculum based. Major time restraints cannot be ignored but time is seen as a flexible resource rather than the factor that controls learning (Killen, 2000). In addition, OBE provides the platform for producing high expectations so that challenging standards can be set for the achievement (Spady, 1994).

2.4 Role of educators and learners in OBE classroom

Unlike traditional models of education, OBE encourages the educator to be a facilitator, one who is able to motivate learners to know how to learn and to demonstrate this learning (Killen, 2000). This enables learners to become

active learners and to take control of their own learning. Thus as learners develops ownership of the outcomes, they participate in their education. An active partnership between educators and learners is critical in OBE.

2.5 Purpose of teaching and learning mathematics

"We live in an increasingly numerical world, in which numbers and quantitative methods are used to describe the world and are used in attempts to exercise control over the world, nature, risk, and even life itself. Data, graphs and tables, bombard our sense through television, newspapers and other media. In South Africa, as in other countries, being at ease with numbers is a prerequisite for meaningful participation in society" (DoE, 2002. p19).

According to the above quotation mathematical knowledge may be described as an idealized order that can be used to describe or model the regularities, patterns and structure of the real world. It is a human concept or a mental construction that attempts to define or characterise the order, which we perceive in the world. Mathematics is a structure composed of a whole network of concepts and relationships that are used in the every day life situation. Thus, the vision of mathematics teaching and learning as indicated by DoE (2002) is to equip learners to be able to participate in and contribute to this increasingly numerical world.

Polya (1969) as cited in O'Brien (2001) states that numbers are abstract, thus mathematics can be a good strategy to develop learners' thinking skills. Polya (1969) further states that mathematics is not a spectator sports. Rather learning of mathematics begins with action and perception, proceeds to words and concepts and then to critical and creative thinking. From this statement, it goes without saying that mathematics teaching and learning helps to develop in each learner good mental habits for tackling problems.

2.6 Nature of mathematics instruction as envisaged in OBE

DoE (1997) and DoE (2002) highlight that teaching practices, adopted through OBE, require that learners should participate in classroom activities, become more involved in the learning process and take responsibility for their own learning rather than the use educators' of "chalk and talk" method. It also requires that teachers should give learners the opportunity to work at their own pace according to individual abilities and levels of development. This statement implies that time no longer controls the learning process; rather, educators are required to use a variety of teaching methods and assessment tools to assist each learner to develop and succeed at his/her own pace. Referring to OBE, Pestalozzi Trust (2000) emphasises that the process of providing expanded opportunities and support for learning success, is when educators use a variety of teaching methods and allow each learner enough time to ensure that the curriculum is implemented and the outcomes are achieved.

OBE is radically different from the traditional approach to educational time in which the school year was divided up according to the requirements of the prescribed syllabus. An educator using this approach might, for example, decide to spend three weeks on the study of integers. She then teaches the whole class the same work at the same time. After three weeks she moves on to a new topic, otherwise she will not "cover the syllabus". In my view such an approach promotes inequity because some learners in the class might not, at this stage, have gained the necessary understanding of integers and will thus be excluded from the study of other areas of mathematics requiring this concept.

OBE principle of high expectation implies that educators need to plan and provide learners with worthwhile tasks that foster learners' ability to solve problems, reason and communicate. These tasks should always be clear, and

aligned to learning outcomes and assessment standards, and also developed to make sense of the world. In OBE, educators are urged to create a classroom environment where learners actively construct their own understanding of mathematics, by selecting materials and tasks that build on and extend their learners' understanding. These tasks should also encourage learners to learn to use mathematics to make sense of the world (DoE, 2002).

The educators should consistently expect and encourage learners to work independently or collaboratively to make sense of mathematics. Learners envisaged in OBE should be able to take intellectual risks by raising questions, sharing results and formulating conjectures. They should display a sense of mathematical competence by validating and supporting ideas with mathematical arguments. Learners should be encouraged to use a variety of tools to reason, make connections, solve problems and communicate. They should use models and concrete materials to make sense of mathematics and understand concepts (DoE, 2002).

Educators need to have a full understanding of the mathematical goals of the lesson and be able to decide when to provide information, when to clarify an issue, when to model, when to lead, and when to let a learner struggle with difficult problems. These decisions should always be consistent with the goal and pace of the lesson. Educators need to monitor learners' participation in discussions and decide when and how to encourage each learner to participate. These decisions are based on insuring all learners will learn and be successful in mathematics (DoE, 2002).

Educators need to understand that assessment, instruction and learning are fundamentally interconnected. They should engage in ongoing analysis of teaching and learning by observing, listening to, and gathering information about the learners to assess what they know and are able to do. Educators need to assess what every learner is learning, the concepts they understand and ensure that they are doing significant mathematics. They should change

and adapt instruction based on the ongoing assessment of the learners. A variety of assessment instruments should be used (DoE, 2002).

If educators have to rely on worksheets and textbooks to deliver instruction in mathematics and to cover the curriculum then they will not be able to move towards the vision of mathematics education. To transform into mathematical communities that will develop learners' mathematical competency, educators need to access and be able to use instructional material for thought provoking activities and projects, software for simulation and modelling and resources in the community for authentic learning experiences.

2.6.1 Minds-on activities

DoE (2002) envisages learners who are mathematically competent. Simply being able to compute numerical problems is no longer considered adequate. More emphasis is now placed on higher-level mathematical skills such as complex problem solving, data gathering and analysis. Kulm, Capraro, Capraro and Hasting (2001) claim that the great majority of a person's mathematical knowledge and skills comes from learning to use parts of the brain that can do mathematics. Yet experience tells us that for most young learners, mathematics learning is not concerned with learner's brain but rather comes from the educator's head. And this is against the principles of Constructivism, which state that knowledge cannot be placed inside the learners' heads, rather learners construct their own knowledge by selectively using experiences around them (Kramer, 1999; Cathcart, *et al.* 2000; von Glasersfeld, 1987 (DoE 2002).

Dossey, Mullis and Jones (1993) argue that when learners learn mathematics by grappling with challenging problems rather than by simply memorizing and practicing predetermined procedures, they freely learn to inquire, search for solutions and resolve incongruities. This approach yields understanding. Spady (1994) argues that educators need to support learners to achieve

higher levels of performance. According to DoE (2002) Intermediate Phase learners are starting to think more abstractly and are more critical in terms of their thinking. Thus it is important to provide minds-on activities that focus on the critical thinking process, which is needed for learners to create and re-create mathematical concepts and relationship in their own minds. These activities should compel learners to demonstrate their abilities to use mathematical language, reasoning and analyzing skills, and also strategies and procedures to solve complex problems everyday. This is emphasised by Polya (1975) in Cathcart *et al.* (2000:39) when he said

"A Mathematics educator has a great opportunity. If he fills the allocated time with drilling his learners in routine operations, he kills their interest, hampers their intellectual development and misuses his opportunity. But if he challenges the curiosity of his learners by setting problems proportional to their knowledge and help them to solve problems with stimulating questions, he may give them the taste of some independent thinking."

Teaching and learning of mathematics with understanding involves fundamental forms of mental activities. There are specific instructions that promote high level of thinking during mathematics learning, particularly activities that build on learner's prior knowledge. These activities promote learners' thinking and reasoning since they use their mental structures to link the relationship between existing and the new knowledge. Furthermore, these activities engage learners in communication about mathematics.

Collaborative learning involves a necessary complex set of inter actions, where learners debate and negotiate the meaning of mathematical concepts, which require them to think and reason. Specific instructions that promote a high level of thinking engage learners in worthwhile and challenging activities relevant to the lives of the learners. Contrasted to traditional methods of teaching mathematics, where learners memorized procedures to solve routine problems, these kinds of activities integrate life into mathematics learning.

Through these activities, learners will realise the importance of internal connection of mathematical knowledge (Kulm *et al*, 2001).

2.6.2 Active questioning

According to Johnson (1995) questioning is one of the strategies that could be used to enhance active participation of learners. It does not require a change in learning style or a piece of fancy equipment. All it takes is for educators to model the process and practices. Asking questions enables the learners to stay involved, since their comprehension is verified throughout the lesson. Asking questions enables learners to achieve more, because it models for them how to question themselves when they are trying to solve a problem, and it helps them identify the thinking processes that they need to use. When questioning is used effectively it will stimulate recall and mobilise existing understanding in order to make new understanding and meaning (Borich, 1996).

Effective questioning ensures that learners are led to answer questions which demand increasingly higher-order thinking skills but should be supported on the way by questions which require less sophisticated thinking skills. It helps learners to extend their thinking from concrete and factual to being analytical and evaluative (Borich, 1996). Morgan and Saxton (1994) emphasised the importance of using open, higher-level questions to develop learners' higher-order thinking skills. There is a need to have balance between open and closed questions, depending on the topic and objectives for the lesson. A closed question such as 'What is the next number in the sequence?' can be extended by a follow-up question such as 'How did you work that out?'

❖ **Cognitive levels of complexity used to facilitate questioning**

According to Johnson (1995) questions could be used to promote learners' thinking. Borich (1996) stated that educators need to ask questions of differing degrees of cognitive complexity in order to challenge learners to develop their thinking. When educators are planning higher-level questions, they may find it useful to use Bloom's taxonomy (Morgan and Saxton, 1994). Maree and Fraser (2004) outlined Bloom's taxonomy that described the six level of cognitive complexity as follows:

- Knowledge which represents the lowest level in Bloom's taxonomy involves memorisation and recall of knowledge. It provides the basis for all "higher" cognitive activity.
- Comprehension which involves making meaning of things rather than just remembering them. verbs such as match, describe, convert, illustrate, discuss or summarise are used.
- Application is the ability to use abstract information and ideas in concrete situation, such as solving problems. Calculate, demonstrate, construct, compute, solve, relate, compare, and apply are verbs used to describe activities at this level.
- Analysis is to examine information systematically to identify parts so that the relative hierarchy of the ideas is made clear and the relation between ideas is made explicit. Verbs used at this level are analyse, differentiate, categorise, classify, relate, illustrate, outline, explain, compare and contrast.
- Synthesis is to construct new information by combining several pieces of information to develop a coherent whole. Plan, adapt, combine, create, design, develop, formulate and organise are verbs used at this level.
- Evaluation is the highest level of Bloom's hierarchy. It consists of making judgments based on previous levels of learning to compare a

product of some kind against a designated standard (Maree and Fraser 2004: 69).

❖ **Classroom tactics for effective questioning**

Creating a climate where learners feel safe to make mistakes is very important if the intention is to build learners with the confidence to speculate and take risks. According to Morgan and Saxton (1994) such confidence could be developed by listening to and taking learners' contributions seriously. This could be led by ensuring that appropriate responses are made to contributions.

Using a 'no-hands' rule can ensure that all learners are likely to be asked for a response and makes the questioning process more inclusive. If educators only ask learners with their hands up, it limits who is included and can leave some learners disengaged from the process. The 'no-hands-up' tactic could also let educators direct and distribute questions.

Probes are useful follow-ups and can be used to seek more information, to clarify responses or to get learners to extend their answers. Questions such as 'Can you tell me more about that?' or 'What do you think the next step would be?' are useful probes that extend learners' thinking.

Telling learners the difficult questions in advance helps to reinforce the main ideas and concepts and gives learners' time to prepare for the question as they work through the lesson. You could also provide signals to help learners recognise the range of possible responses to the question being asked and to help them select the most appropriate one.

Allowing time for collaboration before answering is asking learners to consider the question for a set period of time before seeking answers. This leads to

more thoughtful and considered answers. It can also promote engagement by giving learners a very immediate context for their work.

If questioning is effective, then learners should be able to recall ideas, link ideas together and explain their understanding orally. Learners will also engage with the educator because they feel comfortable, they are aware of the purpose of the questioning and do not feel threatened by it. As time goes on they become more aware of how they are learning because the questioning not only probes their thinking, but helps them reflect on their own thinking and learning processes.

2.6.3 Building on learner's prior knowledge

According to Cop and Yaker (1992) it was commonly thought that children lack the ability to form complex ideas and most psychologists accepted the traditional thesis that a child mind is a blank slate (*tabula rasa*) on which the record of experience is gradually impressed. But challenges to this view arose and a major move away from the *tabula rasa* view of the children's mind was taken by the Swiss psychologist Jean Piaget. Piaget argued that the young human mind could be best described in terms of complex cognitive structures. He asserts that all mental activities are constructive and learners acquire new knowledge through active process, that is, assimilation and accommodation. In this process new as well as existing knowledge is transformed as a learner constructs more inclusive schemas of understanding.

Wilensky (1997) emphasises the value of messy half-formed concepts, and that it is important for educators to encourage learners to express these concepts. Ausubel (no date) as cited by Ball (1993) notes that prior knowledge is one factor that influences effective learning. It is important that educators determine what the learners already know and link it with the new information through the use of concept maps. Orton (1992) supports this idea by stating that learners require a foundation of relevant mathematics

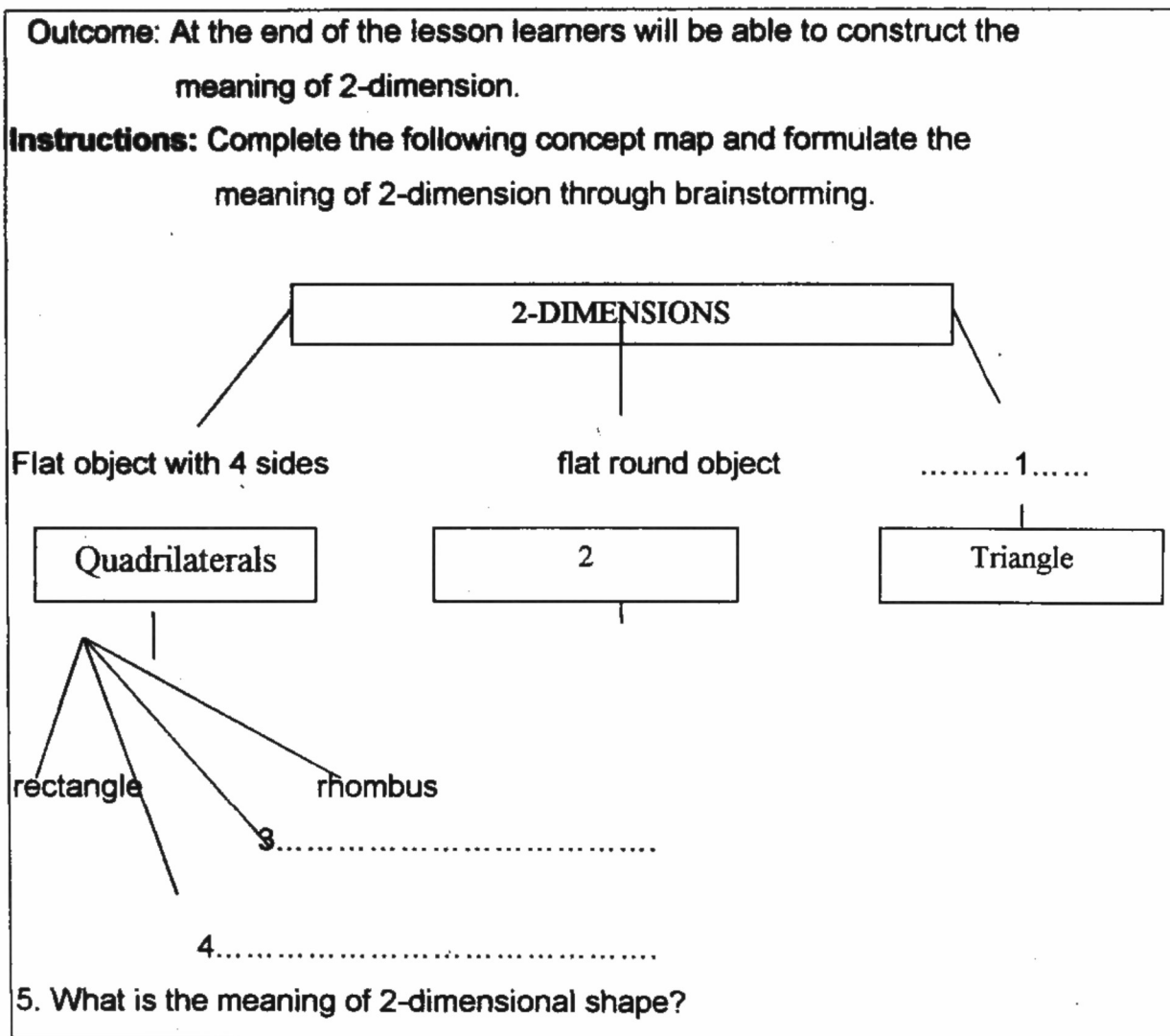
knowledge on which to anchor new ideas, and that justification for using concept maps is seen in relating new knowledge to an existing knowledge, which makes teaching and learning effective.

Cangelosi (1996) argues that most learners think of mathematics as a mystifying subject that is impossible to learn. This is because of the learners' failure in discovering the relationship between mathematical concepts. Therefore, it is important that educators should be familiar with the use of concept maps because concept maps can be used to help learners identify the relationships between the concepts. Concept maps could be used to enhance better understanding of mathematical concepts, which can lead to better learning in mathematics.

Thus during the teaching and learning of new concepts educators need to encourage learners to use concepts maps to explore ideas. Dossey (1993) asserts that concepts of mathematics derive their meaning through connection with other concepts and that meaningful learning occurs when the new knowledge is linked with the existing concepts. DoE (2002) also supports the idea of prior knowledge, by stating that learners' prior knowledge of concepts is an important point of departure for planning the next activity.

The following is an example of concept map that can be used as an activity in the teaching of 2-dimensional shapes:

Figure 1: concept map of 2-dimensional shapes



Learners in grade 5 and 6 have the knowledge of different types of flat shapes. Therefore concept map in figure 1 uses prior knowledge on flat shapes to help learners realise the link between 2-dimensional shapes and construct their own meaning of 2-dimensional.

Ball (1993) argues that if learners are able to link the relationship between mathematical concepts, then they will be able to recognise how to apply these concepts in solving problem. For example, if learners have previously constructed the concept maps of rate, time and distance, then it will be easy

for them to use the relationship of these concepts in solving real life problems like calculating the speed of a car.

2.6.4 Group work

Specific predetermined goals, objectives, and tightly structured lesson plans, which are characteristic of closed-ended systems, are no longer taken as the only valid way of structuring curriculum. The influx of open-ended educational systems into fragmented communities requires a collaborative approach to effective learning (Doll, 1989, Lubisi, 1997, Kramer, 1999 and Slattery, 1995). Thus, in OBE social interaction is a key curricular characteristic to facilitating teaching.

Piaget has long emphasized the important role that learner-to-learner interaction plays in both the rate and quality with which intelligence develops. The opportunity to exchange and discuss ideas promotes a more critical and realistic view of self and others in learners. Piaget calls this decentration, which is the ability to view matters from another perspective (Hilderbrand, 1997). This is an important quality that should be nurtured and encouraged in the learning of mathematics. Vygotsky, who is also a proponent of learner-to-learner interaction, pointed out the role of social environment, as well as people as agents in developing thinking. The most powerful idea from Vygotsky to influence developmental psychology was that of a zone of proximal development. Zone of proximal development refers to a competence that learners can navigate with aid from a supportive context, including the assistance of others (Hilderbrand, 1997). Vygotsky's work has drawn attention to the roles of more capable peers, parents and community in challenging and extending learner's efforts to understand (Hilderbrand, 1997). Since intellectual development cannot be separated from social interactions, a high level of thinking ability can be fostered through the wide spread of group work in the teaching and learning of mathematics.

Cop and Yakei (1992) noted that playing with ideas is extremely exhilarating and when made a lifelong habit, it weaves a web of connected ideas, giving resilience and snap of intelligence. Transferring this concept to the mathematics classroom, educators need to move away from using rote learning and promote communication of mathematics issues through group work to develop deep and coherent understanding of mathematics. Carthcart *et al* (2000) indicate that communication works together with reflection to produce new relations and connections. Learners who reflect on what they do and communicate about their reflections in-group discussions are in the best positions to build useful connections in mathematics. This approach also provides a chance to think abstractly about ideas and that increases the capacity of flexible thinking. Therefore it prepares learners to approach life's-ever changing challenges with confidence.

Through group work learners are given the opportunity to negotiate the meaning of mathematical concepts with members of the group. Learners should be able to discuss their understanding of concepts with others, and with their educator. For example, learners can be asked to calculate the volume of a rectangular prism with the length of 3cm and the breadth of 2cm, and give reasons to substantiate the answers. In this type of question learners are to discuss and negotiate the meaning of the concept of volume. They have to link the given information to the formula of volume to recognise that only two dimensions are given, thus volume is zero. They will be critically identifying constraints that relate to this problem by investigative skill in working with mathematical situations. In of discussions conceptual meaning and understanding is developed.

2.6.5 Hands-on activities

"It is difficult to translate what is said to us to the feel of the conker swing." Clemson and Clemson (1999:8) use these words to stress the disadvantages of using the behaviourist's way of teaching. Stiggins (1997) explains learning

as a process of transformative change that is triggered by experiences. It is important for educators to recognise that learning is a complex process and to create an environment that should spark learners' interest and curiosity by providing challenging and stimulating materials to reinforce learning.

Piaget (no date) as cited in Hilderbrand (1997) theorises that learning is an active and creative process, and mathematics learners assimilate information better when they are actively involved in hands-on activities with concrete objects. Educators are encouraged to build learners' strong mathematical foundation through the use of concrete objects. Dienes (no date) as cited in O'Brien (2001), like Piaget, emphasises the use of hands-on activities by stating that mathematical concepts can be well understood only if presented through a variety of concrete and physical representation. Dienes further explained that constructive experiences form the cornerstone on which all mathematics learning is based. At some future time, attention can be directed toward the analysis of what has been constructed. However, Dienes further pointed out that it is not possible to analyze what is not yet there in some concrete form. One major problem in schools is the fact that many children are asked to do mathematics that is abstract before they have the opportunity to experience it in concrete form (O'Brien 2001).

For example, Intermediate Phase learners are expected to calculate equivalent fractions. It is not easy for them to comprehend the fact that $\frac{2}{3}$ and $\frac{2}{6}$ can add up to make a whole. So, it is important that educators should use physical objects to help learners understand the concept of equivalent fractions. Educators can divide learners into small groups, and give each group a concrete material like apples or pizza divided into 4, 8 and 12 parts. Learners should be asked to take out 1 part out of 4 parts, 2 parts out of 8 parts and 3 parts out of 12 parts and write the fraction of the missing parts ($\frac{1}{4}$, $\frac{2}{8}$ and $\frac{3}{12}$), then discuss the relationship between the missing parts.

This is a discovery activity where learners can compare the parts of pizza or apples and discuss what they have observed.

Manipulation and representation of physical concrete objects is necessary for learners to discover mathematical concepts on their own (Bruner in Kearsley, 1994). At the beginning of the new topic educators need to give learners an opportunity to manipulate physical objects. According to Bruner manipulation and representation of concrete objects develop learners' intuitive thinking (Kearsley, 1994).

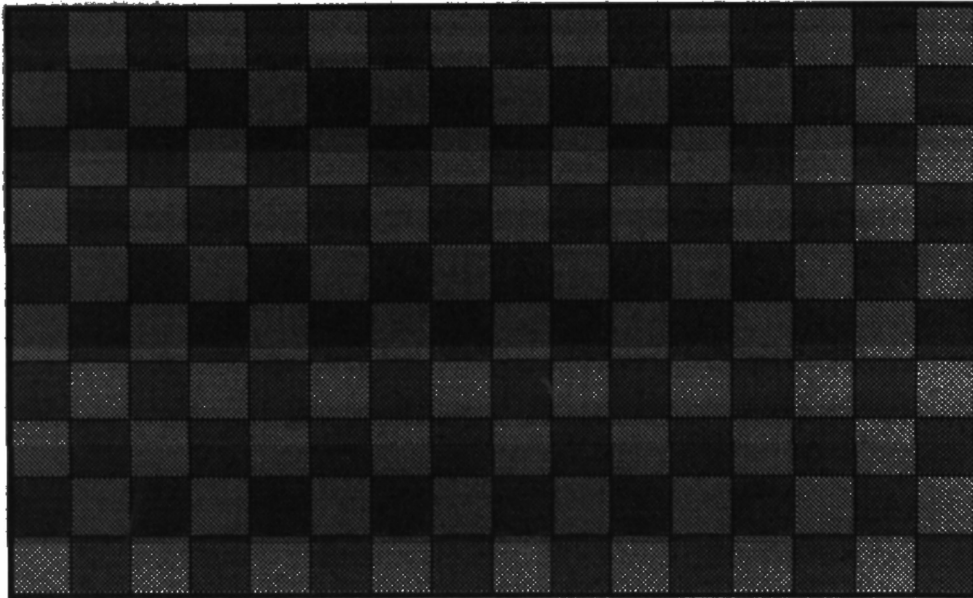
Clemson and Clemson (1999) explain hands-on activities as activities in which learners explore mathematical concepts, discover mathematical principles or apply mathematical concepts in concrete situations. Through hands-on approaches, learners are involved in the real doing of mathematics, experimenting first hand with physical objects in the environment and are exposed to concrete experience before they can learn abstract mathematical concepts. Learners in the primary school are in what Piaget called concrete operational stage, meaning these learners learn better through manipulation of concrete objects (Clemson and Clemson, 1999). Therefore, educators need to engage learners in hands-on activities, rather than passively transmitting knowledge to them.

According to Shiland (1999) hands-on activities allow learners to actively build systems of meaning and understanding through their experiences. For example, railway layouts provide learners the opportunity to gain practical experience of comparing and measuring distances, using straight, curved and parallel lines, discussing positions and movement.

When teaching the concept of patterns and sequences, educators can use weaving to develop learners who are able to recognise, describe and represent patterns. Learners can be asked to make different patterns through weaving. They can use papers of different colours, scissors and rulers to

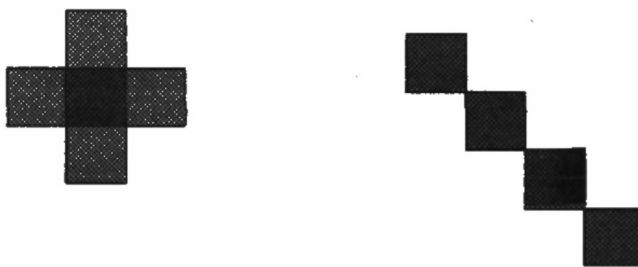
create different patterns. The following is the example of a pattern that can be constructed through weaving:

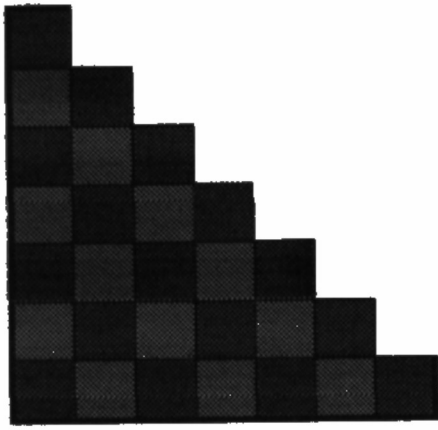
Figure 2: table mat constructed by weaving



Learners can be asked to identify and describe new different geometric patterns using the tablemat in figure 2. The following are examples of possible patterns that can be identified by learners:

Figure 3: patterns identified from tablemat





Weaving is a powerful tool that can be used to develop appreciation of the creative qualities of mathematics. Educators can use it to help learners understand the concept of patterns.

Learners can also make a model of a square and a rectangle, and later use these models to discuss the similarities and differences between a square and a rectangle. Buckets and flat round objects can be used to help learners understand concepts of 2 and 3-dimensions. Such objects can also be used to help learners recognise the difference between area and volume. An analysis of the plan of a house can also help learners realise the importance of learning 2-dimensions and 3-dimensions, measurement and application of these mathematical concepts in the real life situations. By exposing learners to such activities, educator will also be transferring mathematical knowledge to technology, and this might arouse learners' interest in architectural aspects.

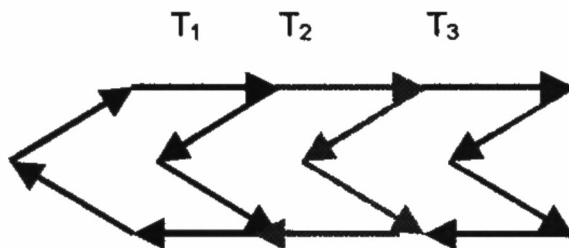
These kinds of activities provide learners with the purpose of learning mathematics and help them to adapt to daily life, while conceptualizing mathematical concepts.

2.6.6 Authentic tasks

South Africa's economic growth depends largely on the international market. Global competitiveness requires learners who can apply mathematics to real life situations (DoE, 2002). Educators need to provide opportunities for learners to generate creative and innovative ideas, and work towards translating ideas into actions. During the teaching and learning of sequences educators can encourage learners to use knowledge of number patterns to create and explain their own patterns.

For example, learners may be asked to use match sticks to form different patterns and explain how these patterns are formed by stating the first term and the rule that is used in the process.

Figure 4: patterns formed using matchsticks



As shown in figure 4, the first pattern may be formed by using 6 match sticks. To form the next pattern four more matchsticks are used. Numbers sequence representing this pattern is as follows:

$$6 + 4 = 10$$

$$10 + 4 = 14$$

$$14 + 4 = 18 \text{ and so on}$$

Learners can also be asked to investigate the patterns of pavements and to find out the rules that are used to form these patterns.

Von Glaserfeld (1989) emphasises that it is impossible to put knowledge in the learner's head, rather learners learn through adapting what they know to

fit with what they experience. DoE (2002) states that learning becomes effective when learners know the value of the task. Therefore practical problems can be used to encourage understanding of mathematical concepts. Educators can use examples of number patterns that are used everyday in schools such as calendar and time-tables to help learners realise the importance of learning patterns. Learners can be asked to investigate and explain how these patterns are formed. Learners may be asked to investigate the time-table of the school and explain how the number patterns are formed. For example if the first period starts at 8h00, the first term is 8H00. Each period takes 40 minutes then the rule is $T + 40$ minutes.

Some mathematical concepts are abstract, thus tasks related to the real life situations can be used to provide practical sense to the learner to foster mastery of mathematical concepts. Through tasks related to real life learners can realise that mathematical skills are not just computational skills, but rather they can see mathematics as a way of looking at the real world. Learners should find out how mathematics works as they experiment and learn through their mistakes, thus taking the responsibility for their own learning. According to Kulm *et al.* (2002), mathematics comes alive when learners participate in the activities that illustrate how mathematical decisions arise from the basic needs of societies.

For example, 'Why do people build their houses in certain shapes and sizes?' Thus an investigation into styles of building houses in various cultures provide valuable experiences with shapes and sizes, perimeters and area, estimation and approximation while at the same time shows the relevance of mathematics to social sciences, technology and arts. Learners can investigate round houses, and mud and wattle houses in the rural areas as compared to urban houses.

Learners' mathematical thinking depend on the quality and richness of their every day experiences, for children learn more from their own actions than

from what they are told. Learners should be allowed to discover, discuss and meaningfully construct mathematical concepts and relationships in the context that involves real-situations Saundes (1992). It is important for educators to provide interesting tasks that amuse learners while guiding their progressive development.

2.6.7 Problem solving in mathematics teaching and learning

According to DoE (1997) and DoE (2002) critical outcomes that address development of thinking and problem solving is that the learner must be able to identify and solve problems and make decisions using critical and creative thinking. Therefore problem-solving skills are important tools which all learners need, to face the ever-challenging world. Dossey (1993) stated that learning occurs when a learner's abilities are fully engaged in overcoming a challenge that is interesting and manageable. While grappling with a problem the learners control the direction of their approach to the task and construct their own learning as they stretch their abilities to master the activity.

Fennema and Romberg (1999) argue that open-ended problem solving is effective in promoting mathematical understanding. Thinking about ideas in problem solving increases the flexibility and thinking capacity that enables learners to read critically, identify fallacies, detect bias, assess risk and suggest alternatives to solutions. Therefore help learners to be better problem solvers is to prepare them not only to think mathematically, but also to approach life's ever-changing challenges with confidence.

It is not difficult to teach mathematics as a series of skills and as a collection of facts to program learners to carry out routines without meaningful learning. According to DoE (2002: 27) routine problems are problems to which the methods and procedures to find the solution are obvious to the learners. They simply need to be executed to find the solution. These problems are often not referred to as problems but rather as exercises. Drill and practice are used to

develop proficiency in the use of a concept (DoE, 2002). But thinking of learners who emerge at the end of the system and go out into the world, one would realise that a very small percentage can use mathematics in their everyday life, if routine problems are the only type of problems learners are exposed to. There must be more to the teaching and learning of mathematics than simply being able to memorise procedures to work out routine problems, theorems and formulae. Problem-solving process should be used to develop learners to be responsible adults who observe and identify problems, adults who will be able to develop and execute their own plans to solve problems to their own satisfaction and be able to assess the solutions before choosing one and accepting it as the best.

Therefore, to promote high-order thinking educators need to allow learners to experiment increasingly with their own ideas and get away from the concept that the educator has pre-conceived set of rules about how the problem should be resolved. As learners get more experienced in resolving and handling problems and discuss procedures used to solve problems with their peers, their learning becomes more sophisticated and effective. Educators need to give learners opportunities to create and enjoy mathematics by setting problems that are interesting to learners. Educators should further provide purposeful activities in meaningful context. Activities should consist of real problems that are credible to the learners and be within learners' range of experiences. Educators should also allow learners enough time to think and generate alternative methods for problem solving.

2.7 Inclusive education in mathematics classroom

Mathematics has long been thought of as a subject only for those with special talents, but now there is a call for a change of this attitude. It is emphasized that all learners need to be given an opportunity to learn mathematics regardless of gender, ethnicity, age, physical challenges or cultural background. It is highlighted that different learners learn in different ways, at

different pace and through different opportunities. Educators are urged to take this into consideration as they plan teaching activities and recognise that learning of mathematics cannot be rushed (DoE, 2002).

Educators are encouraged to acknowledge that mathematics' learners are unique beings who should be provided appropriate learning experiences that are challenging yet geared to their capabilities and needs, and support or assistance they require. Meeting the needs of diverse learners is a challenge. Classrooms with diverse learners are not competitive places in which students attempt to prove themselves but are cooperative environments in which students support and nurture each other's learning (DoE, 2002).

2.8 Nature of assessment in mathematics

For many years, assessment of learners has been characterised by marks and the red pen. The educator's focus was on the number of rights and wrongs the learner got in a particular task. Most unfortunately, the rights and wrongs used to decide the future of a learner were acquired from activities which were not intended to assess understanding, growth and development of learners, but rather how much a learner could memorize. This implies that assessment of learners was not what it ought to have been, and this compels us to look at what assessment actually is.

Assessment according to Kyriachou (1991) refers to any activity used to appraise learner's performance and use different of techniques to monitor learners. Gipps (1994) defined assessment as the process of gathering valid and reliable information about the performance of the learner against clearly defined criteria using a variety of methods, tools and techniques. Cathcart *et al.* (2000, p60) defined assessment as "the process for gathering evidence about a learner's knowledge of mathematics, ability to use mathematics and disposition towards mathematics and making inferences from that evidence for a variety of purposes. The Association for Mathematics Educators in

South Africa [Amesa] (1999) claims that assessment should always place learners at the centre of the process of learning and learners should be seen as the ultimate beneficiaries of assessment.

Assessment of learners is an act that has specific social and educational consequences. Educators should use gathered information to make decisions about learners' progress and performance. Educators should therefore accept the responsibility for the consequences of their work and they should make every effort to be certain that learners' assessment is used appropriately. Assessment should therefore be seen as a means of fostering growth towards high expectations of learning mathematics in particular. If not, it is just a waste of human potential.

2.8.1 Purpose of assessment in mathematics

According to Orlich, Harder, Calahan and Gibson (1998) assessment is not an end in itself, but a vehicle for educational improvement. Assessment should be diagnostic and formative in nature thus allowing educators to establish where learners are in their understanding and then plan meaningful tasks to establish development and progress. Orlich *et al.* (1998) emphasises that the prime purpose of assessment should be to support teaching and learning rather than to indicate the past and current achievements.

Gipps (1994) argues that assessment has to do more than just providing information for certification and selection, but most importantly, assessment should enhance good quality teaching and learning. Gipps (1994) further emphasises that assessment should identify what learners know, what they have not learned and areas where they have difficulties. The main purpose of assessment, according to Orstein and Hunkins (2004), is to help educators to better understand what learners know and make meaningful instructional decisions. A successful assessment allows educators to know where instruction should begin to build on the learner's previous knowledge.

Assessment in OBE should focus on what is important and valuable for the learners and not just what they have been able to remember (Kramer, 1999). DoE (2002) emphasises that assessment should provide an indication of learners' achievement in the most effective and efficient manner. It should also ensure that learners integrate and apply skills. Assessment should help learners to make a sound judgment about their own performance, set goals for progression and provoke further learning.

After reviewing the literature on the purpose of assessment, the following was realised:

- The assessment of learners progress has a strong influence on both teaching and learning, since the two main purposes of assessment are to help make instructional decisions and to monitor learners' progress.
- It is therefore important that educators should at all times be clear about the purpose of the assessment, so that they are able to make the right decisions about when, what, how and whom to assess.

If used appropriately, assessment can promote learning, build confidence and develop learners' critical and creative thinking.

Assessment as envisaged by OBE should be a planned and continuous process of gathering information about the progress and performance of learners measured against the learning outcomes. The level at which learners should demonstrate their achievement of learning outcomes is described by the assessment standards. Progress in the assessment standards is interpreted in terms of increased knowledge and skills developed between grades. Assessment is the heart of teaching and learning in mathematics (DoE, 2002). Thus educators are encouraged to see it as an integral part of teaching and learning, which takes place in the increasingly sophisticated context in which learners can work as they progress from one grade to the next. Assessment strategies need to be varied to cater for different learners in

the mathematics classrooms. Therefore, the use of alternative assessment is encouraged.

2.8.2 Alternative assessment

Alternative assessment, which emerged from the post-modernist view, represents a critical re-appraisal of narrow traditional assessment underpinned by modern view (Doll, 1993). Gipps (1994) emphasises that traditional assessment was too narrow to achieve today's broadening goal of education. Alternative assessment is open and flexible since different assessment types and techniques are used to assess different aspects of learning in order to obtain a more comprehensive view of the learner. Flexibility and openness in alternative assessment are indicated by the fact that educators are no longer regarded as sole assessing agents (assessors). Learners can assess their own work; this is referred to as self-assessment. Peers also, can assess their classmate's work depending on the purpose of assessment (Amesa, 1999).

Openness is also indicated by the fact that learners should be informed about what they need to know, how they will be expected to demonstrate knowledge and what the consequences of assessment will be. When learners understand the criteria used in judging their work, they are likely to improve their performance. Openness contributes to equitable assessment. Educators should explain learning outcomes to learners and learners should participate in the negotiations of learning tasks and actively monitor and reflect upon their achievements and progress (Doll, 1989; DoE, 2002).

Simple traditional assessment expected learners to recall information, which was passively absorbed, while complex alternative assessment offers a sharp contrast to the statement by focusing on understanding, application and problem solving. Complexity of alternative assessment is also indicated by the fact that learners are not assessed at the end of chapter; rather,

assessment is integrated in the lesson. As an integral part of mathematics instruction, assessment contributes significantly to all learning, since learners learn mathematics while being assessed. Assessment is a learning opportunity as well as an opportunity for learners to demonstrate what they know and can do.

2.8.2.1 Different types of alternative assessment

The following are examples of alternative assessment:

❖ Continuous assessment

Traditional assessment as indicated by Cathcart *et al.* (2000) does not provide details that allow educators to describe strength and weakness of their learners. Orlich *et al.* (1998) argue that educators are now encouraged to take assessment as an important daily process, integrated with instruction. When assessment is an integral part of classroom process, learners and educators will always be informed about progress. Amesa (1999) supports these ideas by stating that if educators continuously assess learners' mathematical work, they are able to detect mistakes that learners make. They are also able to determine if learners experience problems or whether learners have a negative attitude towards mathematics. This might provide educators with valuable information upon which instructional modification can be made.

According to Cathcart *et al.* (2000) the advantage of using several kinds of assessment is that learners understanding can be continuously monitored. A single type of assessment can frustrate learners and diminish their self-confidence and make them feel anxious about mathematics. Peer and self-assessment strategies, according to Kramer (1999) can be used to get maximum output on a learner's performance,

because learners tend to understand each other's capabilities. However, peer and self-assessment strategies should be done under the educator's observation to curb irrelevancy. Peer assessment guides learners to assess their own performance. This could be achieved when learners are helped to reflect on their own performance against desired outcomes and criteria. It can help learners to decide on what they need to improve, thus taking responsibility of their own learning.

The use of continuous assessment provides information concerning learner's progress and achievements, which help to inform on going teaching and learning. The use of several kinds of assessment examine the extend to which student have integrated and made sense of mathematics concepts and procedures.

❖ **Performance task**

According to Stiggins (1997) a performance task is a direct and systematic actual work or performance by a learner and product created on completion of the task. Kramer (1999) refers to a performance task as a task that requires learners to demonstrate their skill, competencies and knowledge by performing or producing something related to pre-defined standards. Cathcart *et al.* (2000) argue that performance task in mathematics involve projects, investigations, observations and interviewing. Performance task presents learners with understanding rather than just speed and accuracy. In a nutshell a performance task is a valuable activity, which focuses on learners' use of knowledge, skills and attitude in a variety of realistic situations. It can be complex enough to require learners to work together in small groups.

The advantage of performance task such as project and demonstration are that they reflect real-life situations, problems and challenges (Amesa, 1999). For example learners can be asked to organize tuck

shop day to raise funds for the educational tour. Maree and Fraser (2004) state that performance task requires that learners develop their own approaches to the task under defined conditions, knowing their work will be assessed according to agreed upon standards. Therefore, the educator needs to design criteria that will be used to assess learners work, these criteria must be explained to the learners so that they are clear about what is expected of them. This is supported by OBE principle, clarity of focus, which implies that the educator must ensure that learners are clear about the criteria against which they are to be assessed.

When organising a tuck shop day learners can demonstrate their understanding of basic operations, when they draw a budget and calculate profits. Learners can demonstrate their ability to plan and organise. Educators can also assess learners' behaviour as they work in their small groups. Educator can use just one activity to assess variety of aspects unlike with the narrow traditional test. Learners should be provided with rubrics, which they can use to assess work. Group members should also be provided with the rubrics to reflect on and make judgment about their work. Both the classmates and group members should be given the opportunity to discuss and negotiate their reports. This assessment helps educators to gain information on how learners view their own performance and how peers view their performance and encourage reflection and communication about desirable performance criteria (Kramer, 1999).

❖ **Observation**

According to Cathcart *et al.* (2000:68) "*Success in mathematics often is correlated positively with favourable attitude towards mathematics*". Though attitude has such an impact on learners' progress, traditional assessment did not take attitude into consideration. Educators can use

observations as a means of collecting information about learners' behaviour and attitude towards mathematics.

Amesa (1999) emphasises the need for educators to have observation plan but also to be flexible enough to note other significant behaviour of learners. By observing, an alert educator is often able to spot clues to the causes of a learner's unacceptable behaviour, attitude or lack of understanding.

❖ **Portfolios**

A portfolio is a file or folder that contains sample of learner's work over time that furnishes evidence of learners' understanding, skills and even disposition to act in particular ways. The purpose of a portfolio is assessing knowledge proficiency and measuring growth. (Orstein and Hunkins, 2004).

Crowley (1993) as cited in Carthcart *et al.* (2000) refers to a portfolio as a collection of student work that provides the opportunity for a learner to showcase his/her work and growth in mathematics over a period of time. Cathcart *et al.* (2000) further emphasise that a portfolio promotes learners self-assessment; that is encourages learners to communicate their understanding of mathematics with a high level of proficiency. Through the use of portfolios, shared responsibility is established in a classroom since educators as well as learners are responsible for the making and management of portfolios.

2.9 Conclusion

The development of creative and critical thinking and problem-solving in individuals lies at the heart of South Africa's curriculum, in order to achieve the values of a society striving towards social, justice, equality and

development. If the strategies of OBE in the teaching and learning of mathematics are implemented well, then South Africa would have the potential to compete with the international market and to improve its position on the world scale (DoE, 2002). This statement reminds me of the Chinese proverb that says,

" I hear and I forget. I see and I remember. I do and I understand".

This is an appeal to educators that they should not lose sight of the good intentions of mathematics education and resort back to the ineffective ways of the past. Educators owe a mathematically rich experience to each and every learner, not just those who process information like educators. When educators plan and prepare for mathematics lessons, they should always remember that success in technology and science is impossible without a proper foundation of mathematics.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides a description and presentation of the research method that was used in the study. The rationale behind the methodology employed is explained, focusing on the population, sample chosen and the research instruments. This chapter further explains the procedures on data collection and analysis that was followed.

3.2 Research design

A survey was used to elicit data on classroom practices in the teaching and learning of mathematics. Nesbary (2000:10) defined survey research as "the process of collecting representative sample data from a larger population and using the sample to infer attributes of the population". The main purpose of a survey is to estimate, with significant precision, the percentage of population that has a specific attribute by collecting data from a small portion of the total population. According to Cohen, Manion and Morrison (2000) in a survey, data is collected with the intention of describing the nature of existing conditions. In schools survey could be used to assess the aspects of curriculum and or administrative procedures. Schutt (1996) cited in Mcmilliam and Schumacher (2001) stated that survey is popular because of its versatility, efficiency and generalizability. In this study survey was chosen on the basis that it could be used to investigate almost any problem. A small sample could be selected from a larger population in a way that permits generalization to the population.

3.3 Research methods

This study used qualitative research method. According to Sarantankos (1998) qualitative research in general is more likely to take place in a natural setting, that is, methods could be designed to study interactions in the world of everyday life. Marshall and Ross (1995) added that topics of study focus on everyday activities as defined and enacted by people going about their normal routines. Qualitative research is the study of contextual principles, such as the roles of the participants, the physical setting, and a set of situational events that guide the interpretation of discourse. Thus qualitative inquiry was used to understand and describe classroom practices in the teaching and learning of mathematics in the intermediate phase.

According to the National Statistics Department (2005) qualitative research can stand-alone or can stand alongside and complement survey inquiry to provide depth and richness to an investigation. Qualitative methods play an important role in developing, maintaining and improving survey quality by assessing vital issues that surveys alone might not address (National Statistics Department, 2005).

The key aim of using qualitative methods in this survey inquiry is to ensure that the survey questions are answered in the way intended to meet the research objectives. Qualitative research was also chosen on the basis that it is open and that methods could be changed and adjusted while they are employed and while data is being collected (Sarantankos, 1998).

3.4 Population and sampling

3.4.1 Population

The target population of the research consisted of all intermediate phase educators in the nine primary schools in Itsoseng circuit. The number of educators teaching mathematics was 24

3.4.2 Sample and sampling procedure

Sample is a group of individuals who participate in the study. Common sampling strategies that are used in education research are simple random sampling, stratified sampling, systematic sampling and cluster sampling. Simple random sampling is used when the population is small, and each member of the population has an equal chance of being selected and contains subjects with characteristics similar to the population as a whole (Cohen, *et al* 2000 & Mcmilliam & Schumacher, 2001). Sarantakos (1998) stated that obtaining an unbiased sample is the main criterion when evaluating the adequacy of a sample. Sarantakos (1998) also identified an unbiased sample as one in which every member of a population has an equal opportunity of being selected in the sample. Therefore, simple random sampling was used in this study to ensure the selection of an unbiased sample population.

5 schools were chosen from the 9 schools. All 9 primary schools in Itsoseng circuit were written on a piece of paper. Thereafter pieces of papers were placed in a small box and 5 primary schools were picked from 9 primary schools in Itsoseng circuit. Four of the schools selected have 3 educators teaching mathematics and one school has only two educators teaching mathematics. Thus the sample consisted of 14 educators. All intermediate phase mathematics educators from the selected schools were requested to participate in the study. Three

educators were selected from the total of fourteen educators that completed the questionnaire to participate in the interview and classroom observation. The selection of the educators observed was based on their responses to the questionnaire. Their responses were identified as strongly supporting teaching mathematics in an OBE context.

3.5 Research instruments

A questionnaire, interviews and observations were used in this study to answer the research questions.

3.5.1 Questionnaire

Questionnaires are valuable methods of collecting whole range of data from a larger number of respondents Sarantakos (1998). One set of structured questionnaire was used as one of the instruments to collect data. The purpose of the questionnaire was to gather information about the teaching practice of teachers in mathematics classroom.

3.5.1.1 The structure of the questionnaire

The types of questions that were used in the questionnaire were both closed and open-ended questions.

❖ Closed-ended questions

Closed-ended questions used in the study consisted of questions that required the respondents to place a mark, alongside of several provided possible answers. According to Cohen *et al* (2000) closed-ended questions facilitate answering, making it easy for the researcher to code and classify responses.

◆ **Open-ended questions**

Open-ended questions required more of the respondents' time and thought. Respondents were asked to answer in their own words, to give their opinion freely and to give reasons for their answers. The responses were valuable because they reveal more completely how the respondent viewed teaching mathematics in the OBE context. These questions also allow the researcher to collect detailed data systematically and facilitate comparability among all respondents (Frey and Oishi, 1995).

3.5.2 Interview

According to Cunningham (1993) an interview is one of the important instruments used to collect data in a research with the purpose of getting a view of certain phenomena. Lindgaars (1994) argued that interviews could be used for discovering facts and opinion held by potential users of the system. Nachamias and Nachamias (1997) emphasised that interview should be used with other methods for balanced results. McMillian and Schumacher (2001) defined interview as essential vocal questionnaires, the difference being that it involves direct interaction between individuals.

Interview provided opportunity to deal with a wide range of issues, it allowed for a broader spectrum of expressions on the part of the respondents and revealed which point was regarded by respondents to be very important. The researcher had an opportunity to ensure that all items were answered. Flexibility was highlighted by the fact that respondents were free to choose how to answer the question (Cunningham, 1993).

Interview was used in the study; the aim of interview was to get the views of educators on the use of alternative strategies outlined by OBE in the teaching and learning of mathematics.

3.5.2.1 Types of interview used in the study.

The interview was conducted in a face-to-face situation with one interviewer and one interviewee. Cunningham (1993) supported one-to-one technique by stating that it allows the interviewer to explore issues in depth with the interviewee. Nachamias and Nachamias (1997) argued that the nature of one-to-one can allow mistakes and misunderstanding to be quickly identified and cleared up, and can be used to uncover hidden issues.

Cunningham (1993) stated that face-to-face interview provides the interviewer the opportunity to give a full and detailed explanation of the purpose of the study to the respondent and to ensure that the respondents understand what is required of them. If the respondent misunderstands a question, the interviewer can add a clarifying remark, thus permitting more complex questions to be asked. Lindgaars (1994) added an advantage of face-to-face interview by stating that the interviewer has a great opportunity to motivate the respondent. If the respondent appears to show lack of interest or becomes detached, the interviewer can stimulate and encourage him or her.

Structured interviews are based on strict procedures and a highly structured interview guide, while unstructured interviews have no strict procedures (Sarantakos, 1998). Semi-structured interview was used on the basis of its flexibility. Semi-structured interview contains the elements of both structured and unstructured interviews. The degree to which interviews are structured depends on the research topic, resources, methodological standards, preference and the type of information wanted, which of course is determined by the research objective (Sarantakos, 1998).

Questions were formulated in a completely open-ended format. Lindgaars (1994) emphasised that open-ended questions in an interview are valuable and flexible, since during interview session's responses can be probed, followed up, clarified and elaborated to achieve specific accurate responses, thus providing the opportunity to gain quality information to supplement survey information. Nachamias and Nachamias (1997) added that open-ended questions provide the researcher opportunity to ascertain lack of information on the part of respondents. These types of questions can be used in situations where the respondents have not yet crystallised their opinions.

Frey and Oishi (1995) stated that if all the respondents are asked the same basic questions in the same order, comparability of responses is increased and time can be used efficiently. Data would be complete for each person on the topic addressed in the interview. These advantages provided an opportunity to facilitate organisation and analysis of the data. Open-ended questions will be prepared to collect detailed data systematically.

3.5.2.2 Recording of interview

Interviews data was recorded with a tape recorder on the basis of its convenience. According to Ruane (2005) a recorder provides not only a complete and accurate records of interview, but the interviewer can concentrate on listening without being distracted by trying to write down what has been said. Tape recording ensures that the whole interview is captured and provides complete data for analysis. Permission to use the tape recorder was asked from the respondents well in advance.

3.5.3 Observation

According to Raune (2005) observation is a direct measure of events or behaviour and thus provides concrete evidence of phenomenon under investigation. Marshall and Rossman (1995) defined observation as a systematic description of events or behaviour in the social setting chosen for study. Trochim (2005) explained observation as the methodology that involves watching and recording of events within a clearly defined area, with the purpose of gathering accurate information about how programmes actually operate, particularly about process.

Nachamias and Nachamias (1997) argued that the main advantage of observation is its directness. Demunk and Sobo (1998) emphasised that observation is very important when the researcher tries to understand a process or unfolding situation. Thus observation was used to gain first hand experience of what is happening in the mathematics classroom, so as to be able to describe the process and practices of the teaching and learning of mathematics in the intermediate phase.

3.5.3.1 Types of observation used in the research

Observation was used with the intention of gaining valuable information about the topic. It was also used to minimise the inadequacies of collected data (Cohen *et al*, 2000). According to Taylor - Powell (1996) researchers need to explicitly consider how their presence might influence the findings. McMillian & Schumacher (2001) explained that direct observation is unobtrusive so as not to bias the observation. Taylor - Powell (1996) argues that passive observation has the advantage that it minimises the intrusion. Thus I was not uninvolved in the teaching process, so as not to influence the teaching and learning process.

The purpose of collecting data through direct observation was to describe classroom practices and the process of teaching and learning of mathematics.

3.5.3.2 Recording of classroom observation data

Detailed field notes were compiled to provide a literal account of what happened in the process of teaching and learning mathematics, with specific reference to the intermediate phase. According to Summer-Hill and Taylor (1992) field notes are ways of reporting observation. The observer is free to record almost anything he/she wants to record.

3.6 Enhancing validity through triangulation

In this study questionnaire, interview and classroom observation were employed to ensure validity of data. Cohen et al (2000) stated that triangulation is a combination of more than one method of data collection and advantages of each method complement the other, thus resulting in a stronger research design and more valid and reliable findings. Patton (2001, p. 247) advocated the use of triangulation by stating "triangulation strengthens a study by combining methods that is, using several kinds of methods or data including using both quantitative and qualitative approaches". Crotty (1998) support of triangulation is based on constructivism. Crotty (1998) stated that constructivism values multiple realities that people have in their minds. Therefore, to acquire valid and reliable multiple and diverse realities, multiple methods of searching or gathering data are in order. An open-ended perspective in constructivism adheres with the notion of data triangulation by allowing multiple methods of research. Creswell & Miller (2000, p. 126) argued that triangulation is "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study". Therefore, through the use of questionnaire, interviews and

observation, an attempt will be made to establish and maintain an effective way for obtaining reliable information

3.7

Administration of instruments

This study is an investigation into a way in which mathematics is taught to intermediate phase learners in Itsoseng circuit. Therefore questionnaire, interview and classroom observation were used to answer the research questions.

A questionnaire was designed for intermediate mathematics educators on the basis that they are a good way of collecting certain types of information quickly and relatively cheaply and that they allow variety of questions to be asked (Sarantankos, 1998). Permission to administer questionnaires was asked in selected schools. Questionnaires were hand delivered to sample schools based on number of educators teaching mathematics in each school. The researcher also requested the Head of Departments to facilitate and collect the questionnaires from the colleagues.

The semi-structured interview is generally most appropriate since according to Sarantankos (1998) provides a desirable combination of objectivity and depth and often permits gathering valuable data. The interview schedule was worked out before hand. Nine lead questions were used to explore educators' views on the teaching of mathematics in the OBE context. Appointments were secured with selected educators.

Classroom observations were used to validate data collected through the questionnaires and interviews, to understand educators' instructional practices as well as to seek for the nature of interactions within the context of the classroom settings. Three interviewed educators were observed taking field notes. Each educator was observed for two periods.

Results on the study of teaching and learning of mathematics are portrayed in chapter four. Frequencies of the closed ended questions were counted and data was organised and presented with tables and percentages. Data of open-ended questions, interviews and observations was presented in narrative descriptions. I used analysed data to form the basis for findings and recommendations.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter portrays the results of this study. The chapter is divided into three sections. The first section presents the educators responses to the questionnaire, followed by educators' interview responses and lastly classroom observation field notes. The copies of educators' questionnaire, interview schedule and criteria used for classroom observation appear as appendices B, C and D.

According to Singleton (1993) in Mouton (1996) univariate analysis provides the researcher with a clear picture of the data by examining one variable at the time. Thus univariate analysis was used in the initial step of the data analysis for this reason. Data in analysis could be in frequencies and percentages tables, graphs and charts and statistical index.

4.2 Analysis of educators' questionnaire

This section presents the results of the educators' responses to the questionnaire on classroom practices in the teaching of mathematics. The results were organised and presented as tables of frequencies and percentages. Key F represent frequency, Y represents yes and N represent no.

4.2.1 Mathematics instructions

4.2.1.1 Educator responses on which teaching strategies they use in mathematics lessons.

Table: 4.1 Teaching strategies used in mathematics

		Often		Seldom		Not at all	
		F	%	F	%	F	%
4.1.1	Telling method	14	100	0	0	0	0
4.1.2	Group work	7	50	2	14,3	5	35,7
4.1.3	Cooperative learning	4	28,6	0	0	10	71,4
4.1.4	Learner oral presentations	0	0	2	14,3	12	85,7
4.1.5	Projects	0	0	5	35,7	9	64,3
4.1.6	Class discussions	5	35,7	3	21,4	6	42,9

Table 4.1 shows that all educators used telling method to teach mathematics, while 50% of the respondents indicated that they used group work. This means that although half of the respondents used group work, some educators still use traditional methods to teach mathematics. Data presented in table 4.1 also indicated that larger proportion of the sample never used cooperative learning strategies (71,4%), oral presentation (85,7%) and projects (64,3%) to teach mathematics. The difference between 4.1.1 and 4.1.3 indicates that some educators were not aware of the relationship between group work and cooperative learning. However 35,7% of the respondents indicated that they often use class discussions. Although the OBE principle of expanded opportunity as indicated in chapter two encouraged educators to use various strategies, some of the educators are still using telling method as the only strategy to teach mathematics.

4.2.1.2 Educators' responses to questionnaire items about how learners are engaged in mathematics lessons are presented in Table

Table: 4.2 Engaging learners in mathematics lessons

		Often		Seldom		Not at all	
		F	%	F	%	F	%
4.2.1	Learners working individually	14	100	0	0	0	0
4.2.2	Learners working in pairs	3	21,4	6	42,9	5	35,7
4.2.3	Learners working in groups	7	50	5	35,7	3	21,4
4.2.4	Class projects	0	0	5	35,7	9	64,3

In table 4.2 100% of educators indicated that their learners often work individually, only 21.4% of educators indicated that they often afford learners to work in pairs and 50% of respondents engage learners in group work, while 64.3% indicated that they never engage learners in class projects. A consistency in 4.1.5 and 4.2.4 clearly indicated that most of learners are not given opportunities to do mathematics projects. According to results presented in table 4.2 most of educators did not practice cooperative and collaborative learning in the teaching of mathematics, to encourage learners to share ideas and work as a team.

4.2.2 Mathematics activities

4.2.2.1 The following table presents educators' responses on using problem solving to develop learners reasoning ability.

Table: 4.3 Using problem-solving in mathematics teaching to develop learner reasoning ability

		Often		Seldom		Not at all	
		F	%	F	%	F	%
4.3.1	Recall	14	100	0	0	0	0
4.3.2	Application	4	28,6	2	14,3	8	57,1
4.3.3	Analysis	3	21,4	2	14,3	9	64,3
4.3.4	Data collection	7	50	3	21,4	4	28,6
4.3.5	Investigation	4	28,6	2	14,3	8	64,3
4.3.6	Explanation	5	35,7	0	0	9	64,3

100% of the respondents indicated that they often provided learners with activities that required recall of knowledge, which according to Blooms Taxonomy is the lowest level of mental activity. Low percentages of the respondents indicated they often engage learners in activities that need learners to apply acquired knowledge (28,6%), analyse mathematical information and situations (21,4%), make investigations (28,6%) and explain procedures to justify their solutions (35,7%) . However 50% of respondents indicated that they often require their learners to collect data. Results shown in table 4.3 clearly indicate that educators did not provide activities that promote reasoning.

4.2.2.2 The following table presents the educators responses when they were asked if they linked mathematics teaching to every day life situation.

Table: 4.4 Linking mathematics teaching to every day life situations

	Y		N	
	F	%	F	%
4.4.1	8	57,1	6	42,9

From the data obtained in table 4.4, 8 respondents, which is 57,1% of the sample, indicated that they link mathematics to the real life situation. But not all educators who indicated response “yes” to the question gave examples in item 2.3 of the questionnaire. Out of the 8 educators whose response was yes, 6 described examples that link mathematics to real life situation. Though 6 educators gave examples, only two educators gave example that relates mathematics to the real life situation.

Examples relating mathematics to the real life situation:

- Calculating profit after selling sweets or oranges for the classproject.
- If school begins at 7h30 and knocks off at 2h00, calculate the time you spend in school.
- Calculating percentage of absenteeism per week

Examples that were given by some of the educators, which did not link mathematics teaching to the real life situation:

- Round off these numbers to the nearest 10
- Add the following $50+20$, $703+39$

Responses given by some of the respondents, but irrelevant to the question:

- Learners use time all the times

- Learners apply mathematics to some house chores
- learners know times of TV programs
- Addition and subtraction of fractions

4.2.2.3 Educators' responses about how they encourage learners to construct mathematical knowledge, as identified in the questionnaire are set out in

Table 5

Table: 4.5 encouraging learners to construct their own knowledge

	Always		Sometimes		Never	
	F	%	F	%	F	%
4.5.1	13	92,9	0	0	0	0
4.5.2	0	0	5	35,7	9	64,3
4.5.3	6	42,9	4	28,6	4	28,6
4.5.4	6	42,9	4	28,6	3	21,4

The majority of educators (92,9%) as presented in Item 4.5.1 reported that they used prior knowledge to teach mathematics, while small percentages of educators indicated that they often used physical object and encouraged learners to talk and share ideas and 64,3% of the respondents indicated that they never use concept maps in the teaching of mathematics. The proponents of constructivism such as Piaget, Bruner and Vygotsky as indicated in chapter two theorised that learners create new mathematical knowledge by reflecting on their physical and mental actions, and also through interactions. However results indicated in table 4.5 did not encourage learners to construct mathematical knowledge.

4.2.3 Assessment in the teaching and learning of mathematics

4.2.3.1 Educators responses on the use of assessment in the teaching.

Table: 4.6 Assessment strategies in mathematics

		Often		Seldom		Not at all	
		F	%	F	%	F	%
4.6.1	Observations	7	50	2	14,3	5	35,7
4.6.2	Journals	0	0	0	0	14	100
4.6.3	Portfolios	8	57,1	0	0	6	42,9
4.6.4	Assignment	0	0	9	64,3	5	35,7
4.6.5	Class work	14	100	0	0	0	0
4.6.6	Home work	14	100	0	0	0	0
4.6.7	Test	6	42,9	0	0	8	57,1
4.6.8	Examinations	0	0	3	21,4	11	78,6
4.6.9	Interview	0	0	2	14,3	12	85,7
4.6.10	Practical task	0	0	4	28,6	10	71,4

As indicated in table 4.6 the majority of educators often used class-work (100%) and homework (100%). Over 50% of the respondents often used portfolios (57,1%) and half of the sample indicated that they often used observation, while less than 50% often used test (42,9%). The majority of respondents indicated that they never used interview (85,7%) practical task (71,4%), examinations (78,6%). Furthermore, Table 4.6 showed that 100% of respondents never use journals for assessment. Results presented in table 4.6 indicate that some of the educators did not use a variety of assessment strategies as encouraged by the OBE principle of expanded opportunities.

4.2.3.2 When educators were asked to give advantages of using alternative assessment strategies in teaching mathematics, some of the educators stated that learners becomes critical thinkers, develop reasoning capacity as well as language skills and provide a broader chance for all the learners to achieve.

Some of the responses given indicated that some of the educators confuse alternative assessment to parental involvement. For example some educators stated that alternative assessment provides parents a chance to know their children performance.

4.2.3.2. Educators responses on levels of questions used in mathematics assessment

Table: 4.7 Level of questions used in mathematics assessment

		F	%
4.7.1	Name	14	100
4.7.2	Select	7	50
4.7.3	Compare	4	28,6
4.7.4	Describe	6	42.9%
4.7.5	Explain	6	42,9
4.7.6	Illustrate	2	14,3
4.7.7	Define	5	35,7
4.7.8	Discover	4	28,6
4.7.9	Draw	14	100
4.7.10	Gather	4	28,6
4.7.11	Classify	6	42,85
4.7.12	Design	0	0
4.7.13	Solve	9	64,3

As can be seen from table 7, all educators' (100%) often asked learners to name items (100%), and 50% required learners to select. A low percentage of educators asked questions involving comparison, (28,6%), description (42,9%), explanation (42,9%), illustration (14,3%) and definitions (35,7%). Apart from definitions the rest of questions asked, according to Bloom's taxonomy requires the learners to demonstrate understanding of mathematical concepts. This means that majority of the respondents did not encourage their learners to go beyond simple recall of knowledge and facts. It is also noted that small percentage of respondents provided learners an opportunity to apply the knowledge acquired, since item 4.2.4.5, indicates that small percentage of respondents selected discover (28,6%), gather (28,6%), classify (42,6) which falls under the application level of bloom's taxonomy. design which according to Bloom falls under synthesis level was not selected.

4.2.3.4 Educators' responses on how often they use different assessment tools in the teaching and learning of mathematics.

Table: 4.8 Assessment tools in mathematics

		F	%
4.8.1	Rubrics	6	42,9
4.8.2	Rating scales	0	0
4.8.3	Check list	0	0
4.8.4	Observation sheets	0	0
4.8.5	Marking memorandum	14	100
4.8.6	Assessment grid	0	0

All educators selected memorandum, less than fifty percent selected rubric and none of the educators used rating scales, check list, observation sheets and assessment grid. This response clearly indicated

that most educators did not use a variety of tools in assessing mathematics.

4.2.4 Mathematics Resources

4.2.4.1 Educators' responses on school resources centres

Table: 4.9 Mathematics resource centres

	Y		N	
	F	%	F	%
4.9.1	0	0	14	100

To support effective teaching and learning, mathematical classrooms require a variety of materials for primary learners to explore and manipulate (DoE, 2002), unfortunately non of the schools whose educators participated in the study had mathematics resource centres. This is definitely a challenge to educators if mathematics is to be taught meaningfully.

4.2.4.2 Educators' responses on the use resources in the teaching and learning process of mathematics

Table 4.10: teaching and learning material

		Often		Seldom		Not at all	
		F	%	F	%	F	%
4.10.1	Text book	14	100	0	0	0	0
4.10.2	Mathematical charts	14	100	0	0	0	0
4.10.3	Mathematical instruments	14	100	0	0	0	0
4.10.4	Calculators	10	71,4	4	28,6	0	0
4.10.5	Counters	14	100	0	0	0	0
4.10.6	Games	6	42,9	3	21,4	5	35,7
4.10.7	2-D shapes& 3-D objects	5	35,7	3	21,4	6	42,9
4.10.8	News paper and magazines	14	100	0	0	0	0
4.10.9	Dice	4	28,6	3	21,4	7	50
4.10.10	Money coins and notes	14	100	0	0	0	0
4.10.11	Atlas	0	0	0	0	14	100

From data analysis in table 4.10, 100% of respondents indicated that they often used textbooks, mathematical charts, counters, newspapers and magazines, while 71,4% indicated that they often use calculators. Less than fifty percent of respondents indicated that they often used games (42,9%), 2-Dimensional shapes (35,7) and dice (28,6), while 100% never use an atlas. Although data in table 4.9 indicated that schools do not have resource centres, results in table 10 showed that educators use resources to support mathematics teaching.

4.2.5 Workshops on the teaching of mathematics

4.2.5.1 Educators responses on workshops for mathematics teachers.

Table: 4.11 Work shops on mathematics teaching

		F	%
4.11.1	Once per year	2	14.3
4.11.2	Twice per year	0	0
4.11.3	More than twice per year	0	0
4.11.4	Never	2	14,3
4.11.5	Once since introduction of OBE	10	71.4

Table 4.11 shows that 14,3% of the respondents indicated that they received training once a year. 71,4% of respondents added that they only attended workshops once since OBE was introduced, thus this response showed the urgency of educators to be developed on how to teach mathematics. 14,3% of the respondents indicated that they never attended workshops on mathematics teaching mathematics.

4.2.5.2 When educators were asked to give suggestions on how to improve mathematics teaching in schools, they indicated the following:

- Learners to be given more projects for assessment
- Provision of teaching and learning aids
- Use play to facilitate learning of mathematics
- Parental involvement
- Training, developing and empowering mathematics educators
- Educators need to meet on regular bases
- Attending mathematics workshops

4.3 Analysis of educators' interview

4.3.1 Sharing ideas in problem solving

Two out of three educators did not indicate how they ensure that their learners share ideas when they are solving problems, rather they stated that problem-solving is too difficult for the learners, they become frustrated and confused. The third educator stated that she ensures that her learners share ideas through the use of group work. But she also stated that it is tough because her learners were not able to analyse problems. Although DoE (2002) emphasised that problem solving is the heart of mathematics, educators' responses to this question indicated that they never provided learners the opportunity to work on problem solving activities.

4.3.2 Encouraging learners to justify their solutions

The three educators interviewed indicated that it is important to allow learners to explain procedures they used to find solution and also justify their solutions. But two of the three educators further indicated that learners are unable to express themselves. I think the statement made by the two educators is just an excuse since they could allow learners to use code switching to explain the approach and procedures to finding solutions.

4.3.3 Learner centred approach

The three educators had different views about learner-centred approach. One educator stated that during group work learners make a lot of noise, and become confused, the other educator indicated that even if learner centred approach is important, it wastes a lot of time. The last educator was of the opinion that the approach is excellent, because it promotes independent learning. Though it is crucial for educators to allow learners

to join them in the enquiry (Saundes 1992, Doll, 1993), educators are not comfortable with learner centred approaches.

4.3.4 Continuous assessment

On continuous assessment, two educators replied that it is not possible to assess learners on daily basis. Therefore test is the only possible way to assess learners. The third educator said that she integrated assessment with teaching through asking learners' questions and observing learners as they are working, but recoding on daily basis is impossible. Responses of the interviewees indicated reluctance of educators to accept change.

4.3.5 Advantages of alternative assessment

When educators were asked about advantages of alternative assessment, two educators replied that they did not use alternative assessment rather learners are given a test. The third educator indicated that she sometimes gives learners projects that provided learners with the opportunity to use mathematics practically. None of the respondents gave the advantages of alternative assessment.

4.3.6 Challenges faced by educators in teaching

The following are challenges mentioned by interviewees:

- Over-crowded classrooms
- Educators are not empowered to be able to use OBE teaching strategies
- Learners' negative attitude towards mathematics
- Lack of parental involvement
- Incompetence on medium of instruction
- Lack of resources,
- Text book activities are not relevant to learners' environment,

- Some textbooks are not structured in an OBE context.
- Some text book activities are not addressing learning outcomes and assessment standards are not in line with Department of Education,
- Some of activities are above learners' intelligence.
- Parents are not responding when they are called for learners' intervention.
- Learners are not doing their home work

4.3.7 Suggestions to overcome educators' challenges

To overcome the challenges educators are experiencing, respondents suggested the following:

- Revisit educator-learner ratio
- Educators should be workshopped on how to teach mathematics in an OBE context
- English should be taught from grade 1
- Publishers need to take into consideration the background of learners in semi-rural and rural areas.
- School management team should inform parents on the importance of interventions.

4.3.8 Challenges facing learners during teaching learning of mathematics as indicated by educators

The following are some of challenges experienced by learners in learning mathematics:

- Learners are not independent enough to work on their own
- Most learners are incompetent in English
- Learners have not developed abstract thinking,
- There are no resources and thus it becomes difficult to teach mathematics in a meaningful way.

4.4 Analysis of Classroom observation

4.4.1 Classroom activities

Classroom practices of the three educators were almost the same. They dominated the lesson; educators did the greater percentage of talking while learners were passive. There was no interaction amongst learners themselves and little interaction between learners and educator. All the three educators did not encourage learners to work together, to share ideas and information freely with each other. In lesson A two learners talked to each other while they were doing exercises and the educator reprimanded them, it was clear that educators still regard mathematics classrooms as containing isolated individuals, not as a mathematical community.

According to Capri (1994) teacher-centered approaches and textbook guided classroom have failed to develop thinking learners. However in all the lessons observed, educators depended heavily on the textbook and chalkboard. Examples and exercises were not integrated to the real life situation, to provide learners opportunity to apply what they learned to the life outside the classroom. Educators were not aware that their role is to organise information around conceptual problems, questions and discrepant situations in order to engage learners in discussions, so that they are able to construct their own knowledge (Brooks & Brooks 1993).

Learners were not provided the opportunity to manipulate concrete objects so that they learn mathematical concepts meaningful. Although learners in lesson C were given the text with a picture of round houses, the relevance of this picture to the lesson was not explicit. Educators relied on rules to explain mathematical concepts. Classroom practices were in contrast to what Bruner in Kearsley (1994) called intuition thinking as stated in

chapter 2. According to Bruner in Kearsley (1994) when learners are in intuition mode they learn mathematics without reliance on formal rules or definitions. Bruner in Kearsley (1994) went on to explain that manipulation and representation of physical or concrete objects provide learners an opportunity to gain an intuitive sense that would make it easier for him to understand mathematics concepts.

4.4.2 Assessment procedures

In a well-designed lesson, an educator asks questions during the lesson. Asking questions enables the learners to stay involved, since their comprehension is verified throughout the lesson. Asking questions enables learners to achieve more, because it models for them how to question them-selves when they are trying to solve a problem, and it helps them identify the thinking processes that they need to use (Johnson, 1995). Although asking questions is valuable, one of the observed educators did not use questions to active involve learners and assess their understanding. The other two educators asked learners few questions. Questions that were asked in these lessons belonged to lowest level of Blooms Taxonomy, for example give different types of shapes, nine minus five or two times six. In lessons B learners answered in chorus, thus educators could not indicate whether learners understand or not.

When educator C asked the question and the learners answered incorrectly, the educator turned away from the learner and called on someone else rather than probing learners' answer. This approach indicated that the educator was only interested in the correct answers. The educator did not use learners' answer to reflect on the lesson and evaluate the success of the lesson. According to Johnson (1995) it is important that the educators are able to use right or wrong answers to help learners understand mathematical concepts. Questions such as how

did you arrive at your answer, so that learners can explain and justify approaches used were not asked.

In all the three lessons it was not clear as to how educators integrated assessment in the teaching and learning process. Questions asked were not probing learners understanding of mathematics and how they will use the mathematics learned in the real life situations. In lesson A and B learners gave choral responses. Therefore it is clear that educators are clinging to behaviourist teaching approaches. They are in contract to constructivism, which is the mother of OBE (Kramer, 1999). As indicated in chapter 2 the educators' active role in the teaching of mathematics is guiding and managing learning. Educators could use questions to activate and direct discussions, while learners construct their own knowledge through communication and interactions.

4.5 Questionnaire, interview and classroom observation cross analysis

- **Engaging learners in mathematics classroom**

Questionnaire item 4.1.2 of table 4.1 indicated that half of educators used group work as the strategy to teach mathematics. However during interviews two educators indicated that learner centred approach wastes a lot of times, while observation revealed that during mathematics teaching educators dominated the lesson presentation while learners were passive. Therefore teacher-centred practices were still used in the mathematics classroom. Educators still viewed themselves as knowledge resources and explainers to be listened to and followed. Although it is emphasised that cooperative learning is a major factor in effective mathematics teaching (DoE, 1997, 2002; Cathcart et al2000; Kramer 1997; Saundes, 1992), educators are still not using cooperative teaching strategies to teach mathematics.

- **Linking mathematics teaching to real life situation**

From the data presented in 4.4.1 of table 4 of the questionnaire, 57,1% of the respondents indicated that they link mathematics to the real life situation. Yet in the lessons observed mathematical concepts taught were not linked to life outside the classroom. All the exercises and examples used in all the three lessons were from textbooks, and not linked to the real life situation. It was clear that educators teach mathematics as isolated concepts and procedures, not mathematics as connected ideas and applications. Data presented in item 4.1.5 in table 4.1 also revealed educators were not relating mathematics taught to real life situation, since 64,3% of the respondents stated that they never used projects to provide opportunities for learners to apply mathematical concepts.

- **Use of prior knowledge to teach mathematics**

As shown item 4.5.1 of the questionnaire, 92,9% of respondents indicated that they assessed learners prior knowledge to find out what learners already understand, so that they build new knowledge on learners' prior knowledge. In contrast to item 4.15.1 in table 4.1 of the questionnaire assessment and use of the prior knowledge were not manifested in the lessons observed. In the lesson A the educator introduced the lesson by asking learners to count from 1 to 100 in chorus, while she copied an example on the chalkboard. She could have assessed learners prior knowledge on counting in intervals and use it to help learners recognise number patterns.

Educator B started the lesson by working two examples on the chalkboard. Though the third educator started the lesson by asking learners to give different types of shapes, it was not clear as to how the educator used that knowledge to help learners better understand the concepts of perimeter and area. In contrast to Itsoseng circuit primary mathematics educators, constructivism emphasises that learners come to

mathematics classrooms with certain mathematical conceptions, which could be used to help learners construct their own knowledge

- **Use of concrete objects to teach mathematics**

According to data analysis, 50% of educators indicate that they often use concrete objects to teach mathematics concepts, but observation revealed that none of educators observed used the concrete objects. They taught mathematics as if formulas and rules are the only means of teaching mathematics concepts.

- **Developing learners' communication skills**

Even though DoE (1997, 2002) through critical outcomes emphasises development of learners who are able to work as a team and use communicative skills effectively, small percentage of educators in a questionnaire indicated they often encourage their learners to communicate and share ideas in mathematics classroom. This statement is also validated by the fact that educators dominated the lessons observed; learners were not given opportunity to explain and justify their mathematical ideas. educators' unanimous responses in the item 4.3.2 of the interview was that it is important to allow learners to justify their solutions in different ways, two out three of the educators further indicated that learners are unable to express themselves. I think that latter statement was just an excuse; because educators can still use code switch strategy to allow learners to explain their solutions or they are too rigid to allow their learners to use code-switching strategy.

- **Promoting problem solving and reasoning in mathematics classroom**

DoE (2002) stated that educators need to use curriculum and teaching practices that strengthen children's problem-solving and reasoning processes as well as representing, communicating, and connecting mathematical ideas. Educators are also encouraged to use Bloom's

different levels when planning learners' activities. According to data analysis in table 3 of the questionnaire educators seem not to take this into consideration. Their responses show that small percentage of respondents require their learners to apply mathematics learned, analyse, investigate and explain mathematical problems, while 100% of respondents indicated that they encourage learners to recall knowledge taught. This means that educators' intentions are contradicting DoE expectations. They do not encourage critical creative thinking skills that learners can use to identify and solve problems in the real life situation to develop into the citizen envisaged by South African society.

This inference is supported by interview responses in 4.3.1; when they were asked to explain how they ensure that their learners communicate and share problem solving ideas and thinking to each other, two out of three educators indicated that problem-solving strategies are too challenging for the learners; they become frustrated and confused. I assume that this reaction could be encouraged by lack of information and creativeness in educators or inability to accept changes.

- **Use of various assessment strategies in mathematics classroom**

Data analysis indicated that 64.3% of respondents are still using narrow assessment that is, use of class-works, homework and test as the only means of assessment strategies. They tend to over look the fact that the DoE charged them with the responsibility of developing learners holistically through the use of alternative assessment strategies. This might also be encouraged by the fact that they do not know and understand what alternative assessment is. In the interviews educators seemed to be lost when I asked them to explain advantages of using alternative assessment in mathematics lessons. The inference made is also supported by item 6.2 in tables 6 of the questionnaire. The larger proportion of the respondents clearly indicated that they do not use

journals, interviews and practical tasks as assessment strategies, while they seldom use projects, observations and assignments. The only two strategies that are often used are tests and portfolios. During classroom observations learners were not engaged in investigating mathematical problems to show their mathematical competence.

- **Developing learners cognitive thinking**

Even though DoE (2002) emphasised that educators should provide mathematical tasks that engage learners in communication and writing about mathematical ideas, as well as using mathematical language and notation to describe given situations. Majority of educators expect learners to recall imparted knowledge, while small percentage use compare, explain, illustrate, define, discover, gather, classify and design when planning assessment activities. According to constructivist such tasks do not develop learners' mathematical competencies and critical creative thinking (Cobb, 1994).

Although as indicated in 3.4.2 of chapter three selections of observed and interviewed educators were based on questionnaire responses, which indicated that they strongly support teaching mathematics in an OBE context. Data collected from interviews and observation was in contrast to their responses on questionnaire.

CHAPTER FIVE: DISCUSSIONS, CONCLUSION AND RECOMENDATIONS

5.1 Discussions

According to the findings of this study, Itsoseng primary mathematics educators are still using transmissive modes of instruction. (Roulet, 1998) states that educators using this type of instruction strictly adhere to the textbooks or school curriculum. Their teaching consisted of a static collection of facts, methods and rules, and did not allow for much learners interaction. In contrast to teaching practices of Itsoseng mathematics educators, constructivism, a theory underpinning OBE curriculum introduced in South Africa, emphasises that mathematics teaching is an intellectual activity involving higher order thinking, rather than just the routine application of procedures. Classroom practices need to address mathematical understanding, communication, the ability to solve problems and develop learners reasoning during the teaching of mathematics (DoE,1997,2002, Kramer, 1999, Shiland, 1999) .

Educators in Itsoseng primary schools never seem to understand the significance of learner centred approaches. As indicated in chapter two learner-centred approaches offer learners excellent opportunities to apply as well as to develop independence, persistence, and flexibility in making sense of real-life problems. When learners pursue a project or investigation, they encounter many mathematical problems and questions. With educators' guidance, learners think about how to gather and record information and develop representations to help them in understanding and using the information and communicating their work to others (Cathcart *et al* 2000). Yet data analysis revealed that mathematics educators in Itsoseng circuit are still clinging to teacher-centered approaches, which are outdated (Caprio, 1994).

Findings of this study also indicated that mathematics educators in Itsoseng primary schools are unable to relinquish authority and control. According to Wood (1990) educators in the modern education system are in control of the learning situation. Piagetian theory, which is underpinned

by the post-modernist view, calls for educators to allow learners to take responsibility for their own learning. According to the constructivists, control and responsibility are very important aspects of learning mathematics because it is very difficult to be skilled at problem solving, investigating or discussion, if educators are always dictating what to do and how to do it (Gadiner 1987). Womack (1988) argued that learners, who are allowed to organize themselves in learning activities, are more likely to become confident and creative mathematicians than those who are continually 'spoon-fed'.

According to Bishop and Carpenter (1993) concept maps are powerful tools that could be used in the teaching and learning of mathematics; they can be used to identify and close gaps in the learning of mathematics concepts. Unfortunately the greater percentage (64,3%) of educators stated that they never use concept maps in the teaching and learning of mathematics. This could be because educators do not know that concept maps could be used as the teaching approach in the teaching of mathematics. As stated in 2.3.4 of chapter two, learners' intellectual development cannot be separated from social interactions (Piaget in Hilderbrand, 1997), and communication works together with reflection to produce new ideas (Cob et al, 1992). But according to data analysis educators are not aware of that, since only 42,2% said that they encourage learners to talk and share ideas. DoE (2002) highlighted that learners learn mathematics better when they are actively involved in hands on activities with concrete objects; 42,9% percent of educators indicated that they always use physical and concrete objects in the teaching of mathematics.

Assessment in the mathematics classroom is most useful when it aims to help learners by identifying their unique strengths and needs so as to inform educator planning. For instance, the educators need to use multiple assessment approaches to find out what each learner understands and

misunderstands. Observation, documentation of learners' talk, interviews, collections of learner's work over time, and the use of open-ended questions and appropriate performance assessments are positive approaches to assessing mathematical strengths and needs (DoE, 2002). Although the use of a variety of assessment strategies is crucial to the teaching and learning of mathematics, through the analysis of questionnaire, interviews and classroom observation it is clear that educators are still using traditional classroom assessments used in the *apartheid* education system. I also noticed that learners at primary school were restricted in their intellectual exchange. The learners' conversations with educators consisted of answering questions rather than asking them. Learners rarely had the opportunity to direct the learning according to their particular abilities or interests. These assessment strategies, while valuable in some way, are not sufficient to give a clear picture of learners' knowledge and understanding of mathematics. Different assessment strategies benefit the learners in ways that enhance their learning, provide them opportunities to self-assess their learning and therefore guide future learning, and raise self-confidence in their mathematical abilities (Kyriacou 1991).

According to Hiebert and Carpenter (1992), to help learners learn mathematics with understanding, educators need to know how to help learners connect the knowledge they are learning to what they already know, construct a coherent structure for the knowledge they are acquiring rather than learning a collection of isolated bits of information and disconnected skills, engage learners in inquiry and problem solving, and take responsibility for validating their ideas and procedures. Thus this kind of teaching requires that educators have a coherent vision of the structure of the mathematical ideas and practices they are teaching; the conceptions, misconceptions, and problem-solving strategies that learners are likely to bring to learning those ideas and where they are likely to struggle in learning them; the tasks and tools that are likely to provide a window into learners' thinking and support their learning and problem

solving; the class norms and activity structures that support learning. For educators to be able to teach mathematics with understanding they need flexible knowledge that they can adapt to their learners and the demands of situations that arise in their classes. Acquiring this kind of knowledge requires new conceptions of professional development that go beyond traditional teacher training.

5.3 Conclusion

OBE was adopted as a national policy for teaching and learning in South Africa to replace the traditional learning (Lubisi et al 1999, Kramer 1999, DoE 2002). However the study indicated that educators in Itsoseng primary schools still adhere to traditional approaches practised in the apartheid education system.

In my opinion educators should not be the only one blamed for all the ills or problems in education. Functioning collaborations between the Department of Education, Higher Education Institutions, and In-service Training need to be strengthened and maintained. According to Baroody and Coslick (1998) lack of appropriate educator preparation and development may cause mathematics educators to fail to see mathematics as a priority for primary learners and to lack confidence in their ability to teach mathematics effectively. Thus, both in-service training and continuing professional development need to place greater emphasis on encouraging educators' own enjoyment and confidence, building positive mathematical attitudes and dispositions.

5.4 Recommendations

From the discussions of the findings the following are recommendations to improve the teaching of mathematics.

5.3.1 Professional Development

- There should be continuous development throughout an educators' life to help educators to deal with new DoE expectations. DoE need to plan and organise intensive educator development programmes to develop educators in teaching of mathematics. Developing educators through quality mathematics in-service training can make significant changes in mathematics classrooms. Educators need to cooperate and take much greater responsibility for their own development.

- The responsibility for shaping and restructuring the way educators teach is a shared responsibility between the Department of Education, all Institutions of Education and Non Governmental Organisations. Since the education development and empowerment of educators is crucial not only for the learners, but also for the economic well-being of our society. Thus it is also important that Institution of Higher Education also provide the programs that will develop and prepare educators with proper knowledge and skills to effect changes in the teaching and learning of primary mathematics. The Higher Education Institutions should ensure that excellent instructional practices enable primary mathematics educators to develop mathematical understating, instructional strategies and assessment strategies so that they are able to implement OBE strategies to develop learners in the way envisaged by South African society.

5.3.2 Team teaching

It is also suggested that educators from the same school should practise team teaching, so that they can help each other to develop professionally. Educators can use teaching teams to discuss and reflect about what is happening in their classrooms, clarify misunderstanding of the mathematics concepts, help each other to formulate different types of questions for learners and construct rubrics for holistic assessment. Mathematics educators from different schools can also form Educators' mathematics clubs which can also used to help educators to grow in their mathematical knowledge and in teaching strategies

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APPENDIX A

**P.O. Box 3764
Mmabatho
2735**

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The Principal

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.....
.....

Sir/Madam

Re: A study of teaching mathematics in the intermediate phase, in Itsoseng circuit

I am conducting a research, towards part fulfilment for the degree of Masters of Education (Mathematics Education) in the Department of.....

I therefore, am asking for the permission to conduct research in your school.

Yours faithfully

.....

Nobahlambeni Diale

APPENDIX B

EDUCATORS QUESTIONNAIRE

Kindly answer the following questions on the teaching and learning of mathematics at the intermediate phase, as correctly as possible.

1. MATHEMATICS INSTRUCTION

1.1 Tick the following to indicate teaching strategies you use in mathematics lessons?

	Often	Seldom	Not at all
Telling method			
Group work			
Cooperative learning			
Learner oral presentations			
Projects			
Group presentations			
Class discussions			

1.2 Tick the following to indicate how you engage learners in mathematics lessons

	Often	Seldom	Not at all
Learners working individually			
Learners working in pairs			
Learners working in groups			
Class projects			

2. MATHEMATICS ACTIVITIES

2.1 Tick all the strategies, to indicate how often you include these strategies in problem solving:

	Often	Seldom	Not at all
Recall			
Application			
Analysis			
Data collection			
Investigation			
Explain			

Y	N

2.2 Do you link mathematics teaching to everyday life situation?

2.3 If the answer to question 2.2 is yes, please describe an example of activity that links mathematics taught in classroom to real life situations.

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2.4 For the following questions please select always, sometimes or never

- 2.4.1 Do you base your teaching on learner's prior knowledge and interests?
- 2.4.2 Do you use concept maps in teaching and learning of mathematics?
- 2.4.3 Do you use physical and concrete objects in the teaching and learning of mathematics?
- 2.4.4 Do you encourage learners to talk and share ideas?

Always	Sometimes	Never

3. ASSESSMENT IN THE TEACHING AND LEARNING OF MATHEMATICS

3.1 Tick all the strategies, to indicate how often you include these strategies during assessment:

	Often	Seldom	Not at all
Observations			
Journals			
Portfolios			
Assignment			
Class works			
Home work			
Test			
Examinations			
Demonstrations			

Interview			
Assignment			
Practical task			

3.2 What are the advantages of alternative assessment strategies in the teaching of mathematics?

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3.3 Tick the following to indicate levels of questions you apply when you assess your learners

	Often	Seldom	Not at all
Identify			
Name			
Select			
State			
Compare			
Describe			
Explain			
Illustrate			
Define			
Discover			
Draw			
Gather			
Solve			
Categorise			
Classify			
Compare			
Design			

Develop			
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3.4 Tick the following to indicate assessment tools that you use.

	Often	Seldom	Not at all
Rubrics			
Rating scales			
Check list			
Observation sheets			
Marking memorandum			
Assessment grid			

4 MATHEMATICS RESOURCE CENTRE

4.1 Does your school have resource centre?

4.2 If the answer to question 4.1 is yes, is that resource center well equipped?

Y	N

4.3 Tick the following to indicate resources that you often use in the teaching and learning process of mathematics.

	Often	Seldom	Not at all
Text book			
Work sheets			
Mathematical charts			
Mathematical instruments			
Calculators			
String and beads			
Games			
2-D shapes			
3-D objects			

News paper and magazines			
Scissors			
Dice			
Money coins and notes			
Atlas			

4.4 How often do learners have lessons in the resource centers?

- A: once a week
- B: twice a week
- C: three times a week
- D: all their mathematics lessons

5 WORKSHOPS ON TEACHING OF MATHEMATICS

5.1 Select from the following options to indicate how many times have you received training and support in teaching mathematics in the context of OBE?

- A: once per year
- B: twice per year
- C: more than twice per year
- D: never

5.2 Kindly give suggestions for the improvement of mathematics teaching in your school.

.....

.....

APPENDIX C

INTERVIEW SCHEDULE

1. How do you ensure that learners share their problem-solving thinking and approaches?
2. Learners should be encouraged to justify their solution, thinking and conjectures in a single way. What is your opinion of the statement?
3. How useful do you think learner-centered approach is?
4. How do you integrate assessment in the teaching and learning of mathematics?
5. What are the advantages of alternative assessment?
6. What are challenges you experience in teaching mathematics within the OBE context?
7. How can those challenges be overcome?
8. What challenges do your learners experience in learning mathematics?
9. In your opinion, what can be done to overcome such challenges?

APPENDIX D

CRITERIA THAT GUIDE OBSERVATION

1 EDUCATORS ACTIVITIES

- 1.1 How does the educator introduce the lesson?**
- 1.2 What mathematics information does educator provide?**
- 1.3 What types of questions are asked in the lesson? Do questions require exact answer, explanations and or opinion?**

2. LEARNERS ACTIVITIES

- 2.1 How are learners involved in mathematics lessons? Do they just sit and listen to the educator, interact with the educator and among themselves?**
- 2.2 What types of activities are they involved in? Do activities provide rich mathematical experiences that involve learners in:**
 - ❖ **Problem-solving**
 - ❖ **Hands on activities**
 - ❖ **Authentic activities**
 - ❖ **Challenging problems that promotes use of thinking structures but with appropriate level of complexity**
 - ❖ **Building new information to prior knowledge**

3. ASSESSMENT USED IN THE LESSON

- 3.1 What type of assessment is used in the lesson?**

APPENDIX E
INTERVIEW TRANSCRIPTS

EDUCATOR A

TRANSCRIPT	NOTES
<p>Interviewer: How do you ensure that learners share their problem-solving thinking and approaches with each other?</p> <p>Interviewee: problem solving is too challenging for these learners, it makes them frustrated.</p>	<p>Question not answered.</p>
<p>Interviewer: Learners should be encouraged to justify their solution, thinking and conjectures in a single way. What is your opinion of the statement?</p> <p>Interviewee: I think it is important for learners to explain how they approached the problem, but it is not possible with these learners. They are shy to express themselves in the classroom.</p>	<p>Agrees with the statement, though there are factors that inhibits learners justifying there solutions in different ways.</p>
<p>Interviewer: How useful do you think learner centered approach is?</p> <p>Interviewee: I think it is just a waste of time. They make a lot of noise, and become confused.</p>	<p>Negative response.</p>
<p>Interviewer: How do you integrate assessment in the teaching and learning of mathematics?</p> <p>Interviewee: It is not possible to assess learners on daily basis as they learn; the only way to assess them is to give them a test.</p>	<p>Negative response.</p>
<p>Interviewer: What are the advantages of alternative assessment?</p> <p>Interviewee: this question was asked in the questionnaire, but the problem is I don't know what alternative assessment is.</p> <p>Interviewer: Alternative assessment is using other</p>	<p>Lack of understanding on different strategies for assessment.</p>

<p>types of assessment other than tests, examinations like projects, portfolios and the others.</p> <p>Interviewee: It is impossible to do something that you don't understand, or don't even know.</p> <p>Interviewer: can you please explain how do assess your learners.</p> <p>Interviewee: Every after two weeks I give them a class-test and they write quarterly test.</p>	
<p>Interviewer: What are challenges you experience in teaching mathematics within the OBE context?</p> <p>Interviewee: OBE curriculum emphasised that we need to attend learners individually, while in some classes learners are over fifty, some of the things that are imposed to us are just impossible. I was only work-shopped on how to use OBE documents; I was never work-shopped on mathematics teaching strategies, therefore it is very difficult to implement curriculum if you are not well developed.</p>	Good response.
<p>Interviewer: How can those challenges be overcome</p> <p>Interviewee: Department of education need to revisit the issue of teacher learner ratio. There are too many learners in the classroom, thus it is impossible to attend them individually.</p>	Correct response, though partial answered the question.
<p>Interviewer: What challenges do your learners experience in learning mathematics</p> <p>Interviewee: They are not independent enough to do activities on their own.</p>	Correct response.
<p>Interviewer: In your opinion, what can be done to overcome such challenges?</p> <p>Interviewee: I don't have a clue.</p>	Honest answer.

EDUCATOR B

TRANSCRIPT	NOTES
<p>Interviewer: How do you ensure that learners share their problem-solving thinking and approaches with each other?</p> <p>Interviewee: through the use of group work, but it is not easy because these learners have not yet develop thinking skills, thus in most of the time they become confused and unable to come up with correct answers</p>	<p>Correct response, one of learning outlined by DoE through OBE.</p>
<p>Interviewer: Learners should be encouraged to justify their solution, thinking and conjectures in a single way. What is your opinion about this statement?</p> <p>Interviewee: I do not think that learners should be encouraged to justify their answers in a single way because one can solve problems in different ways as long as the approach is correct.</p>	<p>Agrees with the statement.</p>
<p>Interviewer: How useful do you think learner centered approach is?</p> <p>Interviewee: Learners centered approach is fine since learners are given opportunity to do the work on their own, but learners are slow they wastes a lot of time. There are lots of assessments standard that need to be achieved.</p>	<p>Correct and honest response.</p>
<p>Interviewer: How do you integrate assessment in the teaching and learning of mathematics?</p> <p>Interviewee: through asking learners questions and observing them as the are working, but the recoding is impossible, it is impossible to do it on daily basis</p>	<p>Good response.</p>
<p>Interviewer: What are the advantages of alternative assessment?</p> <p>Interviewee: I don't understand what alternative assessment is!</p>	<p>Lack of understanding on alternative assessment.</p>

<p>Interviewer: it is using different types and techniques of assessment.</p> <p>Interviewee: I don't think I use alternative assessment, because I only use class tests and test to check learners' progress.</p>	
<p>Interviewer: What are challenges you experience in teaching mathematics within the OBE context?</p> <p>Interviewee: hey! There are lots of challenges. It is difficult to change your teaching if you not well developed to implement a new curriculum, lack of teaching and learning aids, some learners' negative attitudes towards mathematics, lack of parental involvement on most of the parents and incompetence on medium of instruction which makes it difficult for learners to comprehend mathematics concepts.</p>	<p>Good response.</p>
<p>Interviewer: How can those challenges be overcome</p> <p>Interviewee: learners should be taught in English from grade1. Department of education should come with intensive programs to develop educators on teaching mathematics in an OBE context. Parental problem can not be resolved because of illiteracy on part of parents.</p>	<p>Correct response</p>
<p>Interviewer: What challenges do your learners experience in learning mathematics?</p> <p>Interviewee: lack of expressing themselves in English,</p>	<p>Correct response</p>
<p>Interviewer: In your opinion, what can be done to overcome such challenges?</p> <p>Interviewee: as I said earlier learners need to be taught in English from grade 1.</p>	<p>Good response</p>

EDUCATOR C

TRANSCRIPT	Comments
<p>Interviewer: How do you ensure that learners share their problem-solving thinking and approaches with each other?</p> <p>Interviewee: problem solving is to challenging for these learners, they unable to analyse mathematical word problems.</p>	Question not answered.
<p>Interviewer: Learners should be encouraged to justify their solution, thinking and conjectures in a single way. What is your opinion about this statement</p> <p>Interviewee: I think it is important to encourage our learners to justify their solution in different ways, but these learners are unable to express themselves in English.</p>	Agrees with the statement.
<p>Interviewer: How useful do you think learner centered approach is?</p> <p>Interviewee: learners are engaged in an active way, they become part of decision making thus take responsibility of their own thinking.</p>	Good response.
<p>Interviewer: How do you integrate assessment in the teaching and learning of mathematics?</p> <p>Interviewee: by giving learners class-tests</p>	Assessment is not the integral part of teaching process
<p>Interviewer: What are the advantages of alternative assessment?</p> <p>Interviewee: I don't understand what you by alternative assessment.</p> <p>Interviewer: the use of different types of assessment techniques and methods.</p> <p>Interviewer: oh! I sometimes give them projects</p>	Lack of understanding alternative assessment.
<p>Interviewer: What are challenges you experience in</p>	Good response

<p>teaching mathematics within the OBE context?</p> <p>Interviewee: Lacks of resources, text books activities are not relevant to learners' environment, and some are not structured in an OBE context. Some of text book activities are not addressing learning outcomes and assessment standards out line by department of education, and some of the text books activities are above learners' intelligence. I am not developed enough to be able to implement OBE curriculum. Classrooms are overcrowded, thus it becomes difficult to engage all learners in mathematics lessons. Parents are not responding when they are called for learners' intervention. Learners are not doing their home works, lack of support because of illiteracy.</p>	
<p>Interviewer: How can those challenges be overcome</p> <p>Interviewee: when developing text books, publishers need to take into consideration the background of learners in semi-rural and rural areas. School management team should inform parents on the importance of interventions. Department of education should employ more educators. It should also come up with programs that will develop us on how to teach mathematics in an OBE context.</p>	Correct response.
<p>Interviewer: What challenges do your learners experience in learning mathematics</p> <p>Interviewee: learners have not developed abstract thinking, there are no resources and thus it becomes difficult to teach mathematics in a meaningful way.</p>	Good response.
<p>Interviewer: In your opinion, what can be done to overcome such challenges?</p> <p>Interviewee: in planning school management team need to take all these factors into consideration.</p>	

APPENDIX F

CLASSROOM OBSERVATIONS

Lesson A grade 4

Educator A lesson was on number patterns, learners were counting backwards and forwards in different intervals. The lesson started by asking learners to count in chorus from 1 to 100. While learners counting educator copied an example from the textbook and wrote it on the chalkboard. An example of number patterns on the chalkboard 1, 7, 13, 19,....., 31,....., 43. Learners were then asked to copy and complete the number pattern on the chalkboard. Learners were working individually, and as learners were writing educator went around observing learners.

Lesson A had two major activities, learners counting from 1 to 100 in chorus and completing a counting grid individually. From my view, when learners responded in chorus, the educator made a conclusion that all learners will be able to count in the intervals of 7. However, when they were asked to copy and complete number patterns, about half the class was not able to complete it.

As learners were working the two learners were talking to each other and the educator reprimanded them, then I realised that the purpose of walking around 'was not to observe approaches learners' used to fill in the missing number but to make sure that everyone was busy working alone and that learners were not talking to each other to share ideas.

Learners were sitting in rows, and at most three learners shared a desk. There were few life orientation posters and the South Africa map on the wall. Mathematics textbooks were also few, and thus learners were not allowed to take the book home. Educator depended solely on the chalkboard and textbooks.

Lesson B GRADE 5

Lesson B was on subtraction with borrowing. Educator B worked out a problem on the chalkboard. She took 13 minutes to work out two problems with learners on the chalkboard and asked learners to copy the two examples and thereafter they were given a problem to solve. Learners were sitting in rows and doing individual class work. After 5 minutes she worked the problem on the chalkboard. Learners' performance when given individual work, contradicted impression they gave when working a problem together with the educator on the chalkboard. When working out examples with learners on the chalkboard, they gave choral responses most of time, thus this misled the educator. After doing corrections on the chalkboard, learners were given two more problems to workout. The period was over before most of the learners could finish the two problems. The educator encouraged learners to finish the work at home.

As the educator was working the problems on the chalkboard, I realised that she did not take the value of numbers into consideration. For example she always said, "borrow one from the tens or hundreds" instead of borrowing ten from the tens or hundred from the hundreds.

The educators spend most of the time talking and working examples on the chalkboard. The lesson was for 30 minutes, 14 minutes was used to work out two examples on the chalkboard and 12 minutes for class-work and correction and the other 4 minutes was for learners to settle and receive their class-work books at the beginning of the lesson.

Lesson C Grade 6

Lesson C was on area and perimeter. The educator started by asking learners to give different types of shapes. There after she drew a rectangle on the chalkboard. She explained to the learners that if they calculate the perimeter of a rectangle they use a formula $2L+2B = \text{Perimeter of a rectangle}$, and if they

calculate the area of a rectangle they use a formula $L \times B = \text{Area of a rectangle}$. She then worked an example of perimeter and there after of an area on the chalk board. After explaining the two examples, learners were given exercises copied from the text book. E.g. the length of rectangle is 6cm; the breath is 4cm. find the perimeter and area of the rectangle. Learners were asked to look at the picture of a house at their own spare time and name all the different shape on the picture.

There were 55 learners in the classroom and learners were sharing desks. Each learner had a mathematics textbook and they were allowed to take books home. There was a science kit in the classroom and few science posters on the wall.

