# RESEARCH PROJECT: 1

## PREPAREDENESS FOR OBE IMPLEMENTATION: A CASE STUDY OF THE MATHEMATICS DEPARTMENT AT A COLLEGE OF EDUCATION IN THE EASTERN CAPE

# RESEARCH PROJECT: 2

## DEVELOPMENT AND EVALUATION OF LEARNING MATERIALS IN LINEAR PROGRAMMING

# RESEARCH PROJECT: 3

## MATHEMATICS FOR ALL: A SOUTH AFRICAN PERSPECTIVE

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

by

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January 2002

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**Dedicated to the memory of late Mr. P.G. Mathew**

## ACKNOWLEDGEMENTS

Many individuals and institutions have made valuable contributions in the development of these projects. I am pleased to acknowledge the support and co-operations given by:

1. The staff members of the Department of Education, Rhodes University, Graham's Town.

2. Mr. Marc Schafer, my supervisor who guided me continuously in completing the projects. I really appreciate his patience and inspiration.

3. My colleagues, friends and students in the college who completed the questionnaires and willingly cooperated with me in the interviews.

4. My superiors and colleagues in OBE training workshops from whom I learnt a lot about the Outcome Based Education.

5. All my colleagues, friends and students in my teaching career from whom I received valuable information which helped me in developing these projects.

6. National Research Foundations and Canon Collins Educational Trust for Southern Africa for providing me with the bursary for the course.

7. The authors of various textbooks from which I used examples of exercises, especially for Linear Programming.

8. My wife and children who always inspired me and patiently sacrificed a lot of their time and enjoyment while I was busy with the projects.

## OVERVIEW OF THE PROJECTS

*The South African education is undergoing transformation. The introduction of Curriculum 2005 and Outcome Based Education (OBE) are important aspects of this transformation process. The implementation of the new curriculum however, has not been smooth. A lack of adequately qualified and trained teachers and effective learning support materials have been identified as some of the major problems facing the implementation of OBE at school level. Even though the colleges of education in the country were not brought on board in the planning and implementation levels of the new curriculum, they could have played an important role in training of educators and developing learning materials for the successful take off of the new curriculum.*

*In the first research project I look into the preparedness of the Mathematics Department of a college of education in the Eastern Cape towards the implementation of Outcome Based Education. The first part of the research project consists of a literature review on Curriculum 2005, Outcome Based Education and the expectations of teachers in the new curriculum and the research methodologies used. The findings revealed that the department, as a whole, was not adequately prepared for the implementation of outcome -based education even though there were some indications that the department effected some modifications in its curriculum and practice teaching.*

*As an OBE facilitator and a college lecturer, I developed some learning materials in Linear Programming. These activity-oriented materials were based on constructivist principles and were used by my first year Secondary Teachers Diploma students. In the second research project, I reflect on the results of using these learning materials by my students.*

*In the first chapter of the project, the context and background of the research and the reasons for selecting Linear Programming as the topic for preparing the learning material are described. This is followed by a brief overview of constructivism together with a brief explanation of the reasons for considering the material to be constructivist. The research paradigm followed in the project, the research techniques employed in evaluating the learning material and the strengths and weaknesses of the evaluation techniques are given in the next chapter. In the following chapter, the findings from the various data gathering methods and the results of the implementation of the material are described. The concluding chapter presents a critical reflection on the whole process involved in the material development*

*The post 1994 government in South Africa seems to attach* much *importance to mathematics, science and technology education. The majority of the population who were previously denied access to these subjects is given more opportunities to learn them. The International Mathematics Union declared 2000 as the World Mathematical Year. One of the aims of the activities organized as part of the celebrations was improving the public image of mathematics to realize the vision of "Mathematics*

*For All". The South African government shows keen interest to improve mathematics education in the country in an attempt to realize the vision of Mathematics For All. Even though the accessibility rate to mathematics has increased, the success rate has not yet increased as anticipated. In this context I, as a post-graduate student in Mathematics Education, thought of reviewing the concept of Mathematics For All in the South African context.*

*In the third research project, which is a literature review, initially an attempt is made to unpack the concept of Mathematics for ALL. In analyzing the concept, answers are sought for questions like: What is mathematics and why should it be taught? It is followed by a brief review of some goals of mathematics education. Then the current situation of mathematics education in South Africa and the efforts to improve it are also looked at. This is followed by an analysis of the reasons for the general unpopularity of mathematics. In the concluding part some suggestions for improving mathematics education in the country are given.*

# PROJECT: 1

# PREPAREDENESS FOR OBE IMPLEMENTATION: A CASE STUDY OF THE MATHEMATICS DEPARTMENT AT A COLLEGE OF EDUCATION IN THE EASTERN CAPE

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ANC | African National Congress |
| C2005 | Curriculum 2005 |
| CFC | Consultative Forum on the Curriculum |
| CNE | Christian National Education |
| COTEP | Committee on Teacher Education Policy |
| DET | Department of Education and Training |
| EMSCEP | ESKOM Mathematics and Science Education Project |
| FET | Further Education and Training |
| GET | General Education and Training |
| HOD | Head of Department |
| JC | Junior Certificate |
| JPTD | Junior Primary Teachers Diploma |
| LA | Learning Area |
| LAC | Learning Area Committee |
| MLA Project | Monitoring Learning Achievement Project |
| MLMMS | Mathematical Literacy Mathematics and Mathematical Sciences |
| NCDC | National Curriculum Development Committee |
| NQF | National Qualification Framework |
| OBE | Outcome Based Education |
| PTD | Primary Teachers' Diploma |
| SADTU | South African Democratic Teachers Union |
| SPTD | Senior Primary Teachers Diploma |

| | |
|---|---|
| STD | Secondary Teachers Diploma |
| TIMSS | Third International Mathematics and Science Study |

**ABSTRACT:**

*In an attempt to transform the education system in the post-apartheid South Africa, the government of national unity has introduced Curriculum 2005 and Outcomes Based Education (OBE). A lack of adequately qualified and trained educators has been described as one of the major problems hindering the smooth implementation of OBE. Colleges of Education, as providers of teacher education, play a vital role in preparing competent teachers for the smooth implementation of Outcome Based Education. This research looks in to the preparedness of the Mathematics Department at a college of education in the Eastern Cape towards the implementation of OBE.*

*In the first part of the research a brief literature review on Curriculum 2005 and OBE and the expectations of teachers under the new curriculum was undertaken. As part of the research, different methods such as observation, interviews, questionnaires and document analysis were used to gather data to investigate the preparedness of the mathematics department at the college. The findings revealed that the department took some initiatives to prepare for the implementation of OBE at the college. Lecturers were sent for OBE training, workshops were conducted for lecturers and students, and lecturers used OBE principles in their teaching. Student teachers in some phases were trained well and they feel confident to use OBE in teaching mathematics. In some other phases, students have the theoretical knowledge in OBE, but require more skills- development for using OBE principles in the classroom.*

*It is hoped that my findings will encourage interested readers to undertake similar attempts to investigate the readiness of various departments in different institutions of Teacher Education in the Eastern Cape or in any other province in the country. It is also hoped that this type of research will help future teacher educators and student educators to be successful implementers of Curriculum 2005 and OBE.*

# CHAPTER 1
# BACKGROUND

## 1.1 INTRODUCTION

This project is based on research conducted at the Mathematics Department at a College of Education in the Eastern Cape. The college is fictitiously named Siyafundisa College of Education. The aim of the research is to gauge the preparedness of the said department for the implementation of Curriculum 2005 (C 2005) and Outcomes Based Education (OBE). In this chapter I will be looking at the context and background of the research, followed by the goals of the research. The chapter also contains a framework of the research project where the contents of each chapter are briefly mentioned.

## 1.2 CONTEXT AND BACKGROUND OF THE RESEARCH

### 1.2.1 Change in the education system in South Africa

The education system in post apartheid South Africa is undergoing fundamental changes. One of the changes is the introduction of a new curriculum. The white paper on education and training (South Africa, 1995) which informed the subsequent establishment of the National Qualification Framework (NQF), emphasised the need for major changes in education and training in South Africa in order to normalise and transform teaching and learning (South Africa, 1997a: 1). In 1995, The Minister of Education announced the introduction of a new curriculum with the intention of completing its implementation in 2005 in all grades of the General Education and Training (GET) band. The GET band, according to NQF, ranges from Grade 0 to Grade 9 which is the compulsory education period for every child. In the new curriculum emphasis is placed on a shift from the traditional aims and objective method to an outcomes based approach. It also places more emphasis on learning which is learner-centred (De Beer, 1999), continuous and lifelong and aims at the development of skills, knowledge, values and attitudes. The new curriculum has already been implemented in Grades 1, 2, 3, 4, 7 and 8.

The implementation of the new curriculum and the outcomes based education has been challenged by problems such as lack of qualified and adequately trained educators, lack of learning support materials and financial constraints. As part of the implementation of the new curriculum and OBE, the National and Provincial Education Departments and various non-governmental organisations have conducted workshops for teachers. In many cases both trainers and trainees reported these workshops as inadequate and ineffective. The Curriculum Review Committee (South Africa, 2000: 57) reported that many teachers appeared to have left the training workshops not knowing what it was they ought to teach. According to the South African Democratic Teachers' Union (SADTU), as reported by the Curriculum Review Committee (South Africa, 2000: 57), "With the introduction of a new curriculum to the South African education system, teachers are desperate for support, both in understanding and accepting the changes required of them and in implementing these changes in their classrooms".

### 1.2.2 Challenges for the Colleges of Education:

There is an acute shortage of mathematics and science teachers in South Africa (The Star & SA Times, 2000 and Pretoria News, 2000l as cited in Lewis, 2000: 5). Recent report on the poor performance of South African Grade 4 learners in numeracy should be another matter of concern. According to the report South African learners have the worst numeracy (with an average score of 30% in numeracy) among the 12 African nations which took part in the Joint International Unesco-Unicef Monitoring Learning Achievement (MLA) Project (Sunday Times, 2000 as cited in Lewis, 2000: 2). TIMSS (1998) also reported the same poor situation about South African performance in the international study in Mathematics and Science. One of the reasons could be the lack of adequately qualified and properly trained teachers in these subjects. In this respect Colleges of Education and other teacher education institutions, especially with the introduction of the new curriculum, have the responsibility of producing competent teachers to meet the dire need for teachers in these core subject areas.

The introduction of the new curriculum made it mandatory for Colleges of Education, as providers of teacher education, to become involved with OBE implementation. Subsequently, like in many other teacher education institutions, some modifications were effected in the academic programmes of Siyafundisa College of Education. Curriculum 2005 and OBE principles were made part of the syllabus in Education courses. Some subject didactics lecturers, at least a few, started using the OBE approach in didactics lessons. Student teachers were encouraged to apply the OBE approaches in their classes during Practice Teaching.

Every year student teachers were sent to various primary and secondary schools around the college to acquire experience in teaching under the guidance of teachers in those schools. Some teachers in some of those schools wanted the student teachers to conduct lessons according to OBE principles. One of my student teachers commented, "*Teachers in schools want us to teach in OBE. They think that we are experts in OBE because we are from a college of education. They want to observe our lessons to learn how to use OBE in their classes*". She added, "*But here at the college we are not trained to teach in OBE. We have only some theoretical knowledge of OBE*". This triggered in me an interest to investigate the preparedness of my own department (Mathematics Department) towards the implementation of Curriculum 2005 and OBE.

## 1.3 GOALS OF THE RESEARCH

In my research I investigated the following:

**To what extent did the Mathematics Department at Siyafundisa College of Education develop a curriculum which is OBE based, and which prepares teachers for implementing Curriculum 2005 and OBE?**

In order to find answers to the above research question I investigated whether:

- the lecturers of the Mathematics Department received adequate and appropriate training and support in implementing Curriculum 2005 and OBE and
- the necessary modification(s) were effected in the current syllabi and academic programmes of the Mathematics Department to accommodate Curriculum 2005 and OBE.

## 1.4 FRAMEWORK OF THE RESEARCH PROJECT

In the first chapter of this research project the context and background and the goals of the research are looked at. In Chapter 2 a literature review on Curriculum 2005 and OBE and expectations of educators and teacher education institutions in the new system is presented. Chapter 3 discusses the research methodology and the approaches used in the collection and analysis of data for the project. In Chapter 4 the research findings are described. The fifth chapter presents the final conclusions drawn from the research.

## 1.5 CONCLUSION

In this chapter the context and background leading to the research are discussed. The goals and framework of the research project are also outlined. The introduction of C 2005 and OBE in South African schools makes the responsibility of the college, like any other teacher education institution, more challenging. The research tries to find out the preparedness of the Mathematics Department in Siyafundisa College of Education towards implementing the new curriculum and OBE. In order to research the preparedness of the Mathematics Department, what is expected of the college in general and the department in particular must be clearly understood. It makes it imperative to undertake a literature review of the principles and philosophy underpinning C 2005 and OBE together with the government's expectations of educators and teacher education institutions. In the next chapter the literature review is undertaken.

# CHAPTER: 2
# LITERATURE REVIEW

## 2.1 INTRODUCTION

In this chapter a brief review of literature on C 2005 and Outcome-Based Education is presented. The implications of the introduction of C2005 and OBE for educators and teacher education institutions on the basis of the government policy document on Norms and Standards for Educators and the COTEP document on Norms and Standards for Teacher Education have also been looked at.

## 2.2 CURRICULUM 2005 AND OBE

### 2.2.1 The need for curriculum change

A curriculum in its simplest form can be defined as subjects included in a course of study (Oxford Dictionary, 1994:196). In a broader perspective it can be defined as everything planned by educators to develop the learner and a good curriculum produces thinking and caring individuals (South Africa, 1997b: 10). According to the African National Congress (ANC) document (1994: 67) the term curriculum refers to:

> All teaching and learning opportunities that take place in learning institutions. It includes the aims and objectives of the education system, the content taught, the skills imparted, strategies for teaching and learning, forms of assessment and evaluation, how the curriculum is serviced and resourced, and how it reflects the needs and interests of those it serves, ...

A curriculum should be concerned with what institutions teach, and what, how and under what conditions learners acquire the required knowledge, skills, values and attitudes. It is no exaggeration to say that the curriculum is at the heart of the education and training system (South Africa, 1997a: 1).

It is common knowledge that during the apartheid era South African education was segregated along racial lines. We had an education system that was content based,

inflexible, oppressive and segregated in terms of disability, race (Naicker, 1999: 93) and *gender* (italics my emphasis). The majority of the population in this country had very little or no access to proper education. Many were either denied opportunities or those who had the opportunities had been unequally treated in terms of resources, compared to their white counterparts. Education in South Africa was characterised by large-scale inequalities in provision. Racial segregation and inequality persisted in education administration, provision of schooling, non-formal education and organisation of higher education and training (South Africa, 1992: 134 as cited in Naicker, 1999: 19).

It is alleged that the apartheid-state in South Africa used education to perpetuate apartheid policies. Christie and Collins (1990:176) clearly revealed the state's intention of introducing Bantu education by quoting the then minister of education:

> As has been correctly stated here, education is the key to the creation of the proper relationship between European and non-European in South Africa.... Put native education on a sound basis and half the racial questions are solved... I say that there should be reform of the whole educational system and it must be based on the culture and background and the whole life of the native himself in his tribe... This whole (present) policy is also a danger for our Western civilisation.

and:

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

Gardening, for example, was a subject in primary schools for the blacks. It could have been done to achieve the intention of producing garden workers for the whites. Gardening was not a subject in the former white schools or the present Model C schools. For quite a long time, up to the mid-nineties, gardening was an optional subject for male students in the curriculum for Primary Teachers Diploma (PTD) offered by the ex-DET colleges of education. In my view, it was one of the many subjects and programmes offered in black schools to produce a subservient and obedient workforce for the ruling race.

South African education followed the philosophies of Calvinist and Christian National Education (CNE). These philosophies influenced, to a large extent, many South African educators who considered a learner as an 'object', who is 'not responsible', ' morally dependent', 'deficient' and 'in need of guidance by an adult' (Naicker, 1999: 77). Beard et al (198: 9) cited the Report of the Commission of Enquiry into Training of White Persons as Teachers (South Africa, 1969) to show the racist state's insistence on loyalty in white teacher training:

> A national system of teacher training must be such as to produce teachers who are willing and able to achieve the aims of education that are pursued or should be pursued in our schools. The system of training must therefore be one that will produce teachers... who ... are imbued with the ideal... of teaching towards the development of their pupils into men and women of rectitude, efficient and loyal citizens of their country...

The apartheid education system produced school leavers who were found wanting in the job market. Too much emphasis on compartmentalised content knowledge without skill development made the learners unsuitable for the job market. According to Mahomed (1996 as cited in Jansen 1997), South Africa's inability to generate an economic growth rate to sustain all of its redress needs is blamed largely on the lack of relevant skills. The reports released by TIMSS in 1998 showed that the South African learners continuously performed very poorly compared to the other countries which participate in International Maths and Science literacy and achievement surveys and studies. The poor performance of our learners, to a certain extent, can be attributed to the type of education we provide in our schools. South Africa being part of the global community has to compete with other nations of the world in fields of technological and economic developments. Globally developed nations are pushing forward with technological advancements and as such their education systems are being restructured. South Africa also should restructure its curriculum in order not to be left behind by the other leading nations of the world.

It is clear that the type of education system described above will not be able to realise post-apartheid South Africa's vision of a prosperous, truly united democratic and internationally competitive country with literate, creative and critical citizens leading productive, self-fulfilled lives in a country free of violence, discrimination and prejudice

(South Africa, 1997c: 5). As suggested in the C 2005 document (South Africa, 1997b: 8), " Some change has to take place. This change is urgently needed. Too many have been deprived of too much for too long". It is therefore imperative, as stated in the Government Gazette (South Africa, 1997c), that the curriculum in South Africa be restructured to normalise teaching and learning and to reflect the values and principles of the new democratic society in the country.

### 2.2.2. Curriculum 2005

Having realised the need to change the curriculum in the country, in August 1995 the Department of Education established a Consultative Forum on the Curriculum (CFC) comprising of representatives of the national and provincial education departments and other national stakeholders in education and training. This forum conducted an investigation in to the existing curriculum and submitted a report: *A Curriculum Framework for General and Further Education and Training.* The report proposed a National Qualifications Framework (NQF) and an outcomes-based approach for the different phases of the GET and the Further Education and Training (FET) bands. The FET band includes Grade 10 to Grade 12 in high schools and equivalent courses offered in technical colleges and other training colleges. Responses, individual and collective, to the document were invited from all interested parties by March 1996. The Curriculum Development Working Groups of the National Curriculum Development Committee (NCDC) considered the submissions received and agreed on an outcomes-based Lifelong Learning Development Framework for South Africa.

Eight Learning Area Committees (LACs) monitored by the NCDC were instituted. To speed up the implementation of the new programmes in schools with the outcomes-based approach, the Department of Education invited nominations for members to serve on a Technical Committee to assist in the writing of standards and frameworks for learning programmes for each of the eight learning areas. The Technical Committee started with their assignment in February 1997 and completed it in March 1997 by issuing a draft document for further discussion. The hard work of the various groups under the National

Curriculum Development Committee produced a new curriculum policy for South Africa. When the Minister of Education initially announced the introduction of the new curriculum in 1995, implementation was scheduled for all grades (1-12) by the year 2000. In 1997 the implementation timetable was revised to 2005 and, in line with this, the new curriculum was named Curriculum 2005 (South Africa, 2000: 3). According to the Minister of Education,

> Essentially, the new curriculum will effect a shift from one that has been content-based to one which is based on outcomes. This aims at equipping all learners with the knowledge, competence and orientations needed for success after they leave school or have completed their training. Its guiding vision is that of thinking, competent future citizens.
>
> The curriculum will begin to integrate education and training- incorporating a view of learning which rejects a rigid division between academic and applied knowledge, theory and practice, and knowledge and skills. It will also foster learning which encompasses a culture of human rights, multilingualism and multiculturalism and a sensitivity to the values of reconciliation and nation building (Bengu as cited in South Africa, 1997: 1).

According to the Curriculum Review Committee (South Africa, 2000: 1):

> Curriculum 2005 is probably the most significant curriculum reform in South African education of the last century. Deliberately intended to simultaneously overturn the legacy of apartheid education and catapult South Africa into the 21st Century, it was an innovation both bold and revolutionary in the magnitude of its conception. As the first major curriculum statement of a democratic government, it signalled a dramatic break from the past. No longer would curriculum shape and be shaped by narrow visions, concerns and identities. No longer would it reproduce the limited interests of any one particular grouping at the expense of another. It would bridge all, and encompass all. Education and training, content and skills, values and knowledge: all would find a place in curriculum 2005.

The paradigm shift in teaching and learning suggested in the new curriculum, in my view, is the most important aspect of C 2005. According to the new curriculum, at the end of a learning experience, learners should be able to demonstrate what they have learnt in the form of competence. The task of the teacher is to provide the learner with the learning experience. In the new curriculum the role of the teacher is that of a facilitator instead of the traditional transmitter of knowledge and the role of the learner becomes that of the creator of knowledge instead of that of a passive recipient. Another important aspect of the new curriculum is adopting the philosophy of lifelong learning and the insistence on the assumption that every learner can succeed. However, there are strong critics like Jansen (1997), Mulholland (1997) and Christie (1995 as cited in Jansen 1997) who are

critical about the implementation of the new curriculum. I do not think that they are against the principles of the new curriculum. Rather they could be critical about, among other issues, the haste shown by the government in introducing the new curriculum when the country is not ready for such a massive curriculum reform while it has so many other societal problems to take care of. Even though the Department of Education seems unprepared to implement the new curriculum with regard to teacher training and support materials, in my view, there is a need for the curriculum change as well as the methods of teaching in our schools.

### 2.2.3.Outcomes- based education

When C 2005 was designed, an Outcomes Based approach was chosen as the method of its implementation. As Bengu (1997 as cited in South Africa, 1997b: 1) claimed, " Essentially, the new curriculum will effect a shift from one which has been content-based to one which is based on outcomes". To critically look at the implications of implementing the new approach in teaching and learning context, it is essential to have a better understanding of OBE.

In simple terms outcomes based education refers to an education based on outcomes or a result-oriented education. The Minnesota State Department of Education (1991 as quoted by Towers, 1994) adopted the following definition:

> Education that is outcome based is a learner centred and result oriented system founded on the belief that all individuals can learn. It further adds that in this system:
>
> - what is to be learned is clearly defined
> - learners' progress is based on demonstrated achievement
> - multiple instructional and assessment strategies are available to meet the needs of each learner [and]
> - time and assistance are provided for each learner to reach maximum potential.

According to William Spady (1996a: 3), an eminent advocate of an outcomes based approach:

> Outcomes are clear, observable demonstrations of student learning that occur at or after the end of a significant set of learning experiences. These demonstrations or performances, will reflect three key things: 1) what the student knows 2) what the student can actually do with what he or she knows and 3) the student's confidence and motivation in carrying out the demonstration. A well-defined outcome will have clearly defined content or concepts and a well-defined demonstration process... like explain, organise or produce.

Spady (1996b: 4) further insists that OBE is inherently about DEFINING, RAISING AND ACCOMPLISHING clearer higher standards of learning and performance for more students.

According to Bellis (1997):

> The outcome is, in South Africa, being formed in the formal education system where both 'outcomes' and 'competence' are being used ( at times it seems) interchangeably in the training or human resource development. This notion of outcomes clearly relates to results. These results are seen to relate to consequences within the person, in economic contexts or in societal contexts. In the present position of South African Education Department, the language around the outcomes is varied. Outcomes are defined as " the results of learning processes and refer to knowledge, skills, attitudes and values within particular contexts". In broader terms, ' critical cross-filed outcomes' are defined as " generic, cross curricular, cross cultural outcomes" ... Yet again in South African education position, 'learning area outcomes' are described as "outcomes related to specific learning areas" while 'specific outcomes' are described as "contextually demonstrated knowledge, skills and values reflecting critical cross-field outcomes".

Outcomes-based Education, according to Spady (1996 a), works on the premise that

- all students can learn and succeed, but not on the same day and in the same way
- successful learning promotes more successful learning and
- schools control the conditions that directly affect successful learning

Spady (1996 a) identified the following purposes of OBE:

- ensuring that all students are equipped with the knowledge, competence and qualities needed to be successful after they exit the educational system and
- structuring and operating schools so that those outcomes can be achieved for all students.

From the discussion so far, it can be seen that Outcome-based Education aims at success for all learners on the premise that every learner can succeed at his/her pace provided he/she is given the right opportunity. If this is what education is all about, in a democratic society like the new South Africa where education is the birth right of every citizen, in my view it should be the government's responsibility to provide learners with the necessary opportunity and support to make them succeed. Schools as providers of public education, as OBE implies, should design and implement instructional activities to enable every learner to accomplish the expected learning outcomes. What is expected of the schools and educators is to identify the necessary outcomes for their learners and then design the required curriculum and instructional activities. This is what Spady (1996 b: 4) calls the 'design down' or 'design back' principle. Teachers should also make sure that there are effective assessment techniques to assess the performances of learners.

## 2.3 NORMS AND STANDARDS FOR EDUCATORS

The Policy Document on Norms and Standards for Educators (South Africa, 1996) stipulates seven roles and their associated competencies that are essential to be a competent teacher in the employ of the South African Education Department. The roles are: learning mediator; interpreter and designer of learning programmes and materials; leader, administrator and manager; scholar, researcher and lifelong learner; community, citizenship and parental role; assessor; learning area/ subject/discipline/phase specialist. According to the Policy Document, competencies associated with the roles are broadly divided into:

- practical competence – the demonstrated ability in an authentic context, to consider a range of possibilities for action, make considered decisions about which possibility to follow and to perform the chosen action.
- foundational competence where the learner demonstrates an understanding of the knowledge and thinking that underpins the action taken and
- reflexive competence in which the learner demonstrates ability to integrate or connect performances and decision-making with understanding and with an ability to adapt to

change and unforeseen circumstances and to explain the reasons behind these adaptations.

It is clear from what Spady and government documents point out that student teachers are expected to be in a position to identify outcomes of a particular learning exercise, design relevant curricula and learning materials. They are expected to facilitate the learning process in the classroom and to use various assessment strategies to assess the learner's performance in terms of the expected outcomes. All the competencies (practical, foundational and reflexive) mentioned above must be developed in all initial education qualification (South Africa, 1996:11).

## 2.4 NORMS AND STANDARDS FOR TEACHER EDUCATION (COTEP)

The Committee on Teacher Education Policy (COTEP) document on Norms and Standards for Teacher Education (South Africa, 1996) identifies the following broader aims of teacher education in the country. The fundamental aim of teacher education has been described as to educate and train teachers to teach effectively in order to facilitate learning. Teacher education should result in the student (teacher) being able to:

- demonstrate the ability to apply, extend and meaningfully synthesise various forms of knowledge
- develop skills
- develop values, attitudes and dispositions
- be active and reflective members of the teaching profession.

Teachers must be empowered to become autonomous, flexible, creative and responsible agents of change in response to the educational challenges of the day and in relation to espoused aims of education in South Africa. In order to evaluate teacher education programmes certain competencies (practical, foundational and reflexive) are suggested in the knowledge-skills-value paradigms. Again specific competences related to specific phases of education such as pre-primary, primary and secondary education which in the

new policy framework are known as foundation, intermediate and senior phases respectively (South Africa, 1996:28) are identified. Specialisation in specific learning areas is also recommended. Moreover teaching practice is recommended as an integral part of teacher education programmes.

## 2.5 CONCLUSION

This chapter looked at a review of some of the available literature on Curriculum 2005 and OBE. The literature review shows that in order to implement the new curriculum using the outcome-based approach, educators should be in a position to

- identify outcomes
- design curricula/instructional activities
- implement the instructional activities/ manage the classes
- design and administer tools to assess learner's performance
- keep proper record of the assessment findings.

Colleges of Education as providers of teacher education have the responsibility of developing teachers who are capable of performing the above tasks. The policy document on Norms and Standards for Educators suggests that all initial teacher-education qualifications must ensure the development of practical, foundational and reflexive competencies in educators. The college, where the research is conducted, being a Pre-service Teacher Training institution should ensure that the teacher education programmes at the college were in line with the policy document. The Mathematics Department at the college has the responsibility of producing competent mathematics teachers who have sound academic knowledge and the required skill of using the OBE approach in teaching mathematics. In order to do this the department has to redesign its curriculum and other academic programmes in line with the OBE principle. That is exactly what the research investigated. The next chapter looks at the research methodology used in this thesis.

# CHAPTER 3
# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

Research, according to Mouly (1978), is best conceived as the process of arriving at dependable solutions to problems through the planned and systematic collection, analysis and interpretation of data. It is a most important tool for advancing knowledge, promoting progress and for enabling people to relate more effectively to his/her environment, to accomplish his/her purposes and to resolve his/her conflicts. This process of collection, analysis and interpretation of data involves techniques and procedures that are called the methods. As Kaplan (1973) says, 'the aim of methodology is to describe and analyse these methods, throwing light on their limitations, and resources, clarifying their presuppositions and consequences, relating these potentialities to the twilight zone at the frontiers of knowledge.' Within a research process the beliefs a researcher holds will reflect in the way the research is designed, how data is both collected and analyzed and how the research result(s) is / are presented (William, 2000: 2). In this chapter, the two main research paradigms, the approaches used in the research, the methods and techniques and their drawbacks and problems experienced in the collection and analysis of the data are discussed.

## 3.2 RESEARCH PARADIGMS

A paradigm provides a conceptual framework for seeing and making sense of the social world. According to Burrel and Morgan (1979), 'to be located in a particular paradigm is to view the world in a particular way'. According to Kuhn (1970:175) a paradigm 'stands for the entire constellation of beliefs, values and techniques and so on shared by the members of a community'. Paradigms shape how we perceive the world and are reinforced by those around us, the community of practitioners (Williams, 2000:2).

There are two main research paradigms, namely quantitative and qualitative research paradigms. Quantitative research is very objective and relies heavily on statistics (Jean Lee, 1992). According to Williams (2000), quantitative researchers view the world as hard, external and objective, and science as value free. They seek to deduce cause and effects relationships to predict patterns of behaviour. The involvement of the researchers in the collection of data is very minimal with the researcher acting as an independent observer. Their investigation will be directed at analysing the relationships and regularities between selected factors in that world under investigation.

On the other hand those researchers who subscribe to the qualitative paradigm view the social world as being of a much softer, personal and humanly created kind. The principal concern for these researchers is with an understanding of the way in which he or she finds himself or herself (Cohen and Manion, 1994: 8). As reported in Sherman and Webb (1990:4), Edson (1990) argues that qualitative inquiry is 'a form of moral discourse, an attempt to understand ourselves in relation to the larger world and is interested in the motives and aims, not just the behaviour of those who studied.' As qualitative implies a direct concern with experience as it is lived or felt or undergone, qualitative research has the aim of understanding experience as nearly as possible as its participants felt it or lived it. A qualitative researcher focuses on natural settings. Nothing is predetermined or taken for granted. In qualitative research the researcher wants the researched to speak for themselves. Taylor and Bogdan (1984) point out that qualitative researchers are more concerned with understanding the social phenomenon from the actor's perspective through participation in the life of the actors. From what has been cited so far, it is quite clear that a qualitative research is mostly interpretivist as it makes meanings of the findings by interpreting the responses of the participants, as they understand the issue under investigation. Also the researcher negotiates meanings from the personal constructs of the participants. Another important aspect of qualitative research is that it is subjective, using language and description rather than numerals and figures (Williams, 2000:8). Erickson (1998) summarises the purpose of qualitative research as discovering kinds of things that make a difference in social life. Qualitative research is context specific (Edson, 1990:46) and what is true in one context may not be true for another and as such

data needs to be gathered in a variety of contexts (Tucker *et al.*, 1995). According to Williams (2000), high researcher involvement in data collection is a main characteristic of qualitative research.

Quantitative and qualitative research tries to explain a situation with the aim of seeking reasonable solutions. Even though both involve processes such as identification of the problem, forming research questions, designing a research design, collecting and analysing data to interpret and present the findings with suitable suggestions for solutions, there are differences between the two in the collection and analysis of data. Quantitative researchers use secondary data, survey techniques and classic experiments when collecting data and use statistical methods to analyse the data collected. Qualitative researchers use techniques such as participant observation, in depth interviews, group interview and documentation collection with an emphasis on fieldwork and seek solutions to the research problems by analysing participants' understanding of the situation. Quantitative research is very objective while qualitative research is subjective. Since both have merits and demerits it would be better if both methods are integrated to find solution to problems so that each method could take care of the drawbacks of the other and complement one another rather than competing with one another (Cohen and Manion, 1994:106). A combination of qualitative and quantitative methods can broaden a study's perspective (Hutchinson, 1990:138). As a result in this research, quantitative methods are also employed in the analysis and interpretation of the data, even though the research is predominantly qualitative.

## 3.3 APPROACHES USED IN THE RESEARCH

This research investigates the preparedness of the Mathematics Department to develop a curriculum that is OBE based and which prepares teachers for implementing C2005 and OBE. A case study approach is considered the most appropriate for this research as it studies the characteristics of an individual unit, in this case the Mathematics Department, (Cohen and Manion, 1994: 106) in its own environment and is trying to understand what is happening there. Qualitative, interpretivist, constructivist and participatory approaches

are followed. Data for the research are collected mainly from the people associated with the department: the students, lecturers and Head of the Mathematics Department. Meanings are sought of the findings by interpreting the personal constructs of the participants. It is considered interpretative as the survey sought the problems and approaches used in the implementation of OBE as perceived and interpreted by the participants. Opinions and ideas of participants in the research are used in designing the survey questions. Suggestions and ideas of my fellow students and the supervisors of the M. Ed programme are also used in the survey process. Perceptions and interpretations of the participants are largely used in interpreting and drawing conclusions from the data.

## 3.4 RESEARCH METHODS

### 3.4.1 OBSERVATION

According to Cohen and Manion (1994), at the heart of every case study lies a method of observation. Case study researchers observe characteristics of the individual unit under investigation. The purpose of the observation is to probe deeply and to analyse intensively the multifarious phenomena that constitute the life cycle of the unit with a view to establishing generalizations about the wider population to which it belongs. Two types of observations, participant-observation and non-participant observation, are employed by researchers in data collection. In participant observation the researchers engage in the very activities they would like to observe. In non-participant observation, the observers stay aloof from the group activities they are investigating and make notes about what is taking place. I used both participatory and non-participatory observations in gathering data.

I have been a staff member of the college for the last nine years. On numerous occasions I was involved in both formal and informal discussions with students, staff members and other stakeholders of the college regarding academic matters and other states of affairs at the college. I also had the opportunity of making notes of many events that happened in the college on a daily basis. These helped me in analysing the situation in the college

with respect to the implementation of OBE. As Cooper and Emory (1995:331) suggest, "much of what we know comes from observation". The findings of these discussions and observations are reported in The Present Situation at the College (Section 4.2.4).

Being a staff member it was easy for me to employ both participant and non-participant observation in the natural settings of the college. Participants in the research might not have even realised that they were under observation. Even after being informed of the research they went on with their normal activities in the usual way. In addition to the observation of the daily activities in the college, lecturers and students were observed during demonstration lessons and OBE workshops conducted in the college. Students were further observed in their classes during Practice Teaching. These observations were conducted to see the attitude and commitment of lecturers and students towards OBE and how they made use of OBE principles and techniques. In some cases the author also took part in demonstration lessons and OBE workshops and took note of what had happened during these lessons and workshops. Non-participant observation was mainly used for observing students in their classrooms. In the case of demonstration lessons no observation chart was used. Being an OBE trainer I used my general knowledge in OBE principles to make note of the aspects of the lessons. An observation chart (Appendix I) was used as to observe and evaluate the students' performance in classroom teaching.

Observation as a research technique has many advantages over other methods. Cooper and Emory (1995) consider observation as a primary source method and a supplement to other methods. The original data can be collected at the time they occur. The researcher does not have to depend on reports of others. Information can be filtered in questionnaires and interviews as a result of respondent's forgetfulness or deliberate non-disclosure of all the important facts. Although observation allows the researcher to capture the whole event as it happens in its natural settings, it has its disadvantages. The first disadvantage is that it demands a lot of time from the researcher. Secondly, the interpretation of information collected through observation is researcher biased. Even if two observers observe the same event at the same context and time, the inferences drawn from the event by them will be different as the inferences depend entirely on how each of

them interprets the event. Another dilemma faced by inexperienced researchers in observation, according to Cohen and Manion (1994), is the quantity of information and to decide on how much to record, in what form to record and what to do with the mass of recorded data.

### 3.4.2 SURVEYS

Surveys were mainly used to gather data for the research. Being a case study of the Department of Mathematics, the population for the survey was selected mainly from the staff and students of the department. However, lecturers from other departments were also included in the data collection process to investigate the general preparedness of the college. General preparedness of the college towards the implementation of OBE was considered vital to the Mathematics Department's preparedness. These people were considered important to give information regarding the Mathematics Department's initiatives towards implementing OBE. In 1999 a pilot study was conducted on the general preparedness of the college towards the implementation of OBE. Findings from the pilot study are also used in interpreting the research findings. Questionnaires and interviews were used in the survey.

#### 3.4.2.1 Questionnaire

The questionnaire is an important tool for gathering data for research purposes.
Although the research is a case study, I thought of involving a wide community of participants. According to Cohen and Manion (1994: 272) the number of respondents who can be reached is extensive in the case of a questionnaire. The total number of students offering either mathematics content and/or didactics in the college during the year of study was roughly around 65[Junior Primary Teachers Diploma III (JPTD) – 26 students; Senior Primary Teachers Diploma (SPTD) III – 29 students; Senior Teachers Diploma (STD) III – 4 students; STD II – 6 students]. These students were considered the key respondents for the research on the Mathematics Department as they are in a good position to talk about the preparedness of the department. As the total student-

population was manageable, I thought of involving all students in the questionnaire to get responses from a large sample. A few days before administering the questionnaire students were made aware of the questionnaire and their voluntary participation was requested. They expressed their willingness. Those who were absent when the questionnaires were distributed collected the questionnaire later. Questionnaires were given to all students except those in JPTD 3 as they were not available during the week. The return of the completed questionnaire was very satisfactory. [STD3 – 4; SPTD3- 22; STD2 – 3]. A total of 29 questionnaires out of 39 were returned showing a 74% return. The high rate of return of the forms could be due to the fact that the researcher, being a member of staff of the institution, had access to the participants. Also it could be due to the researcher explaining the importance and benefits of such research for future educators and learners. However it is worth mentioning that the researcher had to go after the respondents many times to retrieve the forms.

In the pilot study conducted in 1999, separate sets of questionnaires were used for students and lecturers. Each set had a few questions applicable to that group only. So it was considered better to use separate questions to make it simpler for the groups and to avoid confusion. It made the analysis of responses from the questionnaire very easy. The draft copies of the questionnaires were given to two lecturers for comments. After making the recommended changes the questionnaires were piloted. One or two respondents raised some points about the questionnaires and they were also rectified before the final copies were administered. For this research in 2000, questionnaires were used only for the students. The lecturers were not included in this study as most of the lecturers who took part in the pilot study were redeployed to other institutions. A few additional questions related to the Department of Mathematics were added to the questionnaire used in the pilot study and they were administered without any more piloting. Copy of the questionnaire is included as Appendix II.

Questions in the questionnaire mainly focused on the following aspects:

- personal data of the respondent and the reasons for choosing a teaching career and joining the college (Questions 1-4)

- the general preparedness of the college towards the implementation of OBE (Questions5 - 9)
- the preparedness of the Department of Mathematics towards the implementation of OBE ( Questions 10 – 15)
- the support and guidance the students received during Practice Teaching
- the shortfalls the students noticed in the teaching of Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS ) and suggestions for improvement (Questions 16-21). (See Appendix: II)

Most of the questions were close-ended questions with multiple choices and dichotomous answers. Even though open-ended questions are not recommended for questionnaire (Cohen & Manion, 1994: 94), some open questions were included to have some kind of probing on the participant's understanding of the issues and to have a check on their responses. Open-ended questions give respondents an opportunity to air their views on issues which in turn give them a feeling that their views are recognised. However from my experience close-ended questions are found to be more ideal in questionnaires. It is found that respondents prefer close-ended questions. It could be that close-ended questions are easy to answer and the respondents do not have to spend much time in finding the responses. Some respondents either do not answer the open-ended questions or give irrelevant answers. It was also found difficult to code and analyse the responses of open-ended questions during data analysis unlike the close-ended responses, which are very easy to code and analyse.

### 3.4.2.2 Interview

The research interview has been defined as: 'a two person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him on the content specified by research objectives of systematic description, prediction or explanation' (Cannel and Kahn as cited in Cohen and Manion, 1994:272; Cooper and Emory 1995:270). Interviews have many advantages over the other methods of data collection. Interviews, generally informal in nature, augment formal observation

and serve to clarify the meanings participants attribute to a given situation (Hutchinson, 1990: 130). Observing by itself is never enough as the findings can be misinterpreted. In observations and questionnaires it is very difficult and in most cases impossible for the researcher to find out the truthfulness of the participants' responses as there is no opportunity for further probing. In-depth interviews of the participants lend meaning to their observed experiences. They also provide researchers with opportunities to verify, clarify or alter what they thought happened, to achieve a full understanding of an incident, and to take into account the lived experiences of participants. Interviews also allow for greater depth of information (Cohen and Manion, 1994: 272; Cooper and Emory, 1995: 271) by probing the respondents, and they help the researcher see situation through the eyes of the participants (Hutchinson, 1990: 130). The tone, gestures and facial expression of the interviewee can be used to interpret the real meaning the interviewee attaches to the responses.

In this case study of the Department of Mathematics, most of the interviewees were selected from the department as the purpose of the research was to understand how the lecturers and students of the department prepared themselves for the implementation of OBE. The HOD of the Mathematics Department, a mathematics lecturer from the JPTD department, three groups of students from each of the STD 3, SPTD 3 and JPTD 3 classes were interviewed. Being the implementers of the new curriculum the lecturers and the HOD of the department were the appropriate people to talk about the preparation taken in ensuring the implementation of the new curriculum. The students were in a position to talk about the real implementation of the new curriculum at classroom level. Three different lecturers taught the different classes and it was considered better to group the classes separately. As OBE was already implemented in the Foundation and Intermediate phases at the national and provincial levels, the implementation of the new curriculum should have been at an advanced stage in the Junior and Senior Primary sections of the college. The interviews with the lecturers revealed that the level of implementation was different among the different sections of the students. As a result the students were grouped according to their classes. All four students in STD 3 were included in the group. A group of students from JPTD was interviewed. In the SPTD 3, students were grouped

according to the schools where they did Practice Teaching. As one of the issues used in the frame of questions was related to Practice Teaching, grouping them according to the school was thought ideal. One student attached to each school was identified and he/she was given the task of selecting two students from each of the four schools where they did the practice teaching. It ensured a good representation of student participants in the interview following the principle of snowball sampling (Cohen and Manion, 1994:89). The HOD of the Department of Education was also interviewed, as it was considered very important for her to give details about the inclusion of theoretical aspects of OBE principles and philosophies in the department's curriculum. Being in charge of the Practice Teaching, she could also give details of steps taken to ensure that student teachers applied OBE principles in their teaching. Moreover being an OBE trainer for teachers in the region she was in a good position to assess the preparations taken by the college with respect to OBE implementation.

The interview findings from the pilot study conducted the previous year were also used. In the pilot study a former rector of the college who was one of the founding members of the college, the present rector of the college, Head of Department of the Junior Primary Department, Head of Department of Mathematics, and a group of students from various courses were interviewed. The former rector was interviewed to get the full historical details of the growth of the college from its inception. The head of the JPTD department who has been in the college since its inception was considered ideal to give a detailed account of the developments of the college over the years. She could also give an account of her department's preparations towards the implementation of OBE. As she is involved in the IMBEWU programme, an in-service teacher- training programme sponsored by the British Government in the Eastern Cape, she was in a good position to discuss the details regarding the readiness of the college in general and her department in particular. The rector of the college was interviewed to gather information on the steps taken by the management of the college towards introducing C2005 and OBE in the college. The students were interviewed to get their version of the preparation and readiness of the college as a whole and some departments in particular.

Separate interview schedules were drawn up to suit each individual interviewee or group of interviewees. From the researcher's experience with students in the pilot study interviews it became clear that a fully structured interview schedule might not work for students all the time. Most of the time they needed more explanation of questions to give valuable and clearer responses. The same was the case with some other interviewees. Very often the researcher had to deviate from the structured schedules to accommodate the interviewees' backgrounds and interests. As a result, it was decided to design an initial framework for the interview with the important issues to be discussed and to follow this up with an unstructured interview. The last four issues identified in the design of the questionnaire were used as a basis for the interviews. As in the case of the questionnaire, close-ended, open-ended and funnel types of questions were used in the interview. For students close-ended questions were mainly used with very few open-ended questions as it was found difficult to yield valuable responses from them. Open-ended questions were mainly used for lecturers. According to Cohen and Manion (1994) open-ended questions are flexible and they allow the researcher to probe so that s/he may go into more depth if s/he chooses or to clear up misunderstandings. They also enable the interviewer to test the limits of the respondent's knowledge and encourage co-operation and help establish rapport. Open-ended questions also allow the interviewer to make a truer assessment of what the respondents really believe. The weaknesses of both types of questions were taken care of by mixing close-ended questions and open-ended questions in conjunction with probes (Cohen and Manion, 1994: 276).

Having decided on the participants and the issues on which questions were to be asked the next task was to conduct the real interview. First the participants were contacted in person and the purpose of the interview was made clear. Also confidentiality of data was assured and dates for the interview were fixed. I did not have many problems in arranging the interviews since all of the participants were from the college. Even though the dates for the interviews were arranged well in advance, in some cases the interviews did not materialise due to unexpected and unavoidable circumstances experienced by some of the interviewees. Especially in the case of the students the problem was very serious. Also when the researcher arrived at the venue some of the participants who were considered

key respondents were found missing without any warning or information. In some cases the interviews were postponed and this resulted in the researcher struggling to complete the task on time. A researcher should be prepared for these types of eventualities. The only possible precaution any researcher can take is to fix the dates of interviews very well in advance. Even then unforeseen circumstances may occur.

The venues for the interview of HODs were in their offices and for the interviews of most of the students I used a laboratory that was quiet and peaceful. Identifying a quiet venue with minimum interruptions was found to be very important for conducting the interview successfully. Some visitors of the HODs disturbed the interviews. In the case of the JPTD students, I had to use a classroom since the laboratory was not free on that day. The noise created by students outside as well as unexpected invasion of the class by other students really threatened the peaceful conduct of the interview. The real problem caused by the excess noise was revealed only while trying to transcribe the interview. Some of the experienced interviewees locked their rooms to prevent disturbances. I suggest keeping a poster like " *Please don't disturb. Meeting in progress/ Interview in progress*" on the door might help in this respect. Requesting the interviewee politely to lock the door might be another option to solve the problem. Another suggestion given by (Easton et al: 2000) is not to use the office of the interviewee. However, I found it improper to request senior officers to a venue of the researcher's choice. It would be better to conduct the interview in their offices by taking necessary precautions to avoid the shortcomings. It would make them more comfortable and at ease to answer the questions in natural settings.

In the beginning of the interview, as suggested by Tuckman (1972), each interviewee was briefed on the purpose and nature of the interview and was given the reassurance of confidentiality. Such an introduction to the interview is found to make the interviewee more at ease. Permission was sought to use a tape recorder for recording the interview. From the pilot study, tape recording the interview was found to be much easier than taking notes during the interview. The researcher could listen attentively to the responses, watch the gestures and facial expressions of the respondents. It would help in interpreting

the responses later. The interviewees were also found more at ease and co-operative when using the tape recorder as the researcher could devote more time and attention to them. As a precaution the researcher had an extra battery and tapes and always made sure that the tape recorder was in a working condition. It ensured the smooth conduct of the research without any technical problems. The unstructured nature of the interview resulted in extending the time of interview and deviating from the originally planned questions. The researcher should be cautious about the time taken by the respondent for each question, especially open-ended questions. At times you may have to gently intervene in making the responses brief.

### 3.4.2.3 DOCUMENT ANALYSIS

Documents are very valuable in interpreting data gathered from interviews and questionnaires. Document analysis is a useful alternative method as a check on data collected (Conrad as cited in Hutchinson, 1990:131). Documents can be used in supporting and verifying the information collected through interviews. The author sought permission from the rector of the college to make use of the documents available in the college. Confidentiality of the information was promised. Permission was granted and the need to keep sensitive issues confidential was stressed. In this research the issues discussed in the interview regarding the past of the institution was verified by going through the documents. Availability of policy documents and circulars was also checked. Being an exploratory research, documents such as textbooks, internal and external circulars, government documents, magazines and periodicals and journals were perused to gather information regarding the research topics and relevant methodologies. Other research papers on the same or similar topics were also consulted to collect guidelines for the research.

The following internal documents were perused:

- Admission Register to find out the number of students admitted annually in the college since inception. It was also used to see whether the admission requirements were adhered to in admitting students.
- Student files to find out the symbols scored by students in their matric examinations.
- Governing Body meetings file to see whether the implementation of OBE was included in the agenda.
- OBE file to check for internal and external circulars regarding the implementation of OBE in the province and in the college
- EMIS file for information on the resources/ facilities in the college and the number of students and lecturers on a yearly basis
- Course Guides in Mathematics for the various classes to see whether the mathematics curriculum had been modified to accommodate OBE
- Journals of students to see copies of demonstration lessons, lesson plans used by students and evaluation forms used by lecturers for assessing Crit-lessons during Practice Teaching.
- Final Year Question Papers for the year 2000 to see whether OBE issues were reflected in the assessment.

In addition to these internal documents the following external documents were also analysed or perused.

- Government Documents such as a White Paper on Education (1995a) as part of the literature review
- Norms and Standards for Educators
- Norms and Standards for Teacher Education
- Policy Document for Foundation, Intermediate and Senior Phases
- Other Documents and training materials published by the National and Provincial Departments of Education for OBE training for Grade 7 teachers
- IMBEWU Report which includes an audit of the college's capacity
- Curriculum Review Committee (Chislom) Report

- Many articles on OBE from print media and internet
- Research Projects on related topics from the university library

Some of the government documents and other important articles on OBE were accessed through the internet.

Being a staff member of the institution, I thought I had easy access to the documents and could use them whenever needed. But my experience proved otherwise. In institutions like the college where the important documents are kept in the office of the top management, access to these documents is very restricted and limited especially when the head of the institution is away for a considerable period of time. Officials who are assigned to make these documents available have other jobs too. It may not be possible for them to make the documents available when you want them. Sometimes the file may be wrongly marked or labelled and the available documents might not be in any order. Some valuable documents may not be available. The researcher may have to spend hours searching for what he is really looking for. A researcher must always be aware of these problems and start well in advance with proper planning. To make things easier, the researcher should give a list of documents or files well in advance to the officials responsible for making these documents available. The researcher should have a clear idea of what he is looking for since a file has so much data and all of it may not be relevant for the research. Extracting the relevant information from the documents is a hard task that demands a lot of time. Taking extracts from the documents or even making photocopies of relevant pages will make the analysis of data easier. Such copies could even serve as appendices for reference purposes.

## 3.5 DATA ANALYSIS

Data analysis usually involves reducing accumulated data to manageable size, developing summaries, looking for patterns and applying statistical techniques (Cooper and Emory, 1995:67). Even though the research is predominantly qualitative, some quantitative methods were employed to analyse the data. For the questionnaires, frequency tallies of

the responses for each question were made. For open-ended questions the main themes or concepts emerging from the responses were identified and tallies were made. These tallies were used to find out the general trend of agreement or disagreement by the respondents. The ' don't know' and irrelevant responses were discarded as they were very small in number compared to the total responses.

Interviews were transcribed and edited to remove irrelevant references which occurred during the interview. Questions and responses in the interview were coded for reference purposes. Questions and responses for Interviewee No:1 among lecturers were coded like AQ1, AQ2 ... and AA1, AA2... respectively . Questions and responses for SPTD 3 students were coded like SPQ1, SPQ2 ... and SPA1, SPA2. For STD and JPTD similar codes were used. The transcribed interviews are not included in the book but are available on request. As suggested by Hycner (1985), I read the transcribed interviews many times and listened to the original interviews many times and made rough summaries of the main themes in each interview. Following the principle of content analysis (Cooper and Emory, 1995:385-87), categories of responses of the interviewees for the questions related to the main frame were grouped together and compared to look for emerging patterns, ideas, explanation and understanding (McMillan, 1996).

The data collected from observation, documents, questionnaire and interviews were triangulated. The responses of lecturers on main issues were compared. Responses from the three groups of students were also compared. Then the responses from lecturers and students were crosschecked. Findings from the interviews were crosschecked with those from the questionnaire. Again these findings were compared and contrasted with those from observation and document analysis looking for consistencies and inconsistencies in the findings.

Analysis of data was found to be tedious and time consuming. In this study it was made more difficult by the nature of the unstructured interview. I would like to use the difficulty I experienced in analysing the interviews to caution novice researchers on the importance of following a structured interview schedule, especially in the beginning. It

also highlights the importance of reducing the number of interviews and the number of questions in the interviews. The researcher should be focussed on the research question, especially in small-scale research like this. I hope that the wealth of information gathered through the various data gathering techniques will have improved the validity and reliability of the findings.

## 3.6 CONCLUSION

In this chapter an overview of the two main research paradigms, quantitative and qualitative paradigms, was given. Being a case study, following a qualitative paradigm, a qualitative, and interpretivist and a constructivist approach was mainly used in the research. However in analysing the data, quantitative methods were also employed. A blend of different research techniques such as observation, surveys (questionnaire and interviews) and document analysis was used in collecting the data. A brief description of each method and its merits and demerits, the real data gathering processes and the problems encountered in the processes are also given. I realised that it was very important to go through relevant literature related to the research topic and research methodology to be employed before embarking upon the research. Going through the literature helped me realise the merits and demerits of each research techniques. I chose to employ a blend of various methods following the various paradigms so that each method and paradigm can complement the other.

# CHAPTER 4
# RESEARCH FINDINGS

## 4.1 INTRODUCTION

The first part of this chapter gives the findings about the research site which is the Siyafundisa College of Education and the Mathematics Department in the college. In the following section the research findings from the various research methods and tools are described under separate headings.

## 4.2 SIYAFUNDISA COLLEGE OF EDUCATION

In order to understand the current state of affairs and the success of any programme in an institution, knowledge of its historical background is very important. Knowledge about the ethos of the institution, what it is at present and where it is heading to can indicate the level of success of any programme initiated there. Preparations for the future in any organisation depends to a large extent on its past. " To prepare (and *to understand the preparations)* for the future we need to understand the past" (Van Harmelen, 1997) (italics my emphasis). It seems ideal to have a brief look at the history of the college to investigate the preparedness of the college in general and the Mathematics Department in particular.

In this section a brief description of the college where the research has been conducted is given. The historical background to the establishment of the college, its bio-physical and socio-political situations and the present situation are given. The situation at the Mathematics Department, which was the focus site of the research, has also been presented.

### 4.2.1 BACKGROUND TO THE ESTABLISHMENT OF THE SIYAFUNDISA COLLEGE

Siyafundisa College of Education is centrally situated in one of the largest townships in the Eastern Cape. It was established, according to the Bantustan Education Policy of "own development and self determination" for the black population. Prior to the establishment of the college, there was no tertiary institution in this thickly populated township. The matriculants of this area who did not get matriculation exemption had no chance of pursuing any further education. This prompted a group of concerned citizens of the early 70s to request the then Homeland Department of Education to open a teacher training institution in the area. The request was granted and the Masakane Training School (fictitious name) came into operation in January 1976. The training school began functioning in the premises of a primary school under the leadership of a retired principal with 70 intakes and 23 teachers. Towards the end of December 1976 a prominent local educationist took over as the principal. Since the admission requirement was the then Junior Certificate (JC), the graduands of the training school were considered inferior to matriculants. There was a desire to upgrade the institution into a College of Education and a formal request was forwarded to the Homeland Department of Education. The Masakane Training School was upgraded into a college of education in 1978. The institution was named after a very prominent educationist and civil rights campaigner and it started operating on its present site in 1979.

### 4.2.2 PHYSICAL OVERVIEW OF THE COLLEGE

The college grew in size in a very short period. The highest intakes were reported in the 1990s. In 1994 there were almost 900 students and 61 lecturers. 75% of the lecturers had postgraduate qualifications. The admission requirements were raised and new courses were also introduced. The college, which initially started with JC course in the year 1983, started offering courses in JPTD, SPTD and STD.

The college has a reasonably good infrastructure. It has spacious classrooms, demonstration rooms, a great hall, laboratories, library, chalkboard room, media centre, computer lab and other facilities required for the efficient operation of a college of education. Even though some of these facilities are not in the best operational state, with minor modification they could be upgraded sufficiently. However lack of hostel facilities for students and accommodation for lecturing staff limits the teaching and learning activities to the prescribed tuition hours only. Even though the college is centrally located in the township, students on a regular basis come late for morning lessons, especially for the first lesson. This is mainly attributed to the transport problem faced by the learners who are living in the suburbs of the township. Taxis are the common transport for majority of learners and a few lecturers. As a result students and lecturers who mostly live away from the college rush for their residences as soon the lectures are over. Very few tutorials or mentoring activities take place at the college after the official lecture hours of 8: 00 in the morning to 2: 00 in the afternoon.

### 4.2.3 SOCIO-POLITICAL OVERVIEW

As mentioned earlier in the background to the establishment of the college, the college was established to uplift the children of the poor community of the surrounding townships. The socio-political situation of the community, to a very large extent, affected the college in many ways. According to the HOD of the JPTD department, "*most of the early students were taxi drivers, factory workers and housewives. They were students during the day and workers and housewives in the evening*". As gathered from the admissions register of the college, parents and guardians of most of those students were unemployed or "labourers, maids, pensioners etc". Only a very small portion of the parents had permanent jobs like nursing, teaching and other clerical jobs. A good portion of students (75%) who responded to the questionnaire cited financial problem as one of the reasons for joining the course and the college (Appendix 2: Q3). Most of the students at the college come from poor families which are not in a position to give enough financial support for the learners. As a result the learners are not in a position to

buy the necessary textbooks and other learning support materials. They mainly depend on the skeleton handouts and notes given by the lecturers.

Like many other tertiary institutions in the country Siyafundisa College also experienced political interference in its 24-year history. As Interviewee No.1 commented the present situation at the college is not conducive to learning. As he correctly observed, the situation at the college has changed over the years in such a way that " *seemingly now students are in charge of the college*". The college witnessed many toyi-toyis from the students to protest against the then homeland government and the education department (as part of the struggle against apartheid), the management of the college and even against some lecturers. In most of the toyi-toyis the students won or their demands, including forced removals of lecturers and even the rector at one stage, were granted. This resulted in students gaining the upper hand in college affairs, which in many cases caused frustration for the lecturers. However in recent years the atmosphere in the college has been relatively calm. It could be due to the relatively small student population or due to the management style of the new administration in the college to please the students at any cost. Even though there are various politically affiliated student organisations in the college, no real tension exists among them. However, it seems, there is a clear division among the academic staff. The most noticeable groups are the pro-management and anti-management groups. The two groups fight for supremacy and point fingers at each other. This has resulted in developing a negative attitude among the lecturing staff towards the college and the teaching profession causing deterioration in the overall standard of the college. In my opinion this resulted in bringing down the academic standard of the college.

### 4.2.4 THE PRESENT SITUATION AT THE COLLEGE

The present situation at the college with respect to tuition is chaotic and frustrating. As a staff member of the college, I was able to witness the gradual fall of the college from its past reputable state to the present lamentable state. The college which was recognised as one of the best in the then homeland has deteriorated to such an extent that you can easily

notice lack of discipline, work ethics and commitment among learners and lecturers. It is very doubtful whether any serious academic work takes place in the college. Those learners and lecturers who once were eager to join this college, now seemingly regret doing so. Some of the respondents of the questionnaire expressed disappointment and unhappiness at joining the institution.

Nowadays when the college starts at 8: 00 in the morning, not even a quarter of the student population is in the classes. Very often by the break time at 11: 15 students leave the classes. Either they go home or bask in the sun. The location of the college also affects the tuition. Being the only educational institution with a reasonably large hall right inside the residential area, the local community on a regular basis uses it for social gatherings such as weddings, funerals and other functions. On Monday mornings after such weekend gatherings in the college hall one or two lessons will be lost before the chairs and tables are put back in the classrooms. Sometimes the surroundings and even some classrooms will be in such a mess that students and lecturers will not be able to enter the classrooms.

Lack of job opportunities for the new graduates in the post-election South Africa resulted in a decrease in new admissions. In 1999 the college was unable to select candidates with the correct admission requirements to fill the 50 seats allocated to it. To keep the institution going entry requirements were lowered and students with inferior entry points were admitted. Students who did not get the required symbols in matric examination were admitted on condition that they would rewrite those subjects in which they did not get the required symbol. Most of them have not passed these subjects even now since they were not given the opportunity to sit for the matric exams in the subsequent years. The fact that some of the third year diploma students were registered for matric examinations in the year 2000 in their subjects of specialisation is a matter of concern. This really poses a problem for the lecturers especially in the content subjects. As Interviewee No.3 said" *these poor intakes every year really has a negative impact on the academic programmes of the college*". Students find it difficult to cope with the academic programme of the courses offered and lecturers get frustrated at the poor performance of the students.

According to government policy, as part of rationalisation of education system in the country, the college will be disestablished by the end of year 2000 and new admissions have been discontinued. At present the college has approximately 125 students and 25 lecturers. In the rationalisation process conducted in 1999, only 18 lecturers were retained and the others were declared in excess. Some of those excess lecturers are not yet redeployed. There is no clear direction about the fate of the present second year students and the remaining staff of the institution. This caused low morale among the existing staff and they are not serious in their work. As one of the interviewees said, *" I am no longer happy because I do not know what is going to happen to me at the end of the year. As a result it is not easy sometimes to go to the classroom. It is natural. You don't feel secured because there is a lot of uncertainty"*. Most of the lecturers entertain similar feelings. Seemingly the staff morale is at its lowest level and most of them take a "don't-care" attitude in participating in the college activities and even in honouring their lesson commitments. Lecturers and learners not honouring lessons were major concerns raised by many learner-respondents to the questionnaire. The management of the college has also adopted a laissez-faire attitude towards the lecturers and learners. No effective steps to control the general absence of learners and lecturers from the college and lessons are taken. No proper attendance record of learners is kept either by subject lecturers or by the departments. Even though there is an attendance register for lecturers, lecturers do not sign in and out regularly in the register. Moreover those who do not attend the college regularly do sign for the days they were absent whenever they come to the college. It is alleged that even those in the top management of the college also practise this. As a result even those lecturers who were always serious with their work are losing their morale and spirit in performing their duties.

### 4.2.5 THE MATHEMATICS DEPARTMENT

The Mathematics Department at the college came into existence as a separate department in 1983 when the college started with JPTD, SPTD and STD courses. Before that the Mathematics Department was part of the Science Department. Since 1983, the department has been offering courses in mathematics content and didactics. Mathematics

content is offered during the 1st and 2nd years in JPTD and the 1st, 2nd and 3rd years in SPTD and STD. The content course is offered in SPTD and STD only for those who specialise in Mathematics. The didactics course is compulsory for JPTD and SPTD courses and for those who specialise in Mathematics in STD and is taught during the three years. The department, except for the JPTD course, handles the didactics course. The JPTD department handles its own didactics course.

The Mathematics Department started with one lecturer. Concurrent with the growth of the college the department also grew in numbers. At times, to meet the demands caused by the increased intake, lecturers from the Science Department also handled some classes. More lecturers were appointed and gradually the department became self-reliant. In 1991 there were 5 lecturers in the department and in 1996 the number increased to 6. All these lecturers had the required qualifications and experience to be college lecturers. At present there are only two lecturers who cater for about 42 students offering various courses in mathematics. Since inception the department of mathematics maintained high standards with respect to the number and qualifications of academic staff, the running of the courses it offered, maintaining the academic standards and producing good results. It had the recognition as an efficiently run department. This could be attributed to the leadership of the department over the years and the harmonious co-operation which existed between the staff and the leadership of the department. It used to have lecturers of different nationalities and cultures who always worked cordially.

The department did not have its own staff room as the college did not have separate staff facilities for each department. Each lecturer occupied a place in one of the common staff rooms where he/she was comfortable. With the limited facilities, the department was able to run a functional departmental library. The department used to have a maths room where mathematical displays such as charts, pictures and mathematical publications were kept. The departmental library and the maths room were closed down in 1996 as part of the renovation effort of the new administration. It is a pity that most of the books transferred to the main library are now missing.

As I mentioned earlier the Mathematics Department in the college used to produce good results in the external examinations conducted by the former DET up to 1996. Since 1996, when DET stopped its functions, the college was affiliated to the Education Department in one of the leading universities in the province for moderating the external examinations (Third year examinations). Since the affiliation close link between the lecturers in the two departments was established and many workshops were arranged in order to modify the syllabus, especially in the Mathematics didactics paper, to accommodate the changes brought about by the introduction of Curriculum 2005 and OB. The courses run by the department and the question papers and memoranda were always approved. There was not a single occasion when the question papers and their memoranda and the marked scripts were rejected by the university staff. This shows that the Mathematics Department at the college used to do a good job over the years. Up to 1996 the management of the college used to support the Mathematics Department very well in its endeavour for academic excellence. In 1996 when the new administration took full control of the college, a negative attitude towards the department started developing and at present the co-operation between the department and the top administration is not that healthy.

## 4.3 FINDINGS FROM MY OBSERVATIONS

As mentioned earlier, the researcher has had the opportunity of observing events in the college for the last nine years. These observations, especially those for the last three to four years, related to Outcome Based Education are mentioned here. Since the inception of the new curriculum, especially in the beginning, there was an enthusiasm and eagerness among the staff and management in implementing the new curriculum. Staff members, mainly from the JPTD department were sent to workshops organised by the Department of Education and various Non-Governmental Organizations (NGOs). Lecturers from the Mathematics Department and one lecturer from JPTD department responsible for Mathematics didactics used to attend, on a regular basis, workshops organised by Eskom Mathematics and Science Education Project (EMSCEP). These workshops mainly focussed on the redesigning of the mathematics curriculum and

teaching strategies based on OBE principles. During 1996-1997 period two or three OBE workshops were organised by the college. From the very beginning lecturers from the college were involved in the OBE training programme organised by the regional office. In year 1999 ten lecturers were selected for OBE training and two of them were from the Mathematics Department. In year 2000 also, all members of the JPTD department and at least one staff member from each of the other departments were involved in the provincial OBE training workshops organised by the region and IMBEWU. However, no initiative was taken by the management to conduct OBE workshops for the rest of the lecturers. Lecturers involved in the regional OBE training programme could have been used in facilitating workshops for the lecturers and students. It was only at the beginning of 2000, after a very long period, an OBE workshop was organised for staff and students of the college. It was only through the initiatives of lecturers who are members of the regional OBE training team that the workshop was conducted. The support and co-operation received from the management was very poor.

It was noted that most of the lecturers were positive about the new curriculum and OBE. However only very few lecturers tried to implement OBE principles in their teaching. The theoretical aspects of OBE principles were discussed in general education classes. But the didactics lecturers were not keen to give the students practical exposure in conducting lessons according to the new method. Only very few lecturers conducted demonstration lessons according to OBE principles. Even some lecturers who are OBE trainers were not prepared to conduct lessons using the new method. Some of the lessons mixed the traditional and new method.

The researcher observed SPTD3 student teachers' lessons during Practice Teaching. They were able to select specific outcomes and design some learning programmes and activities relevant to the outcomes. Facilitation of the learning activities revealed that they needed more skills in managing lessons according to the OBE principles. Even though they started well in the beginning, they gradually slipped in to the old system. Most of the time they were not able to make use of the continuous assessment strategies effectively in the classrooms. However lessons conducted by one or two students were

very impressive. They were able to conduct lessons according to OBE principles. Integration of other learning areas into MLMMS was attempted in many lessons.

JPTD lecturers and STD lecturers observed their students. According to the JPTD lecturer, JPTD students also taught their learners according to the OBE principles. They were also found to be in need of more support and guidance. In the case of the STD students most of the lessons were conducted according to the traditional method since OBE was not introduced in secondary schools yet. Generally it was felt that students needed more support from the lecturers and teachers in the schools where the students were attached for teaching practice. It was also noticed that many teachers in those schools gave the students very little or no support in using the OBE principles in their teaching.

## 4.4 FINDINGS FROM THE QUESTIONNAIRE:

A tally of the responses for the questionnaire was made (Appendix III) and the findings are given below.

### 4.4.1 General feelings about the college

Most of the students had just met the minimum admission requirement and only 50% of the students joined the teaching course because of their desire to be teachers. Forty nine percent of the students joined teaching course because of other reasons such as not getting admission for other courses and parental influence (Q: 2). Similarly 75% of the students joined the college because of financial problems while for 32% nearness of the college to their home was the motivating factor. The reputation of the college was cited as a reason for joining the college by only 7%(Q: 3). Eighteen percent of the students were very happy about joining the college, 39% reasonably happy and 46% were either not at all happy or unhappy and disappointed. The reasons given by the happy group included learning for a teaching qualification, application of new methods of teaching by lecturers, teacher motivation etc. The reasons given by 57% of those who are unhappy

and disappointed included lack of proper tuition and training, no motivation, not realizing expectations of the college and lecturers not honouring classes. Fourteen percent of the students cited disorganised situation in the college as a reason for their unhappiness (Q: 4).

### 4.4.2 General preparedness of the college

From the questionnaire it was discovered that 96% of the students had some knowledge about Curriculum 2005 and OBE. Forty six percent of the students are excited about the changes suggested in C2005 and OBE with 18% doubtful and 36 % confused about the changes (Q: 5). Regarding the preparedness of the college 7% were of the opinion that the college was very well prepared towards OBE implementation; 29% rating the preparedness reasonably well while 68% of the students said that the college was either not well prepared or not at all prepared. Introducing changes in the college curriculum according to OBE, making Curriculum 2005 and OBE part of the course, presenting lessons according to OBE, conducting OBE workshops, presenting demonstration lessons according to OBE and the introduction of continuous assessment techniques were cited as evidence by those suggesting that the college was prepared. According to the other group implementation of OBE in the college is very scanty. One respondent even suggested that there is nothing at all taking place in the college to indicate the implementation of OBE (Q: 6). Fifty percent of the students were of the opinion that they were trained according to OBE principles. Lecturers using OBE principles in their teaching and demonstration lessons, discussion of OBE and its terminology in classes using Policy Documents, encouragement given by lecturers to use OBE methods in teaching during Practice Teaching were given as reasons to support their claim. Those (46%) who think that they were not trained according to OBE principles gave incidents like lecturers using traditional methods, saying that they were not sure about OBE, lack of worksheets and other learning materials and lack of training for lectures in OBE as reasons for their belief (Q: 7). Ninety six percent of the students seemed to have taken part in the OBE workshop organised at the beginning of year 2000 and most of them rated the workshop positively (Q: 8). Sixty one percent of the students agreed that there were changes in methods of

teaching in the college (Q: 9) and some of the various new methods used by lecturers were mentioned.

### 4.4.3 Preparedness of the Mathematics Department

Eighty nine percent of the students agreed that the MLMMS department was prepared for implementing OBE. The reasons given in support of the general preparedness of the college were again given by all of the students as the reasons to show the preparedness of the department. However 17% of the students were either not sure or have negative feelings about the department's preparedness. Lack of motivation from the department was given as a reason (Q: 10). Eighty six percent of the students agreed that OBE principles were either taught or used in lessons and demonstration lessons while 14% were on the negative side (Q: 11 and 12). The majority of the students were of the opinion that lecturers in the department used various new methods such as assignments and peer assessment as part of continuous assessment while 29% are of the opinion that tests and examinations were the only form of assessment in the department (Q: 13). Eighty nine percent of the students were positive about receiving training in making learning programmes and learning units and 82% is confident that they were able to make learning programmes and learning units on their own (Q: 14 and 15).

### 4.4.4 Preparedness for Practice Teaching

Sixty eight percent of the students used OBE methods in MLMMS classes during practice teaching (Q: 16). Insistence by teachers in the schools, help given by MLMMS lecturer in using OBE methods and the exposure to OBE methods in the college are cited as motivational factors for using OBE in their teaching. Eighteen percent of the students did not use OBE methods in their classroom teaching. According to them they did not get enough support from teachers in the schools. Moreover some teachers in the schools did not allow student teachers to use OBE methods as OBE was not officially implemented in the grades students were supposed to teach. Only 14% got full support from the teachers in the schools during their teaching practice. Confusion and lack of understanding about

the OBE methods among teachers in schools and the negative attitude of those teachers towards college students are given as reasons for not getting support and co-operation from teachers in schools (Q: 17). Seventy one percent of the students feel that they got guidance and supervision from the lecturers during teaching practice. Advice on how to plan lessons according to OBE, how to develop activities using available resources, how to prepare and present lessons, observing lessons and giving guidance for improvement etc are cited as some guidance given by lecturers (Q: 18). About 78% of the students rated the preparedness of the MLMMS department above average (Q: 19).

### 4.4.5 Shortfalls identified by the students and suggestions

The students identified certain shortfalls in the preparation of the department and the college towards the implementation of OBE. Lack of workshops, lack of resources and facilities, poor methods used by lecturers in teaching, lack of interest shown by lecturers and students, lack of proper training, no proper feedback from lecturers who attend workshops, lack of training in MLMMS etc are cited as main shortfalls. The following suggestions were made to improve implementation of the new curriculum and OBE:

- More OBE workshops should be conducted
- More new books on OBE should be kept in the library
- More textbooks according to OBE should be bought
- More demonstration lessons according to OBE should be conducted
- All lecturers should be trained in OBE
- Everyday one period should be given for OBE
- More co-operation between learners, facilitators and parents should be encouraged
- OBE training of lecturers should be conducted during holidays
- Department of Education should make more funds available

## 4.5 FINDINGS FROM THE INTERVIEWS

### 4.5.1 Interviews of Lecturers

The findings from the interviews of lecturers are summarised as follows:

#### 4.5.1.1 General preparedness of the college

The college is not fully prepared for the implementation of OBE. Some departments especially the JPTD department and some lecturers in other departments are in the process of implementing the new curriculum. Only very few lecturers got adequate OBE training. According to Interviewee No.1, *" amongst lecturers there are some lecturers who have been exposed to OBE in that they are trained for OBE and they are prepared for OBE"*. According to Interviewee No.2, most of the lecturers in the JPTD department went for OBE training. So it was easy for them to integrate other learning areas. According to Interviewee No.5, *" When I teach numeracy, the other lecturers teaching life skills and languages, we come together and plan so that we can integrate the various learning areas"*. According to Interviewee No.3, *"A lot of OBE has been taught theoretically. Enough preparation was not actually made towards the implementation of OBE even in the teaching aspect*". He continued, *"The students themselves were not prepared"*. All lecturer-interviewees were of the opinion that the OBE workshops conducted over the years and the one conducted this year were not enough. Interviewee No.3 expressed concern over the discriminatory way lecturers from various departments were selected for OBE training. However all of them were of the opinion that some kind of preparations was done in training lecturers in OBE.

#### 4.5.1.2 Policy towards implementing OBE

From the interviews it has emerged that no clear policy was adopted at the college with regard to the implementation of OBE. According to Interviewee No.3, " *only in one or two occasions during the HOD council meeting the issue (of OBE) was raised and the JPTD department was given the encouragement to try and implement whatever they learned from the course. Regarding the intermediate and senior phases the impression was that still there was time. There was no clear policy guideline from the management regarding the implementation of OBE"*. According to the interviewee, if at all OBE was

implemented in any learning area it was only through the initiative of the department concerned. According to Interviewee No.1, " *No policy was made by the college. It is only those lecturers who have been exposed to OBE who took the initiative to implement it*". The interviewee continued, " *a mention was made of the Curriculum 2005, no emphasis as such was made. There was no consensus reached by all members of the HOD council for the full implementation*". The other lecturer also had the same view when it was said that there had been no guideline or policy from the head of the institution. Regarding the support the various departments received from the management, Interviewee No.2 commented, " *That is a problem. I don't think we got it. We had a problem in the college. I don't know how to answer this question*". The response by Interviewee No.3 on the same issue was " *I'd rather not go into that*". This confirms the lack of support the departments received with respect to OBE implementation.

#### 4.5.1.3 Changes effected in the curriculum

The college curriculum was not changed fundamentally to incorporate the new changes suggested in Curriculum 2005 and OBE principles. According to Interviewee No.1b, *"We did not do much to change curriculum. The rector approached me as the HOD of Education Department and said that the only way we can start this is by me teaching the theory part so that the students will have knowledge of OBE*". In the words of Interviewee No.2b, " *Here at the college we are trying to (lecture) principles of OBE rather than implementing it. I mean using activities when we do our micro teaching, something like that...*". According to the HOD of mathematics department, " *We worked as a team with the other colleges affiliated to the university for moderation of question papers and memoranda to look at OBE issues. Assessment techniques changed. We started giving projects as part of assessment. No changes were effected in paper. But the theoretical aspects of assessment techniques were treated theoretically. The syllabus is not redrawn. But the course guides show the changes. No major changes were made in Maths content*".

#### 4.5.1.4 Demonstration Lessons

According to Interviewee No.3b, " *After the workshop, demonstration lessons in OBE were organised for the students by the lecturers and later by students themselves. These were done with the hope that the students should try their best to implement the idea of OBE teaching*". This interviewee expressed the department's intentions to organise more demonstration lessons. As the HOD of Education Department said some lecturers demonstrated lessons according to OBE. According to the HOD, teachers in the Mathematics Department tried to implement OBE. The JPTD lecturer also explained how she conducted demonstration lessons using group work and the new assessment techniques.

#### 4.5.1.5 Teaching Practice

According to the three lecturers most students in JPTD and SPTD tried to use OBE methods in their teaching. In the words of Interviewee No. 1b, "*the students tried to do a little in implementing OBE*". According to Interviewee No.3b, "*STD students were not able to use OBE methods as it was not introduced in high schools. More over the teachers in most of the high schools did not allow them to try OBE methods*". Some teachers in the Junior Primary and Senior Primary (Foundation and Intermediate Phases respectively according to the new policy document) classes did not allow students to teach according to OBE principles. OBE was not introduced in some of the grades in some schools where the student teachers taught. Most of the teachers were found wanting in OBE principles and techniques and as such they were not in a position to render any assistance to the student teachers.

### 4.5.2 Interview of students

Students were interviewed in different groups according to their classes and the responses are summarised as follows. Almost similar responses were obtained from the three groups.

Most of the students were of the opinion that the college was not fully prepared for the implementation of OBE. According to the groups those lecturers who attended OBE workshops tried to implement the new methods of teaching according to OBE. According to JPTD students, *" Some of them are teaching in OBE. There is only one teacher who is using OBE. The others are not using OBE. For example in Maths we are doing OBE. In Primary Science we are taught in OBE. Others are not using OBE"*. SPTD students were of the opinion that they were not well prepared in OBE. However SPTD students named subjects like Technology, Mathematics, Education, School Management, English and Xhosa where OBE is used. STD group was taught the theoretical aspects of OBE only in Education. They had no exposure in group work activities and continuous assessment.

All three groups expressed satisfaction about the way OBE workshops in the beginning of year 2000 were conducted. According to SPTD students, *" From that workshop we are able to implement OBE. There were some new things I learnt about like the assessment criteria"*. Some of the students reported using OBE methods in teaching and they feel confident in using OBE methods in classes. JPTD students started OBE in Course I and they studied themes like constructivism, group work and co-operative learning. All students in the interview were of the opinion that lecturers conducted demonstration lessons according to OBE. It became clear in those interviews that there were some efforts from some lecturers to implement OBE. Mathematics lecturers in the JPTD and SPTD sections implemented OBE in the classroom teaching and they tried to help the students to make use of OBE method in their classrooms. All interviewees raised concern over the support and co-operation they received from the teachers in the schools. All of them expressed the need for more workshops and demonstrations for equipping them with more skills in OBE implementation. It was also suggested that all lecturers should be given OBE training.

## 4.6 FINDINGS FROM DOCUMENT ANALYSIS

Copies of returns to the provincial Department of Education gave a summary of student strength, number of lecturers and other resources available in the college. As mentioned

earlier, documents were used to verify claims by the interviewees. Some circulars for sending lecturers for OBE workshops were found. No policy document regarding the implementation of OBE was found in the departmental files. Also there was no indication of any discussion on the implementation of OBE in the agenda or minutes of meetings of the governing council. However, from the OBE file, the names of lecturers who attended OBE training were obtained. It confirmed the claim that some lecturers were trained in OBE. OBE related topics were found in the course guides for the different classes. Contents of course guides in Mathematics Didactics showed that some changes were made in the syllabus to incorporate OBE principles. Copies of demonstration lessons found in the Teaching Practice journals of JPTD and SPTD students indicated the use of OBE methods during demonstration classes. In the journals of JPTD students a new evaluation form (Appendix IV) for assessing students' lessons was found. Copies of lessons (Appendix V) taught by some of the students indicated that those students took some initiative to conduct lessons according to OBE principles. Questions related to OBE themes were found in the final examination question papers. However there was no indication of changes in the assessment policies. As a whole some of the documents indicated that some lecturers tried to implement OBE methods.

## 4.7 CONCLUSION

The findings from the various research tools and methods are given in this chapter. The findings from each of the tools and methods are described under separate headings. Results of the questionnaires of the lecturers and students given under separate headings of important issues as described in section 3.4.2.1.Findings of the interviews of the lecturers were also put under separate subheadings. In the case of the student-interviews, findings were just summarised in one heading. Findings from observation, questionnaires, interviews and document analysis were compared and crosschecked to arrive at the concluding remarks of the research given in the next chapter.

# CHAPTER 5
# CONCLUDING REMARKS

## 5.1 INTRODUCTION

In this chapter the findings from the research are summarised. The limitations of the research and suggestions arising from the research are also presented. The chapter concludes with an overall reflection of the research project.

## 5.2 FINDINGS FROM THE RESEARCH

It is concluded from the research that the Mathematics Department at Siyafundisa College of Education is not fully prepared in effecting changes proposed in the new curriculum and in implementing the OBE approach in teaching. Analysis of the data collected in the research shows that the department is in the process of implementing OBE. Some lecturers try to implement OBE in their teaching. Most of the student interviewees were of the opinion that the students have a reasonably good understanding of the principles behind OBE. However, there is a general consensus that more could have been done to make the implementation of OBE more effective if there were more concerted effort from the department as a whole instead of interested lecturers taking individual initiatives.

With regard to the two research questions it is found that some lecturers of the mathematics department received proper training towards the implementation of Curriculum 2005 and OBE. It is also found that some modifications were effected in the current syllabi and academic programmes of the department to accommodate Curriculum 2005 and OBE. However, the HOD's statement that 'nothing is put on paper' with regard to modifications made in the mathematics curriculum shows the lack of planning and commitment in the department toward OBE implementation. Clearly it is an indication of lack of preparedness and commitment of the department in implementing the new curriculum.

The following were identified as possible reasons for the department's non-preparedness in fully implementing the new curriculum and OBE.

- Lack of urgency in The Provincial Education Department's effort in bringing colleges of education on board for OBE training.
- Lack of and delay in communication from the Provincial Department of Education with regard to the new curriculum implementation.
- Lack of enthusiasm and commitment in the top management of the college and the head of the Mathematics Department in implementing the new curriculum
- Lack of adequate policy guidelines and directives given to various departments with respect to the implementation of the new curriculum.
- Lack of cooperation and mutual support between the management and the Mathematics Department.
- Non-identification of collective responsibility for curriculum change rather than individual effort.
- Lack of commitment from all stakeholders in making sure that the implementation of the new curriculum succeeded.

All the above points are worth researching with respect to implementation of a new curriculum.

Even though some lecturers from the college used to attend OBE workshops over a period of two to three years, it was only in the year 2000 one reasonably successful workshop was organised for the other lecturers and students. Lecturers developed a negative attitude towards OBE due to the uncertainty regarding its future coupled with their anxiety regarding the redeployment process. It also might have affected lecturer's initiative to implement OBE methods in their classes. As most of the student interviewees suggested, some lecturers did not want to change their old method of teaching because OBE was confusing to them.

Lack of discipline and poor attitude to work among students and lecturers created by the general lawlessness in the college were cited as reasons for the poor implementation of

OBE. Even those who were serious about their work were not able to carry out their functions. The effect of weak and dispirited students in implementing a challenging system like OBE proved disastrous. However the researcher is of the view that if lecturers had tried as an organised group with a long-term vision of introducing OBE in the college, it would have yielded better results. Those who tried to implement OBE at least succeeded in initiating the change. This would have encouraged other lecturers and the college management. If the management were serious about implementing OBE and had formulated some policies towards that, definitely all departments would have tried to implement it. However I am of the opinion that the Mathematics Department, at the departmental level, could have been proactive and could have taken a leading role in initiating the process of implementing OBE. It had all the necessary human resources at its disposal and many of the lecturers did get training in OBE over the years. The failure of not achieving the desired progress in the implementation of OBE by those who started it could be attributed to the lack of support from the department and the top management of the college. The example of the Mathematics Department at Siyafundisa College could be taken as a typical example of what is happening in most of the educational institutions in the Eastern Cape. The OBE programme, like any other programme in any institution, will succeed only if the top management are enthusiastic about it.

## 5.3 LIMITATIONS OF THE RESEARCH

This research was conducted by a lecturer in the Mathematics Department which was researched. The issue of researcher bias, to a certain extent, could be mentioned as one of the limitations of this research. However the researcher mainly depended on the responses of the participants in drawing the conclusion to minimise the bias. Another point of concern is the fact that the researcher is also the lecturer of most of the student participants in the survey. It threatens the reliability of the data collected. Sometimes the students could have given responses to please the lecturer. Or they could have deliberately withheld some valuable information which they considered displeasing to the lecturer. Another limitation is the fact that the researcher used responses collected in the pilot study conducted the previous year. No attempt was made to confirm whether the

respondents still hold the same view. Some of the respondents might have changed their views in the interim. Another drawback is the inability of the researcher in rectifying confusions created by multiple answers and incorrect responses found in the questionnaire.

## 5.4 SUGGESTED SOLUTIONS

With the closure of Siyafundisa College of Education, it seems that the suggestions given below are of little value. However, as curriculum changes are ongoing processes in education, it is hoped that the suggestions would be beneficial to other teacher education institutions or any other educational institutions embarking on curriculum changes.

One of the main problems identified in the research towards the implementation of OBE in the Department of Mathematics was the lack of direction and co-operation from the top management of the college. Any change in school programmes, especially changes in curriculum requires the support of the head of the institution. The positive attitude and commitment of the head of the institution could, to a large extent, influence the way the changes are implemented. Advocacy workshops should be organised for the heads of institutions prior to the implementation of the new curriculum. In educational institutions like colleges of education, members of the HOD council should be encouraged to increase their awareness of the curriculum change. Clear policy guidelines should be formulated to make sure that the new curriculum policies are implemented in the curriculum of the institution. Mechanisms should be placed to ensure that various departments implement the policies and the implementation should be monitored. As suggested by all participants, the college or any educational institution embarking on curriculum changes should organise workshops for all those who are affected by the change. Such workshops could help in increasing the awareness and appreciation of the changes and the development of skills needed by the staff to implement the changes. The closure of the institution and redeployment of staff should not have been taken as an excuse for not implementing the changes. The students who are trained to be teachers of the future had every right to be taught according to the new policies to be successful

implementers of the new curriculum. Moreover the lecturers should have taken it as self-empowerment since those who are going to be in the service of Department of Education have to teach according to the new policies very soon.

## 5.5 REFLECTION

The research project was initiated with the intention of making suggestions towards the Mathematics Department's preparedness in implementing C2005 and OBE. Before the researcher finished the project, the college was disestablished as part of the rationalization and redeployment process. I thought of abandoning the research as I was confronted by the question: Who is going to benefit from the research? However, I continued with the project hoping that the research findings would be of assistance to any educational institution, teacher education institutions in particular, embarking upon the introduction of a new curriculum.

The research itself was more challenging and demanding than initially anticipated. I always remembered the analogy given by Prof. Irwin in his research methodology classes (Irwin, 1995). He compared conducting research to learning how to ride a bicycle. Many times I lost direction and went off track. Disappointments due to unsuccessful attempts to conduct interviews, irrelevant answers from participants as a result of them not understanding the questions, inability to meet deadlines proposed by supervisors, inability to fulfil other commitments as a result of research commitments and the delay in getting desired results etc. are some issues which caused disappointments for me. However I managed to complete the project. In my view commitment and perseverance are very important for a researcher.

The data gathering process, though tedious went on without serious problems. Most of the participants were willing to cooperate and support me in my endeavour. Most of the data and findings in the research belong to the participants. It is difficult for me to claim ownership of any particular section of this research. In this regard I am highly indebted to all participants in this research project.

Research findings were not that encouraging. The college as a whole and the Mathematics Department in particular were not fully prepared for the implementation of the new curriculum and OBE. It was more hurtful to observe the inability of the student teachers to conduct lessons according to the OBE methods even though they received training in OBE for three years. This could reveal the inadequacy of the in-service OBE training given to the teachers by the curriculum officials in the provinces across the country in one week. The college as a whole and the Mathematics Department in particular could have done more in modifying the present curriculum to suit the new approach. They could have changed their approach of *siyafundisa* (we teach) to the new approach of *sifunda* (we learn).

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## LIST OF REFERENCES

African National Congress. (1994). A policy framework for education and training. In South Africa (Republic). Department of Education (2000). *National curriculum framework for further education and training*. Pretoria: Government Printer.

Beard, P.N.G., Enslin, P.A and Morrow, W.E (1981). The significance of pedagogics in schooling in South Africa. In Beard, P.G.N and Morrow, W.E. (Eds.), *Problems of pedagogy*. Durban: Butterworths.

Bellis, I. (1997). *Outcome-based education: Issues of competence and equity in curriculum and assessment*. Presented at the International Association for Educational Assessment Conference, Durban.

Bengu, S. (1997). *Curriculum 2005: Lifelong learning for the 21st century*. Pretoria: Government Printer.

Burrell, G. and Morgan, G. (1979). *Sociological paradigms and organisational analysis*. London: Heinemann Educational Books.

Christie, P. and Collins, C. (1990). Bantu education: Apartheid ideology and labour reproduction. In Kallaway, P. (Ed.), *Apartheid and education*. Johannesburg: Ravan Press.

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

Cooper, D. R. and Emory, C. W. (1995). *Business research methods*. Chicago: Irwin.

De Beer, J. (1999). *Teaching natural sciences: How to excel in science teaching*. OBE workshop: Thursday 10 June 1999, Vista University, Bloemfontein.

Easton, K. L., McComish, J.F. and Grenberg, R. (2000). Avoiding common pitfalls in qualitative data collection and transcription. *Qualitative Health Research, 10,* (5), 703.

Edson, C.H. (1990). Our past and present: Historical inquiry in education. In R. R Sherman, R. R and Webb, R. B. (Eds.), *Qualitative research in education: Focus and methods*. London: The Falmer Press.

Erickson, F. (1998). Qualitative research methods for science education. In Fraser, B and Tobin, K. (Eds.), *International handbook for science education*. Dordrecht: Kluwer.

Hycner, R.H. (1985). Some guidelines for the phenomenological analysis of interview data, human studies,8. In Cohen, L and Manion, L. (1994). *Research methods in education* (4th ed.). London: Routledge.

Hutchinson, S. A. (1990). Education and grounded theory. In Sherman, R. R. and Webb, R. B. (Eds.), *Qualitative research in education: Focus and methods*. London: The Falmer Press.

Irwin, P. (1995). *Research methodology*. Lecture notes, Department of Education, Rhodes University, Grahamstown.

Jansen, J.D. (1997). *Why OBE will fail*. Macro-Education Policy Unit, Faculty of Education, University of Durban Westville, Durban.

Jean Lee, S.K. (1992). Quantitative versus qualitative research methods: Two approaches to organisation studies. *Asia Pacific Journal of Management, 9* (1), 87-94.

Kaplan, A. (1973). *The conduct of inquiry*. Aylesbury: Intertext Books.

Kuhn, T. S. (29 October 2000). The structure of scientific revolutions (2nd ed.). In Williams, E. (29th October 2000). Research and paradigms. Unrefereed publication submitted as a requirement for the MComms programme at Victoria University of Wellington. http://www.vuw.ac.nz/~ericw/531a2.htm

Lewis, C. (2000). Provincialisation of education: A review. *Edusource Data News, 30, 1- 23.*

McMillan, J. H. (1996). Educational research fundamentals for the consumer (2nd ed.). Harper Collins College Publishers. In Ngoepe, N. G. and Grayson, D. J. (2000). How teachers prepare students for matric examination: Interviews with mathematics teachers. Proceedings of the 8th Annual Conference of the Southern African Association for Research in Mathematics and Science Education (SAARMSE), 19 –22 January 2000, University of Port Elizabeth, Port Elizabeth.

Mouly, G. J. (1978). *Educational research: The art and science of investigation.* Boston: Allyn & Bacon.

Mulholland, S. (1997, 1 June). The dumbing of SA's school children. *Sunday Times,* p.19.

Naicker, S. M. (1999). *Curriculum 2005: A space for all: An introduction to inclusive education.* Cape Town: Oxford University Press.

Ngoepe, N. G. and Grayson, D. J. (2000). How teachers prepare students for matric examination: Interviews with mathematics teachers. Proceedings of the 8th Annual Conference of the Southern African Association for Research in Mathematics and Science Education (SAARMSE), 19 –22 January 2000, University of Port Elizabeth, Port Elizabeth.

Sherman, R. R. and Webb, R. B. (1990). Qualitative research in education: A focus. In Sherman, R. R. and Webb, R. B. (Eds.). *Qualitative research in education: Focus and methods*. London: The Falmer Press.

South Africa (Republic). (1969). *Report of the Enquiry into the Training of White Persons as Teachers*. Pretoria: Government Printer.

South Africa (Republic). (1992). National Education Policy Investigation. *The framework report and final report summaries*. Cape Town: Oxford University Press.

South Africa (Republic). (1995). *White paper on Education and Training*. Pretoria: Government Printer.

South Africa (Republic). Committee on Teacher Education Policy (COTEP). (1996). *Norms and standards for Teacher Education*. Pretoria: Government Printer.

South Africa (Republic). Department of Education. (1997a). *Senior phase policy document*. Pretoria: Government Printer.

South Africa (Republic). Department of Education. (1997b). *Curriculum 2005: Lifelong learning for the 21st century*. Pretoria: Government Printer.

South Africa (Republic). Ministry of Education. (1997c). *Government Gazette*, No.18051, 6 June 1997.

South Africa (Republic). (1996). National Education Policy Act, 1996. *Norms and standards for educators*. Pretoria: Government Printer.

South Africa (Republic). (2000). *A South African curriculum for the twenty-first century: Report of the Review Committee on Curriculum 2005*. Pretoria: Government Printer.

Spady, W. G. (1996 a). *Dispelling the myths about outcome-based reforms.* Silverthorne: Breakthrough Learning Systems.

Spady , W. G. (1996 b). *The trashing and survival of OBE.* Silverthorne: Breakthrough Learning Systems.

Taylor, S.J and Bogdan, R. (1984). Qualitative research methods: The search for meanings (2nd ed.). New York: Wiley. In Ngoepe, N.G and Grayson, D.G. (2000). How teachers prepare students for matric examination: Interviews with mathematics teachers. Proceedings of the 8th Annual Conference of Southern African Association for Research in Mathematics and Science Education (SAARMSE), 19 –22 January 2000, University of Port Elizabeth, Port Elizabeth.

TIMSS. (1998). *Mathematics and science literacy of final- year school students in South Africa: A report on the performance of South African students.* Third International Mathematics and Science Study. Pretoria: Human Science Research Council.

Towers, J.M. (1994). The perils of outcome-based education. *Phi Delta Kappan, 75* (8), 624.

Tucker, M. L., Powell, K. S., and Meyer, G. D. (1995). Qualitative research in business communication: A review and analysis. *Journal of Business Communication, 32* (4), 383 – 399.

Tuckman, B. W. (1972). *Conducting educational research.* New York: Harcourt Brace Jovanovich.

Van Harmelen, U. (1997). *Two views of education: Where we have come from and where we are going to?* Lecture notes, Education Department, Rhodes University, Grahamstown.

Williams, E. (29th October 2000). Research and paradigms. Unrefereed publication submitted as a requirement for the MComms programme at Victoria University of Wellington. http://www.vuw.ac.nz/~ericw/531a2.htm

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# APPENDICES

# APPENDIX: 1

**OBSERVAION CHART FOR OBSERVING LESSONS CONDUCTED BY STUDENT TEACHERS**

Indicate the correct response for the following questions using a × in the appropriate block

| | YES | NO |
|---|---|---|
| 1. Is the classroom prepared for an OBE lesson? | | |
| 2. Are the learners seated to do group work? | | |
| 3. Is the lesson prepared according to OBE principles? | | |
| 4. Is the lesson learner centred? | | |
| 5. Did the teacher deliver the lesson according to OBE principles? | | |
| 6. Did the teacher deliver the lesson using the traditional methods? | | |
| 7. Did the teacher use both OBE methods and traditional methods? | | |
| 8. Were the learners constructively involved in the learning process? | | |
| 9. Did the learners really work in groups? | | |
| 10. Did the teacher effectively use learning support materials? | | |
| 11. Did the teacher use continuous assessment techniques to assess the learners? | | |
| 12. Did the lesson achieve the proposed outcome? | | |

# APPENDIX 2: QUESTIONNAIRES

Dear students

I am doing a research into the preparedness of the mathematics department at ( ) College of Education towards OBE implementation. May I request you to spend few minutes of your time to go through the following questionnaire and answer the questions as objectively as possible. You may remain anonymous. I assure you that the information given will be used only for educational purposes and as such they will be treated strictly confidential.

I thank you in advance for your patience and valuable time.

## QUESTIONNAIRE

1. Please complete the following table :

| | | |
|---|---|---|
| A | Course you are registered for (Tick the correct response) : | STD 3 STD2 SPTD3 JPTD3 |
| B | Subject(s) you specialise : | |
| C | Year of passing matric : | |
| D | Subjects in matric : | |
| E | Grade and symbol in maths In matric : | |

2. Which of the following motivated you to choose teaching career?[ Tick the correct response(s)]

( ) Teaching is a respected and noble profession.
( ) I had the desire to be a teacher and I like teaching
( ) Teachers earn good salary
( ) Teaching is regarded as an easy job
( ) I did not get admission for any other course
( ) I was forced by relatives/ other circumstances
( ) .....
( Any other reason)

3. Which of the following motivated you to join ( ) College? [ Tick the correct response(s)]

( ) Nearness to house
( ) Reputation of the college
( ) Influence of parents and friends
( ) Availability of the course which I wanted
( ) Financial matters
( ) Other reasons
.....

4. (a) Are you happy and excited about the college and the course you are doing? [ Tick the correct response]

( ) Very much
( ) Reasonably
( ) Not at all
( ) Unhappy and disappointed

(b) Give reasons for the answer to Question:4(a)

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5. Curriculum 2005 and Outcome Based Education have been introduced in our schools.

(a) Do you have any knowledge about Curriculum 2005 and OBE?

Yes/ No [Tick the correct response]

(b) How do you feel about the changes suggested in Curriculum 2005 and OBE?
[ Tick the correct response]
( ) Excited
( ) Doubtful
( ) Confused
( ) I have no idea about what OBE is all about.

6 (a) How do you rate the preparedness of the college as a whole towards the implementation Outcome Based Education?[ Tick the correct response]

( ) Very well prepared
( ) Reasonably well
( ) Not well prepared
( ) Not at all prepared

(b) Which of the following observations / supporting evidence you noticed in the college helped you give the response in (a)? [ Tick the correct response(s)]

( ) The curriculum/ syllabus of the courses are changed according to OBE principles
( ) Curriculum 2005 and OBE principles are taught as part of the course.
( ) Lessons are presented according to OBE principles
( ) Lecturers attend/ attended OBE workshops to get trained
( ) Workshops are conducted for lecturers and students
( ) Demonstration lessons are conducted according to OBE principles
( ) Continuous assessment method is used.
( ) We are encouraged to use OBE method(s) during Practice Teaching.
( ) Implementation of OBE in teaching is very scanty.
( ) None of the above is done at the college.
( ) .....
[ Any other evidence]

7. (a) Do you think you are trained according to OBE principles?[ Tick the correct response]

Yes / No / I am not quite sure

(b) Give reason(s) / evidence(s) to support your answer above.

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8. (a) Did the college conduct any workshop in OBE? [ Tick the correct response]

Yes/ No / I am not quite sure

(b) If your response is yes, how many workshops were conducted?

1 2 3 4 5 Many [ Circle the correct response]

(c) Which of the following is true about the workshops?

( ) Workshop(s) was/were well organized / poorly organized
( ) Issues of Curriculum 2005 and OBE were handled in detail/ not in detail
( ) Participants were grouped according to various phases and learning areas / no separate groups
( ) Enough handouts and notes were given / handouts and notes were not enough
( ) We were workshopped in the preparation of learning programmes and learning units according to OBE principles/ We were just told how to make them
( ) Workshopped on how to make Learning Support Materials(LSM) / no workshop on LSM
( ) Issues in assessment were treated in detail/ very scanty discussion on assessment
( ) Follow up discussions were conducted in didactics classes
( ) .....
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[Any other point(s)]

9. (a) Is there any change in the method of teaching used by the lecturers from the traditional chalk and talk or lecture method? [ Tick the correct response]

Yes/ No / Not quite sure

(c) If your response is Yes, which of the following methods are used by the lecturers?[ Tick the correct response]

( ) Participatory
( ) Group work
( ) Discussion
( ) Discovery method
( ) Interactive method

10. (a) Do you think the MLMMS department in the college is prepared for implementing OBE in their lessons? [ Tick the correct response]

Yes/ No / Not quite sure

(b) Give reasons for your answer above.

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11. Do the MLMMS lecturer(s) use OBE methods in their lessons? [ Tick the correct response]

Yes / No / Not quite sure

12. Do the MLMMS lecturer(s) use OBE method during the demonstration lessons? [ Tick the correct response]

Yes/ No / Not quite sure/ Mixed traditional and OBE methods

13. Which of the following assessment method is used by the MLMMS lecturer(s)?

( ) Tests and examinations only
( ) Continuous assessment
( ) Assignments
( ) Projects
( ) Portfolio
( ) Peer assessment

14. (a) Are you trained how to make Learning Programmes/ Learning units in MLMMS?

Yes / No / Not quite sure.

(b) If the answer is YES how were you trained?[ Tick the correct response]

( ) we were workshopped on the general principles of how to make the learning programmes
( ) we were given examplers of learning programmes and learning units
( ) we thoroughly analysed the critical and specific outcomes in MLMMS
( ) we were workshopped on the use of assessment criteria and performance indicators.
( ) in the class we were given group task to make the learning programmes and learning units
( ) we were given individual task to make them
( ) during teaching practice we were encouraged and supervised to make learning units

15. Are you confident that you will be able to make a learning programme and learning unit in MLMMS? [ Tick the correct response]

Yes / No / not quite sure

16. (a) Did you use OBE method during your Practice Teaching?[ Tick the correct response]

Yes/ No

(b) Give reasons for your response to (a) above

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17. (a) Did you get enough and proper support and guidance from teachers in the schools where you did teaching practice? [ Tick the correct response]

Yes / Some support and guidance/ poor support and guidance/ No support and guidance at all

( b) Give possible reason(s) for the treatment you received at those schools.

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18. (a) Did you get enough guidance and supervision before and during the practice teaching from your MLMMS lecturers? [ Tick the correct response]

Yes/ No / Not quite sure

(b) List down some types of support you received from your MLMMS lecturers

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19. Rate the preparedness and commitment of your MLMMS lecturer(s) in preparing you in OBE. [Tick the your rating . 1 for the lowest and 5 for the highest]

1 2 3 4 5

20. List some shortfalls you have noticed in the implementation of OBE in MLMMS teaching in the College.

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21. Give some suggestions to make the training in OBE and its implementation in classrooms or elsewhere more challenging and effective.

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Once more thank you for your valuable time and patience.

C.Thomas
Department of Matheamtics
( ) College of Education.

# APPENDIX 3: ANALYSIS OF QUESTIONNAIRE

| ITEMS | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 1. GENERAL<br>Number of students responses received from | 21 | 4 | 3 | 28 | |
| Subjects of specialization:<br>Mathematics: 23 Physics: 22 Others: 6 | | | | | |
| Number of years since passed matric<br>Less than 5 years: More than 5 years: | | | | | |
| Symbols:<br>F: E: D: C: B: A: | | | | | |
| 2 Motivation for choosing teaching career | | | | | |
| Teaching is a respected and noble profession | 8 | 1 | - | 9 | 32 |
| Desire to be a teacher | 9 | 3 | 2 | 14 | 50 |
| Did not get admission for any other course | 4 | - | - | 4 | 14 |
| Teachers earn good salary | 1 | - | - | 1 | 3 |
| Forced/ influenced by relatives | 7 | 1 | 1 | 9 | 32 |
| 3. Reason to join the college | | | | | |
| Nearness to house | 7 | 1 | 1 | 9 | 32 |
| Reputation of the college | 2 | - | - | 2 | 7 |
| Financial problems | 17 | 2 | 2 | 21 | 75 |
| Influence of parents and friends | 3 | - | - | 3 | 11 |
| Availability of the course(s) wanted | 3 | - | - | 3 | 11 |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 4(a) Happy and excited about joining the college | | | | | |
| Very much | 5 | - | - | 5 | 18 |
| Reasonably | 8 | 3 | - | 11 | 39 |
| Not at all | 4 | 1 | 1 | 6 | 21 |
| Unhappy and disappointed | 5 | - | 2 | 7 | 25 |
| 4(b) (i) Reasons for being excited | | | | | |
| Facilitation for the required teacher qualification | - | - | - | - | - |
| Provides other courses/skills, new methods are taught, course reasonable, teacher motivation etc | 5 | 3 | - | 8 | 29 |
| Course easy and what is desired | 1 | 1 | - | 2 | 7 |
| 4(b) (ii) Reasons for being unhappy | | | | | |
| Not getting enough tuition and training, no motivation, not realizing expectations of the college, lecturers not honouring classes | 11 | 3 | 2 | 16 | 57 |
| Uncertainty of getting job | 1 | - | - | 1 | 3 |
| Disorganized situation in the college | 3 | - | 1 | 4 | 14 |
| Other reasons | 7 | - | 1 | 8 | 29 |
| 5 (a) Knowledge about Curriculum 2005 and OBE | | | | | |
| Yes | 20 | 4 | 3 | 27 | 96 |
| No | 1 | - | - | 1 | 3 |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 5(b)Feeling about the changes suggested in C2005 and OBE | | | | | |
| Excited | 7 | 3 | 3 | 13 | 46 |
| Doubtful | 4 | 1 | - | 5 | 18 |
| Confused | 9 | 1 | - | 10 | 36 |
| No idea | 1 | - | - | 1 | 3 |
| 6 (a) Rating the college preparedness towards OBE implementation | | | | | |
| Very well prepared | 1 | - | 1 | 2 | 7 |
| Reasonably well | 6 | 2 | - | 8 | 29 |
| Not well prepared | 13 | 2 | 2 | 17 | 61 |
| Not at all prepared | 2 | - | - | 2 | 7 |
| 6(b) Reasons for the above answer(s) | | | | | |
| Change in curriculum according to OBE | 5 | - | - | 5 | 18 |
| Curriculum 2005 and OBE are part of the course | 7 | 1 | - | 8 | 29 |
| Lessons are presented according to OBE | 4 | - | 1 | 5 | 18 |
| Lecturers attend OBE workshop | 9 | 2 | 1 | 12 | 43 |
| Workshops in OBE are conducted | 7 | 1 | - | 8 | 29 |
| Demonstration lessons are conducted according to OBE | 8 | 2 | - | 10 | 36 |
| We are encouraged to use OBE during practice teaching | 17 | 1 | 1 | 19 | 68 |
| Implementation of OBE is very scanty | 2 | - | 1 | 3 | 11 |
| None of the above is done at the college | 1 | - | 1 | 2 | 7 |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 7(a) Do you think that you are trained according to OBE principles? | | | | | |
| Yes | 10 | 1 | 3 | 14 | 50 |
| No | 2 | - | - | 2 | 7 |
| Not quite sure | 8 | 3 | - | 11 | 39 |
| Reasons given for the YES response:<br>Some lecturers use OBE method in their teaching; Demonstration lessons are conducted in OBE; OBE principles and terminology discussed in class; Group work and discussions are encouraged; Trained how to use the policy document to look for SO, AC, PI etc; Encouraged to use OBE method during practice teaching | | | | | |
| Reasons given for the NO response:<br>Most lecturers use traditional methods; NO worksheet and other support materials used by lectuers; Lecturers say that they are not sure about OBE;<br>Lecturers give work and other tasks without teaching claiming that OBE encourages learners to be researching; Some lecturers describe OBE not understandable; Lecturers and educators in schools are not trained properly and they have no idea of OBE. | | | | | |
| 8(a) Any OBE Workshop organized? YES<br>NO | 20<br>1 | 4<br>- | 3<br>- | 27<br>1 | 96<br>3 |
| b) Number of workshops: 1 workshop | 21 | 4 | 3 | 28 | 100 |
| ( c) Organization: Well organized<br>Poorly organized | 19<br>3 | -<br>2 | -<br>1 | 19<br>6 | 68<br>21 |
| Issues dealt with in detail<br>Not in detail | 9<br>3 | -<br>2 | 1<br>- | 10<br>5 | 36<br>18 |
| Participants grouped<br>Not grouped | 13<br>1 | 4<br>- | 1<br>- | 18<br>1 | 64<br>3 |
| Enough handouts were given<br>Handouts were not enough | 8<br>5 | -<br>2 | 1<br>- | 9<br>7 | 32<br>25 |
| Trained how to make Learning Programmess and Learning Units<br>No proper training in LPs and LUs | 13<br>5 | 1<br>1 | 1<br>- | 15<br>6 | 54<br>21 |
| Learning Support Material preparation was part of training<br>It was not part of training | 6<br>5 | 1<br>- | 1<br>- | 8<br>5 | 29<br>18 |
| Assessment issues were dealt with in detail<br>Assessment issues were not discussed in detail | 8<br>3 | 2<br>2 | 1<br>- | 11<br>5 | 39<br>18 |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 9 (a) Any change in method of teaching by lecturers? | | | | | |
| Yes | 13 | 1 | 3 | 17 | 61 |
| No | 3 | 2 | - | 5 | 18 |
| Not quite sure | 3 | - | - | 3 | 11 |
| Not by all lecturers | - | 1 | - | 1 | 3 |
| (b) Different methods used by lecturers | | | | | |
| Participatory | 1 | 1 | 1 | 3 | 11 |
| Group work | 11 | 1 | 2 | 14 | 50 |
| Discussion | 4 | 1 | 1 | 6 | 21 |
| Discovery | 4 | 1 | - | 5 | 18 |
| Interactive method | 5 | - | - | 5 | 18 |
| 10 (a) Preparedness of MLMMS Department | | | | | |
| YES | 19 | 3 | 3 | 25 | 89 |
| NO | 1 | - | - | 1 | 3 |
| NOT QUITE SURE | 3 | 1 | - | 4 | 14 |
| Reasons for the YES response: Tries to implement OBE teaching, Gives tasks, group work etc according to OBE principles; Demonstration and other lessons in OBE; Trains how to make LSM; Learner centred lessons; Attends workshops and report back; encouraged to prepare lessons and teach them according to OBE principles | 21 | 4 | 3 | 28 | 100 |
| Reasons for the NO response: No motivation from the department; never tried to find out learners' problems. | 2 | - | - | 2 | 7 |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 11 Use of OBE methods in lessons: | | | | | |
| YES | 18 | 3 | 3 | 24 | 86 |
| NO | 3 | 1 | - | 4 | 14 |
| 12. Use OBE methods in demonstration lessons: YES | 20 | 2 | 2 | 24 | 86 |
| Uses both traditional and OBE methods | 1 | 2 | 1 | 4 | 14 |
| 13 Different methods of assessment used by MLMMS lecturers | | | | | |
| Tests and examinations only | 6 | 2 | - | 8 | 29 |
| Continuous assessment | 14 | - | 1 | 15 | 54 |
| Assignments | 15 | 2 | - | 17 | 61 |
| Peer assessment | 4 | - | 1 | 5 | 18 |
| 14(a)Were you trained how to make LPs and LUs? : YES | 20 | 2 | 3 | 25 | 89 |
| NO | - | 2 | - | 2 | 7 |
| Not quite sure | 1 | - | - | 1 | 3 |
| (b) Workshop was conducted to show how to make LP and LU | 12 | 1 | 3 | 16 | 57 |
| Examples of LPs and LUs were given | 9 | 1 | 1 | 11 | 39 |
| SOs, COs, ACs and PIs analysed thoroughly | 14 | 1 | 1 | 16 | 57 |
| Group tasks and individual tasks to make LPs and LUs were given | 14 | - | - | 14 | 50 |
| Encouraged to make LPs and LUs during the practice teaching | 12 | - | 1 | 13 | 46 |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 15 Do you have confidence in making LPs and LUs? YES | 18 | 3 | 2 | 23 | 82 |
| NO | 1 | 1 | - | 2 | 7 |
| Not quite sure | 2 | - | 1 | 3 | 11 |
| 16.(a) Did you use OBE method during practice teaching? YES | 15 | 2 | 2 | 19 | 68 |
| NO | 2 | 2 | 1 | 5 | 18 |
| (b) Reasons for the YES response: Teachers in schools asked us to use OBE methods; MLMMS teachers and lecturer helped us use OBE methods; college uses OBE methods; tried OBE method during 1st semester | | | | | |
| Reasons for the NO response: Teachers from schools did not want us to use OBE methods, teachers in schools did not support us; OBE was not officially implemented in the grade we taught | | | | | |
| 17.(a) Did you get support from the teachers in schools? YES | 2 | 1 | 1 | 4 | 14 |
| Some support | 3 | - | 2 | 5 | 18 |
| No support | 15 | 3 | - | 18 | 64 |
| (b) Possible reasons for no support from teachers in schools: | | | | | |
| Teachers do not have proper understanding of OBE; OBE is confusing to them as they are used to traditional/ old methods; did not want to share their knowledge; college students are considered privileged of getting knowledge in OBE; thought that students are going to take their posts; teaching practice time was considered a free time for teachers in those schools | | | | | |

| | SPTD:3 | STD:3 | STD:2 | TOTAL | % |
|---|---|---|---|---|---|
| 18 (a) Did you receive guidance and supervision during practice teaching? YES<br>NO | 16<br>3 | 1<br>3 | 3<br>- | 20<br>6 | 71<br>21 |
| (b) Types of guidance and supervision received:<br>How to plan lessons according to OBE; how to develop activities using available materials; observed lessons and offered guidance and help; assisted in preparing and presenting lessons; showed how to adapt to situations. | | | | | |
| 19. Rating of preparedness and commitment of mathematics department in implementing OBE. | | | | | |
| 1 | - | 1 | - | 1 | 3 |
| 3 | 1 | 3 | 1 | 5 | 18 |
| 4 | 10 | - | 1 | 11 | 39 |
| 5 | 11 | - | - | 11 | 39 |
| 20 Shortcomings of the department in implementing OBE:<br>Lack of workshops conducted; lack of resources and facilities; ineffective methods of teaching; lack of interest shown by learners and lecturers; lack of training for lecturers in the college and especially in MLMMS; lack of report back from lecturers; lack of time for proper preparation | | | | | |
| 21 Suggestions:<br>Conduct more workshops; parents and teachers should attend more OBE workshops; lecturers and facilitators should use relevant resources; more demonstration lessons in OBE should be conducted; more cooperation among lecturers, parents and learners, there should be at least one period per day for OBE, all lecturers should be trained in OBE, more research should be conducted. | | | | | |

# APPENDIX:4

## EVALUATION FORMS USED BY JPTD DEPARTMENT FOR CRITICISM LESSONS AND DEMONSTRATION LESSONS

DR W B RUBUSANA COLLEGE OF EDUCATION

EVALUATION FORM FOR CRITICISM LEARNING UNITS

LEARNER & TEACHER COURSE:..... DATE:.....

SCHOOL NO. OF LEARNERS GRADE:.....

1. LEARNING UNIT PREPARATION

1.1 LEARNING PROGRAMME
PHASE ORGANISER
PROGRAMME ORGANISER:

CRITICAL OUTCOMES :

SPECIFIC OUTCOMES A.C. R.S. P.I.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENT | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

2. RESOURCES
PREPARATION: EFFORT TAKEN
ORIGINAL/ATTRACTIVENESS
QUALITY OF PRINTING: MAY NOT BE ALL PRINTED
RELEVANCE TO THE ORGANISERS
QUALITY/QUANTITY OF CONCRETE MATERIALS

3. INTEGRATION WITH RESOURCES
READY FOR USE
EFFECTIVE USAGE
INTEGRATION WITH LEARNING UNIT
PLANNED LAYOUT OF RESOURCES

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENTS | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

4. FACILITATION STYLE
CLASS ORGANISATION : CONTROL DISCIPLINE
CLASS ARRANGEMENT :
SUITABILITY OF OUTFIT :
BODY PRESENTATION/STANCE:
GESTURES/FACIAL EXPRESSION
EYE CONTACT
AVOIDANCE OF UNNECESSAY MANNERISM

5. ATTITUDE FRIENDLY/WARM/LOVING
SELF CONFIDENCE
SENSE OF HUMOUR

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENTS | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

6. LANGUAGE USAGE CLEAR/AUDIBLE VOICE
TEMPO/VOLUME/PITCH VARIATION
COMMAND OF LANGUAGE/FLUENCY

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENTS | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

7. ACTIVITIES

KNOWLEDGE, SKILLS AND VALUES, JUDGEMENTS INHERENT

DID LEARNERS GAIN KNOWLEDGE OF THE ACTIVITY
IS IT INTERESTING TO THEM
ARE QUESTIONS CLEARLY PHRASED
ARE THEY PARTICIPATING WELL

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

8. SKILLS
WHAT DO YOU THINK ARE THE MAJOR SKILLS BASED IN THE ACTIVITY?
IS COLLABORATIVE LEARNING EFFECTIVE?
GROUP WORK ACTIVITY
OTHER SKILLS ACUIRED

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

9. VALUES

ARE THERE ANY CULTURAL VALUES FROM THE ACTIVITY?
WAS PRIOR LEARNING RECOGNISED?
OTHER VALUES IN THE ACTIVITIES

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

10. LEARNER CENTREDNESS

ENCOURAGING LEARNER INVOLVEMENT
CO-OPERATIVE LEARNING INVOLVED
SUFFICIENT EQUIPMENT FOR LEARNER ACTIVITY

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

11. INTEGRATION OF OTHER LEARNING AREAS

IS THERE ANY INTEGRATION?
EFFECTIVELY DONE
RELEVANT/FORCD

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

SUMMATIVE EVALUATION MARK (PERCENTAGE AND SYMBOL)

MARKING STRATEGY

RATING SCALE

1. 0 - 39% BELOW E SYMBOL
2. 40 - 49% E SYMBOL
3. 50 - 59% D SYMBOL
   60 - 69% C SYMBOL
4. 70 - 79% B SYMBOL
5. 80% AND ABOVE A SYMBOL

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| PERFORMANCE DOESN'T MEET REQUIREMENTS | PERFORMANCE MEETS REQUIREMENT | AV. PERFORMANCE | V.GOOD PERFOR-MANCE | EXCELLENT PERFOR-MANCE |

EVALUATOR : .....

COMMENTS : .....

COLLEGE OF EDUCATION

# TEACHING PRACTICE: LESSON EVALUATION

| **final mark |
|---|
| |

Date .....

No. of pupils .....

Standard .....

| JECT | | | | | | | | * Circle the mark awarded for each particular section and write the total of each section opposite the relevant heading. |
|---|---|---|---|---|---|---|---|---|
| IC | | | | | | | | |
| GUAGE MEDIUM | | | | | | | | |
| TERIA | 'EVALUATION' | | | | | | TOT | REMARKS |
| ERSONALITY AND APPEARANCE | | | | | | | | |
| 1 Appearance: Groomed? Neat/Untidy? Flashy? | | 4 | 3 | 2 | 1 | 0 | | |
| 2 Bearing: Self-confidence; movement; mannerisms; facial expression; animate/dull; spontaneous/tense | | 4 | 3 | 2 | 1 | 0 | | |
| 3 Teaching style: Attitude towards pupils; enthusiasm; motivating ability; gaining pupils' attention | 9 | 8 | 6 | 4 | 2 | 1 | | |
| 4 Delivery and language usage: Quality of voice; articulation; clarity; fluency and correctness of language | 9 | 8 | 6 | 4 | 2 | 1 | | |
| ESSON PREPARATION | | | | | | | | |
| 1 Teaching aims/objectives: Meaningful? Clear? Relevant? Adequate? | | 4 | 3 | 2 | 1 | 0 | | |
| 2 Method(s): Appropriate? Correct? Original? Is it appropriate to the particular subject and topic? | | 4 | 3 | 2 | 1 | 0 | | |
| 3 Lesson design: Quality of lesson scheme/notes—layout; system; sufficiency; neatness | | 4 | 3 | 2 | 1 | 0 | | |
| 4 Teaching aids/materials: Suitability; relevancy; adequacy; originality; trouble taken | 5 | 4 | 3 | 2 | 1 | 0 | | |
| 5 Choice of subject matter: Scope/quantity; correctness; arrangement/logical sequence; relevancy to aims/topic | 19 | 16 | 12 | 8 | 4 | 2 | | |
| RESENTATION OF THE LESSON | | | | | | | | |
| *1 Introduction* | | | | | | | | |
| Creating relationships/desirable atmosphere; effecting motivation and instillation to learning | 9 | 8 | 6 | 4 | 2 | 1 | | |
| Actualisation of pre-knowledge: Recalling relevant pre-knowledge, linking it to new matter | 9 | 8 | 6 | 4 | 2 | 1 | | |
| Posing the problem: Were pupils led to observe the problems of new matter in the context of pre-knowledge? | 9 | 8 | 6 | 4 | 2 | 1 | | |
| *2 Exposition of the new subject matter* | | | | | | | | |
| Mastery of subject matter: Has student mastered content? Has it been presented logically and clearly? | 14 | 12 | 9 | 6 | 3 | 1 | | |
| Teaching strategy: | | | | | | | | |
| Questions: Clear? Well-aimed? Properly timed and spaced? Reaction to pupils' questions/answers | 9 | 8 | 6 | 4 | 2 | 1 | | |
| Chalkboard work: Neatness; legibility; lay-out; effective use; used throughout; sufficient | 9 | 8 | 6 | 4 | 2 | 1 | | |
| Other teaching aids: Effectivity; synchronisation; integration | 5 | 4 | 3 | 2 | 1 | 0 | | |
| Method/techniques: Suitability; meaningfulness; effectiveness; success | 5 | 4 | 3 | 2 | 1 | 0 | | |
| Communication and pupil involvement: Class involvement; individualisation; activity; explanation of concepts | 9 | 8 | 6 | 4 | 2 | 1 | | |
| *Conclusion* | | | | | | | | |
| Actualisation of content: Opportunity of gaining insight/productive thinking; schematising of insights | 5 | 4 | 3 | 2 | 1 | 0 | | |
| Gaining of objectives: Have aims/objectives been achieved? | 5 | 4 | 3 | 2 | 1 | 0 | | |
| Functionalising: Integration of pre-knowledge and new matter; application of new knowledge; mastery | 9 | 8 | 6 | 4 | 2 | 1 | | |
| *Class control:* Quality of guidance/control; spontaneous reaction encouraged? (Disregard discipline) | 9 | 8 | 6 | 4 | 2 | 1 | | |
| *Time allocation:* Realistic for each part of lesson? Steady pace? Time spent profitably throughout? | 9 | 8 | 6 | 4 | 2 | 1 | | |
| *Didactic flexibility:* Continuous evaluation? Accommodation of circumstances; reaction to pupils | 9 | 8 | 6 | 4 | 2 | 1 | | |
| otal: | ** The final mark is obtained by dividing this total by two → | | | | | | | |

TEACHER'S COPY

COLLEGE OF EDUCATION
DEMONSTRATION LESSON

**SPTD:3**
**PRESENTER: C.THOMAS**
**GRADE:7**
**DATE: 15 MARCH 2000**
**TIME: 1 HOUR**

**LEARNING AREA : MLMMS**
**PHASE ORGANISER: PERSONAL DEVELOPMENT AND EMPOWERMENT**
**PROGRAMME ORGANISER: SPACE**
**FOCUS IDEA : MEASUREMENT [ SURFACE AREA OF A BOX: MATERIAL NEEDED TO MAKE A BOX]**

**CRITICAL OUTCOMES**: 2, 3, 4, 5,6 AND 7

**SPECIFIC OUTCOMES:**

| SO s | ASSESSMENT CRITERIA/ RANGE STATEMENT(S) | PERFORMANCE INDICATOR(S) |
|---|---|---|
| SO 1 | 4 / 4.1 | * 1 |
| SO 5 | 1 / 1.1 , 1.2<br>2 / 2.1 , 2.2, 2.3 | * 1 , 2<br>* 1 , 2 , 3 |
| SO 7 | 1 / 1.1 | * 1 |
| SO 9 | 1 / 1.1<br>2 / 2.1<br>3<br>4 | * 1<br>* 2<br><br>* 4 |
| SO 10 | 1 / 1.1<br>2 /2.1<br>3 /3.2 | <br><br>* 2 |

**OTHER LEARNING AREAS INTEGRATED**:

LLC: **SO 6 , SO 7** TECHNOLOGY: **SO 3 , SO 2**

LIFE ORIENTATION: **SO 2** ARTS AND CULTURE: **SO 2, SO 3, SO 6**

**RESOURCES:** Model box, ruler, scissors, calculator, worksheet etc.

**ASSESSMENT TOOLS:** Observation sheet, written work, project work.

**ACTIVITIES:**

**ACTIVITY:1 ( 5 MINUTES)**

Examine the box given to you and answer the following questions.

What is the shape of the box? .....

How many edges does the box have? .....

How many faces does the box have? .....

How many vertices does the box have? .....

What do you notice about the opposite faces of the box?

.....

.....

Give some examples of where these types of boxes are used.

.....

.....

.....

Give examples of materials used to make these types of boxes.

.....

.....

Draw a sketch of the box in the space below:

* One student should describe a box.

**ACTIVITY: 2 ( 5 MINUTES)**

Number the faces of the box from 1 to 6.

Measure the length , breadth and height of the box and record the values.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Length | = | | cm | Length | = | mm | |
| Breadth | = | | cm | Breadth | = | mm | |
| Height | = | | cm | height | = | mm | |

| | | |
|---|---|---|
| Length | = | m |
| Breadth | = | m |
| Height | = | m |

**ACTIVITY : 3 ( 5 MINUTES)**

Open the box so that the faces stay together. [cut it along the edges]

Sketch the shape of the paper you got.

What do you call the sketch?

On the sketch write the measurements of the sides of the box. Use the measurements you got in Activity2.

**ACTIVITY: 4 ( 20 MINUTES)**

Calculate the area of the faces of the box .

What do you notice about the areas of the opposite faces?

What is the total area of the six faces of the box?

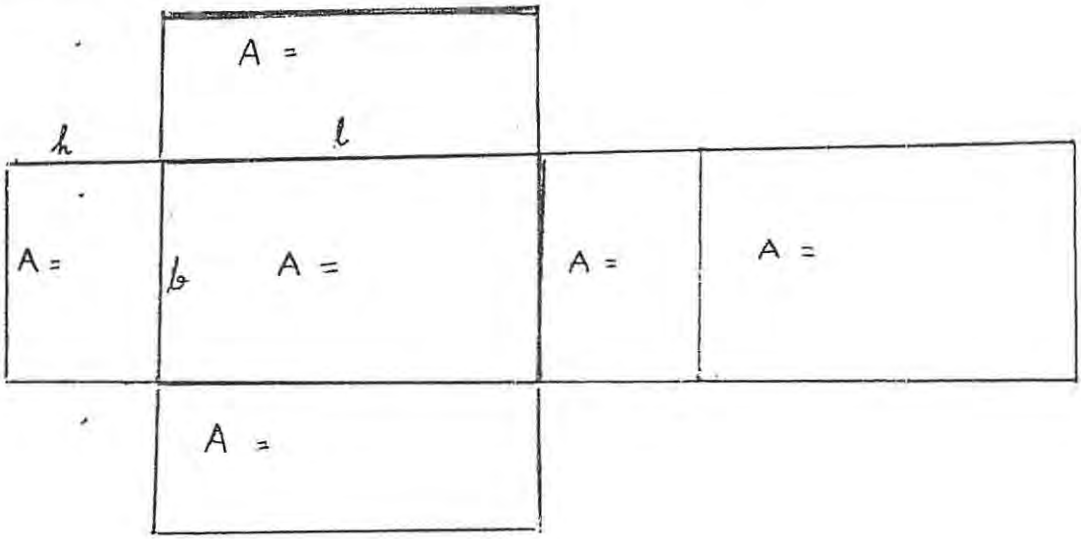
What is the area of the paper used to make the box?

What is the surface area of the box?

Describe how you calculated the surface area of the box.

**ACTIVITY:5 ( 10 MINUTES)**

Write the area of the six faces of the box in the given sketch . The length of the box is l, the width is b and the height is h.




Total area of the six faces =

= 2 (  +  +  )

Total surface area of a box with lid =

Talk about extra material needed for making the box.

**WRITTEN WORK**: ( 10 MINUTES)

1. Draw a sketch of a box whose length, width and height are equal.

   Write the formula for the total area of the box.

   A =

2. Calculate the total surface area of a box with lid which measures 3m x 2m x 1m.

3. Calculate the area of wood needed to make a box which is 75cm long, 50cm wide and 40 cm high. The box has a lid.

**PROJECT WORK: [MAKING A PENCIL CASE]**

Your teacher allowed you to come for today's lesson. You should thank your teacher by giving her a gift.

Each one of you should use an old calendar.

Make a pencil case 20cm long, 10cm wide and 5cm high.

Decorate the outside of the pencil case.

Write one sentence to thank your teacher for letting you to go for the class.

Write your name on the case.

Give your pencil case to your teacher as a gift.

[YOU SHOULD GIVE THE PENCIL CASE ON OR BEFORE 22 MARCH 2000.]

# ASSESSMENT SHEET

**LESSON: MEASUREMENT - SURFACE AREA OF A BOX**

**DATE : 15 MARCH 2000.**

**Name of student(s)**

| Assessment Criteria | Yes | No |
|---|---|---|
| Co-operates with others | | |
| Shares ideas with others | | |
| Communicates effectively | | |
| Identifying edges | | |
| Identifying faces | | |
| Identifying vertices | | |
| Drawing the diagram of the box | | |
| Able to identify uses of boxes | | |
| Able to identify materials used to make the box | | |
| Able to measure accurately | | |
| Able to draw the net of the box | | |
| Able to calculate the area of one side | | |
| Able to calculate the total surface area | | |
| Able to derive the formula for total surface area | | |
| Completed the written work | | |
| Completed the project work. | | |

| | | |
|---|---|---|
| *SCHOOL* | : | *P SCHOOL* |
| *GRADE* | : | *4* |
| *NO. OF LEARNERS* | : | 24 |
| *DATE* | : | *11 May 2000* |
| *Learning Area* | : | *MLMMS* |
| *Phase Organiser* | : | *The learner as communicator and as active participant* |
| *Programme Organiser* | : | *Data collection and handling using a graph.* |
| *Focus idea* | : | *Pictograph and Bar Graph* |
| *Critical Outcome* | : | *Work effectively as members of a team/group* |
| *Specific outcome* | : | *MLLMMS SO6 use data from various contexts to make informed judgements* |

| *Assessment Criteria* | *Range Statement* | *Performance* |
|---|---|---|
| *Identification situation for investigation* | *Identify situations for data collection* | *Indicator This is evident when learners' identify natural experiences from where to collect, gather and sort data in various categories and provide data from various sources* |
| *Organisation of data* | *Sort and classify data* | *Sort by various categories and represent data* |
| *Display of data* | *Display data using graphs* | *Draw and read graphs* |

| | |
|---|---|
| *Knowledge:* | *collection and handling of data. How to draw and read graph.* |
| *Skills:* | *Investigate, Identify, interprete, draw etc.* |
| *Attitudes:* | *co-operation, creativity, independence* |
| *Values:* | *Importance of collecting and handling data; interpreting and representing data.* |
| *Resources:* | *papers, smarties, rascals.* |
| *Other Learning Areas.* | *Tech SO3 and L.L.C. SO4.* |

*STEP 2*

*- Pictograph - to show the birthday months of the members of the group.*

*Draw a graph with 12 columns, each column will represent a month of the year.*
*Each person in the group should take a turn to draw their face in column of the month of their birthdays. Learners should remember to fill in the faces from the bottom up.*

*STEP 3*

*Now they are going to use the same information to draw a bar graph. (vertical bar graph).*
*show them(Bar of chocolate e.g. kitkat - )*
*(Graph with 12 columns) starting from January to December.*

*As I prepare this learning unit in an outcomes based way, I asked myself the following questions:*

*STEP 1: what to do I want to achieve in this learning unit?*
*In other words, what will the outcomes of this learning unit be?*

*STEP 2: How will I know if my learners have achieved the outcomes?*
*You will need to decide what your learners need to do in order to 'prove' that they have achieved the learning outcomes. by setting the performance indicators*

*STEP 3 : How and what shall I teach in order to assist the learners in achieving the outcomes?*
*OBE is a mixture of content, activities and assessment.*
*You need to construct learning activities, forms of assessment which will assist you in guiding your learners to achieve the outcomes set.*

*STEP 4: How should I assess?*
*Make use of different types of assessment.*

# APPENDIX: 5

## COPIES OF SOME LESSON PLANS DEVELOPED BY STUDENT TEACHERS

# MLMMS

LOOKING AFTER OUR WORLD

LEARNER

Knowledge : reading weather report map
: understanding range of temperature
: reading a graph

Skill : interpreting
drawing a graph

Attitudes : co-operation

Values : (i) Impatance of knowing weather focus
(ii) Importance of knowing how thermometer is used.

Resources : (i) chart (thermometer)
(ii) chart (weather focus)
(iii) chart (table of thermometer reading)

Other learning Areas : LO, LLC & HSS

Learning Outcome : i) To be able to read and understand weather focus
ii) To be able to understand how the thermometer works and what it is used for.

ACTIVITY

STEP 1

Learners will be given a chart with the weather report map where they will be asked the ff questions.

(1) Which town is expecting the hottest temperature?
(2) Which town is expecting the lowest temperature?
(3) What is the minimum temperature given for East London
(4) What is the maximum temperature given for C. Town
(5) Which town has a maximum temperature of 24°C?
(6) Which town has a minimum temperature of 9°C?

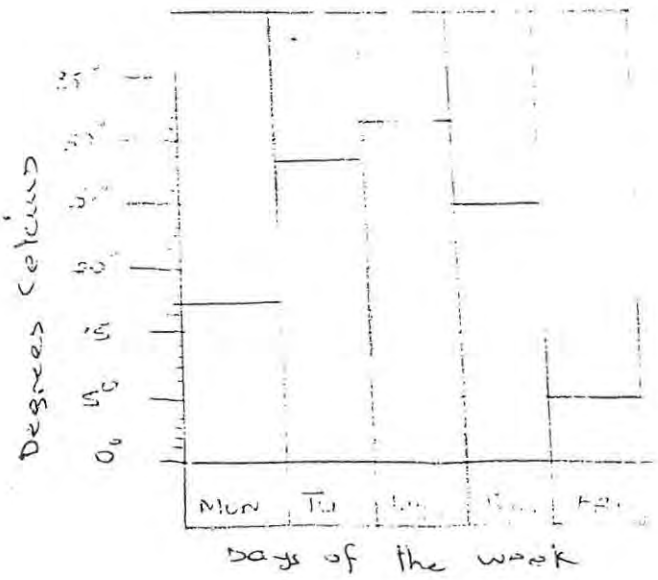
STEP 2

Learners must be able to copy and complete the ff table

| Town | Minimum | Maximum |
|---|---|---|
| Cape town<br>Johannesburg<br>Durban<br>Kimberly<br>Pretoria<br>East London | | |

STEP 3

Learners will be given a graph with maximum temperatures so that they can do their reading e.g they will also answer the questions that will ff




① What day was the hottest?
② What day was the coldest?
③ During which season did this week occur?

EXTENDED ACTIVITY

INVESTIGATION : Record the maximum temperatures in your town from Monday to Friday. Use your information to draw a graph.

28/07/2000

COLLEGE OF EDUCATION

EVALUATION FORM FOR CRITICISM LEARNING UNITS

LEARNER & TEACHER . COURSE: T.L.3 DATE: 28/07/2000

SCHOOL P. NO. OF LEARNERS 36 GRADE: 4

U

1. LEARNING UNIT PREPARATION

1.1 LEARNING PROGRAMME PHASE ORGANISER PROGRAMME ORGANISER: MLMMS LEARNER AS Communicat LOOKING AFTER OUR WORL

CRITICAL OUTCOMES : C.O.5

SPECIFIC OUTCOMES A.C. R.S. P.I.

MLMMS S05 K6

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENT | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

2. RESOURCES (3)

PREPARATION: EFFORT TAKEN
ORIGINAL/ATTRACTIVENESS
QUALITY OF PRINTING: MAY NOT BE ALL PRINTED
RELEVANCE TO THE ORGANISERS
QUALITY/QUANTITY OF CONCRETE MATERIALS

3. INTEGRATION WITH RESOURCES

READY FOR USE
EFFECTIVE USAGE
INTEGRATION WITH LEARNING UNIT
PLANNED LAYOUT OF RESOURCES

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENTS | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

4. FACILITATION STYLE (4)

CLASS ORGANISATION : CONTROL DISCIPLINE
CLASS ARRANGEMENT :
SUITABILITY OF OUTFIT :
BODY PRESENTATION/STANCE:
GESTURES/FACIAL EXPRESSION
EYE CONTACT
AVOIDANCE OF UNNECESSAY MANNERISM

5. ATTITUDE FRIENDLY/WARM/LOVING
SELF CONFIDENCE
SENSE OF HUMOUR

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENTS | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

6. LANGUAGE USAGE CLEAR/AUDIBLE VOICE
TEMPO/VOLUME/PITCH VARIATION
COMMAND OF LANGUAGE/FLUENCY

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|
| DOESN'T MEET REQUIREMENTS | NEEDS ATTENTION | GOOD | V.GOOD | EXCELLENT |

7. ACTIVITIES

KNOWLEDGE, SKILLS AND VALUES, JUDGEMENTS INHERENT

DID LEARNERS GAIN KNOWLEDGE OF THE ACTIVITY
IS IT INTERESTING TO THEM
ARE QUESTIONS CLEARLY PHRASED
ARE THEY PARTICIPATING WELL

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|

8. SKILLS
WHAT DO YOU THINK ARE THE MAJOR SKILLS BASED IN THE ACTIVITY?
IS COLLABORATIVE LEARNING EFFECTIVE?
GROUP WORK ACTIVITY
OTHER SKILLS ACUIRED

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|

9. VALUES

ARE THERE ANY CULTURAL VALUES FROM THE ACTIVITY?
WAS PRIOR LEARNING RECOGNISED?
OTHER VALUES IN THE ACTIVITIES

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|

10. LEARNER CENTREDNESS

ENCOURAGING LEARNER INVOLVEMENT
CO-OPERATIVE LEARNING INVOLVED
SUFFICIENT EQUIPMENT FOR LEARNER ACTIVITY

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|

11. INTEGRATION OF OTHER LEARNING AREAS

IS THERE ANY INTEGRATION?
EFFECTIVELY DONE
RELEVANT/FORCD

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|

SUMMATIVE EVALUATION MARK (PERCENTAGE AND SYMBOL)

MARKING STRATEGY

RATING SCALE

| | | |
|---|---|---|
| 1. | 0 - 39% | BELOW E SYMBOL |
| 2. | 40 - 49% | E SYMBOL |
| 3. | 50 - 59% | D SYMBOL |
| | 60 - 69% | C SYMBOL |
| 4. | 70 - 79% | B SYMBOL |
| 5. | (80%) AND ABOVE | (A) SYMBOL |

| 1 | 2 | 3 | 4 | (5) |
|---|---|---|---|---|
| PERFORMANCE DOESN'T MEET REQUIREMENTS | PERFORMANCE MEETS REQUIREMENT | AV. PERFORMANCE | V.GOOD PERFOR-MANCE | EXCELLENT PERFOR-MANCE |

EVALUATOR : .....

COMMENTS : A very good lesson, learners were given chance / opportunity to think and come up with their own ideas. Good use of questions which make learners to think critically. Learners were involved in solving realistic problems whereby they worked co-operatively. They were able to construct deep understanding of maths ideas and process

| | |
|---|---|
| PRESENTER'S NAME | |
| PRESENTATION DATE | 19 APRIL 2000 |
| PHASE | INTERMIDIATE |
| GRADE | Six (6) |
| LEARNING AREA | MLMMS |
| PHASE ORGANISER | COMMUNICATION |
| PROGRAMME ORGAMISER | NEWSPAPER |
| FOCUS IDEA | Weather. |
| DURATION | 45 MINUTES |
| RESOURCE(S) | CHALKBOARD, pencil, RULER, RUBBER. |
| CRITICAL OUTCOME(S) | [CO2], Work effectively with others as members of a team, group, organisation, community. |
| | [CO5], COMMUNICATE EFFECTIVELY USING VISUAL, MATHEMATI AND/OR LANGUAGE SKILLS IN THE MODE OF ORAL AND/C WRITTEN PRESENTATION. |
| | [CO1], IDENTIFY AND SOLVE PROBLEMS IN WHICH RESPONSES DISPLAY THAT RESPONSIBLE DICISIONS USING CRITICAL AND CREATIVE THINKING HAVE BEEN MAD |
| SPECIFIC OUTCOME(S) | [SO3], DEMONSTRATE UNDERSTANDING OF THE HISTORICAL DEVELOPMENT OF MATHEMATICS IN VARIOUS SOCIAL AND CULTURAL CONTEXTS. |
| | [SO9] Use MATHEMATICAL LANGUAGE TO COMMUNICATE MATHEMATICAL IDEAS, CONCEPTS, GENERALIZATIONS AND THOUGHT PROCESSES. |
| | [SO2] MANIPULATE NUMBER PATTERNS IN DIFFERENT WAYS. |

| SPECIFIC OUTCOMES | RAMGESTATEMENT | ASSESSMENT CRITERIA | PERFOMANCE INDICATOR |
|---|---|---|---|
| SO3 | 1.1 | 1 | 1. |
| SO9 | 1.1 | 1 | 1 |
| SO2 | 1.1 | 1 | 1.2 |

ACTIVITIES : 1. Discussions, Writting Summaries, sketching graphs, MAKING / IDENTIFYING DEGREES OF COMPARISONS, REPORTS FROM DIFFERENT GROUPS.

ACTIVITY 1 ° LEARNERS ARE ASKED TO IDENTIFY THE TYPES OF DAYS THEY LIKE (SPECIFICALLY COLD DAYS OR HOT DAYS i.e SUMMER & WINTER DAY) AND THEY MUST GIVE REASON FOR THEIR ANSWERS.

INDIVIDUAL TASK

CERTAIN POINTS ARE WRITTEN ON THE BOARD FROM LEARNERS

ACTIVITY 2 ° THE FACILITATOR DISTRIBUTES EXTRACTS FROM NEWSPAPER AND ASK THEM TO IDENTIFY WHICH TOWNS ARE SUNNY AND ASK THEM TO TELL THE CLASS WHETHER THE MINIMUM AND MIXIMUM TEMPERATURE IMPLIES HOTTNESS OR COLDNESS, CLOUDY OR SNOWY.

GROUP WORK

REPORT FROM GROUPS

ACTIVITY 3 ° 1. LEARNERS ARE ASKED TO FORM SENTENCES IDENTIFYING TEMPERATURE AND WEATHER OF THE TOWNS THEY MENTIONED ABOVE.

2. THEY ARE ALSO ASKED TO IDENTIFY / TO USE DIGREES OF COMPARISONS ON THE MAXIMUM AND MINIMUM TEMPERATURE

PEERS

REPORT FROM PEERS AND SOME ARGUMENTS ARE EXPECTED.

ACTIVITY 4 ° LEARNERS ARE ASKED TO PLOT ON THE GRAPH THE FOLLOWING TOWNS MAXIMUM TEMPERATURES

GROUP 1 = CAPE TOWN, KIMBERLY, UPINGTON, EAST LONDON.

GROUP 2 = PIETERSBURG, BLOEMFONTEIN, DURBAN, JO'BURG

GROUP 3 = PRETORIA, EAST LONDON, DURBAN, NELSPRUIT

GROUP 4 = BEAUFORT WEST, JO' BURG, NELSPRUIT, KIMBERLY

GROUP 5 = Kimberly, Upington, Port Elizabeth, Pietersburg.

Groups are asked TO ANSWER THE FOLLOWING QUESTIONS USING THEIR BAR GRAPH.

(a) How many towns that has got the SAME TEMPERATURE?

(b) WHAT is THE FRACTION OF THOSE TOWNS?

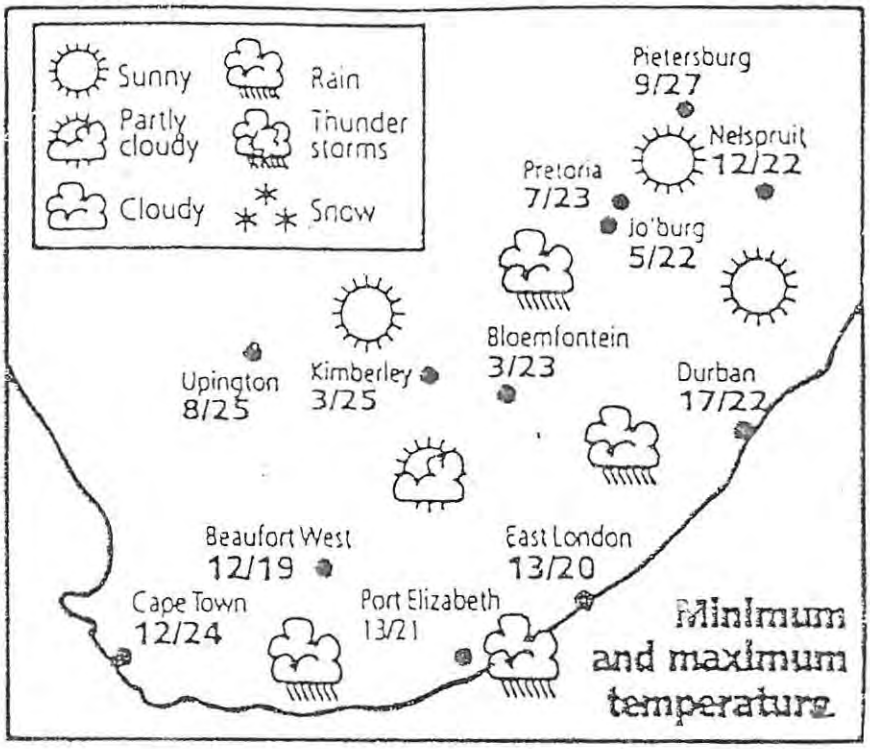
(c) WHICH TOWN is HOT, HOTTER & HOTTEST?

(d) What is the difference between the MAXIMUM TEMPERATURE OF THE HOTTEST TOWN AND THE HOT TOWN?

(e) IF YOU ARE ASK TO FIND THE SUM OF THE HOT TOWN & HOTTER TOWN WILL IT BE GREATER THAN THE TEMPERATURE OF THE HOTTEST TO SHOW NECESSARY CALCULATIONS. IF POSSIBLE. ??

(f) LEARNERS MUST IDENTIFY. THE WEATHER & TEMPERATURE OF 1. EAST LONDON
2. BEAUFORT WEST
3. UPINGTON
4 Pietersburg.

I.P. SCHOOL
E Badenhorst ..... H.O.D.
DATE ..... 22/5/20


Sunny
Rain
Partly cloudy
Thunder storms
Cloudy
Snow
Pietersburg
9/27
Nelspruit
12/22
Pretoria
7/23
Jo'burg
5/22
Bloemfontein
3/23
Upington
8/25
Kimberley
3/25
Durban
17/22
Beaufort West
12/19
East London
13/20
Cape Town
12/24
Port Elizabeth
13/21
Minimum and maximum temperature

PRESENTER :
SCHOOL : SECONDARY SCHOOL
GRADE : 9
DATE : 22 MARCH 2000
DURATION : 45 MINUTES

LEARNING AREA : MLMMS
PHASE : SENIOR PHASE
PHASE ORGANISER : PERSONAL DEVELOPMENT & EMPOWERMENT
PROGRAMME ORGANISER : SPACE / AREA
FOCUS IDEA : MULTIPLICATION OF BINOMIAL IDENTITIES.
CRITICAL OUTCOMES : 1, 2, 3, 5 AND 7

SPECIFIC OUTCOMES

| SO's | ASSESSMENT CRITERIA RANGE STATEMENT(S) | PERFORMANCE INDICATOR(S) |
|---|---|---|
| SO 1 | 4/4.1 | *1 |
| SO 2 | 3/3.1 | *1 |
| SO 6 | 7/7.1 | *1 |
| SO 9 | 1/1.1<br>4/4.1<br>6/6.1 | *1<br>*1<br>*1 |
| SO 10 | 1/1.1<br>2/2.1<br>3/3.2 | *2<br>*2. |

## Activity: 2 (10 minutes)

1. $2a^3b - 4ab^3 - 3a^2b^2$

(a) Arrange the polynomial in ascending powers of a

(b) Arrange the polynomial in descending powers of a

(c) Arrange the polynomial in ascending powers of b

2. Write down the degree of the ff terms

(i) $-4p^3q^2r$

(ii) $2x^3y$

(iii) $2a^4b - 4ab$

## Activity: 3 (10 minutes)

1. Find the Product of the ff binomial

(i) $(x+2)(4x-3)$

(ii) $x(x-3)$

(iii) $p(q-4r)$

3. Calculate the following.

(i) $85^2 - 35^2$

(ii) $65^2 - 35^2$.

Activity 5 (10 minutes)

Homework / Classwork

1. On each of the ff polynomials.
(i) Arrange the powers in descending order

(a) $a^2 - 4 - a$

(b) $a^3 - 2a - a^2$

(c) $2a - 7a^3 - a^4$

(d) $a^2 + a + a^3 + 1$

2. Write down the degree of the ff.

(i) $-8x^3y^2$

(ii) $-3p^3q$

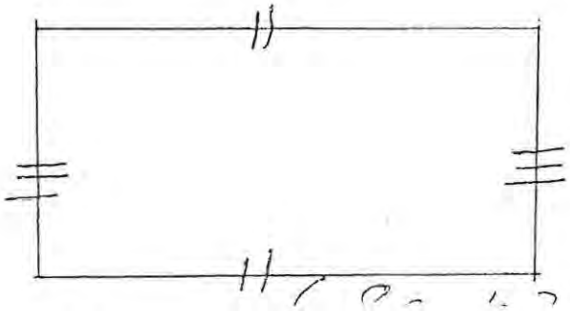
3 Find the Product of the ff.

(i) $x(x+3)$

(ii) $(x-3)(x+2)$.

4. Find the area of the figure below.

(i)



# ASSESSMENT.

| ASSESSMENT CRITERIA. | Yes | No |
|---|---|---|
| 1. Are they able to identify. | Yes | N |
| (i) Monomial<br>(ii) Binomial<br>(iii) Trinomial<br>iv Polynomial | | |
| (ii) Are they able to write the expression in ascending / descending order. | | |
| (iii) Are they able to write the degree of the expressions. | | |
| (iv) Are they able to multiply the binomials. | | |
| (v) Are they able to derive the Identity | | |
| (vi) Are they able to use the identity in Calculation. | | |

# PROJECT: 2

# DEVELOPING AND EVALUATING LEARNING MATERIALS IN LINEAR PROGRAMMING

# TABLE OF CONTENT

# LIST OF ABBREVIATIONS

| | |
|---|---|
| HG | Higher Grade |
| HOD | Head of Department |
| LSM | Learning Support Materials |
| M. Ed | Masters in Education |
| OBE | Outcomes Based Education |
| SG | Standard Grade |
| STD | Secondary Teachers Diploma |

# ABSTRACT

*The introduction of Curriculum 2005 and the Outcomes Based Education in South African education system has been met with the challenges of developing adequate learning support materials. As OBE emphasizes child centred, constructivist learning the learning support materials need to be constructivist. I, as an OBE facilitator and a lecturer in a college of education, developed a learning material based on constructivist principles. In this research project, I reflect on the results of using the learning material in Linear Programming with my STD students.*

*In the first chapter of the project, the context and background of the research and the reasons for selecting Linear Programming as the topic for preparing the learning material are described. In the second chapter a brief overview of constructivism is given. It is followed by a brief explanation of the reasons for considering the material to be constructivist. The second chapter also looks at how the material facilitates understanding of the key concepts in Linear Programming. In Chapter 3, which focuses on the research methodology of the project, a brief description of the research paradigm followed in the project, the research techniques employed in evaluating the learning material and the strengths and weaknesses of the evaluation techniques are given. In chapter 4 the findings from the various data gathering methods and the results of the implementation of the material are described. Chapter 5 concludes the research project by looking at the research findings. The concluding chapter also presents a critical reflection on the whole process involved in the material development.*

# CHAPTER 1
# CONTEXT AND BACKGROUND OF THE RESEARCH

## 1.1 INTRODUCTION:

This project is based on research conducted to evaluate learning materials designed to teach Linear Programming to a group of 1st year students studying Secondary Teachers Diploma (STD) course in a college of education in the Eastern Cape. The aim of the research is to investigate the effectiveness of the learning materials which used a constructivist approach. This chapter begins with the context and background of the research. It is followed by the reasons of selecting Linear Programming as the topic for preparing the learning material and the purpose of the research. This chapter also contains a framework of the research where the contents of each chapter are briefly outlined.

## 1.2 CONTEXT AND BACKGROUND OF THE RESEARCH

The South African education system is currently undergoing fundamental transformation. The introduction of Curriculum 2005 and Outcomes Based Education (OBE) is one of the major changes in this transformation process. While many experienced educationists agree that the new curriculum has the potential to succeed, they also point to the difficulties the new curriculum change encounters in terms of the non-availability of Learning Support Materials (LSM) (Kgobe, 1996: 8). Lack of relevant learning support materials based on constructivist principles is identified as one of the problems hindering the implementation of OBE (South Africa, 2000: 62 –74). A study commissioned by the Gauteng Institute for Curriculum Development reported that, although most teachers were receptive to the introduction of OBE, the implementation of Curriculum 2005 was hampered by inadequate training of teachers, lack of relevant materials and poor communication between department officials and teachers (The Teacher, January 1999 as cited in Kgobe, 1999: 9). The same concern has been raised by many of the Grade 7 educators who attended the OBE workshops organized by the Central Region in the

Eastern Cape. In the workshops the importance of developing learning materials based on OBE principles was highlighted. The Curriculum Review Committee (South Africa, 2000) recommended that teachers should not only be able to use new textbooks effectively, but also be able to prepare learning materials themselves. For quite some time, being an OBE facilitator, I have been thinking about developing learning materials based on the constructivist and OBE principles. I thought of using such materials with my 1st year STD students so that they could appreciate the application of constructivist principles and the OBE approach in mathematics teaching.

## 1.3 THE REASON FOR CHOOSING LINEAR PROGRAMMING AS THE TOPIC

Linear Programming is used in different fields like businesses, industries, agriculture, the public sector, engineering, laboratories and many other fields (Daellenbach, 1995). In businesses and scientific applications mathematicians are often asked to find the **best** solution to a problem that involves a number of different conditions. These conditions or **constraints** must be **maximized** or **minimized** to give the **optimum** result. If we can express the constraints as a system of linear inequalities and then as linear equations, then we can use a technique called **linear programming** to determine the optimum value of the objective (Commins *et al.*, 1987:42). The techniques of Linear programming are used mainly by businesses for effective and proper management of available resources to make maximum profit taking care of controlling constraints. They also use the process of Linear Programming to analyze situations and make meaningful judgements.

Linear Programming is described as one of the most challenging topics in South African schools (Laridon, 1992). As a mathematics teacher in high schools, I noticed that learners had serious problems in the topic and they were afraid of it. They had difficulties in understanding the concepts involved in the topic as well as solving problems in it. In tests and examinations a large number of students avoided the Linear Programming questions and many of them who answered the questions scored very low marks. From discussions with the matric examiners in Mathematics Higher Grade (HG) Paper I, it was learnt that candidates usually scored less marks in Linear Programming questions. However, gradual

improvement in the marks scored in the topic is reported. As a teacher educator I also noticed that many of the student teachers who joined the first year STD course in Mathematics had no idea of the topic. Most of the students studied mathematics at Standard Grade (SG) level and the topic is not taught at SG level. Linear Programming is prescribed exclusively for HG mathematics. As a result it is considered a difficult topic, which is meant only for the top achievers in mathematics. Even those top achievers who studied the topic had problems with the topic. My interaction with mathematics teachers in schools where our student teachers did Practice Teaching revealed that many of them had difficulty in teaching the topic. Many of them are reluctant to teach the topic and some of them even skip it. It became clear as some of those teachers used to request the student teachers from the college to teach the topic during the Practice Teaching period. Unfamiliarity with the topic was cited as a reason for avoiding the topic. According to Laridon (1992) Linear Programming was introduced in South African school curriculum only in the mid-eighties (around 1983) and only at HG level. However, it is surprising to see that there are secondary school teachers who are unfamiliar with the topic almost seventeen years after it had been introduced in to the curriculum.

As a teacher educator I am of the opinion that colleges of education can play an important role in producing mathematics teachers who are more confident in Linear Programming. The topic could be handled in a better and meaningful way at the colleges so that the new teachers who come out of the colleges will be more confident and well footed in it. These teachers will be able to handle the topic better and they could help in reducing learners' problems and fear in the topic. Colleges should also develop learning materials which are user friendly for both teachers and learners in schools.

One of the Critical Outcomes outlined in the Senior Phase Policy Document (South Africa, 1997: 11) expects learners to be able to collect, analyze, organize and critically evaluate information. Specific Outcomes 4 and 6 in Mathematical Literacy Mathematics and Mathematical Sciences (MLMMS) as given in the Senior Phase Policy Document are about the development of skills in 'analyzing how mathematical relationships are used social, political and economic relations' and 'using data from various contexts to make

informed judgements' respectively (South Africa, 1997: MLMMS 3). One important aspect of the new curriculum and OBE is the integration of Learning Areas through relevant activities. It aims at minimizing the compartmentalization of learning experiences by learners. I thought of exposing my students, as part of the 1st year Mathematics Didactics course, to the constructivist and OBE principles and the implications of these principles to classroom teaching.

I was interested in developing learning materials in Linear Programming as it was a topic for the first year STD course. Furthermore, being the lecturer responsible for both content and didactics aspects of the STD first year mathematics courses, I thought of integrating the two aspects of the topic in my lessons. It was at this time I was given the assignment, as part of my Masters in Education (M. Ed) course, to develop a learning material using constructivist principles. I considered Linear Programming a very suitable topic to enlighten the students on the usefulness of mathematics in other fields and to discuss the principle of integration of Learning Areas. I also felt that I could use Linear Programming to expose my students to the theory of constructivism by integrating the content and didactic aspects of the theory through practical activities. I also wanted to give my students an opportunity of experiencing constructivist teaching so that they could appreciate the usefulness of constructivism in teaching and learning situations. For that I wanted to give them learning materials developed using constructivist principles. After considering all the above possibilities the topic could offer, I decided to develop the learning material in Linear Programming as my third research project.

## 1.4 PURPOSE OF THE RESEARCH

The purpose of this research is to evaluate the effectiveness of the Linear Programming learning materials which were designed according to constructivist principles. The research tries to investigate the following research question:

How effective is the learning material in Linear Programming developed according to constructivist principles in assisting students to understand the concepts and principles in the topic?

As a secondary goal the research also tried to investigate the effectiveness of the material in terms of making my student teachers appreciate constructivism in teaching and learning.

## 1.5 FRAMEWORK OF THE RESEARCH

In the first chapter of the project, the context and background of the research and the reasons for selecting Linear Programming as the topic for preparing the learning material are described. The purpose of the research is also included towards the end of the chapter. In the second chapter a brief overview of constructivism is given. It is followed by a brief explanation of the reasons for considering the material to be constructivist. The second chapter also looks at how the material facilitates understanding of the key concepts in Linear Programming. Chapter 3 focuses on the research methodology of the project. It contains a brief description of the research paradigm followed in the project, the research techniques employed in evaluating the learning material and the strengths and weaknesses of the evaluation techniques. In chapter 4 the findings from the various data gathering methods and the results of the implementation of the material are described. Chapter 5 concludes the research project by looking at the research findings. The concluding chapter also presents a critical reflection on the whole process involved in the material development.

## 1.6 CONCLUSION

In this chapter the context and background leading to the research project is briefly mentioned. Having realized the advantages of applying constructivist and OBE principles in the teaching of mathematics, I thought of designing a learning material based on those principles. I considered Linear Programming as a suitable topic for exposing my 1$^{st}$ year

STD students to the theory and practical application of constructivism. Moreover Linear Programming is described as a difficult topic for both learners and educators in the nearby schools. I thought of developing the learning material in this difficult topic with the intention of making my students more confident in it. The purpose of the research and the brief framework description of the research project are also included in the chapter. The purpose of the research is to evaluate the learning material designed using constructivist principles. Knowledge of constructivism and its implication to classroom teaching and learning support materials is very important for evaluating the learning material. The next chapter presents an overview of constructivism and its implication in the teaching and learning situations.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

This chapter mainly presents an overview of constructivism. The structure of the learning material and the key concepts presented in the material are briefly described. The reasons for considering the learning material constructivist are also presented.

## 2.2 AN OVERVIEW OF CONSTRUCTIVISM

Constructivism is described as a learning theory, as a philosophical perspective on knowledge and learning and is seen to derive directly from Piaget's work in genetic epistemology (Jawarski, 1994). Constructivism challenges the epistemological views held by the positivists. Positivists, as defined in the Oxford Dictionary (1994), belong to a philosophical system recognizing only facts and observable phenomena. They treat the social world like the world of natural phenomenon which is hard, real and external to the individual (Cohen & Manion, 1994: 7). According to Hinchey (1998), the positivists conceptualize the knowledge as a thing – essentially as verifiable information born of scientific investigation. For a positivist, knowledge constitutes factual and verifiable information and waits for the person who wants to acquire it to look for it and find it. Positivists are of the opinion that knowledge is infallible, immutable and cannot be wrong. They uphold that knowledge is fixed; unchangeable and it cannot make mistakes. To the positivists " to know" means "to be familiar with what has been discovered or recorded by researchers or experts" and "knowing" means "having information about". The task of the school, according to positivists, is to help young learners acquire more and more of the information already discovered by experts. Teachers are expected to become experts in what is known and then pass on the information to their learners. The goal of education, to the positivists, is for those who have the information (teacher) to pass on to those who do not have it (students). According to the positivist philosophy, teaching consists of transmitting sets of established facts, skills and concepts to students.

Constructivism offers a sharp contrast to the positivist views regarding 'knowledge', 'knowing', and 'teaching and learning'. According to the constructivists, 'knowledge' is not something external to the individual and waiting for to be found; instead knowledge comes into being only when human being examines the data (facts, artifacts and so on) and assigns meanings to it (Hinchey, 1998:45). A child should be able to create or invent knowledge for himself instead of receiving it passively from the environment. From the constructivist point of view, knowledge is fallible and mutable as it is created and continuously refined by individual from his/her contexts. To the constructivist knowledge keeps on changing as the individual constructs knowledge and the meanings he/she attaches to events can change over a period of time with the change in his environment or situation. Moreover there is nothing like true knowledge. Today's true knowledge can be proved wrong tomorrow. Constructivists disagree with the behaviorist view on how knowledge is acquired. According to the behaviorists, knowledge can be transmitted and the learner receives the knowledge from the transmitter, in most cases the teacher or the expert. It is in line with the positivist thinking. Since knowledge is fixed and is always true, a person who acquires it is considered a storage tank of knowledge and it can be just given to another person. The behaviorists also compare teaching and learning situation with the cup and mug situation where the teacher who has the knowledge pours his knowledge into the learner who is an empty vessel. But constructivists are of the view that every learner has his/her wealth of knowledge and constructs new knowledge based on his/her experiences which are meaningful and relevant to him/her.

According to Matthews (1992), constructivism has so much influence in present day education. Constructivism stresses pupils' active engagement in learning and the importance of students' prior conceptual knowledge for successful learning. Constructivism stresses dialogue, conversation, argument and the justification of learner and teacher opinions on issues. Constructivism insists on understanding rather than on rote learning; active participation of learners in constructing knowledge through making sense out of their learning experiences. Many countries all over the world are busy trying

to incorporate constructivist principles in the teaching learning situations in their schools. According to Jawarski (1994) many mathematics curricula in the US were seen grounded in constructivism. It is further reported that in the UK and in other parts of the world many educators believed that constructivism had significant implications for mathematics teaching. The Curriculum 2005 and OBE introduced in the South African education system is also based on constructivist principles. The document on OBE, Theory and Practice (South Africa, 2000), used for training Grade 8 educators advocates the use of constructivist principles in teaching and learning.

As Matthews (1992) rightly puts it, constructivism can be considered as a theory of education. It is a view about how teaching should proceed, how children should be treated, how classrooms should be organized, how curricula should be developed and implemented, and sometimes even a view about the purpose of schooling. Hodson and Hodson (1998) also claim that the term constructivism has been used to refer to views about learning, teaching, curriculum development and teacher professional development.

Radical constructivism and social constructivism are two important schools of thought on constructivism. Piaget who believed that knowledge is acquired as the result of a life-long constructive process in which we try to organize, structure and restructure our experiences in light of existing schemes of thought, and thereby gradually modify and expand these schemes is considered the architect of constructivism (Bodner, 1986). Radical constructivists strongly believe in Piaget's view that knowledge is constructed in the mind of the learner and uphold that individual solely creates the knowledge by making sense out of his/her experience (Thomas, 1994).

Social constructivists are of the view that knowledge is a social construct and it is constructed through interaction with others (Ernest, 1991). According to social constructivists even though the creation of knowledge takes place in the mind of the individual, he/she is not alone in the process of knowledge creation. He is assisted by the other members of the society and the existing body of knowledge. As reported by Wilmot and Euvrard (2000: 12):

> This view (social constructivism) claims that learning is not an individual phenomenon, rather that it takes place through social interactions. Further it claims that no learner comes to school with a mind that is a blank slate waiting to be written upon and filled with knowledge through a process of transmission from an expert (teacher) to the learner. Instead, it is claimed that all learners actively construct their own knowledge and that learning takes place when these constructs are challenged by new ideas

What Ernest (1991:43) says about social constructivism regarding the creation of mathematics knowledge is worth mentioning:

> Social constructivism links subjective and objective knowledge in a cycle in which each contributes to the renewal of the other. In this cycle, the path followed by new mathematical knowledge is from subjective knowledge (the personal creation of an individual), via publication to objective knowledge (by inter-subjective scrutiny, reformulation and acceptance). Objective knowledge is internalized and reconstructed by individuals, during the learning of mathematics, to become the individuals' subjective knowledge. Using this knowledge, individuals create and publish new knowledge, thereby completing the cycle.

From what Ernest (1991) says above, a person can create his or her own subjective knowledge. But that subjective knowledge has to be scrutinized against the existing body of objective knowledge by experts (preferably by experts in that field) before it can be accepted as knowledge. The body of any knowledge is warranted by proofs, whose basis and scrutiny rests on linguistic knowledge and rules. The scrutiny and criticism are used to judge the correctness of inferences, the consistency of assumption, the consequences of definitions, the validity of formalization in expressing informal notions, and so on. In that process of public scrutiny, a lot of discussions, arguments and negotiations take place where the individual may have to modify, refine and even recreate his/her knowledge. Unless scrutinized, that piece of subjective knowledge has no validity and it cannot be accepted as a valid piece of information. Without public criteria the word 'knowledge' is reduced to belief (Author unknown). Language plays an important role in this process of testing and verification of the knowledge created by an individual. Vygotsky (1978), a prominent figure among social constructivists, identified the role of language in the development of higher cognitive functions. According to Vygotsky, (1978 as quoted by Hodson and Hodson, 1998: 36), the cognitive functions (which includes creation of knowledge) originate in social activity and, as they develop, are inextricably linked with language. It is through social interactions - initially with parents or other caregivers,

family members and peers, later via teachers and other knowledgeable adults- that children learn the cognitive and communicative tools and skills of their culture. According to Jawarski (1994:19), " teachers can powerfully employ language to help students' construal". On the use of language by children to solve problems, Vygotsky (1978 as reported by Hodson and Hodson, 1998: 36) further claims: "children solve practical tasks with the help of speech, as well as with their eyes and hands".

The most fascinating aspect of constructivism, to me, is the fundamental shift from the traditional chalk and talk method to the activity oriented classroom teaching. I am inclined to be in line with social constructivists who acknowledge that both social processes and individual sense making have central and essential parts to play in the learning of (mathematics) (Ernest, 1991). According to Lerman (1992) talk in the classroom is essential to learning and concept formation. This talk could be discussion, argument, negotiation or purposeful intervention by teachers. A learner is helped immensely by the people around him in knowledge construction. Hodson and Hodson (1998) call these people around him as ' more expert others' - teachers, family members, other adults and , sometimes , peers. All these people help the learner in the process of enculturation. I am more in favour of the social constructivists since I firmly believe that a learner is not just alone in the process of knowledge construction, rather he is helped by many others. And also his knowledge has to be communicated to the society through language for verification before it can be accepted as objective knowledge.

The constructivist model of knowledge has important implications for instruction. According to Bodner (1985:876) the constructivist model requires a subtle shift in perspective for the individual who stands in front of the classroom: a shift from someone who 'teaches' to someone who facilitates learning; a shift from teaching by imposition to teaching by negotiation. In the constructivist model of teaching, both learners and teachers are involved in a give and take situation. The teacher has to acknowledge that the learners come with their prior knowledge and he should be trying to advance their prior knowledge. Facilitators have to provide all necessary tools necessary for the advancement of the learners' knowledge. As Hodson and Hodson (1998) report,

Vygotskian theory gives teachers a central role: leading children and students to new levels of conceptual understanding by interacting and talking with them. Thus, teaching comprises the activities associated with enabling the learner to participate effectively in the activities of the more expert; and learning is seen as enculturation via guided and modeled participation. From these it becomes clear that teachers' task in the constructivist model is very challenging. The constructivist teacher, by offering appropriate tasks and opportunities for dialogue, guides the focus of the student's attention (Bruner, 1986). Designing suitable child-centred and activity oriented learning materials for a constructivist lesson could be one of the important challenges of a constructivist teacher. S/He should design learning materials which can encourage learners to work together more cooperatively in exchanging ideas to teach each other. (1991). In South Africa, with the introduction of the OBE, the demand on teachers to develop learning materials according to the constructivist and OBE principles is very high. However, the Curriculum Review Committee reported that in the majority of schools in the country, teachers do not have the time, resources and often skill to develop their own materials (South Africa, 2000: 20). Hence the committee recommended that the learning support materials should be produced by dedicated units or institutes and publishers and the teachers should be trained in the use of learning support materials, and especially the text books.

## 2.3 WHY IS THE LEARNING MATERIAL CONSIDERED CONSTRUCTIVIST?

Initially the key concepts covered in the material and its structure on a daily basis are discussed. The reasons for considering the material constructivist are also presented

### 2.3.1 Key concepts considered in the learning material

From my discussion with other educators I have gathered that many learners grapple with the concepts and terminologies in Linear Programming. It is also learnt that they have problems in analyzing and understanding the word problems in the topic. According to

Dikigomo (1998:150), "Inequalities are perceived with a measure of difficulty or unease by both teachers and students of mathematics". Hence learners' conceptual understanding of inequality is given some importance in the material. Terms or phrases such as constraints, is less than, is not less than, more than, not more than, at least, at the most, feasible region, optimum value, maximize, minimize are found difficult for learners to conceptualize. These concepts and terms are also dealt with in the learning material. In my teaching Linear Programming for the last 20 years, I realized that many learners had difficulties in the identification and writing of the constraint inequalities and objective functions from word problems in Linear Programming. Distinguishing between constraints and objective functions is another difficulty experienced by learners. Discussion with colleagues and other mathematics teachers confirmed this view. According to some of the educators, *translation of word problems into mathematical expressions and equations is a problem generally experienced by learners in almost all areas of mathematics*. It could be attributed to language problems faced by learners whose first language is not English. A large portion of students with English first language is also found to experience problems in this area of translating word problems into mathematical expressions and equations. As a result writing of constraint inequalities and objective functions are considered key concepts or key issues in the material. Drawing of linear graphs for inequalities, identifying and shading the correct feasible region, sketching and optimizing the objective function etc. are also equally important areas where learners experience difficulties. According to Laridon (1992), "Linear programming tests the pupil's ability to interpret graphs. Dealing successfully with intersecting lines, areas and half planes has to be taught to most pupils - it does not come naturally to all". Accordingly drawing of graphs and their interpretations are also given serious consideration in the material.

### 2.3.2 Structure of the learning material

The learning material is developed following the constructivist principle underpinning the Outcomes-Based Education (OBE) approach suggested in the Curriculum 2005 .The

material is designed with learning activities spread over a period of eight days. The structure of the learning material on a daily basis is given below.

**Day 1**

On Day 1 two activities are used to set the stage for motivating the learners on the need for Linear Programming. Activity 1 is used to introduce the concept of variables in mathematical situations in Linear Programming. It is also intended to bring out the idea of minimizing the cost per student and the concept of objective function. In Activity 2 only two variables are used in line with the present syllabus requirement for the Grade 12 and STD courses. Activity 2 also provides another context to think about variables and objectives as well as the concept of maximization.

**Day 2**

Activity 3 on Day 2 is intended to provide the learners with an opportunity to think about a wider context where real Linear Programming techniques are employed. It is also intended to introduce or link some concepts with the general terminology. Worksheet 1 (Activity 4) on Day 2 is a revision exercise to identify the learners' prior learning in writing mathematical expressions for situations described in words.

**Day 3**

Activity 5 on this day is designed to make the learners construct inequalities and objective functions for the conditions given. They are asked to discuss the conditions in pairs and report to the class how the inequalities are formed. They are given another task on the proposed Cape Town trip to form inequalities.

**Day 4**

Activity 6(a) involves the representation of inequalities by graphs. Inequalities involving $<$; $>$, $\leq$ and $\geq$ are given.

Activity 6(b) is on writing the inequality for the given graphs. It also involves describing the x and y-coordinates of points using the inequality signs.

In Activity 6 (c) learners are given four inequalities to draw graphs. The inequalities are selected in such a way that the lines representing them enclose a region. One of the aims of this activity is to enable the learners to write the coordinates of points using ranges. The other aim is to introduce the concept of feasible region.

Activity 6(d) is about region on both sides of a line representing inequalities in two variables. It aims at the writing of inequalities for the regions on the two sides of a line representing the conditions involving two variables.

Further Task on Day 4 is intended to reinforce what the learners have studied. They are given important concepts or terms in connection with the topic. First they have to write answers and then compare their answers with the explanation given in the handout.

**Day 5**

In Activity 7 on Day 5 students are asked to represent the inequalities they obtained for the constraints in the situations of Nomsa and the Cape Town trip. They are asked to shade the feasible region for the two situations on separate diagrams.

In Activity 8 learners are expected to write objective functions for the two cases (Cases of Nomsa and the Cape Town trip).

The Further Tasks (Worksheet 3) on Day 5 gives the learners additional exercises for writing the objective functions. They are also asked to write the gradients of the lines to enable them draw the search lines.

**Day 6**

Activity 9 on Day 6 is aimed at finding out the maximum or minimum values from the feasible region. First, learners are asked to calculate the coordinate of the four corners and substitute the x and y coordinates in the equations for the objective functions. Then they are asked to draw the objective functions and slide it by drawing lines parallel to it through the feasible regions to search for the point(s) which could give maximum or minimum value for the constraints. This exercise intends to give the learners context to find the optimum value from the maximum and the minimum values.

**Day 7**

Activity 10 on Day 7 is a practical activity using Lego blocks to integrate the theory and practice. It is aimed at giving more insight to the learners on the applicability of Linear Programming.

**Day 8**

On Day 8 learners are given a diagram representing the constraints in a Linear Programming problem. This activity is included to give the learners an opportunity to interpret information presented in graphs. The learners are expected to form inequalities from the graphs and also to find the optimum value(s) for the given constraints.

In the end learners are given some typical Linear Programming questions from past Grade 12 question papers. These questions are given as additional exercises.

### 2.3.3Why is the material considered constructivist?

Having given a brief overview of constructivism let me explain why I consider the learning material in Linear Programming constructivist. Even though the material may not meet all the requirements, I am certain that it meets some criteria to be considered constructivist. According to constructivism learners construct knowledge based on their prior learning experience. Hence by implication a constructivist learning material should help learners create or construct new knowledge making use of their previous knowledge. In learning Linear Programming conceptual knowledge of inequalities and their graphical presentation are very important. The material is based on the assumption that the students have knowledge in these areas. In most of the daily activities a revision or checking of the relevant previous knowledge is incorporated in the form of discussion or other activities. For example, before coming to the real writing and graphing of the inequality constraints, students are given some task as a revision in writing and graphing inequalities which they studied earlier. According to constructivism learners create knowledge through activities, interaction with others and self-reflection. The learning material provides a lot of opportunities for those types of activities, which could promote learning. Perusing the Appendix: I could reveal the activities incorporated in the material.

The most important aspect of the material I want to point out is that there is a shift from the traditional chalk and talk approach to activity oriented approach. The material tries to move away from the traditional teacher-centred approach to a child-centred approach. In the introduction of the module learners are given two activities. In the first activity they are asked to reflect on their trip to Cape Town regarding the number of people going for the trip, the mode of transport and its cost and other costs involved together with the amount each person has to pay for the trip. They are asked to identify the factors which could make the contribution by each participant as minimum as possible. The second activity on collecting information from the lady selling fruits in the college campus is aimed at collecting information on the buying and selling of fruits by the lady to highlight the constraints governing the businesses of the ladies to make maximum profit. These two activities are aimed at providing learners with situations or problems they are

familiar with in their own immediate environment. These activities are designed to give learners opportunity of research, discussion in groups, report back, reflect on their findings and refine their own understanding and knowledge.

Activity 3 on Day 2 is intended to give them a chance of reflecting on their experience the previous day and relate it to similar situations. Activity 5 on Day 3 is especially designed to show how a simple situation of the fruit seller could be developed into a mathematical problem. It is further intended to make them aware of the use of mathematics in simple daily life situations and more complex situations influenced by many constraints.

Activity 4 on day 3 is intended to refresh their memories on what they already studied on linear inequalities. Activities 6a, 6b, 6c and 6d are intended to help students revise their knowledge and skills in graphs and graphing of linear inequalities. Some new concepts of area bounded by different inequality graphs and a line dividing a plane into greater than and less than regions are also included. In most of the questions learners are encouraged to formulate their own ideas and concepts based on what they already knew. These activities are aimed at preparing the ground for the new knowledge construction. Learners are given a handout on Linear Programming. Some questions based on the handout are deliberately included in the material to make sure that learners read the handout. This in turn is used to make the learners accept responsibility for learning. In the Further Task at the end of Day 4 (page 11 of the material) learners are given opportunity to learn the important terminologies in the topic. Activities 7 and 8 on Day 5 are used to help learners construct meanings of constraint inequalities and objective function.

In Activity 9 on Day 6 the fruit seller's case is fully developed into a typical Linear Programming problem. Activity 10 on Day 7 is another typical Linear Programming problem. In this activity Lego blocks are used to simulate the problem situation in the class. T. G. Edwards and K.R Chelst (1999) used this method in their lessons in Linear Programming. Learners are required to look for all possibilities and identify the optimum situation. It is hoped that using the various methods learners would be able to grasp the

use of linear programming in determining the ideal situation for maximizing and minimizing the constraint variables. One of the main problems learners face is translating constraint situations in word problems into mathematical inequalities. An exercise in translating word problems into mathematical inequalities is added in the material. At the end, both familiar and unfamiliar situations from the learners' immediate environment and outside their environment are given as additional problems to solve.

In all activities a lot of opportunities for reflection, interaction with peer and teachers are given. Lerman (1992) suggests that the internalization of experiences, through discussion, argument, conjecture, and counter examples, is what classrooms are about. The learning materials I prepared provide most of these activities suggested by Lerman. A constructivist view of learning suggests that we may need to consider the content of a (science) curriculum from a more developmental point of view (Science, Mathematics and Technology Education: 2000). What the author implies, perhaps, is that a good constructivist material helps the learner develop and complete understanding conceptual areas gradually; i.e., a constructivist material is developmental. The learning material in Linear Programming is also developmental as it takes the learner step by step to the final stage of solving problems in linear programming. I hope, in the light of what I have discussed, the material could be considered reasonably constructivist.

## 2.4 HOW DOES THE MATERIAL HELP TO UNDERSTAND THE KEY CONCEPTS?

The material as pointed out earlier placed emphasis on certain key points or concepts for learners to understand. These are the terms or concepts which are found to be problematic for the learners. Those words or phrases were frequently used in the word problems to make the learners familiar with them. Activities 5(a), (b), (c) and (d) in worksheet on Day 4 are given as a revision of what they studied earlier. It was prepared with inequalities in one variable at first and gradually increasing the difficulty of the inequalities with two variables. In worksheet 1 on Day 2 learners were asked to write mathematical expressions for few statements involving inequalities. Towards the end of the task they were given

statements with inequality constraints to translate in to mathematical expressions. Similarly they were given expressions for writing objective functions. All these activities were followed by group discussions by learners alone and class discussion with the teacher. Wherever necessary the concepts and terminologies were properly explained. In the exercises at the end these terminologies and inequality constraints and objective functions were generously used to give the learners enough practice in the key concepts.

## 2.5 CONCLUSION

In the first part of this chapter an overview of constructivism is presented. A comparison between the views of positivists and constructivists is presented. I tried to defend my inclination to social constructivism by making a brief comparison between radical constructivism and social constructivism. The implication of applying constructivist principles in classroom teaching is also looked at. In the second part of the chapter the reasons for considering the learning material constructivist is presented. Prior to pointing out the reasons, the key concepts covered in the learning material and the structure of the material are outlined. In the last part of the chapter, a brief discussion of how the material helps understand the key concepts is attempted. It leads us to the next chapter where the actual research of evaluating the effectiveness of the material is explained.

# CHAPTER 3
# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

In the first part of this chapter, a brief description of the research paradigm upon which the research is based is given. It is followed by the different methods, tools and techniques used in the research. Lastly a critical evaluation of the strengths and weaknesses of the various research methods and tools used in the evaluation of the learning material is also given.

## 3.2 RESEARCH PARADIGM

The research follows a qualitative research paradigm. A detailed description of the qualitative paradigm was given in the previous research project. I, therefore, do not intend to go over the issues related to qualitative research methodology. However, a brief description of the main research approach used in this project, the interpretivist approach, is attempted.

According to Cohen and Manion (1994), the interpretivist paradigm is characterized by its concern for the individual and its antipositivist nature. The central endeavour in the interpretive paradigm is to understand the subjective world of human experience. The interpretive researchers try to understand the interpretations of the individuals regarding the researched issue. According to Thomas, A.S. (1994:121), interpretivists consider social agents autonomous, intentional, active and goal directed; they construe, construct and interpret their own behaviour and that of their fellow agents. Interpretivist focus on the process by which meanings are created, negotiated, sustained and modified by individuals within a specific context of human action. All interpretive inquirers watch, listen, ask, record and examine the personal constructs of the participants. The learning material is evaluated on the basis of opinions of people (educators and students) who had

the opportunity of either going through it or using it. The personal constructs of the participants in this research are interpreted to arrive at the conclusion regarding the effectiveness of the material.

## 3.3 RESEARCH TECHNIQUES AND TOOLS USED FOR EVALUATING THE MATERIAL.

### 3.3.1 Classroom Evaluation.

Classroom evaluation, being a very important aspect of determining the suitability and effectiveness of the learning materials, had been incorporated through out the unit. Being the implementer of the units I had the opportunity of getting first hand information. Both informal and formal techniques and tools like questioning, class-work based on daily activities, worksheets etc were used for evaluating the material. Report of the group discussion of activities was used to assess students' understanding. At the end of the daily activities, **Tasks** and **Further Tasks** were given to assess the conceptual understanding developed by the learners. Tasks were designed for class-work and the Further Tasks were given as homework. Answers to these tasks were discussed the next day and the responses were used for evaluating the material. A good performance by the learners in the tasks was taken as an indication of the effectiveness of the material. At the end of the lesson unit, learners were given an evaluation sheet to check whether there was any improvement in the conceptual understanding in the learners.

### 3.3.2 Observation

Observation was used as another tool to evaluate the learning material. As a participant in the classroom activities, being the mathematics lecturer of the class, I used participant observation. The enthusiasm shown by the students in the material and the student participation in the learning activities in the form of discussion, reporting back of the discussion results, answering questions in the worksheets and other tasks etc while using the material were observed. As I mentioned earlier the material was intended to serve a

dual purpose of facilitating content learning in linear programming and evaluating the effect of constructivist approach in teaching. The material was also used to see the attitudinal change of learners towards the constructivist approach in teaching and learning, in which they had no practical experience so far. The smiling and gloomy faces, the nodding and shaking of heads by the learners while going through the material and the dialogue and discussion which took place while doing the activities and tasks were used to assess the effectiveness of the material. The interest shown by the learners in carrying out the task was used as an indication of the motivating effect of the material. The happy faces and active participation in the activities was used as a positive indication of the learner friendliness of the material. The results of observation were taken note of on a daily basis.

### 3.3.3 Interviews and Questionnaire

Interviews and questionnaires were also used to evaluate the learning material. Copies of the material were given to the head of the Mathematics Department in my college and two other mathematics lecturers; one in another College of Education and the other in a university. There is a policy in the Mathematics Department that lecturers should consult the HOD and obtain his consent to the academic programmes run by lecturers. I considered the HOD of the Mathematics Department an authority in the subject as he taught the topic of Linear Programming for a very long period in many schools and the college. So I thought of seeking his opinion on the effectiveness of the learning material. The lecturer in the other College of Education also had many years of experience in mathematics teaching. Since 1999 this lecturer and myself have been facilitators of OBE workshops organized by the Central Region in the Eastern Cape for training Grade 7 and Grade 8 teachers. The workshops deal with constructivist approaches in teaching and learning situations in classrooms using learning activities. So I considered this lecturer another suitable person to evaluate my learning material. The university lecturer, before joining the university, was the Head of the Mathematics Department at my college. I considered him ideal to evaluate the material considering his many years of experience in mathematics teaching at different levels of educational institutions.

The assessors were requested to peruse the material and evaluate the material with reference to its suitability, constructivist nature, learner-centredness, depth of content and its motivating effect. They were given an evaluation form for assessing the material. It is included as Appendix II. After they had gone through the material, informal interviews (discussions) with the evaluators were arranged to find out their views on the material. I used unstructured interview schedules, as the interviews were conducted as informal talks. The interviews focused on the same features of the material as mentioned in the evaluation form. They were also requested to comment on the suitability of the material in promoting constructivist approach in teaching.

When I finished with the learning unit, an assessment task in the form of a test (Appendix III) was given to the students to assess their understanding in Linear Programming. A questionnaire (Appendix IV) was given to the learners to evaluate the learning material with reference to the mathematical knowledge and the new approaches, especially the constructivist approach, used in teaching the topic. As there were only six students in this course all of them were given the questionnaire. Here I was faced with the problem of asking my own students to evaluate my learning material and my approach of facilitation. Group and individual interviews were conducted to cross check the responses to the questionnaire. The interviews were informal and unstructured questions were used to allow in-depth probing of the students' responses. My earlier experience in interviewing students proved that informal interviews were better with students. However I jotted down the important points to be stressed upon to have a clear direction for the interview. These interviews were also used to clarify some responses to some questions in the questionnaire. I asked the class as a group questions regarding the suitability of the material and the new approach. I talked to two of the students individually to get more personal views about the material and to confirm the views expressed by the class in the group interview. Before the discussion, both in the group interview and individual interview, the purpose of the interviews was explained to them. It was made very clear to them that the material was prepared in an effort to assess the effectiveness of constructivism and the facilitation approach suggested in the OBE approach.

Through out the lesson units there were tasks set out to evaluate the learners' understanding of the concepts and development of skills. At the very end of the unit a consolidated exercise in the form of more problems was added to check their performances as a way of evaluating the material. In my view a good learning material should promote understanding of the concepts and principles used in it. Initially I thought of conducting a test to assess the learners' performance in the topic. However I was not able to do it due to time constraints. The learners' answers to the questions on Linear Programming in the final examination was also used to evaluate the effectiveness of the materials.

## 3.4 STRENTHS AND WEAKNESSES OF THE RESEARCH APPROACH, METHODS AND INSTRUMENTS USED TO EVALUATE THE LEARNING MATERIAL

### 3.4.1 Strengths of the research methods and techniques

Evaluation of the research methods and techniques used for the evaluation of the learning material is a difficult task. The difficulty is aggravated when the evaluator is the designer of the material himself. Initially, the strengths of the research methods are looked at. The methods and techniques used in the evaluation of the learning material are suitable for the interpretivist and constructivist research paradigms followed in the project. The research findings were interpreted using the constructs of the participants. Most of the participants in the research are from the college. The performances and opinions of the students for whom the material was prepared were mainly used for the evaluation purpose. Submitting the material to teacher educators who are very experienced in mathematics teaching and currently handling the topics can be considered as a strong point of the evaluation technique. Seeking educators' opinion on a teaching and learning material is a general practice among those who are involved in the production of such materials. Book publishers in cooperation with departments of education usually organize book evaluations. The relevance and suitability of the material, the coverage of the content knowledge, didactic flexibility, learner friendliness etc. were used as criteria for

evaluating the material. The evaluators of the learning material were also requested to comment on the same aspects.

After the teacher educators had gone through the material, interviews in the form of informal discussions were arranged with them. The interviews provided a chance to probe the suitability of the material and to verify the validity of the written comments of the evaluators about the material. As the developer and presenter of the material, through participant observation, I got the chance of getting the first hand information on the learners' attitude towards the material. I was also able to observe the way the learners made use of the material and the difficulties they faced with the material. This is another important strength of the techniques used in evaluating the material. Use of group interviews, questionnaires and individual interviews with two learners to find out the strengths and weaknesses of the material can also be cited as another strength of the evaluation technique. The views of the different educators and learners regarding the material were compared and contrasted with those obtained from the learners through interviews and questionnaires. These findings were compared with the findings from the observation. This method of triangulation of findings from various methods can be cited as another strength of the approaches used in the research.

Incorporation of the tasks and activities through out the material is another strength of techniques used for evaluating the material. Students' performances in the tasks and activities were used to assess the effectiveness of the material.

### 3.4.2 Weaknesses of the research methods and techniques

Choosing colleagues and friends as the learning material evaluators can be regarded as one of the weaknesses of the evaluation technique. The objectivity and reliability of their opinion can be questionable. I could have added a few mathematics teachers who are currently teaching the topic in the nearby secondary schools in the group of external evaluators. They could have pointed out extra weaknesses of the material from the high school context. They could have also given additional suggestions for improving the

material. Another weakness in the evaluation technique is the exclusion of other lecturers and teachers from observing the lesson. The observation report is very subjective and hence it can be biased as the observer himself is the developer of the material. I could have asked my HOD or another lecturer or a teacher from a secondary school to observe the lessons. It would have been better if some external evaluators were also involved in the collection and analysis of the feedback.

The learning material was not piloted. It is another drawback of the evaluation strategy used to assess material. Plot running the material could have revealed many drawbacks of the material. The fact that an observation schedule was not used during the lesson observations is another weakness of the evaluation process. An observation schedule could have provided a proper guideline and criteria for assessing the effectiveness of the material. Another drawback is not using a properly structured interview schedules for the interviews. Most of the interviews were very informal and as such the interpretations of the responses were difficult. These weaknesses could have been avoided if I were a bit more serious and careful about the task. I never realized that evaluating my own material would be such a challenging task.

## 3.5 CONCLUSION

In this chapter the research methodology followed in the research is presented. A brief description of the interpretivist approach is given. The methods and techniques used in the data collection together with a reflective analysis of the strengths and weaknesses of the methods and techniques are presented. Lecturers who had many years of experience in teaching the topic evaluated the learning material.. Informal interviews with them were organized to get their opinion regarding the standard, suitability and the constructivist approach used in the learning material. The results of implementation of the material in the classroom are also used in evaluating the material. The findings from the various research methods are described in the next chapter.

# CHAPTER 4
# RESEARCH FINDINGS

## 4.1 INTRODUCTION

In this chapter the research findings regarding the effectiveness of the learning material is presented. The reports of the evaluators of the learning material and the results of the implementation of the material in the classroom are discussed.

## 4.2 REPORT OF EVALUATORS OF THE LEARNING MATERIAL

The evaluators made positive criticism about the material. All of them were of the opinion that the material was constructivist and up to standard to teach Linear Programming for STD and Grade 12 classes. My HOD commented, "*It's a good material*". In the interview he explained, "*The material contains a lot of activities which enables the learners to do on their own and they will be able to make sense out of the activities. In the activities learners are encouraged to work cooperatively*". He commented on the selection of examples which are familiar and relevant to the learners situation. However he was of the opinion that some examples were not easily understandable to the learners.

The other two evaluators were also of the opinion that the material was constructivist. The lecturer from the other college of education just described it as constructivist. She did not make any further comments or any suggestion to improve the materials. The university lecturer gave some valuable suggestions. For example, in the first draft of the material, Activity 2 consisted of many variables. He suggested that the number of variables should be reduced to two. According to him, " *The Grade 12 and College syllabus in Linear Programming requires only two variables to be considered. It will be difficult for the learners to handle more variables*". Again he suggested that each activity should have a theme and a particular concept to be taught. He was of the opinion that one example should be used through out to develop the whole lesson units gradually, starting

with identifying the constraints to the final stage of optimizing the constraints. In the original draft material different examples were used to deal with different concepts. Following his advice the example of Nomsa (Activity 2 on Day 1) was used for development of the lesson units. However, more examples were given for reinforcement and enrichment. The HOD and the lecturer from the university gave suggestions regarding the logical sequencing of the themes and activities on a daily basis and phrasing of questions and problems that could reduce misconception in learners. I am indebted to them for their valuable support.

## 4.3 RESULTS OF IMPLEMENTATION OF THE LEARNING MATERIAL

Before commenting on the results of the implementation of the learning material I would like to point out some of the difficulties I faced in the implementation process. As I have indicated earlier the material was developed for my normal lessons according to the work programme designed at the beginning of the year. This class of six learners was already behind the schedule due to their poor background in the subject. Three of them were required to rewrite and pass Std: 10 Mathematics examinations to achieve the required symbol for admission. None of the six students studied mathematics at the Higher Grade (HG) level. Only one student in the class got symbol C in mathematics at the Standard Grade (SG) level. Others got D or E symbols. All of these students studied English as a second language.

In Activities 1, 2 and 3 the learners discussed the Cape Town trip and the selling of fruits by the ladies. It laid the foundation for introducing the need for Linear Programming. The discussions and interaction among the students in Activity: 1 followed by the report back on the activities were taken as indications of achieving the expected outcomes of the activities. During the discussion on Activity 1, students identified different modes of transport such as buses, mini-buses and combies. The total number of students, the number of passengers which can be accommodated in the various types of vehicles, the amount to be paid to each vehicle for the trip and the amount students are able to afford etc were identified as factors to be considered while deciding on the type of transport for

the trip. Making the cost per student as minimum as possible was described as the objective of the organizers of the trip.

For Activity 2, each student did some research and reported back his or her findings on the different types and quantities of each type of fruit bought and sold by the ladies. They were able to identify the link between the number(s) of fruit(s) bought and sold, the relation between the available funds and the number of fruits bought. It was reported that the number of each type of fruit bought by the ladies depended on the demand for each type and the fund each lady had. They were able to link profit made in the business to the number of each type of fruit sold. They also reported on almost the same profit margin made by the ladies. They also appreciated the importance of small businesses in the economy of the families in rural areas. The most important point in the report was that they were able to identify the objective of the ladies in their businesses. The ladies wanted *to make maximum profit by selling the maximum number of different varieties of fruits with the available resources.* The intentions of the ladies were reported as buying the most selling fruit at the minimum cost and making the maximum profit.

The week before I was supposed to start with the topic I was chosen to attend the Provincial OBE workshop for Grade 7 teachers about which I mentioned earlier. As a result I had to leave the students after the introductory part of the lesson units. I left the students on their own on the second day after the report back of the findings of each of the three groups and Activity 3. The students were able to relate the situations and findings from the two cases in Activities 1 and 2 to those in bigger businesses and companies. They were also instructed to attempt activity 4 in pairs. Activity 4 was intended for students to do on their own to enable them to translate situations explained in words into mathematical expressions using inequalities. As usual students found this difficult. Only one or two learners even made reasonably good attempt. The following are examples of some of the answers:

For expression 1, some of the answers were $N = R50$; $A < R50$; $A > R50$.
For expression 4, some of the answers were $P = 5000$; $P < 5000$; $P \leq 5000$.

For expression 7, some of the answers were $x + y = 25$ and $x + y \leq 25$.
For expression 8, the answers were $c + b = 8$.

The students were found completely lost on Activity 5 on Day 3. *"We are not used to this type of mathematics and we do not know how to proceed. The problem seems difficult to understand".* These were the comments made by one of the learners as reason for not attempting the task. The learners were asked to go through the reading material on linear programming, which was extracted from the mathematics textbook Essentials of College Mathematics by Raymond A. Barnett and Michael R. Ziegler (1989: 277-340). When I was away for OBE workshop learners were given Worksheet: 2 with activities 6(a), 6(b), 6(c) and 6(d). They were on their own. The learners were able to draw the graphs for 6(a) (i) and (ii) correctly. However they were not able to use dark dot for the $\leq$ and $\geq$ signs. In 6(b) the inequalities for the shaded regions were identified correctly. But they had difficulties in describing the x- and y- co-ordinates of points P and Q in the activities. In activity 6(c) the graphs of the inequalities were drawn and the feasible regions were shaded well. Writing the co-ordinates of a point P inside the shaded region was again found difficult by the students . It showed their inability to write the co-ordinates using inequalities. For questions 6(c) (iii) on how many other points similar to P can be found in the region the popular response was "many". They were not able to suggest `infinite points` as answer. The name for the shaded region was correctly given as feasible region. It was learnt that they got the name for the region from the handout and other textbooks. However only after a brief explanation they were able to get clear understanding of what was meant by the feasible region. Activity 6(d) was also responded reasonably well. Even though they were able to draw the graphs well, they had difficulty in describing the un-shaded area.

In the Further Task on Day 4, students were able to draw the graphs for the inequalities and they shaded the region bounded by the three lines. The question about a point inside the shaded region was not well answered. They named the shaded region 'Feasible Region'. Learners were able to locate and write the meaning of the words from the handout or dictionary. However it was very clearly evident that they did not have a real

conceptual and contextual understanding of the terms. For example, even though they named the shaded region 'feasible region', they were not able to explain what was meant by 'feasible region'. I had to explain most of the terms with suitable examples. It reconfirmed the importance of using simpler words which are more familiar to the learners for better understanding.

On Day 5 the learners were able to represent the inequalities described in Nomsa's business and the Cape Town trip. With some mediation they were able to understand the concept of objective function and to calculate the gradient of the two lines representing the objective function. They were able to make sense out of the situation described in Worksheet 3 and managed to get the expression for the two cases. They were able to write the expressions for the objective functions for situations given in the Further Task. The answers for questions 1 to 4 were respectively $P = 200x + 400y$, $P = 5x + 4y$, $W = 5x + 7y$ and $A = 200x + 250y$.

The students were able to answer the questions in Activity 9 on Day 6. They were able to calculate the values of the profits at the different corners and they could identify the point where the maximum profit could be realized. They were not able to slide the objective function to find the optimum point. They needed some assistance in that respect.

The Activity 10 of Day 7 was very interesting. Learners could make use of Lego blocks and got the number of chairs and tables they could make with the available stock. Finding out all possibilities of number of chairs and tables was not that easily understood by all learners. After a brief explanation they were able to write down all possibilities. The discussion, arguments and negotiations for finding out the possibilities and impossibilities were interesting to watch. They calculated the maximum profit and they were able to identify the maximum number of chairs and tables they could make with the Lego blocks as the optimum numbers. However they had problems in writing the inequalities describing the constraints. Writing the expression for objective function, drawing the graphs, identifying and shading of feasible region were found relatively easy for the learners. But making use of the objective function was not attempted. However

they used the co-ordinates of the corners of the feasible region to determine the profits to identify optimum number. They were asked to reflect on the practical activity and the mathematical way of arriving at the same answers. They really had problems in translating the results of the practical activity in to mathematical equations. This could not be an isolated case in my class alone or only for that particular activity. This could be happening in most of the mathematics lessons in all other topics where teachers use activities based on constructivist principles. We can be sure of real learning taking place when the learners are able to explain the mathematical concepts involved in the practical activities and are able to translate the mathematical situations into mathematical expressions and equations. Otherwise the activities become just a sort of games without any learning takes place. I do not think that is the intention of classroom activities. Teachers should be very careful in this regard. After a lot of intervention in the form of questioning, probing and explanations my students were able to form the equations for the activity. Learners had difficulty with the word problems in activities on day 6. They appeared gloomy and lost after reading the questions. The question appeared complicated to them. However with the explanation of the questions they were able to write the inequalities and they managed the rest of the task.

Implementation of the learning material revealed many problems associated with the teaching and learning of Linear Programming. First of all it confirmed the popular opinion that learners really had difficulty in word problems in general and Linear Programming in particular. It identified one of the most problematic aspects of the topic as translating constraints in words into mathematical inequalities. Language issue was identified as a crucial factor affecting the learning of the topic. Another problem identified was that most of the time learners did not understand the questions. It became clear from the fact that once the question was explained they were able to form the linear inequalities and draw the graphs and shade the feasible region. It provided an opportunity to assess the suitability and the effectiveness of the learning material. Implementation of the material exposed the important role played by proper intervention in the teaching learning situations. Most of the time learners had difficulty in understanding some concepts and processes involved in the topic and proper intervention at the right time

really helped learners in understanding the topic. It also revealed the central roles played by teachers, as suggested by Hodson and Hodson (1998), in helping learners create knowledge which are beyond their reach. As Hodson and Hodson (1998: 37) suggested extensive guidance and support were provided for those aspects which were just beyond the students' current unaided capability. This could be taken as a valid point to support the role of social constructivism in constructing knowledge.

## 4.4 FINDINGS FROM THE QUESTIONNAIRE AND INTERVIEWS WITH LEARNERS

### 4.4.1 Findings from the questionnaire

The responses to the questionnaire were not encouraging. Some of the answers were not relevant to the question. The responses indicated the poor calibre of the learners. However, from the questionnaire it became clear that the students liked the new method of lesson presentation. They liked the chance given to them for reading and reporting back about their findings. They also liked the chance of cooperative learning given to the students. *We share our views and combined those views to get a solution. We want to work in groups. It is a chance for each other to participate and concentrate well in the discussions.* The students wanted to have more lessons taught according to the new method. When asked whether they would follow the method used in the learning material, the answer was 'yes'. *This is OBE method, and is useful in these days. We are not going to be the traditional teachers who said a command to the pupils so that they(pupils) would not come with their views.*

### 4.3.2 Findings from the interviews

The group interview was mainly used to gather the learners' views about the new method used in teaching Linear Programming. Learners were happy about the new method. Their views about the new method are summarized as follows:

*This method made us to think and solve the problems ourselves. It gave us opportunities to discuss the problems in groups and share ideas. It also made us report what we discussed. It made us confident to talk about our answers. It would be better if we could use the same method with our learners.* According to the class, the learning material showed them how to design activities based on the OBE approach. It was also gathered from the class discussion that they needed more clarification in the content aspect of the lesson units. They found it difficult to analyze some of the problems in Linear Programming.

In the individual interviews the same opinions were expressed. According to one of the interviewees, " *the learning material and the new method used in the material are good. Even though it demands a lot from the teacher, I think the method can help the learner a lot. Even though I still have problems with some of the new things in the lesson unit, I like the new approach in it. I will try to make use of constructivism in my lessons. By all means it is a nice method.*"

## 4.5 STRENGTHS AND WEAKNESSES OF THE LEARNING MATERIAL

### 4.5.1 Strengths

I found it very difficult to evaluate my own material. I am afraid of my objectivity in the process. I am of the opinion that the material has some strength and so many weaknesses. The first strength that can be attributed to the material is that it is based on constrictivist principles. The reasons cited in Chapter 2 section 2.3.3 to justify why the material is considered constructivist can be cited as its strengths. The shift from the chalk and talk method to teaching through activities can be considered as a major strength of the material. The learner-centred approach where the prior knowledge of the learner is used in designing learning activities on a daily basis can be added to the strengths of the material. Selecting examples from the immediate environment of the learners is another strong point about the material. Inclusion of tasks and worksheet intended to provide the learners with opportunities to reinforce their knowledge and to reflect on their own

learning can be added to the list of strengths of the material. The tasks and worksheets are intended for the teacher for continuous assessment. These can also be used by the teacher to find out the learning difficulties of the learners to give them ongoing support in the topic. Another strength of the material is its developmental nature. The material was designed to take the students gradually from the very basic concepts of inequalities in one variable and two variables through the formation of constraint inequalities and objective function to the concepts of maximization and minimization. The interactive style used in the development of the material is another strength of the material. The material tries to establish communication with the user through out.

### 4.5.2 Weaknesses

The material has a lot of weaknesses. Even though the material was prepared to serve dual purpose of teaching both content and didactics of teaching, it is purely content oriented in nature. The didactic aspect as the intended outcome of the learning material is not very noticeable in the material. Following the OBE principle the expected learning outcomes and assessment criteria should have been stated at the very beginning of the learning material. The expected learning outcomes and related assessment criteria are not specified in the learning material. The learners' prior knowledge(s) were only assumed. I confess that the material was prepared without making any effort to find out the learners' real background knowledge in some of the important content aspects such as linear inequalities and their graphs. It really posed some problems during the lessons. Another important weakness of the material is that it was not piloted before using in the class. It would have been much better if it were piloted at least in another school to seek other teachers' opinion on the material. It would have also revealed difficulties experienced by the learners in following the material. However as the attempt is part of an ongoing process to improve the material it can be considered as a first draft. The fact that the material was not able to achieve the desired learning outcomes is another weakness of the material. Even though the learners are of very poor calibre, the learning material would have been prepared to their level and to suit their needs. The learners experienced problems in understanding some terminologies and some issues used in the material. It

was also revealed that proper care was not taken to make sure that the learners understood the instruction. Even though the material used examples and situations familiar to the learners, the real word problems provided at the end of the material as exercises and tasks did not have much connection and relevance to the learners. Those examples were randomly picked from different textbooks. During the implementation of the material it became quite obvious that the learners had real difficulties in analyzing those word problems. In my opinion the material should have been more learner-friendly.

## 4.6 CONCLUSION

In this chapter the findings of the research are presented. The report from the evaluators after going through the learning material and the findings from the interview with them are presented. The findings of the implementation of the material in the classroom are discussed next. The findings of the questionnaire and the interviews with the learners are also presented. Lastly the strength and weaknesses of the material are discussed. All those who were involved in the evaluation of the learning material were of the opinion that the material was up to standard and that it was based on constructivist principles. The learners appreciated the new method of teaching used in the material. Some of them even made up their mind to use this constructivist approach in their classes. After the implementation of the material in the classroom I was able to reflect on the strengths and weaknesses of the material. I came to the conclusion that the material had more weaknesses than the strengths and I could have made it more effective.

# CHAPTER 5
# CONCLUDING REMARKS

## 5.1 INTRODUCTION

In this concluding chapter the conclusion from the research findings are outlined. It is followed by a reflection on the research process.

## 5.2 CONCLUSION FROM THE RESEARCH

The following conclusions are made from the research findings.

- Learners had difficulties in Linear Programming.
- The main difficulty was in getting grips with the terminologies and concepts involved in the topic.
- Language was a factor contributing to the difficulties in the topic.
- Learners were able to proceed with the Linear Programming problems once the question was explained to them.
- Examples from the environment of the learners made the learners interested in the unit.
- Step by step approach through activities could be more useful in using constructivist principles.
- Constructivism could be used effectively in teaching Linear Programming.
- Mediation played an important role in helping learners construct knowledge.
- Practical application of constructivism resulted in learners appreciating the effectiveness of the constructivist approach in teaching and learning.

Cooperative learning and peer teaching were found effective in teaching Linear Programming.

Regarding the research question it was concluded that the constructivist learning material in Linear Programming was effective and it helped learners develop the necessary knowledge and skills to solve problems in the topic. It was also concluded that the material was effective in making learners appreciate constructivist approach in teaching. Some of them even expressed their desire to use the constructivist approach in their classes. It is worth investigating to find out whether student teachers really follow the different teaching methods they are exposed to.

## 5.3 LIMITATIONS OF THE RESEARCH

This research project is based on the study conducted on the effectiveness of a learning material designed for student teachers in a college of education where the researcher was a lecturer. The findings of the research cannot be generalized since the situation at other institutions may not be the same as at the college. As the researcher is a staff of the college and the designer of the material the element of bias could have crept in analyzing the findings. The evaluators of the learning material were colleagues and students of the researcher. I have a concern that the association of these evaluators with the researcher could have affected the objectivity of their evaluation. My doubt could be unsubstantial when I consider the integrity of the HOD of the Mathematics Department and the other lecturer from the university. I believe that my learners also gave me their frank opinions as I made them aware of the importance of their objective opinions regarding the learning material.

## 5.4 RECOMMENDATIONS

My experience in applying constructivist approach in the design and application of the learning material makes me recommend the approach to be implemented as part of implementation of OBE. Having realized the challenges involved in the design of the learning material, I recommend more workshops to be organized for educators in the development of learning support materials. I also recommend a forum where educators from the rural schools can consult educators from the Model C schools on how to apply

constructivism in their schools. According to the principal of a leading school in King William's Town, " The schools under the former Cape Education Department started applying constructivist approach in the early 70s and 80s. That is why we have no problem in implementing OBE in our school curriculum". I also urge educators to try to develop learning materials based on constructivist principle as part of their empowerment.

## 5.4 REFLECTIONS

This research project was very challenging. Developing the learning material was very challenging. Evaluating my own material made it more challenging. Having been fascinated by constructivism and considering my experience and background knowledge in Linear Programming I was of the opinion that it would be very easy for me to design the learning material. Only after starting with the designing of the material I realized the real challenges involved in the process. Designing the materials according to constructivist principles made it more challenging. It involved a lot of thinking, writing some activities, reading through them, refining them, rewriting them and in some instances I had to start afresh with some activities. This exercise made me appreciate the pain and hard work of writers of textbooks and other learning support materials. Up to this time I was under the impression that writing of textbooks and other learning materials were very easy and I used to pass comments about the books without giving due consideration of the writers' efforts and the problems they faced. The designing of this material made me reflect on the task the educators in our schools are involved with in designing learning materials according to OBE principles. As an OBE facilitator I used to encourage the educators to make their own learning materials instead of depending on textbooks. Now I fully realize the amount of work involved and the challenges educators face in the development of learning - materials.

Applying constructivist approach in the classroom made me realize the challenges involved in implementing the new method of teaching in our schools. My learners were used to the traditional way of transmission mode of knowledge and they had no

experience of constructivist approach. It took me some time to make my learners apply the constructivist approach in learning. It made me reflect on the challenges faced by educators in rural schools with fifty to sixty learners in each class. I have doubts about how successful these educators are going to be in applying constructivism in their classes. However there are schools in our midst, especially the former Model C schools, where the OBE approach is well introduced. Further research is needed to find out how these schools are successfully applying constructivist principles in their schools. We should try to adapt present classroom situations in our rural schools to suit the constructivist approach in teaching.

Reflecting on the project as a whole I feel good. Even though it took me quite a lot of time to complete the project I consider it a worthwhile exercise. The feeling that I was able to develop a learning material according to constructivist principles makes me feel proud. The fact that I was able to evaluate my own material objectively made my task more challenging. Taking the comments of the evaluators on the learning material in a positive spirit made me realize the flaws in my views about designing learning materials. It also made me realize the importance of seeking others' opinion on learning materials. The evaluators assisted me by pointing out drawbacks like conceptual misunderstanding, illogical and non-sequential presentation of the concepts and vague or unclear instructions. It is encouraging to find that the learning material was able to produce some of the expected outcomes. If I had been more serious and careful in designing the material, it would have been more effective. My experience in this project tells me to urge other educators to try to develop learning materials for their classroom activities. It is challenging and time consuming; but you will be successful and you can proudly say that you were able to contribute in bringing constructivist teaching in your school. That is the approach which should be and is going to be used in our schools.

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## LIST OF REFERENCES

Barnett, R. A. and Ziegler, M. R. (1989). *Essentials of college mathematics.* San Francisco: Dellen Publishing Company.

Hinchey, P. (1998). *Finding freedom in the classroom: A practical introduction to critical theory.* New York: Peter Lang

Bodner, G. M. (1985). Constructivism: A theory of knowledge. *Journal of Chemical Education, 63,* 873- 878.

Bruner, J. (1986). *Actual minds, possible worlds.* Cambridge, MA: Harward University Press.

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

Commins, B., Duxbury, D. and Makgamathe, S. (1987). *Successful mathematics 9.* Cape Town: Oxford University Press.

Daellenbach, H.G. (1995). *Systems and decision making: A management science approach.* Chichester: Wiley.

Dikigomo, P. (1998). *Conceptual difficulties: The case of inequalities.* Proceedings of the 6th Annual Meeting of SAARMSE, 14 – 17 January 1998, UNISA, Pretoria.

Eastern Cape Department of Education. (2000). *OBE theory and practice: Introductory module. Facilitator's training manual.* Bisho: Government Printer.

Edwards, T. G. and Chelst, K. R. (1999). Promote system of linear inequalities with real world problems. *The Mathematics Teacher, 92* (2), 118 – 123.

Ernest, P. (1991). Social constructivism as a philosophy of mathematics. In Ernest, P. (Ed.), *The philosophy of mathematics education.* London: Falmer Press.

Hodson, D. and Hodson, J. (1998). From constructivism to social constructivism: A Vygotskian perspective on teaching and learning science. *School Science Review, 79, 289.*

Jawarski, B. (1994). Constructivism: A philosophy of knowledge and learning. In Jawarski, B. (Ed.), *Investigating mathematics teaching: A contructivist enquiry.* London: Falmer Press.

Kgobe, M. (1996). Realising change: The continuing process of policy development and implementation. *Quarterly Review of Education and Training in South Africa, 4* (2), 1-10.

Kgobe, M. (1999). Realising change: The continuing process of policy development and implementation. *Quarterly review of Education and Training in South Africa, 6* (1), 1- 9.

Laridon, P. (1992). Linear programming. In M. Moodley., R.A.Njisane and N.C. Presmeg (Eds.), *Mathematics education for in-service and pre-service teachers.* Pietermaritzburg: Shooter & Shuter.

Lerman, S. (1992). *The position of the individual in radical constructivism in search of the subject.* Paper presented to Topic Group 10 at the 7th International Congress on Mathematics Education, Quebec.

Matthews, M. R. (1992). Constructivism and empiricism: An incomplete divorce. *Research in Science Education, 22,* 299- 307.

Science, Mathematics and Technology Education. (2000). *A constructivist approach to teaching and learning in science*. Lecture notes, University of Port Elizabeth, Port Elizabeth.

South Africa (Republic). Department of Education. (1997). *Senior phase policy document*. Pretoria: Government Printer.

South Africa (Republic). (2000). *A South African curriculum for the twenty first century: Report of the review committee on Curriculum 2005*. Pretoria: Government Printer.

Thomas, A. S. (1994). Constructivist, interpretivist approaches to human inquiry. In Denzin, N.K and Lincoln, Y.S. (Eds.), *Handbook of qualitative research*. Thousand Oaks: Sage Publications.

Thomas, R. S. D. (1994). Radical constructive criticism of von Glasersfeld's radical constructivism. In P. Ernest. (Ed.), *Constructing mathematical knowledge: Epistemology and mathematical education*. London: The Falmer Press.

Wilmot, D. and Euvrard, G. (2000). *Cooperative learning*. Lecture notes, Education Department, Rhodes University, Grahamstown.

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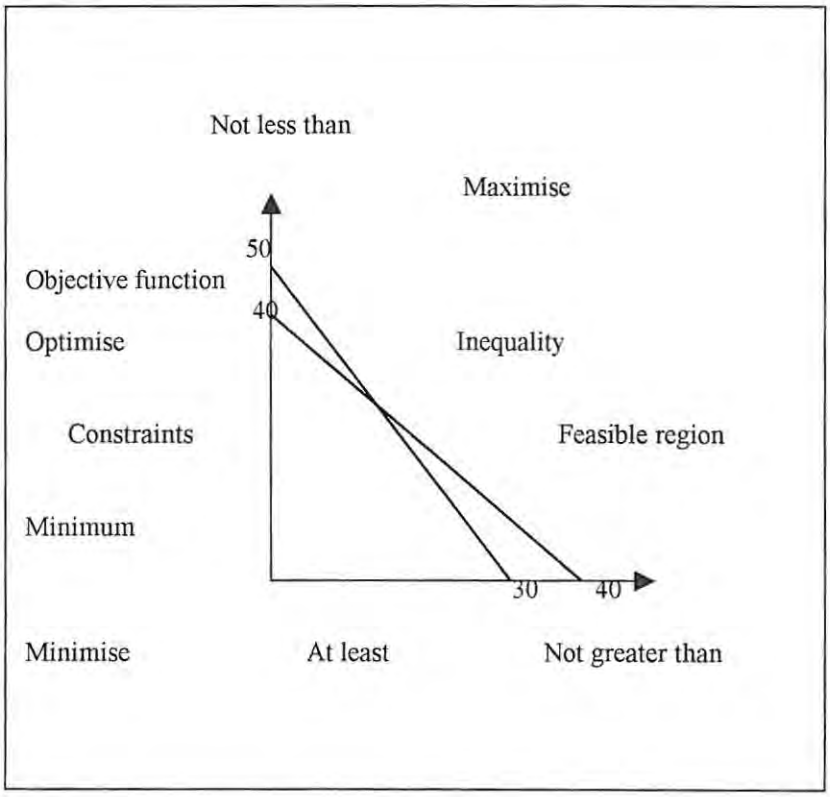
# APPENDICES

# APPENDIX: 1

# INEQUALITIES OF CONSTRAINTS




## LEARNING MATERIALS
## IN
## LINEAR PROGRAMMING

## FACILITATOR: C.THOMAS

Dear students

This is a learning material prepared for the topic Linear Programming. In this topic I would like us to follow an approach different from our usual traditional method of lecturing. In this approach I want all of you to be actively involved in the lessons. You will discuss the issues in groups or pairs, go through the extra reading material given to you and make use of the worksheets provided in this handout. On a daily basis you are given tasks which will enable you to make sense of and master some important aspects in Linear Programming. You are given further tasks for consolidation purposes. Step by step, I assume, you will be able to realize the usefulness and application of Linear Programming to solve problems involving constraints. By the end of 8 to 9 days you are expected to apply linear programming in solving problems involving constraints. At the end of the handout you are given extra exercises for practice. You may try to work out more similar problems available in the other reading materials provided.

**DAY 1**

**ACTIVITY: 1**

Think about your educational trip to Cape Town. Discuss in your group about the trip and identify the important aspects to be considered.

One of the important matters you have to consider is the number of students for the trip. [Now discuss other important issues to be considered and list them down. For each of the issues identify some key points to be considered]

1. 1 Number of students

1.2

1.3.

1.4

2. Discuss and list down some objectives of the trip.

3. What is your economical/ financial objective of the trip?

**ACTIVITY: 2**

Arrange a discussion with a lady who sells fruit in the college campus. [It would be better if you can identify a lady who sells only two types of fruits. Collect the following information from her.

2.1. the amount she puts in to buy the fruits

2.2. the number of each type of fruit she buys daily and the reason for that

2.3. the profit she makes on each type of fruit

2.4. her daily business objective

I hope your answer to Q3 in Activity 1 is 'to see maximum number of places by paying the **minimum** possible amount'.

In question 2.4 in activity the lady selling the fruit might have told you that she likes to make the **maximum** profit'.

Is it possible for you to make use of your mathematical knowledge in giving suggestion to:

(i) your friends organising the trip to make the cost minimum?

(ii) the lady on the number of each type of fruits she has to buy in order to make maximum profit?

Discuss your findings in pairs and make a report of your findings to the class.

## DAY: 2

Report back on the findings by each group. (10 minutes each)

## ACTIVITY: 3

3.1 Do you think planning is essential for achieving the maximum from spending the minimum?

3.2 Compare the situation of the fruit-seller with that of a bigger shop where so many different items are sold or a factory where various raw materials are used to produce different products making use of different machines and human labour for much longer period. Discuss the need for proper planning (programming) in order to achieve the objective of minimum cost and maximum profit within the available resources.

How can the planning be done? Mentally? Always manually? Or making use of computers? Can mathematics be used to solve these problems? If possible, how? Discuss the issues mentioned above.

You might have seen that there are conditions to be satisfied to spend the minimum amount and to make maximum profit. In businesses and scientific applications mathematics can be used to find the **best** solutions to problem that involves a number of different conditions. These **conditions** or **constraints** must be **maximised** or **minimised** to give the **best (optimum)** result. The technique used by mathematicians is called **linear programming.**

In linear programming, conditions are expressed as linear inequalities and the objective (what we want to find out) as a linear equation. Graphs of inequalities and the linear equation are used to find the optimum value. So we need to look at graphing of linear inequalities which we studied earlier.

**ACTIVITY: 4**

**WORKSHEET: 1**

Write the following expressions or statements mathematically:

1. Nomsa should donate at least R50,00 for a party.

   .....

2. A bus can carry a maximum of 45 passengers.

   .....

3. We can expect at least 500 people in a gathering.

   .....

4. There could have been at the most 5000 people in the rally.

   .....

5. Thandeka can give anything from R5,00 to R15,00 .

   .....

6. The bus can carry 25 to 28 people.

   .....

7. Kulati wants to buy two types of chairs. The total number of chairs should not exceed 25.

   .....

8. The picnic party can use combies and buses. The maximum number of vehicles should not be more than 8.

   .....

Discuss your answers.

**DAY 3**

Discussion of answers to the questions in Worksheet 1

## ACTIVITY: 5 (a)

You are given the situation described by Nomsa, one of the ladies selling fruits. She sells only apples and oranges.
She has to buy at least 10 apples and 20 oranges
She cannot sell more than 50 fruits. An apple costs 30c and an orange costs 20c. She has only R12 to buy the fruits.
She makes a profit of 10c on an apple and a profit of 5c on an orange.

You have to advise the lady on how many apples and oranges she has to buy to make maximum profit.

In pairs analyse the situation and identify the conditions she has to meet.

Write the inequalities for the conditions

Report to the class how the inequalities were formed.

## ACTIVITY 5(b): Further Task

Your friends responsible for arranging transport for the Cape Town trip came to you with the following conditions they have to satisfy:

There are 118 students for the trip and 2 staff members must accompany the students. A combi can carry 15 passengers ( excluding the driver) and a mini-bus can carry 30 passengers (excluding the driver).At least one combi and one minibus must be hired and there are only 5 drivers available.

- Write the inequalities for the constraints

## DAY: 4

Discussion of answer(s) to the Further Task on Day 3

Having identified and written the inequalities, we should look at representing these inequalities graphically.

**WORKSHEET: 2**

**ACTIVITY: 6(a)**

In pairs, draw graphs for the following inequalities:

(i) $-3 < x$ (ii) $y > 2$

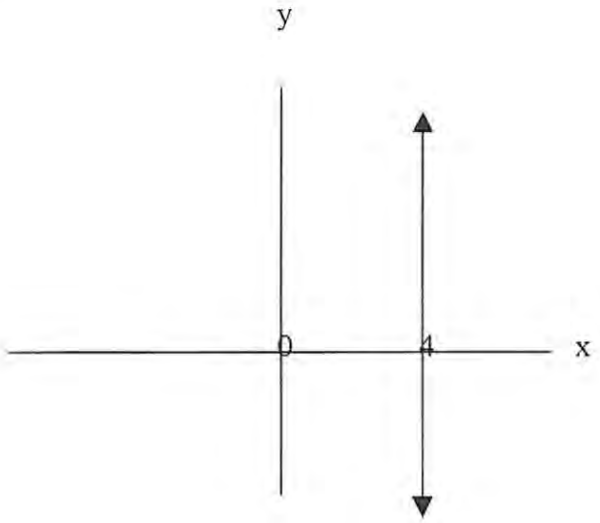
(iii) $-3 \leq x$ (iv) $y \geq 2$

What technique did you use to graph (i) & (iii) and (ii) & (iv)?
Discuss your answer with the class.

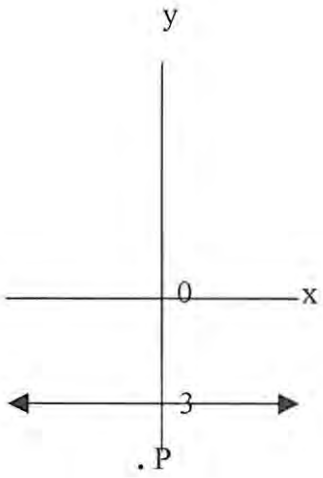
**ACTIVITY: 6(b)**

Write the inequalities for the shaded regions

(i)

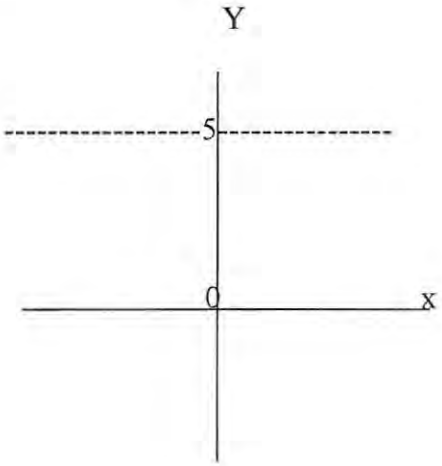


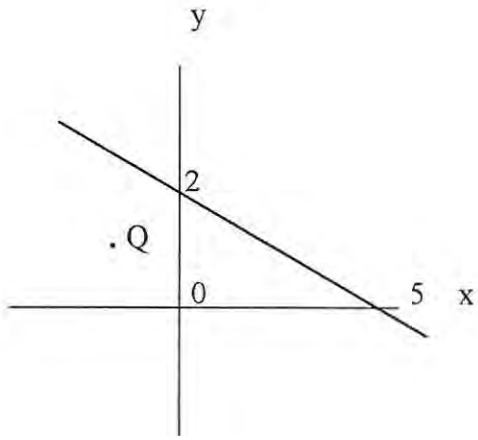

(ii)




Write the y -co-ordinate of point P as an inequality.

(iii)




Write the x-coordinate of point Q as an inequality.

**ACTIVITY: 6 (c)**

On the same set of axes draw the lines for the following inequalities:

$x > 2$ ; $x < 6$ ; $y < 5$ and $y > 3$

(i) Shade the region bounded by the four lines.

(ii) Write the co-ordinates of P, a point inside the region.

(iii) Is the x-co-ordinate exactly equal to 3 or 5?

(iv) What can you surely say about the x-co-ordinate of P?

(v) What can you say about the y-co-ordinates of P?

(vi) How many other points similar to P can be found in the region bounded by the four lines?

**(vii)** What name can you give the shaded region? [Remember it gives solutions]

**ACTIVITY: 6(d)**

Refer to the graphs of linear equations you studied earlier.

Draw the graph of $6x + 2y = 36$

Shade the region $6x + 2y > 36$

What do you know about the un-shaded area on the other side of the line?

Write the mathematical expression for the un-shaded area.

**FURTHER TASK:**

1. Draw, on the same set of axes, the graphs for the following inequalities:

$$3x + 4y < 48$$

$$x - y < 2$$

$$y > 4$$

- Shade the region bounded by the three lines.
- What do you know about a point inside the shaded region?
- What is the term, as found in the handout, for the shaded region?

2. Write what you understand by the following:

- Feasible region
- Constraints
- Objective
- Objective function
- Maximise
- Minimise
- Optimise
- Optimum value

Now you may refer to the handout and find the meanings of the words given above. Compare them with your answers.

## DAY: 5

Discussion of task given on the previous day.

**ACTIVITY: 7**

Represent the inequalities you got to illustrate the conditions in Nomsa's case graphically.

You might have got the following inequalities:

$$x > 10 ; y > 20 ; x + y < 50 \text{ and } 3x + 2y < 120$$

Now represent them graphically.
Shade the feasible region.

**FURTHER TASK:**

Consider the trip in **Further Task** in Activity 5 on Day 3

- Represent the constraint inequalities graphically.
- Shade the feasible region.

**ACTIVITY: 8**

Consider the two cases given below:

1. Nomsa makes a profit of 10c on an apple and 5c on an orange.

2. The college gets a rebate of R30 for the combi and R20 for using the minibus.

- What is the objective of Nomsa in her business?

- How can you find the profit made by Nomsa?

- Write expressions for the profit made by Nomsa

- How can we find the rebate received by the college?

- Write expression for the rebate the college gets.

- What is the name given to the two expressions?

- Write the two expressions in the form $y = mx + c$

- Calculate the gradients of the two lines.

**FURTHER TASK:**

**WORKSHEET 3**

Consider the following two cases:

**Case: 1**

Thandiwe sells pears and bananas. She makes a profit of 5c on a pear and 8c on a banana. Write an expression for the profit she can make by selling x number of oranges and y number of bananas.

.....

**Case: 2**

A combi can carry 15 passengers and a bus can carry 50 passengers in one trip. Write an expression for the number of passengers carried by x number of combies and y number of buses in one trip.

.....

What are the objectives in cases 1 and 2?

What do the expressions in the two cases describe?

What name can be given to the two expressions?

**FURTHER TASKS:**

Write Objective functions for the following:

1. A farmer makes R200 profit by selling a cow and R400 by selling a bull. He sells x number of cows and y number of bulls. The profit ( P ) made by the farmer is given by

   .....

2. A car can carry 5 passengers and a combi can carry 14 passengers. There are x cars and y combies. The number of passengers ( P )carried by the cars and combies is

   .....

3. A chair needs 5m of wood and a table needs 7m of wood. Write the objective function for the total length of wood needed to make x number of chairs and y number of tables.

   .....

4 A conference can sponsor R200 for each delegate from town A and R250 for each delegate from town B. There are x delegates from town A and y delegates from town B. The total amount sponsored is given by

   .....

In each of the four cases write the gradient of the lines representing the objective function.

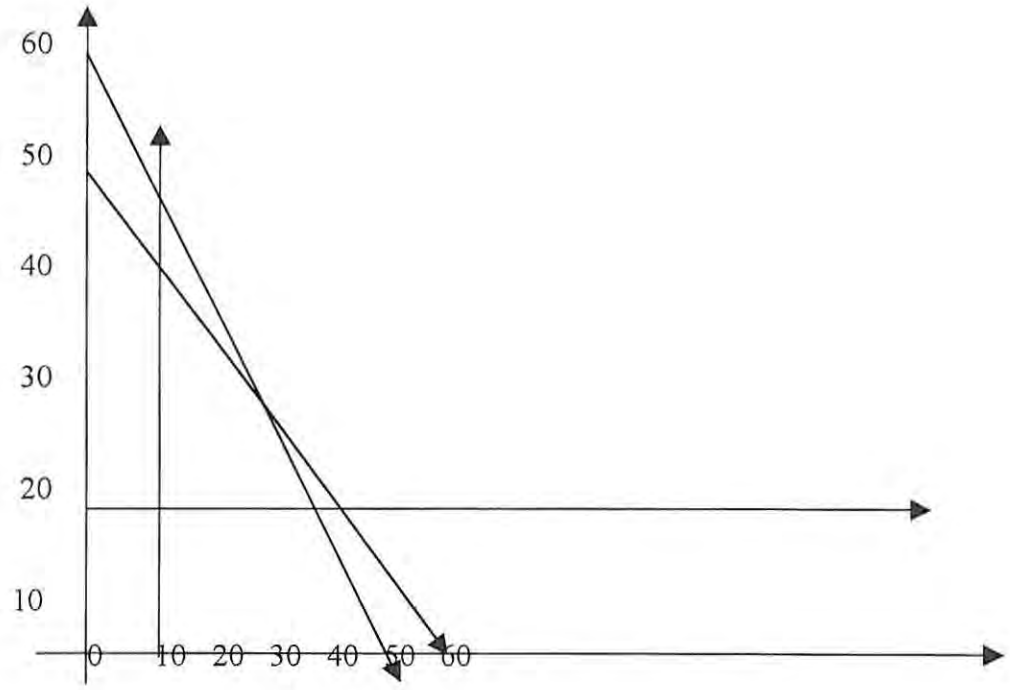
**DAY: 6**

Discussion of tasks given the previous day

**ACTIVITY: 9**

Consider the inequality graphs you drew on Day 5 to illustrate Nomsa's case.

You might have got the diagram shown below:




Do the following in pairs:

Write down the co-ordinates of the four corners of the feasible region.

What do the co-ordinates represent?

Substitute the co-ordinates in the expression for the profit.

What do you notice about the values of the profits obtained?

Are they the same? Or different?

At which point is the value the minimum?

At which point is it the maximum?

Now draw, on the same diagram, the graph of the objective function you got in Activity 8.1

Draw lines parallel to the objective function to pass through the four corners. What do you call these lines?

How do you think that you can use the line for the objective function to find the maximum or minimum profit Nomsa can make?

**FURTHER TASK**:

Find the maximum and minimum rebate the college can make using the inequality graph and the objective function for the rebate.

**DAY: 7**

**ACTIVITY: 10**

Read the following regarding a factory:

A factory manufactures only tables and chairs. Profit on one chair is R15, 00 and on one table is R20, 00. Each chair requires a large piece of stock of wood and two small pieces of stock. Each table requires two large and two small pieces of stock. There are only 6 large and 8 small pieces of stock. How many chairs and how many tables should the factory manufacture to make maximum profit?

Make use of Lego blocks given to you to make models to find out how many tables and chairs can be made from the available materials.

Find out all possible number of chairs and tables, which can be made using the available materials.
Calculate the possible profit in each case.

Identify the ideal (optimum) number of chairs and tables that could be made to make maximum profit.

Write the situations mathematically using inequalities.

Represent the inequalities in graphs.

Find out the optimum number from your graph. [Consider the corners of the feasible region]

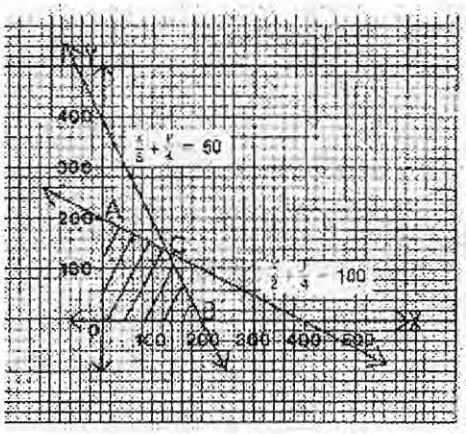
Explain how you identified your optimum number of chairs and tables.

Explain how you would proceed in a similar situation.

**DAY: 8**

**ACTIVITY: 11**

The following diagram shows the inequality constraints Thobeka had while making biscuits and doughnuts for a fundraising in her son's school. The constraints were for the mass of mixture used for the biscuits and the doughnuts and the time taken to shape the biscuits and the doughnuts.




If **x** is the number of biscuits and **y** is the number of doughnuts:

(i) write four inequalities represented in the diagram

(ii) find the maximum number of biscuits and doughnuts she has to make to make maximum profit if she makes a profit of 3 cents on a biscuit and 5 cents on a doughnut.

(iii) calculate the maximum profit she could make.

## MORE EXERCISES

In pairs discuss the following question and answer the questions that follow:

**Question: 1**

Pumla has 10 kg biscuit -mixture to make biscuits and doughnuts to sell at her son's school fund-raising concert. Each biscuit takes 25 g of mixture and each doughnut takes 50 g of mixture. It takes 30 seconds to shape one biscuit or two doughnuts. Pumla has 1 hour to shape all the doughnuts and biscuits. She wants to make 5c profit on each biscuit and 7c on each doughnut. If there are x biscuits and y doughnuts,

- Write the inequalities for the constraints.
- Represent the inequalities graphically.
- Shade the feasible region
- Write the objective function for the problem.
- Find out the maximum number of biscuits and doughnuts made by Pumla.
- Calculate the maximum profit made in the concert.
- What do you think about Pumla's effort in raising funds for her son's school?

**Question: 2**

A factory manufactures two types of instant coffee, INSTANTO and BLITS. Two basic processes, roasting and granulation, take place. Every 100 kg INSTANTO requires 2 hours of roasting and 3 hours of granulation while BLITS requires 4 hours of roasting and 2 hours of granulation per 100 kg. On the INSTANTO the profit is R10, 00 per 100kg, and on the BLITS R15, 00 per 100 kg. The roasting oven can only be used for 8 hours per day and the coffee granulator only 6 hours per day. Assume that daily production is x kg of INSTANTO and y kg of BLITS.

a. Write down applicable constraints and represent them graphically on a graph paper. [Use a scale of 10mm = 25kg]

b. Shade the feasible region

c. Determine the daily production of INSTANTO and BLITS in kg that will give the maximum profit by:

- writing the objective function

- using graph of the objective function and indicating by means of A and B where the readings are made and

- calculating the quantities algebraically

d. Show how to determine the maximum possible profit by using

- algebraic calculation and

- reading from the graph.

**Question: 3**

A bookbinding factory binds textbooks and writing pads. Both items are handled in two separate sections of the plant. One section is called A and the other B. One textbook takes 1 minute in A and 2 minute in B. One writing pad takes 2 minutes in A and 1 minute in B. The profit made by selling the items ins R3, 00 on a textbook and R1, 00 on a writing pad. How many textbooks and writing pads should be bound to make maximum profit in 30 minutes?\

**Question: 4**

The owner of a carpet store can spend R 31200,00 on new stock. He is interested in two types of carpet, namely woollen and acrylic. He has storage space for 42 rolls of carpets. The woollen carpets cost R1000, 00 per roll and the acrylic R600, 00 per roll. He knows from experience that at the most he sells 3 times as many acrylic carpets as woollen carpets. His profit per roll is R400, 00 for a woollen carpet and R250, 00 for an acrylic carpet. Let x be the number of woollen carpets and y be the number of acrylic carpets. Use a scale of 1cm = 5 carpets.

4.1 Give the constraint inequalities.

4.2 Represent the above constraints, clearly on graph paper.

4.3 Clearly indicate the feasible region.

4.4 The objective is to maximise profit.
Write down an equation to determine the profit, P.

4.5 Determine how many of each type of carpet he must buy in order to make a maximum profit.

**4.6** Calculate the maximum profit.

.....0.....

## APPENDIX:II

## EVALUATION OF THE LEARNING MATERIALS ON LINEAR PROGRAMMING BY OTHER LECTURERS

**Dear sir/ madam**

May I request you to evaluate the enclosed learning material as objectively as possible. Your valuable suggestions will be used in improving the material. You may use the attached form for evaluating the document.

Thank you.

1. The material is based on constructivist principle. Why, in your opinion, this material can be considered constructivist?

2. Comment briefly on the coverage of key principles and concepts in the material from LINEAR PROGRAMMING as required by the STD syllabus.

3. How does the material support the understanding of the key concepts?

4. Briefly comment on the strength(s) and weakness(es) of the learning material.

5. Comment on the user friendliness of the material?

6. Give suggestions to improve/ modify the material

## EVALUATION OF THE LEARNING MATERIAL ON LINEAR PROGRAMMING

# Dear sir/ madam

May I request you to evaluate the enclosed learning material as objectively as possible. Your valuable suggestions will be used in improving the material. You may use the attached form for evaluating the document.

Thank you.

.....

**1. The material is based on constructivist principle. Why, in your opinion, this material can be considered constructivist?**

.....

The material, without doubt, can be considered constructivist for the following reasons:

- The learners are given the opportunity to construct meanings from what they see, hear and experience and may not be what the facilitator intended.
- The learning outcomes depend on what the learners bring with them such as prior knowledge, alternative conceptions, understanding, etc
- The learners have final responsibility for their learning, i.e. they have to direct their attention to the learning task, draw on their current knowledge to construct meaning for themselves and evaluate their meaning.
- Some meanings are shared, i.e. there are patterns and similarities in meanings learners construct due to shared experiences and language.

**2. Comment briefly on the coverage of key principles and concepts in the material from LINEAR PROGRAMMING as required by the STD syllabus.**

.....

The key principles and concepts in the material from Linear Programming are adequately covered to meet the demands of the STD Mathematics syllabus.

The section dealing with practical applications of linear programming in economic and industrial sectors has been brilliantly presented.

3. **How does the material support the understanding of the key concepts?**

The step-by-step approach through activities seems to be the most effective way of assisting the learners to grapple with the key concepts.

4. **Briefly comment on the strength(s) and weakness(es) of the learning material.**

Some of the **strengths** include the following:

- Learner-centred
- Practical examples given in the activities
- Effective use of worksheets
- Practical applications of the Linear Programming

The only weakness identified is:

- Not encouraging learners to construct own practical example of the applications.

5. **Comment on the user friendliness of the material?**

- Easy –to-understand language
- Graphs neatly and clearly labelled
- Practical examples used in activities

6. **Give suggestions to improve/ modify the material**

The only suggestion is that the learner should be encouraged to construct own practical example of the applications.

## APPENDIX:III

## ASSESSMENT TASK GIVEN TO STUDENTS

## EVALUATION OF LESSON UNITS IN LINEAR PROGRAMMING

Having gone through the handout and conducted the activities in the Lesson units:

1. Explain what do you understand by Linear Programming.

.....

.....

.....

2. What is Linear Programming used for?

.....

.....

.....

3. Give examples of at least 3 various areas where Linear Programming is used.

.....

.....

.....

4. Explain what do you understand by the following:

(i) Constraints:.....

.....

(ii) Feasible Region:

.....

.....

(iii) Objective Function: .....

.....

(iv) Optimum Value .....

.....

.....

5. Draw graphs for the following inequalities:

   $2x + y \leq 10$ ; $x + 2y \leq 8$ ; $x \geq 0$ ; $y \geq 0$

   Shade the feasible region. If $x + 3y$ is an objective function for the constraints, find its maximum value.

6. A clothing factory makes shirts and trousers. Making one shirt requires two hours on machine A and one hour on machine B. A pair of trousers requires an hour on machine A and two hours on machine B. The profit obtained from selling one shirt is R3 and from a pair of trousers is R4.The machines cannot be used for more than twelve hours a day.

   - Write down the constraints for the situations
   - Write down the objective function
   - How many shirts and pairs of trousers should be manufactured daily to make maximum profit?

7. A shoe company owns two factories P and Q. Factory P can produce 1 batch of school shoes and 4 batches of army boots. Factory Q can produce 2 batches of each type of footwear. The company requires at least 60 batches of school shoes and 120 batches of army boots. It cost R400 per day to run factory P and R600 per day to run factory Q.

   How many days should each factory run if the company has to minimize costs?

..... 0.....

**APPENDIX: IV EVALUATION OF LEARNING MATERIALS BY STUDENTS**

**EVALUATION OF LESSON UNIT: LINEAR PROGRAMMING**

Dear students

1. Do you think the method used in learning linear programming was different from the usual method used by your lecturer?

   If different briefly describe how it was different.

2. Did you find the new method more interesting and helps you understand the lesson better?

   What features of the lesson unit made it more interesting and more understandable? ( Give at least three important points)

   How many points did you write? Why?

3. Do you think that you benefited more from this new approach of presentation of lesson(s)? Motivate your answer.

4. What did you learn from solving questions in groups? Do you want to work in groups or individually in future? Give at most two reasons.

5. Would you like to have more lessons taught in the new method? Why?

6. When you become teachers will you follow this method? Give reasons for your choice.

.....0.....

# PROJECT: 3

# MATHEMATICS FOR ALL:
# A SOUTH AFRICAN PERSPECTIVE

# ABBREVIATIONS

| | |
|---|---|
| AMESA | Association for Mathematics Education of South Africa |
| CAPME | Change Agent in Primary Mathematics Education |
| CASME | Centre for the Advancement of Science and Mathematics Education |
| CAT | Common Assessment Task |
| CCETSA | Canon Collins Educational Trust for Southern Africa |
| CEM | Council of Education Ministers |
| CEMP | College of Education Mathematics Project |
| EAT | External Assessment Test |
| EMSCEP | ESKOM Mathematics and Science Education Projects |
| FDE | Further Diploma in Education |
| GET | General Education and Training |
| GETC | General Education and Training Certificate |
| HSRC | Human Science Research Council |
| ICMI | International Commission on Mathematical Instruction |
| ICT | Information, Communication and Technology |
| IMU | International Mathematical Union |
| ISME | In-service Science and Maths Education |
| JET | Joint Education Trust |
| MDP | Mathematics Development Programme |
| MEC | Member of Executive Council |
| MHIP | Mathematics High School In-service Project |
| MIP | Matric Improvement Programme. |
| MLMMS | Mathematical Literacy, Mathematics and Mathematical Sciences |
| MSSI | Mpumalanga Secondary Science Initiative |
| MST | Mathematics, Science and Technology education |
| NGO | Non-Governmental Organizations |
| NRF | National Research Foundation |
| OBE | Outcomes Based Education |

| | |
|---|---|
| PMP | Primary Maths Project |
| PrIME | Primary Initiatives in Mathematics Education |
| RADMASTE | Research And Development in Mathematics, Science and Technology Education |
| RDP | Reconstruction and Development Programme |
| RUMEP | Rhodes University Mathematics Education Project |
| SAARMSTE | Southern African Association for Research in Mathematics Science and Technology Education |
| SABC | South African Broadcasting Corporation |
| SAMS | South African Mathematical Society |
| SIMS | Second International Mathematics Study |
| SMATE | Science, Mathematics and Technology Education |
| SMET | Science, Mathematics, Engineering and Technology |
| SO | Specific Outcome |
| SYSTEM | Students and Youth into Science, Technology, Engineering and Mathematics |
| TIMSS | Third International Mathematics and Science Study |
| UNISA | University of South Africa |
| USAID | United States Agency for International Development |

## ABSTRACT

*The Year 2000 was declared World Mathematical Year. One of the aims of the activities organized as part of the celebrations was improving the public image of mathematics to realize the vision of "Mathematics For All". The post 1994 government in South Africa is keen to improve mathematics education in the country in an attempt to realize the vision of Mathematics For All. Even though the accessibility rate for mathematics has increased, the success rate has not yet increased as anticipated. In this context I, as a post-graduate student in Mathematics Education, thought of reviewing the concept of Mathematics For All in the South African perspective.*

*In this literature review, initially an attempt is made to unravel the concept of Mathematics for ALL. In analyzing the concept, answers are sought for questions like: What is mathematics? and Why should it be taught? It is followed by a brief review of some goals of mathematics education. The literature review revealed that the current situation of mathematics education in South Africa is not that encouraging even though there are concerted efforts by the government and non-governmental organizations to improve the state of mathematics education. In addition to the general unpopularity of the subject, the euro-centrism attached to mathematics, unqualified and under-qualified teachers with low morale and commitment, lack of personnel in the education department to give guidance and support to the teachers were identified as some of the reasons for the poor state of mathematics education in the country. In the concluding part some suggestions for improving mathematics education in the country are given.*

## 1. INTRODUCTION

The International Mathematical Union (IMU) declared the year 2000 as the World Mathematical Year (Ernest, 1996 & Brombacher, 2000). As a result a range of activities and programmes were organized in many countries all over the world with the aim of improving the public image of the nature of mathematics and an understanding of the role of mathematics in the modern society. The foci of the IMU for the World Mathematical Year were the Great Mathematical Challenges of the 21st century, mathematics as a key for development and the image of mathematics (Olivier, 2000). According to Olivier, the committee for the IMU, through its member organizations, the South African Mathematical Society (SAMS) and the Association for Mathematics Education of South Africa (AMESA) had declared 16 – 20 October 2000 as National Mathematics Week. Some local branches of AMESA printed T-shirts and fliers depicting various mathematics related logos as part of their initiatives for popularizing mathematics. In the Western Cape, AMESA hosted a series of workshops on "Family Maths" and held an AMESA Mathematics Challenge for pupils in Grades 4 – 7 in an effort to involve primary school children in the Mathematics Week activity. SAMS, in their annual congress meeting held at University of South Africa (UNISA) during the Mathematics Week, included several popular lectures by distinguished mathematicians and those lectures were open to the public. The organizers hoped that the concept of the Mathematics Week and the activities organized during the week would increase public awareness of mathematics and mathematics education in the country.

In the post-apartheid South Africa, it is claimed by the government that more attention is attached to the improvement of mathematics, science and technology education. The establishment of the Department of Arts, Science and Technology by the new government is portrayed as an attempt on its part to improve these subjects in the country. The 1996 White Paper on Science and Technology acknowledges that the government "has a responsibility to promote science

culture, science education and literacy amongst both children and adults ... and influence the attainment of equity by providing incentives for disadvantaged groups to study mathematics, science and achieve computer literacy" (Department of Arts, Culture, Science and Technology as cited in Naidoo and Lewin, 1998). Various non-governmental organizations are also involved in various projects to improve mathematics education in this country. Some examples of these projects and their activities are given later in the section on the *Efforts To Improve Mathematics Education*. However, I am of the view that the mathematics education in South Africa is not improving as is expected by all stakeholders. " The number of young people who study mathematics with any degree of understanding and proficiency has declined when it should have been increasing rapidly" (Asmal, 2001 as quoted by Pretorius, 2001: 19). In this context as a post graduate student in mathematics education I thought of reviewing the concept of 'Mathematics for All' to look at the issue in a South African perspective, with the vision of advocating Mathematics for all South Africans.

In this literature review, initially an attempt is made to unravel the concept of Mathematics for ALL. While trying to analyze the concept, answers are sought for questions like: What is mathematics and why should it be taught? It is followed by a brief review of some goals of mathematics education. Then the current situation of mathematics education in South Africa and the efforts to improve it are also looked at. This is followed by an analysis of the reasons for the general unpopularity of mathematics. In the concluding part some suggestions for the improvement of mathematics and mathematics education are given.

## 2. UNPACKING THE CONCEPT OF MATHEMATICS FOR ALL

In unpacking the concept of 'Mathematics for All', initially I want to look at what is meant by the concept. In order to unpack the concept further, I want to establish the genuineness of the cry for mathematics for all by looking at the

need and truthfulness in the cry. This requires finding out whether mathematics is accessible to all or not. Other issues looked at in this project are what makes mathematics so important that everybody is recommended to have it, who should be included in the 'ALL' as well as what type of mathematics should be given to 'ALL'. Another aspect of unpacking the concept is finding out how the vision of mathematics for all can be achieved.

Mathematics for All sounds like a long-term oriented vision or a call similar to 'Food for All', 'Houses for All', 'Electricity for All' and 'Education for All'. It can be viewed as a vision trying to achieve a situation where the whole population in the country will be capable of using mathematics in their everyday lives. The concept suggests that every citizen of the country should have access to mathematics so that s/ he will be in a position to use it to suit his/her needs at his/her level. Volmink (1994) suggested that 'mathematics by all' should be the culminating result of 'mathematics for all'. This implies that only when all the people are able to use mathematics in their respective contexts, the vision of 'Mathematics for All' can be achieved. In a country aspiring for the vision of 'Mathematics for All', as suggested by Ernest (1996), " All citizens must be confident in applying mathematical knowledge and acquiring any needed skills and be able to use their knowledge and skills to interpret and critically evaluate the mathematics embedded in social and political systems and claims, from advertisement to government pronouncements, from national lottery to the stock market". The majority of my colleagues and friends with whom I interacted on this issue are of the view that the concept of 'Mathematics for All' is a Herculean task and hence virtually impossible. However, I am optimistic that the vision can be realized in the future.

In the cry for 'Mathematics for All', there is a hidden implication which suggests that mathematics has not been accessible to all. The call for Mathematics for All and the efforts by various bodies all over the world to realize the vision clearly indicates that mathematics is not accessible to all. In the past, until the $19^{th}$ century, general education itself was the privilege of the 'happy few' in society.

According to Niss (1996:24):

> In most countries in the world, it was not until the 19th century that society began to provide education to wider segments of the general, common population. Before that time formal education of any generality, offered in particular institutions such as schools, was reserved for the 'happy few' who belonged to the ruling or rich classes or were recruited to special institutions, e.g. of an administrative, scientific or religious nature. ... However, as far as mathematics education is concerned it seems plausible that primary concern was to contribute to the political, ideological and cultural maintenance of society.

According to Volmink (1994:51),

> Mathematics, even before its professionalization, has always been the domain of the select few. ... The social arrangements of early civilizations were such that only the rich, the powerful, the influential, had access to mathematical knowledge.

From what Niss and Volmink suggest it becomes clear that until the 19th century only very few people who were identified to occupy political and administrative posts had access to mathematics education. However, following political changes in many parts of the world, public education systems in many countries have undergone changes and more people started getting access to general education and to mathematics education (Niss, 1996). The effort of the post-apartheid government in South Africa in making education compulsory, at least among the school -going population is an example.

In South Africa, since the 1994 elections, more people are getting educational opportunities and access to key subjects like mathematics and the sciences (Naidoo and Lewin, 1998). According to a survey (South Africa, 1999/ 2000), the number of candidates who wrote mathematics examination at Senior Certificate level increased from 215061 in 1996 to 279702 in 1998 showing an increase of 30%. But out of a total of 552862 students who registered for the matriculation examination in 1998 only 279702 students (only 51%) wrote the mathematics examination. A recent statistical study of students registered for the 2001 Grade 12 examination in one education district in the Eastern Cape revealed that out of a total of 2647 students only 1259 (48%) were registered for mathematics. Out of the 1259 students registered for the mathematics, only 35 (less than 3%) registered on

the higher grade. Moreover during the period from 1996 to 1998, the pass rate decreased from 50% to 42% and the percentage of students who passed on higher grade in the subject dropped from 10% to 7%. In 2000 only 3128 out of 20243 African candidates passed mathematics on the higher grade (Pretorius, 2001:19). These figures indicate that all is not well with mathematics education in South Africa. Even though the access rate to mathematics has increased in the post apartheid South Africa, the success rate is still a problem. The statistics from the district in the Eastern Cape is an example of the rural areas in South Africa where the accessibility and participation in mathematics is still a problem. In a country like South Africa where the majority of the population had very little access to mathematics, the call for 'Mathematics for All' can be considered very genuine and needs serious and urgent attention. One of the challenges to be tackled in the realization of 'Mathematics for All' is making the subject more accessible to the majority of the population who in the past were deliberately excluded from it. One of the ways of making the subject more accessible to the public is by popularizing it in order to draw more people towards it.

Many countries, especially the ex-colonies, were confronted by the problems of houses, water, food and education for all. Even now some of these countries in Asia, Latin America and Africa have a high percentage of their citizens illiterate (Jacobsen, 1996) and face the challenges of achieving a hundred percent literacy and numeracy. It is generally accepted that mathematics plays an important role in every aspect of life – in business, in science and technology, in community affairs and even in politics. Basic numeracy is very important and essential in today's world of information technology. Mathematical knowledge to understand and analyze information is very crucial for an effective citizenry. It will be difficult for an innumerate person to make sense of information presented in graphical and tabular forms in the mass media like newspapers and televisions. Thus it can be seen that mathematics for all is very important in order to have and maintain a democratic society where everyone will be able to analyze information and take informed decisions on affairs affecting them. More reasons

for including mathematics in the curriculum are given in detail in a separate section.

While analyzing the concept of 'Mathematics for ALL', we have to consider two pertinent questions: Who should be included in "ALL"? and What type of mathematics should be given to those included in the "ALL"? It makes it necessary to define the meaning of 'ALL' in this context. To make the questions clearer, we have to ask the question: Do we have to provide mathematics education (everything defined as mathematical knowledge) to everybody or certain sections of mathematics to certain group(s) of people? In spelling out the rationale for Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS) teaching, the Senior Phase Policy Document (South Africa, 1997) recommends that 'All people should have a right of access to the domain of mathematical knowledge and their benefits'. This statement clearly suggests that every citizen of this country should be included in the "All".

In order to make mathematics accessible to everybody, we have to consider the type of mathematics to be provided for everybody. This takes us to a further question: Do we have different types of mathematics or mathematical knowledge? If so, does every citizen of the country need all the mathematical knowledge? Or is it that certain section of the population can have certain types of mathematics knowledge? Or is it that others can have some other types or all of what is termed the mathematical knowledge? In order to answer these questions we have to look at the mathematics curriculum offered in schools to identify the type of mathematics suitable for the different groups of people and to find ways of making it more accessible to them according to their needs. As Jacobsen (1996) suggested, the type of mathematics offered in schools should be such that 'every student receives the tools for survival, for work, for participating in community affairs and for being a responsible citizen politically. The type of mathematics taught in schools should be the one which can be used by all (as suggested by Volmink, 1994) with confidence and skillfully in their various contexts according to their needs (Ernest, 1996).

The last question to be tackled, as mentioned earlier is how the vision of mathematics for all can be achieved. Here I want to compare the accomplishment of the vision of maths for all with the accomplishment of visions like food for all, water for all, houses for all and electricity for all. In the latter visions the providers will be able to provide the facilities with or without the actual involvement of the recipients in the process. Education is not a commodity like a cake or an apple that can be sliced and shared among all those who want it. Nor is it like houses built and handed over to the recipients without them being involved in the building process. In order to make education for all a reality, those who really need it should be involved in the process. What the providers of education can do is to give everybody equal opportunities for education by making education more accessible and available to everybody. They could also find ways of attracting the general public towards education. The same thing is applicable in the case of mathematics education. In order to realize the vision of mathematics for all, mathematics education should be made more accessible to everybody so that everybody will get equal opportunities for mathematics education. Those involved in mathematics education should find ways of making it more attractive to the public.

From what has been mentioned so far it is evident that in order to realize the vision of 'mathematics for all', serious efforts are needed in attracting more people towards it. To do that, there is a need to increase the public awareness of mathematics. Efforts are needed to popularize mathematics and to make the subject curriculum more attractive to the public. In order to do that an effective mathematics education programme is very important. This mathematics education programme, among other efforts, should try to give the general public an understanding of what mathematics is, what its nature is and why it should be taught in schools. In the next two sections I will be looking for answers to these questions.

## 3. WHAT IS MATHEMATICS?

It is difficult to define mathematics in one sentence. I requested my colleagues, other educators and students in different levels of schooling to define mathematics. They too had difficulty in defining it in one sentence. They all saw it as a multidimensional concept of issues and activities. I also asked the Grade 7 and Grade 9 teachers who attended my Outcomes Based Education (OBE) training session in Mathematical Literacy Mathematics and Mathematical Sciences (MLMMS) in the Central Region in the Eastern Cape to define mathematics and to give their reasons for including it in the curriculum. In their attempt to define mathematics, most of these teachers cited concepts and activities involved in mathematics. Fig 1 shows the concept map drawn by these OBE trainees.

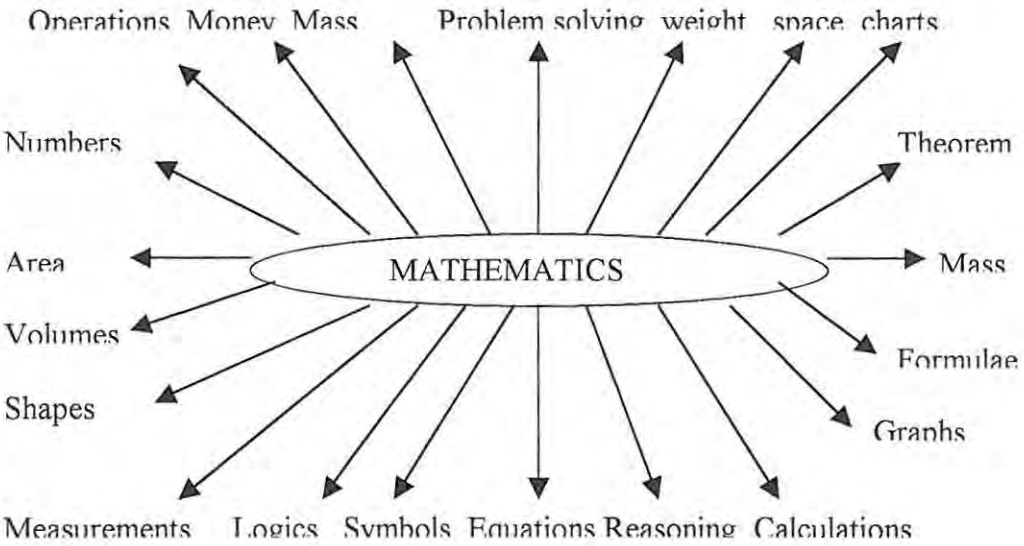



Fig.1: A concept map of "mathematics" drawn by different OBE trainees.

It is interesting to note that only a very few participants suggested the different branches of mathematics like algebra, trigonometry, calculus, geometry and analytical geometry taught in high schools. Most of the issues suggested by the

teachers were those important in their daily lives. They were the mathematical concepts or ideas, which everybody needed and used in their day- to- day activities. Most of the concepts identified by the teachers embraced the basic number manipulations and concepts related to shapes and figures taught in primary classes together with problem solving. It is evident from the concept map that what ordinary people normally think about mathematics is the everyday mathematics which is commonly used by everybody to solve routine basic problems.

Another difficulty experienced in defining mathematics is the use of different names by which it is referred to. What we generally call mathematics is referred to as mathematics, numeracy, adult numeracy (Fitzsimons *et al,* 1996), and 'quantitative literacy' (Steen, 1990a). It is difficult to draw clear demarcation lines separating them. According to Fitzsimons *et al.* (1996), numeracy is generally used where elementary mathematics education of very young children and that of adults are involved. In the case of adults, numeracy and mathematics are interchangeably used. For example, in German speaking countries mathematics is widely used for all types of mathematics education. In the Anglo-American areas the subject is termed Adult Numeracy and the meaning of numeracy also varies (Gal, 1993 and Galbraith *et al.*, 1992). In the new curriculum introduced in South Africa, the learning area (previously referred to as subject) dealing with elementary mathematical concepts in the foundation phase is called numeracy. In the intermediate and senior phases the same learning area is called Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS) (South Africa, 1997). In my view the concepts included in the different versions of mathematics and the goals of teaching each of them overlap as can be seen from the explanations pertaining to each of them. Hence, in this paper, the term mathematics is used to describe what we generally call mathematics or numeracy or adult numeracy without differentiating between them.

In the Crowther Report of 1959 (as quoted in Fitzsimons *et al.*, 1996: 756) the term numeracy means 'the minimum knowledge of mathematics and scientific subjects any person should possess in order to be considered educated'. Being numerate means having developed certain basic mathematical skills applicable to various situations in everyday life' (Fitzsimons *et al.*, 1996:756). They further claim that there are some mathematicians who insist that mathematics and numeracy are different. These mathematicians see numeracy as 'a low level mathematics, often taught by non-mathematicians, to people who have no aspiration to be mathematicians'. To some other mathematicians, numeracy means quantitative and spatial ideas in the context of a practice other than school mathematics or professional mathematics. Numeracy is again described as elementary skills or abilities and as having a good command of the four operations (addition, subtraction, multiplication and division), fractions and percentages, being familiar to some extent with statistical description, or with the interpretation of Cartesian graphs. The Cockcroft Report (1982 as quoted by Fitzsimons *et al.*, 1996: 757) emphasized the importance of numeracy for a person's everyday life as follows:

> We would wish the word 'numerate' to imply the possession of two attributes. The first of these is an at homeness with numbers and an ability to make use of mathematical skills which enables an individual to cope with the practical mathematical demands of his everyday life. The second is an ability to have some appreciation and understanding of information which is presented in mathematical term, for instance, graphs, charts, or table or by reference to percentage increase or decrease

According to Fitzsimons *et al.* (1996:759) numeracy is a means of helping people cope with their life situations and a means to gain insight into the structure of the society and to enable people to take an active part in political decision-making.

Having outlined numeracy, let us look at some formal definitions of mathematics suggested by a few authors. According to Zaslavsky (1973:7), "For many mathematicians, mathematics as a discipline originated in ancient Greece with the formulation of logical systems based on definitions, postulates and formally proved theorems... To the average person, mathematics is a subject that deals

with numbers in counting and the computations of elementary arithmetic ". Hogben (as quoted by Zaslavsky, 1973: 6) calls it 'the technique of discovering and conveying in the most economical possible way useful rules of a reliable reasoning about calculation, measurement and shape'. Paling (1982:2) defines mathematics as " a way of finding answers to problems, a way in which we use information, use our knowledge of shapes and measures, use our ability to calculate and most importantly think for ourselves in seeing and using relationships". In the 1982 Cockcroft report (as quoted by Moodley, 1992), mathematics is described as a means of communication that is powerful, concise and unambiguous. Mathematics can be described as 'a way of viewing and making sense of the real world'. It can also be described as the material and the means for creating new imaginative worlds to explore.

From the above definitions it is clear that mathematics has been developed and refined over the years. It has been developed in an effort to understand the nature and to solve problems involving counting and measurement and to explain relations between physical quantities using numbers and symbols. In the senior phase policy documents (South Africa, 1997: MLMMS 1), MLMMS is defined as follows:

> Mathematics is the construction of knowledge that deals with qualitative and quantitative relationships of space and time. It is a human activity that deals with patterns, problem solving, logical thinking, etc. in an attempt to understand the world and make use of that understanding. This understanding is expressed, developed and contested through language, symbols and social interaction

Numbers, signs, shapes, patterns, rules, algorithms and theorems are all parts of mathematics. The perceptions of the teachers who attended the OBE workshops mentioned earlier about mathematics are embedded in the formal definitions given for the subject by the various authors. Putting together the ideas given by the educators and the various definitions cited above we can define mathematics 'as a tool used logically by people in various situations to solve problems they face. These problems may include the measurement of space and time, or

problems in economics, technology, daily activities and in other fields where abstract thinking involving numbers and space is required'.

## 4. WHY MATHEMATICS SHOULD BE INCLUDED IN THE SCHOOL CURRICULUM?

The definitions given earlier suggest that mathematics is used in various fields for counting, measuring and representing information. Some people like solving mathematical problems and puzzles to derive pleasure just like some people find pleasure in playing jigsaw puzzles. These utilitarian and intrinsic values of mathematics can be cited as the simple reasons for the inclusion of the subject in school curricula throughout the world. However, I would like to look at these reasons more closely to substantiate the importance attached to mathematics in school curricula all over the world.

According to Burton (1986), " By the Stone Age people were using systems of numbers. By 3000 BC people were putting up large stone buildings and crossing the sea in ships, so they must have known something about mathematics". While describing the Hindu and Arabian mathematics, Eves (1953: 179) talked about the 5000-year-old ruins of a city at Mohenjo Daro as follows:

> Evidence of wide streets, brick dwellings and apartment houses with tiled bathrooms, covered city drains, and community swimming pools, indicates a civilization as advanced as that found anywhere else in the ancient orient. These early peoples had systems of writing, counting, weighing and measuring, and they dug canals for irrigation. All this required considerable basic mathematics and engineering

From what Burton and Eves stated it is clear that people as early as 3000 BC had knowledge of mathematics and they used it in various spheres of life. It is natural to think that those societies were involved in the teaching of the subject to their young ones to enable them to make use of it in their future lives. There is a growing consensus that achievement in mathematics and science subjects is symptomatic of the quality of education and training in a country and a good yardstick of a country's potential to be economically competitive (Engelbrecht,

1997: 1). The development achieved by the developed countries could be attributed to the importance they had attached to the teaching of mathematics and science. In many parts of the world, especially in the developing countries, one of the reasons cited by the curriculum developers for including mathematics in the curriculum is that the developed countries had been involved in the teaching of mathematics to their young ones (Niss, 1996). The curriculum developers in these developing countries, perhaps, could be of the opinion that the mathematics education for their young generation could help in the technological development of their countries also.

Everybody needs basic mathematics in his/her daily life. Everybody has to handle money which involves calculations with respect to wages, expenditure, buying and selling and budgeting; to make measurements and to do calculations involving them; to make calculations involving time and space and to interpret information given in various mass media in the form of charts and graphs. While emphasizing the importance of numeracy in our modern 'data drenched society', Steen (1990a) claims:

> To develop an informed citizenry and to support a democratic government schools must graduate students who are numerate as well as literate. The age of information is an age of numbers. Data, graphs and statistics both enrich and confuse our lives. Numbers and quantities overwhelm current events, from medical reports to political trends, from financial advice to social policy. News is filled with graphs, while quantitatively based decisions control education, health and government.... No longer mathematics is a requirement only for prospective scientists and engineers; now some degree of mathematical literacy is required of anyone entering the modern high-performance workplace or seeking advancement in a career.

According to Cockcroft (1982 as reported in Moodley, 1992: 1), "It would be difficult to lead a normal life in many parts of the world in the 20th century without making use of some kind of mathematics". How much more difficult will it be to live n the 21st century without making use of mathematics everyday? Ordinary workers, street vendors, hawkers, menial labourers, shop owners, large industrialists, housewives, and professionals like scientists, engineers, doctors, accountants, architects, carpenters and technicians need mathematics. All these people make use of mathematics in their daily lives. It is difficult to think of any

person who does not make use of basic mathematics on a daily basis. Similarly it is difficult to think of a field where mathematics is not used. This makes it so important to provide every person with the necessary mathematical experiences and skills to use in daily living. However, as the level of complexity of the problem to be solved by different individuals or groups changes the type of mathematics needed by them also changes. For example, the level and type of mathematics needed by an engineer or an architect or an actuary is different from the level and type of mathematics needed by an ordinary clerk or a technician. The engineers, architects and actuaries need more sophisticated and abstract mathematics compared to the elementary mathematics or arithmetic needed by non-professionals. Whatever the case, everybody needs some kind of mathematics to suit his/ her level. There should be provision to cater for the mathematical needs of every individual at his/ her level by providing him/her with the appropriate mathematics curriculum.

The second reason for the inclusion of mathematics in the school curriculum is its intrinsic values. Most of the mathematics, especially what we call abstract mathematics, is the work of eminent mathematicians who found enjoyment in working with numbers and other mathematical ideas. For example, Eves (1953: 90) reports on about 120 entries in the developments of $\pi$, each one being worked out by different people during different periods. Eves (1953: 243) further reports that Henry Briggs (1561- 1631) constructed a 14- place table of common logarithms of the numbers from 1 to 20,000 and from 90,000 to 100,000. Over the years more and more extensions, addendums and corollaries were added to many fundamental theorems in geometry. Different ways of proving various theorems were also suggested by different mathematicians. For example, the theorem of Pythagoras has numerous different proofs suggested by different mathematicians. According to Eves (1953:59), E. S. Loomis had collected and classified 370 demonstrations of the Pythagoras's theorem. All these were the works of people who found pleasure in working with mathematical ideas. This process should be continued. Modifications and extensions to already existing mathematical knowledge should be encouraged. New knowledge must be

developed. Proofs and solutions to many unproved conjectures and theorems are to be derived. The conjecture regarding prime numbers that there are infinitely many pairs of twin primes or primes of the form p and p + 2, like 3 and 5, 11 and 13 and 29 and 31 is one of these mathematical conjectures to be proved (Eves, 1953: 146). These types of modifications and new discoveries in the mathematical knowledge are possible only if individuals who have passion for the subject and who are keen to work with mathematical ideas are encouraged to do so. In order to help the future generation develop passion for the subject, they have to be exposed to the necessary mathematical knowledge and skills. That is possible only if mathematics is included in the school curriculum.

In South Africa a lot of emphasis is placed on education for technological development. As already mentioned, the establishment of the Ministry of Arts, Culture, Science and Technology in South Africa, perhaps, is an example of the government's initiative in pushing the nation technologically forward. The White Paper on Science and Technology released in September 1996 (South Africa, 1996) explains the nation's vision and strategy towards achieving technological advancement. The introduction of Technology as a new learning area in the newly introduced Curriculum 2005 can be cited as an initiative of the department of education to give young learners a feel for technology from their early school years. Technology, as defined in the senior phase policy document (South Africa 1997: Tech 2), is the use of knowledge, skills and resources to meet human needs and wants, and to recognize and solve problems by investigating, designing, developing and evaluating products, processes and systems. The ability of all learners to succeed in today's technically oriented environment is increasingly dependent on their understanding of mathematical and computational sciences and their application in practical situations (South Africa, 2001). Mathematics is the basis of all new technologies because (mathematical) algorithms are the basis of software and materialized logic is the basis of hardware computers and microprocessors (Maasz and Schloeglmann, 1988:295 as quoted in Fitzsimons *et al,* 1996). Calculations ranging from simple to complex, very precise and accurate measurements and effective and accurate data management are very

essential in every aspect of technology. According to Steen (1990b), "the creation of a scientist or an engineer takes nearly two decades of education grounded in the study of mathematics". According to Kahn (2000: 21), " .. science and mathematics education is the base upon which technology development rests. Without this base, countries lack the skills needed for local advancement of technologies and remain perpetually dependent on outsiders". All these suggest that mathematics is an integral part of science and technology and thus mathematics education becomes the corner stone of the modern technological development. This could be the reason why mathematics is taught as a prerequisite course for the science and technology courses all over the world. A high symbol in higher-grade mathematics is a prerequisite in many other tertiary courses such as accounting and medicine. One of the reasons for including mathematics in the school curriculum should be to prepare learners for tertiary courses for which mathematics is a prerequisite.

The reasons I have put forward for supporting mathematics education have been succinctly summarized by Niss (1996: 3):

> Analyses of mathematics education from historical and contemporary perspectives show that in essence there are just a few types of fundamental reasons for mathematics education. They include the following:
> - contributing to the technological and socio-economic development of society at large, either as such or in competition with other societies/ countries;
> - contributing to society's political, ideological and cultural maintenance and development, again either as such or in competition with other societies/ countries;
> - providing individual with prerequisites which may help them to cope with life in the various spheres in which they live: education or occupation; private life; social life; life as a citizen

In addition to the above reasons I would like to add a moral dimension to the reasons for the inclusion of mathematics education in countries like South Africa where the majority of the population did not have access to adequate mathematic education. If mathematics education is a prerequisite for an individual to cope with life as a citizen, it should be the birthright of every citizen, and the curriculum designers and implementers have a moral obligation to provide everybody with the relevant mathematics education. According to the Universal

Declaration of Human Rights, 'everyone has a right to education' (Jacobsen, 1996:1239). Mathematics education is part of the general education. According to Wilder (1968:4), mathematics is something that people create, and the type of mathematics they work out is just as much a function of the cultural demands of the time as any of their other adaptive mechanisms. Moreover every culture has contributed to the development of mathematics. As a result every citizen in every culture should have the opportunity to be made aware of the contributions of his/her culture in the development of mathematics. Drawing on the traditions of the various cultures, indicating that their cultures are recognized and valued would also help to counter entrenched historical devaluation of them (Ghevarghese, 1994). For that, the history of mathematics development should become part of the mathematics curriculum. Mathematical literacy is a means of empowering people to make them useful and responsible citizens. In a country like South Africa where the majority of the people had been in a disadvantaged position for too long in the field of mathematics education, there is an urgent need to redress the imbalances by making the mathematics more accessible to the people. One way of achieving this redress is by making mathematics learning compulsory for all students until the end of the compulsory schooling period.

Next I want to look at the rationale cited in the senior phase policy document (South Africa, 1997) for including MLMMS in the new curriculum. The policy document accepts MLMMS as domains of cultural achievements of humanity, which has both utilitarian and intrinsic values. The right of access of every individual to these domains and their benefits is also acknowledged. It is further accepted that these domains of mathematical knowledge provide powerful numeric, spatial, temporal, symbolic and communicative and other conceptual tools, skills, knowledge, attitudes and values to analyze, make and justify critical decision and take transformative action. The learning area is assumed to empower the citizens to work towards the reconstruction and development of the country. It also embodies the principle of providing equal opportunities to everybody to work for the personal and societal development in the rapidly changing technological context. It also seeks to help learners derive pleasure and

satisfaction through the pursuit of rigor, elegance and the analysis of patterns and relationships. The reasons cited as the rationale are not different from those mentioned earlier. The main reasons, therefore, for having mathematics in the South African school curriculum can be summarized as its utilitarian and intrinsic values and to fulfill the need to redress the imbalances of the past.

Mathematics is an integral part of most of the new eight learning areas in Curriculum 2005 introduced in the South African school curriculum. I was one of the participants in a workshop organized by the National Department of Education from the 24th to the 26th July 2001. This three-day workshop was organized to train two facilitators from each of the nine provinces in each of the eight learning areas in preparation for the piloting of Common Assessment Tasks (CATs) and External Assessment Tests (EATs) for assessing the Grade 8 learners in 2001. These CATs and EATs will form part of the assessment tools to be used in Grade 9 in 2002. In one of the plenary sessions participants from each of the eight learning areas were asked to identify specific outcomes (SOs) unique to their respective learning areas. When all other learning areas proudly identified and reported their unique SOs, the representatives of MLMMS struggled to find their unique SO. They were of the opinion that they did not have any unique SO since most of the SOs in MLMMS integrated into all other learning areas. At the end of the discussion representatives of other learning areas were surprised to see how their learning areas were complemented by mathematics. This incident is just mentioned to highlight the important role mathematics occupies in all other learning areas like Natural Science (NS), Technology, Economic and Management Sciences, Arts and Culture. I am of the firm belief that a country like South Africa which focuses on the reconstruction and development of the nation through technological development and economic empowerment of the majority of the population needs an effective system for the teaching and learning of mathematics. The fact that mathematics is well integrated in all these learning areas clearly explains the reasons why it should be taught in our schools.

I want to close this section by recalling the concern raised by Asmal (2001 as quoted by Pretorius, 2001) on the declining number of mathematics and science students in our schools. According to Asmal, "As a result (of declining number of maths and science students in high schools), the pool of recruits for further and higher education in the information and science-based professions is shrinking. This has grave implications for our national future in the 21st century". Asmal's comment highlights the importance of mathematics and science education for the information and science based professional courses. It implies that to have a bright future in the 21st century for the country, an effective system of mathematics and science education is imperative to increase the number of recruits for those courses he mentioned. " ... these sciences (mathematical and computational) have become essential for all learners, including those preparing to become technicians, engineers, educators, leaders in business and government, and more generally, for developing scientifically, mathematically and technologically literate citizens" (South Africa, 2001: 7). Through the effective teaching of the subject we may be able to produce more students, offering mathematics related courses for further and higher education courses to produce the competent human resource which is very scarce in our country.

## 5. SOME GOALS OF MATHEMATICS EDUCATION

The goals of mathematics education have crucial implications for its shape and for its outcome (The Reorganization of Mathematics in Secondary Education, 1923:390 as quoted in Niss, 1996: 22). The curriculum and its implementation in any country or in any institution are determined by the goals of education in the country. The goals of mathematics education determine what mathematics should be taught and how it should be taught. The goals also determine the initiatives of all stakeholders (policy makers, curriculum designers, educators, parents and students) involved in the enterprise of mathematics education in making sure that the subject is taught effectively in order to realize the goals. For example a society like South Africa which acknowledges the importance of mathematics in technological developments attaches more importance to

mathematics education and tries to make sure that it is well taken care of in the school curriculum.

According to Niss (1996: 17), the goals of mathematics education are embedded in the three fundamental reasons (mentioned earlier on page 11) for teaching mathematics. The reasons for teaching a subject and the goals of teaching the subject are generally compatible. For example, as it is found that good drinking water is essential for maintaining a good health care system, one of the goals of the department of water affairs should be to provide the public with good drinking water. Similarly if mathematics education should be included in the school curriculum for certain reasons, the goals of mathematics education should be the realization of the issues in those reasons. Taking the issue of providing good drinking water, some years back one of the goals of the water affairs department could have been to dig wells in order to realize the goal of providing drinking water to the public. As a result of technological advancement the aims changed in constructing boreholes. Very soon it may change into providing running water in every household. Niss (1996) reports on the way the goals of mathematics education changed over the years since the inception of formal education including mathematics education. Initially general education and mathematics education were meant for the very few selected individuals and as such the goal of mathematics education was to educate those selected few. As larger numbers of the population were given educational opportunities the goals of mathematics education also changed to make it more accessible to more people. Niss also reports that over the years the goals of mathematics education had shifted from the political, ideological and cultural maintenance of society to the technological and socio-economic development of the society.

Niss (1996) succinctly summarized the goals of mathematics education as follows:

> The goals of primary and lower secondary education have been broadened considerably so as to encompass the essential aspects of numeracy and mathematical literacy in society. ... The goals included providing mathematics education for all taking into consideration the need for differentiated teaching and learning to cater for personal background of the learner, encouraging

> participation and cooperation among learners in mathematical tasks and the assessment of the mathematical potential and achievement of learners. Other goals included the whole development of the learner such as development of personality, development of critical and creative thinking, enabling him/her to appreciate the role and usefulness of mathematics and to make learner familiar with the development of the current information technology in relation to mathematics.

The goals of mathematics education, like any other subject, are usually indicated in the introductory part of the syllabus for each class. During the past twenty-five years of teaching I worked through the mathematics syllabi for different courses in countries such as Nigeria, Lesotho, United Kingdom, India and South Africa. The goals of teaching mathematics in all these countries are similar to those suggested by Niss. The goals suggested in the Core Mathematics Syllabus for Standards 5 to 7, published by the Department of Education and Culture in South Africa (South Africa, 1991), for example, included enabling pupils to gain mathematical knowledge and proficiency, to develop number sense, to develop insight into spatial relationships and measurement, to increase their ability to apply mathematics in daily life and to enable them to solve routine and non-routine problems individually or cooperatively. Other goals included enabling pupils to develop the ability to think logically, to generalize, specialize, organize, abstract, draw analogies and to prove; to provide basic training for future study and careers; to develop a love for, and an inquisitive attitude towards mathematics and to develop an appreciation of the place of mathematics and its widespread applications in other subjects and our world. In the introductory section on the aims it is stated that the aims of mathematics have been selected with the intention of fostering the general, formative educational goals for pupils of self-esteem, dignity and control over both themselves and their world. It was further pointed out that the aim should be realized as much through the method of teaching and inquiry as through the understanding of the content.

In the 1990 mathematics syllabus for Senior Primary Teachers' Diploma (SPTD), the aims of teaching mathematics included developing a love for, an interest in and a positive attitude towards mathematics, providing for a deeper understanding and application of mathematics and developing the ability of the

student to apply mathematical knowledge and methods in other subjects and in their daily lives (South Africa, 1990). The fundamental goals of mathematics education highlighted in the mathematics syllabi of the other countries mentioned above are also very similar. It is seen from the above that the teaching and learning of mathematical knowledge and the development of the learner are the most important goals of teaching mathematics.

D'Ambrosio (1979), as quoted in Niss (1996), listed the following goals of teaching mathematics:

1. To achieve for each individual the mathematical competence appropriate for him/ her.
2. To prepare each individual for adult life, recognizing that some students will require more mathematical instruction than others.
3. To foster an appreciation of the fundamental usefulness of mathematics in our society.
4. To develop proficiency in using mathematical models to solve problems.

The fundamental aim of mathematics education, as seen from the above discussion, focuses on the development of the individual learner to enable him/ her to cope with his/ her life in the future and to contribute to the society's well being. The curriculum developers, politicians, educators and even the society at large have the same expectations of teaching mathematics. The educators who attended my OBE workshops in various centers of the Central Region in the Eastern Cape, for example, also identified almost the same goals. Their goals included developing critical thinkers who have skills in calculation, analyzing problems and problem solving. Preparing the learners for suitable careers, helping them with the mathematics needed in other subjects, preparing the learners for the job market and instilling in the learners a love for mathematics were also cited as the goals of mathematics education. Similar goals are found in the critical outcomes outlined in the new curriculum introduced in South Africa. The ten specific outcomes stipulated for MLMMS can be clustered in to themes of number concepts, measurements, space and time, data management,

communication and problem solving. The goals of mathematics education are aimed to equip the learners with these mathematical competencies for their future life and for the well being of the society.

Jacobsen (1996) reveals another goal of mathematics education appropriate for most of the developing countries. According to him, most of the developing countries, especially those who gained independence from their colonial masters, were faced with the task of nation building. They had to face the challenges of establishing institutions like curriculum development centers, educational statistics departments and faculties of education. They faced the further task of developing personnel to organize and manage these institutions and other government offices. Either most of the colonial officers who managed those offices left the countries when the countries were made independent. Or the new government wanted to replace the colonial officers with officers from their own countries. This was followed by a huge demand for locally skilled labourers and professionals in almost all fields such as engineering, health care systems, telecommunication, education, businesses, financial management. One of the desired outcomes of education in each level of schooling in these countries was to educate learners for the next stage successively to take them through to the university level to produce the much needed manpower for the top offices. Thus, primary schools would prepare students for secondary schools, which in turn would prepare students for tertiary institutions. Jacobsen further reports on the officially stated goals of mathematics teaching in ten African countries like Kenya, Lesotho and Swaziland as prepared by the African Commission on Mathematics Education for UNESCO in 1983. According to the report the major goal of teaching primary school mathematics in two-thirds of those ten countries was to prepare pupils for secondary school. For half of these countries, the main goal of teaching secondary mathematics was to prepare students for university. Similar goals are found in most of the countries, especially in the developing countries all over the world.

The post apartheid government of national unity in South Africa established the Reconstruction and Development Programme (RDP) as its initiative towards nation building. It is known that South Africa, like most of the other African countries, faces a huge demand for locally skilled labourers and professionals like engineers, architects, technicians, accountants and financial managers. The shortage of these skilled professionals among the rural black population is alarmingly acute. Sustainable development of the rural population through self-managed community projects is one of the visions of the RDP (South Africa, 1995). The rural population needs to be literate and numerate in order to establish and sustain viable developmental programmes. The importance of mathematics teaching in developing an informed citizenry has already been highlighted. One of the goals of the mathematics education in our country should, therefore, be assisting the majority of our rural population in acquiring the basic skills in mathematics. It will contribute towards developing the skilled work force that will be able to mange and sustain developmental programmes in the local communities.

Another important goal that is found in almost all of the early mentioned - mathematics syllabi is to instill a love for mathematics among the pupils. However, the number of students doing mathematics beyond the compulsory phase of education is very small. Especially at the secondary and tertiary levels in South Africa the number of those who are doing mathematics related courses is far less than that of other courses. The reason could be that students find mathematics more difficult, irrelevant, uninteresting and full of rote learning of algorithms and formulae. This situation should change. One of the main goals of mathematics education should be that of promoting the subject among the learners so that the students will be able to identify mathematics as a creative subject which is useful in their daily lives. Hence as David Pimm (1987) suggested one goal of mathematics education should be to explore ways of making children see mathematics as a useful and creative subject and to make them interested in it.

## 6. MATHEMATICS EDUCATION IN SOUTH AFRICA TODAY

The year 2000 was declared the International Year of Mathematics in order to popularize the subject. As Ernest (1996) asked: "Why should mathematics be popularized?" Is the present situation of mathematics education that bad? Does it mean that declaring year 2000 as the International Year of Mathematics imply that mathematics has not been well received or it has not been getting the desired popularity worldwide? As reported earlier (page 3), with the growth of democratic movements in many parts of the world there was an attempt to increase the accessibility of the subject to more people. But those efforts did not yield the desired result. According to Jacobsen (1996: 1240):

> In the 1980's, the elimination of illiteracy became a major goal of UNESCO, leading to the declaration of 1990 as International Literacy Year. UNESCO's mathematics education programme also changed, emphasizing numeracy... Thus the offering in mathematics was streamlined such that every student received the tools for survival, for work, for participating in community affairs and for being a responsible citizen politically. However, national and international surveys had shown again and again that this was not happening, that the majority of adults do not function mathematically; and even their arithmetic skills are poor. Citizens are literate but not numerate.

According to Kirsch and Jugeblut (1986 as reported in Steen, 1990b), fewer than 40 percent of young adults could carry out simple restaurant calculations (adding the cost of two items, adding a tip, and determining change). According to a report by the National Research Council (1989 as reported by Steen 1990b), the US mathematics education system loses 50 percent of students each year. From an approximately 3,2 million students entering the high school, only a few hundred attain a Ph. D in mathematics. According to Steen (1990b), in addition to the general aversion a majority of the population developed towards mathematics, the Americans had to face the problem of varying popularity of the subject among the different cultural groups and between males and females. She further pointed out that:

> Only 4 percent of the bachelor's degrees in mathematics and fewer than 2 percent of the Ph.D. degrees go the U.S. black or Hispanics, our largest populations. Three of every four citizens who receive Ph. D degrees in

> mathematics are not only white, but male. ... One- fourth of our population- the underrepresented minorities- currently produce fewer than 2 percent of our scientists, mathematicians, or engineers. ... .. virtually none of the black college freshmen who score highest on the SAT mathematics test indicate interest in majoring in mathematics.

South Africa also faces a similar situation with regard to mathematics education. As already mentioned, it is common knowledge that during the apartheid era the majority of the population in this country did not have access to quality education as education was divided on racial lines and it was considered the privilege for a selected few. Mathematics education was not an exception. As Kahn *et al.* (1995) pointed out, "... the attainment of matriculation exemption with physical science and mathematics at higher grade among the black students is one-sixtieth that for white students, who are in the small minority". Furthermore, only very few, even in that very few brilliant white males, had the chance of studying mathematics at tertiary level (Volmink, 1994). The ratio of whites to Africans who were awarded degree in mathematical sciences in 1996 was 3,2: 1 (South Africa, 2000). In the post-apartheid South Africa the access rate of the previously disadvantaged population to priority subjects like mathematics and science has increased as mentioned earlier on pages 3- 4.

At present all South African schools have a 'science and mathematics for all' policy in operation, at least up to the ninth year (Grade 9) (Kahn *et al.*, 1995). Even though the number of students doing mathematics in Grade 12 has increased as reported earlier,

> Most of those who wrote mathematics (in the matric examinations) wrote it on the standard grade.... An analysis of the maths results shows that for every 100 candidates in Grade 12, only 45 took maths, of whom only 21 passed. Of the 21 that passed, only four attained a higher-grade pass, while 14 attained a standard grade pass, and three a lower grade pass (South Africa, 2000).

This situation was earlier illustrated with the number of students registered in mathematics in 2001 matric examinations in the Zwelitsha District of the Eastern Cape. The South African Institute of Race Relations report (2000) further

pointed out that between 1992 and 1996 there was an 18 percent increase in the number (from 858 in 1992 to 1010 in 1996) of degrees, diplomas and certificates awarded by South African universities and technikons in mathematical sciences. However, according to the report out of the 85985 total awards in 1996 there were only 1010 awards, i.e. just 1 percent in mathematical sciences (South Africa, 2000). In 2000, at five top universities there were just 26 maths and 17 science students who expected to graduate at the end of the year (The Star, 10 March 2000 as quoted in Lewis, 2000). According to Pretorius (2001), " ... the residential universities collectively produce around 160 maths and science graduates a year. At Wits University, for example, only eight maths and 10 science high-school teachers will graduate this year." These numbers indicate the poor state of popularity of mathematics among the secondary and tertiary students in South Africa.

It is well known that South Africa is experiencing an acute shortage of teachers, particularly in key subjects like mathematics and sciences (Lewis 2000; Kahn *et al*, 1995). Research conducted in Johannesburg College of Education shows that SA will face a dire shortage of teachers by 2005, particularly teachers qualified to teach maths and science (The Star & SA Times International 2000, 14 February as reported in Lewis, 2000). The newspapers further reported that in Gauteng Province alone about 700 new maths and science teachers were needed annually. At present less than 20 percent of maths and science teachers have completed one university course in these subjects. According to the provincial member of executive council (MEC) for education in the Gauteng Province, the shortage of teachers in maths and science in formerly black schools amounted to a crisis that threatened the economic and social future of the province. In 2000, the province of KwaZulu-Natal had a shortage of about 500 maths and science teachers (Pretoria News 2000, 6 April as quoted in Lewis 2000).

The situations regarding the shortage of teachers in the other provinces are not different from what is described above. Heard and Pretorius (2000, 2 April) reported that fewer than 300 high school teachers would complete their training

in South Africa in 2000, a far cry from the estimated shortage of 4000 – 12000 teachers. Heard and Pretorius further reported on the submissions made by Professor Jill Adler and Aarnout Brombacher to the Education Minister Kader Asmal and the Members of Executive Council (MEC) for Education from the nine provinces on the crisis of mathematics education in South Africa. In the submission it was revealed that only four teachers qualified as high school maths teachers at Wits University in 1999 and only one at the university of the Western Cape. It was further reported that in 2000 not even one student had enrolled for the higher diploma with maths as a specialist subject at the University of Durban-Westville. According to Heard and Pretorius (2000, 2 April), "The shortage of qualified teachers shows in the poor matric maths result - last year's pass rate was 43,4 percent – and estimates that only 1 percent of African matriculants achieved an A or B symbol for higher grade maths". These statistics indicates that all is not well with mathematics education in South Africa.

At this juncture, I would like to highlight some reports on the performance of South African students in mathematics and science. In 1995 the Human Science Research Council (HSRC) conducted a survey on mathematics and science among 15 000 South African students from more than 400 primary and secondary schools, as part of the Third International Mathematics and Science Study known as TIMSS. TIMSS questionnaires and other achievement instruments were administered to Std 5 (Grade 7), Std 6 (Grade 8) and Std 10 (Grade 12) students. According to the study South African students in Std 6 performed poorly in mathematics in comparison to students of the same age group in other countries, achieving the lowest score of 354 points out of 800 points compared to the international average of 513. In Std 5 also South African students scored the lowest score of 348 compared to the international average of 484 points. In science also South African students scored the lowest points 326 and 317 points by the Std 6 and Std 5 students compared to the respective international averages of 516 and 479. On the Std 10 (Grade 12) mathematics and science literacy tests, the study reported that the overall scores of the South African students were significantly lower than those of students in other

countries; suggesting that South African final year students have a low level of general numeracy and scientific understanding and skills. The study further reported that South African results did not display any area in science and mathematics in which students performed well. In many of the individual test items, South Africa performed the worst. According to another report South African Grade 4 learners have the worst numeracy (with an average score of 30% in numeracy) among the 12 African nations which took part in the Joint International Unesco-Unicef Monitoring Learning Achievement (MLA) Project (Sunday Times, 2000 as cited in Lewis, 2000: 2).

From what has been discussed above it is quite clear that all is not well with mathematics education in South Africa. However, there are a lot of initiatives to improve mathematics education in the country. In the next section I will discuss some of these initiatives aimed at improving mathematics education in South Africa.

## 7. EFFORTS TO IMPROVE MATHEMATICS EDUCATION

There have been concerted efforts across the globe to improve or boost the level of mathematics education across the globe. There are international efforts as well as efforts by individual nations. I do not want to do a detailed and complete audit of all the international efforts to improve mathematics education. The limited scope of this project does not warrant such a detailed audit. However in this section I will briefly discuss some of the international efforts followed by some efforts in South Africa in improving mathematics education.

UNESCO, in collaboration with the ministry of education of its member states, strives to improve mathematics education. UNESCO also collaborates with other international organizations like the International Commission on Mathematical Instruction (ICMI), the International Institute of Statistics, International Federation for Information Processing and the International Association for the Evaluation of Education Achievement. ICMI together with UNESCO and their regional branches all over the world organizes conferences and working

commissions on issues related to mathematics education. One of the main themes of the Fifth International Congress on Mathematical Education was 'Mathematics For All'. In the group presentation, problems of cultural selectivity and unequal distribution of mathematical education and future perspectives on mathematics teaching for the majority were discussed (Damerow *et al.*, 1986). A detailed list of different conferences held in various parts of the world is available in Jacobsens' (1996) article: International Co-operation in Mathematics Education. Various international studies in mathematics and science like Second International Mathematics Study (SIMS) and the TIMSS are examples of attempts to evaluate the levels of competence of students in the participating countries in mathematics and science. These conferences and studies are aimed at bringing various nations with diverse cultural and societal background together "to contribute to a better understanding of the problems of teaching mathematics successfully, not only to very able students, but teaching worthwhile mathematics successfully to all in a range of diverse cultures and circumstances" (Damerow *et al.*, 1986).

Ernest (1996) gives a sample of illustrative popularization projects and initiatives organized in Britain and Anglophone countries in order to popularize mathematics. He was of the opinion that there could be equally good projects around the world in addition to those he had mentioned in the article. The Primary Mathematics Year 1988 organized through the initiatives of the Primary Initiatives in Mathematics Education (PrIME) project in Britain; NCTM Mathematics Education Month organized by North American National Council of Teachers of Mathematics in the North American states in April every year; The Pop Maths Road Show organized by the Royal Society in Britain; Zeeman's Lectures and Masterclasses organized by the mathematician Christopher Zeeman are some of the projects Ernest included in his list. Others included IMPACT and FAMILY MATH which encouraged mathematics among primary school aged children and parents in Britain and USA respectively, Fractals in Youth Computer-Culture, Enactive and Displacement Games, Children's Books, Mathematical Magazines, Mathematical Puzzle and Recreation Books and

Television programmes. Those who are interested in the details about these projects and initiatives may refer to Ernest (1996) and Howson and Kahne (1990 as quoted in Ernest, 1996). Some of these projects were found successful while others were not.

In South Africa also there are similar projects and initiatives organized with the aim of improving mathematics education. The Department of Education and Non-Governmental Organizations (NGO) play important roles in this regard. The introduction of Students and Youth into Science, Technology, Engineering and Mathematics (SYSTEM) was one of the main initiatives of the post- apartheid government to improve maths, science and technology education in South Africa. According to the SYSTEM concept (South Africa, 1995: 5 - 6):

> The project recruited students who either failed or did not get required symbols in maths and physical science for university admission. SYSTEM proposed to offer a full-time, one year, certified, day-scholar programme of study to the students admitted to the programme in order to open career path open to them. The successful completers from SYSTEM enter selected Colleges of Education or tertiary education, the training sector or employment.

The introduction of Curriculum 2005 and making all learning areas including MLMMS compulsory during the General Education and Training (GET) band is another initiative by the South African government to improve mathematics education in the country. According to Kuiper (2000), "The new curriculum has clearly taken a large step in the direction of developing scientific and mathematical literacy". It is hoped that making MLMMS compulsory will go a long way in improving numeracy among the young learners. In the new curriculum the largest share of the notional time (13 percent) is allocated to MLMMS. Notional time represents contact time, learners' efforts and time, preparation time and other time spent in each learning area and show a relative weighting of learning programmes within a phase (South Africa, 1997: 27-28). The White Paper on Science and Technology (South Africa, 1996:40), suggests overwhelming support for maintaining compulsory mathematics and science education up to Grade 9 which is the exit level in the compulsory phase of general education and training. The paper also outlines plans to include these

subjects in the General Education and Training Certificate (GETC). In the Discussion Document for Public Comment on the GETC, 16 credits out of 120 credits are allocated to MLMMS. This is the highest credit allocated to any single learning area except the languages. This, perhaps, could be an indication of the importance the Department of Education attaches to the mathematics education in this country (South Africa, 2000:19). Mathematics is identified as a priority subject in the Matric Improvement Programme (MIP). This programme used to be called Metric Intervention Programme and its focus as the name suggests is improving the results in matric examinations. It is reported that there was slight improvement in the results of these priority subjects, including mathematics, in 2000.

Professor Michael Kahn, a maths, science and technology lecturer from the University of Cape Town has been appointed as a part-time science and technology advisor to the Department of Education with special brief to review science and maths curricula at all levels to solve the problems of under performance in these fields (Lewis, 2000 & Pretorius, 2001:19). The Council of Education Ministers (CEM) agreed in March 2000 to embark on a five-year programme, headed by Kahn, to promote maths, science and technology (Lewis, 2000: 4). In July 2000 a pilot workshop was held at the National Research Foundation (NRF) to discuss a strategy to enhance mathematics, science and technology (MST) education in South Africa (Kuiper, 2000).

South Africa also participated in the TIMSS which is the largest and most ambitious international study of mathematics and science achievement at school level ever undertaken (Howie, 1998:4). TIMSS tests, as claimed by Howie, were designed to measure mathematics and science achievement in order to help inform governments, policy makers and educators about the mathematics and science proficiency of their students at key points in the educational process .The results of TIMSS in South Africa may be regarded as baseline information to mark the *status quo* of education in mathematics and science in a new nation (Engelbrecht, 1998). Participating in TIMSS is a step in the right direction as the

feedback from the study can be used to evaluate and monitor the progress of the learners in these subjects.

National and Provincial governments are looking into ways of alleviating the shortage of teachers. According to media reports, as a short-term solution, the national government is planning to recruit maths and science teachers from other countries like Cuba. In the long term basis the government is trying to train more local teachers in these priority subjects. In Gauteng, the bursary allocation for teachers studying maths and science is to be increased and 450 promising learners will be selected from black schools and sent to an academy for special attention (Business Day and the Citizen, 2000 as reported in Lewis, 2000). Lewis (2000) further reported that In KwaZulu-Natal the Department of Education would be offering a free four-year university degree if they specialize in science and maths. The other provinces are also reported to have similar programmes aimed at the general skill developments of teachers in all learning areas. In the Eastern Cape R20 million was earmarked by the Department of Education for the year 2000 for teacher development projects (Lewis, 2000).

For a long time, numerous NGOs were seriously involved in mathematics education in this country. Jerome Murphy (1992 as reported by Rogan and Gray, 1999) of Harvard University described several key education reformers who came from the NGOs which had flourished in South Africa despite years of repression and autocratic rule. According to Kahn (1994) as quoted in Rogan and Gray (1999)

> There are more than one hundred NGOs active in science and mathematics education offering service to both students and teaches in syllabus related work as well as career and vocational education. ... They have provided a significant means of innovation, maintaining and building morale, and a platform for the development of alternative approaches in education.

Some of these organizations, still active in the country, are the Open Society, Joint Education Trust (JET), Zenex Foundation, United States Agency for International Development (USAID) and the Canon Collins Educational Trust for Southern Africa (CCETSA). These NGOs provide financial support for

educational initiatives in the country. They also provide scholarships and bursaries to deserving candidates, especially in mathematics and science related disciplines. They also promote research programmes in educational issues.

The Association for Mathematics Education of South Africa (AMESA) is one of the leading mathematics associations in South Africa. AMESA organizes conferences of mathematics educators. In these conferences issues and concerns related to mathematics education in South Africa and other parts of the world are discussed. It runs a newsletter which focuses on issues in mathematics education. Members' contributions are also published. AMESA also looks into serious issues related to mathematics education and makes recommendations to the government. The Curriculum Committee report on the MLMMS curriculum (AMESA, September 1997) and the submission by the Mathematics Education Community to the Council of Education Ministers (AMESA, March 2000) are examples of initiatives taken by AMESA in improving the state of mathematics education in this country. Most of the NGOs in South Africa working in the area of mathematics are members of AMESA. AMESA members are also members of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE). These members take active participation in the conferences organized by SAARMSTE every year. "SAARMSTE is a rapidly growing body of professionals in the fields of science, mathematics and technology education which focuses on research that is aimed at enhancing teaching and learning in these fields at all levels of education. Membership of SAARMSTE comes from across southern Africa; viz. Zimbabwe, Mozambique, Lesotho, Botswana, Malawi and South Africa" (Webb, 2000: 15).

The ESKOM Mathematics and Science Education Projects (EMSCEP) is an initiative of ESKOM in developing maths and science education in South Africa. One of its functions was to sponsor a second chance programme for learners who performed poorly in mathematics and physical science in matric examination. In this programme, well experienced teachers offered intensive tuition in these two subjects. The objective was to improve their symbols in these two subjects so

that they could get admission to tertiary courses for which mathematics and science were prerequisites. Initially some colleges of education in a few of the provinces were chosen to run the programme. Dr.W.B. Rubusana College of Education and Cape College in the Eastern Cape were two colleges involved in the programme. Another aim of the project was the empowerment of mathematics and science lecturers from the selected colleges by organizing workshops in the content and methodology of the teaching of the subjects. The project awarded bursaries to many college lecturers for higher studies in the two subjects. Later more colleges were included in the programme and more bursaries were awarded. At present, following the disestablishment of the colleges of education, the bursaries are awarded to teachers throughout the country. Preference is given to those teaching the priority subjects like mathematics and the sciences. Many students and teachers benefited from the EMSCEP project.

Another important programme to be mentioned is the Foundation Courses run by some tertiary institutions in the country. The foundation programmes run by the Border Technikon and the University of the North are worth mentioning. These institutions offer tuition mainly in maths and science to those who did not get the required symbols for admission. At the end of the course, those students who get the required symbols in the examinations conducted by these institutions are absorbed into various programmes offered by the institutions. Other students can get admission into other tertiary institutions which recognize these programmes. Some Colleges of Educations also conducted such programmes. Dr.W.B. Rubusana College of Education in Mdantsane, Eastern Cape ran a similar Foundation Course programme. With the closure of the college, these programmes, however, ceased to operate. The programmes at Border Technikon and University of North are still running. The coordinators of these programmes in these two institutions met in June 2001 to review the programmes with the intention of making it more functional. Many other tertiary institutions are also planning to organize such bridging courses to prepare students to meet their admission requirements.

There are many other projects and programmes run by different universities and other educational institutions in order to improve mathematics education in the country. Rhodes University Mathematics Education Project (RUMEP) at Rhodes is one of the projects. RUMEP is an independently funded non-governmental organization linked to Rhodes University, with the specific purpose of assisting teachers in disadvantaged schools. The aim of the project is to improve the quality of teaching and learning mathematics in primary schools. RUMEP achieves this through interactive workshops, in-class support, materials research and development, diploma courses and monitoring and evaluation (RUMEP, 2001). RUMEP is also involved in developing learning support materials for the IMBEWU project. In addition to RUMEP, the Department of Education at Rhodes University runs post graduate courses in mathematics and science education. The department intends to run a B. Ed (Mathematics and Science) degree which has been designed for those matriculants who would like to teach mathematics and science, even though they may not have had very good grounding in the subjects at school. The department in cooperation with the Carneige Corporation of New York will offer bursaries to students interested in the course (Rhodes University, 2001).

The Department of Science, Mathematics and Technology Education (SMATE) at the University of Port Elizabeth (UPE) also runs many projects aimed at improving mathematics education. A list of projects and activities run by SMATE is found in its Annual Review for 2000 (SMATE, 2000). Staff members are involved in writing IMBEWU training modules in science and mathematics, training facilitators, training and mentoring educators in the field, producing resources, planning, writing and training in the use of resources and researching the process and its effectiveness (Webb, 2000 as reported in SMATE, 2000: 3). The 'Family Maths' programme run by SMATE in many schools in the Eastern Cape is reported to have positively impacted on teachers, parents, learners and the wider community. "This programme (Family Maths programme) incorporates Science, Maths, Language and Technology and aims to

bring parents, children and community members together (for maths lessons) in an informal, relaxed manner" (Webb, 2000: 11). This programme is reported to be popular and spreading in the Eastern Cape. SMATE also offers B. Ed courses for primary and secondary school teachers. The focus of these courses, especially the B. Ed (Maths and Science) course, is the improvement of mathematical and science content knowledge among the educators. The In-service Science and Maths Education (ISME), Primary Maths Project (PMP) and the Khula Project are some of the other projects run by SMATE.

The Khula Project in the Eastern Cape is another project started in 1998 with funding from Lucent Technologies and Management by Rutgers University-Camden in the USA. It is a three-year project aimed to develop the teaching of mathematics and science in the Eastern Cape. The project has been implemented at University of Fort Hare, Rhodes University and University of Port Elizabeth. The primary focus of the project has been to integrate computers into the teaching of mathematics and science (SMATE, 2000). The Distance Education Project run by University of Fort Hare is also involved in conducting workshops and in-service courses for mathematics teachers. According to a Daily Dispatch report (November 16, 2001), the University of Fort Hare is to run mathematics and accountancy workshops for matrics and teachers from 2002. The workshops are part of a South African Institute of Chartered Accountancy project to improve Eastern Cape student marks in key subjects for university entry. The project would focus on the top 10 mathematics and accountancy learners in the areas targeted.

Another organization to be mentioned in connection with the efforts to develop mathematics education in the Eastern Cape is the All Saints Education Development Centre in King William's Town. All Saints conduct workshops and courses in mathematics and other related subjects for teachers as well as students in schools around King William's Town. They also produce learning materials in these subjects for Grade 12 students. Teachers and students describe these materials as very useful. For the last three years, the centre has been conducting

Saturday classes in mathematics, science, technology, English and world of work. However, the main focus was mathematics and science. The project started in 1999 with Grade 10 students from local schools in partnership with PROTEC. Now the programme is replaced by a Homework Club on Saturdays where students discuss and solve problems in mathematics. The effect of these programmes will be known only at the end of this year when these students write matric examinations. All Saints is a satellite campus for SMATE at UPE.

The Research And Development in Mathematics, Science and Technology Education (RADMASTE) Centre at University of the Witwatersrand is also committed to the improvement of mathematics education in South Africa. The aim of the centre, as outlined in its mission statements, is the development of educators in mathematics, science and technology through various projects run by the centre (RADMASTE, 2001). One of the projects run by RADMASTE is the College of Education Mathematics Project (CEMP) which works mainly with lecturers in colleges of education to deepen mathematical and pedagogical knowledge. Other projects include the Mathematics High School In-service Project (MHIP) which targets teaching and learning in township and rural schools and the Change Agent in Primary Mathematics Education (CAPME) which develops 'key teachers' under the guidance of participating NGOs. RADMASTE also issue certificates to the participants at various levels of accreditation. Other activities of the centre include the production of learning support materials in the form of texts and other manipulatives and posters relating to OBE.

The Centre for the Advancement of Science and Mathematics Education (CASME) is another organization involved in the development of mathematics education in this country. Its mission is "to be a centre of excellence in science, mathematics and technology education through the development of sustainable models for the professional development of educators" (CASME, 2001). CASME developed Further Diploma in Education (FDE) courses accredited by University of Natal. The FDE programme enables teachers to further their

studies part time over two years in a specific subject area. CASME also runs teacher leadership programmes, teacher workshops, subject interest groups and the resource centre network (CASME, 2001).

The AMESA newsletter, Mathematical Digest and Pythagoras are some of the publications in South Africa trying to develop mathematics education in the country. The Mathematical Digest, from the University of Cape Town circulates throughout South Africa and further afield. This contains puzzles, challenges and articles and is directed at school children (Ernest, 1996). Pythagoras is published by AMESA. It also contains articles on new developments in mathematics education, puzzles, challenges and some interesting presentations in various topics in mathematics.

TV programmes like "A Word or Two" and the Education Channels on South African Broadcasting Corporation (SABC) also contribute to the development of mathematics in this country. The programme "A Word or Two" has two components: a language component and a mathematics component. In the language component, two contestants are asked to make words with a number of selected alphabets and the person who makes the word with maximum alphabets gets maximum points with each alphabet worth a point. In the mathematical component, the two contestants are required to make a number shown by a machine using the numbers selected from a pool of numbers consisting of units, tens and hundreds. The enthusiasm shown by the viewers in working out the numbers is interesting to watch. A programme like this, I hope, should help young learners greatly in number manipulation skills. In the Education Channels, mathematics and science lessons are broadcasted regularly. In addition to the regular lessons, learners are encouraged to phone in to the presenter with their specific problems in the subjects and get solutions. This programme assists the matric students immensely, especially when they prepare for their final examinations. One of the insurance companies, Liberty Life, sponsors the Education Channels. Businesses like ESKOM, Old Mutual, Liberty Life, Telkom and many others give bursaries to students and teachers interested in the fields of

mathematics and science. They also sponsor programmes and projects for the development of mathematics. Maths Olympiads are sponsored by the Old Mutual and "A Word or Two" is sponsored by ABSA bank.

There are other similar programmes and projects throughout the country contributing to the development of mathematics education in South Africa. The 100 Schools Project is a national initiative with mathematics and science focus in the country. This project aims to provide 100 schools from all the nine provinces with the necessary infrastructure and to train the teachers in these subjects. The aim of the project is to double the number of the higher grade learners in mathematics and science in these selected schools. The programme hopes to achieve close to 100% results in these two subjects. It also aims to set up Information, Communication and Technology (ICT) centers and to train the teachers in these schools. Recently the Eastern Cape Department of Education conducted a workshop to plan the provincial strategy for the Science, Mathematics, Engineering and Technology (SMET) (SA, 2001). The workshop was described by the Eastern Cape curriculum director as the initiative taken by the department to draw up an intervention strategy aimed at improving performance and the level of participation of learners and the public at large in science, mathematics and technology in the province. One of the delegates from Mpumalanga Province to the GETC workshop held in Pretoria talked about The Mpumalanga Secondary Science Initiative (MSSI). This project funded by the Japanese government aims to improve the mathematics and science education in the Mpumalanga province. MSSI also aims to institute a system of school based inservice teacher programme for mathematics and science teachers for all schools in the province.

There are various projects and programmes run by governmental and nongovernmental organizations in all provinces in the country trying to improve mathematics education in South Africa. However, as the statistics mentioned earlier (page 3) indicate, more students turn away from mathematics and related courses once they enter secondary and tertiary institutions. The number of

students writing the higher grade mathematics examination in South Africa is declining every year. This indicates that the popularity of the subject among the learners is decreasing. It would be better for the organizers of the various projects to know the reasons for the unpopularity of the subject. It might help them in focussing their efforts in those areas. In the next section I will be looking at some of the factors hindering the popularity of the subject.

## 8. SOME REASONS FOR THE UNPOPULARITY OF MATHEMATICS

One of the main reasons for the unpopularity of mathematics is the misconceptions about the subject itself. Many people consider it as a subject of absolute knowledge. According to Ernest (1996: 807), those who believe in the absolute nature of mathematical knowledge perceive:

> Mathematical knowledge as an objective, absolute, certain and incorrigible body of knowledge. According to absolutism mathematical knowledge is timeless, although we may discover new theories and truths to add; it is superhuman and ahistorical, for the history of mathematics is irrelevant to the nature and justification of mathematical knowledge; it is pure isolated knowledge, which happens to be useful because of its universal validity; it is value-free and culture-free, for the same reason.

As the absolutists insisted that mathematics is the one and perhaps the only realm of certain, unquestionable and objective knowledge many people considered it uninteresting and beyond their reach. Another group, the fallibilists, came with an opposing view regarding the nature of mathematics. According to the fallibilists, mathematics is a social construction, its result is relative to time and place and subject to revolutionary change as much as other forms of knowledge (Lerman, 1990). However, it will take time to wipe out the negative image people already have developed about mathematics.

Another reason cited for the unpopularity of the subject is the euro-centrism attached to it. "Mathematics is believed to be European. Contributions from other cultures are ignored" (Ghevarghese, 1994). This euro-centric nature of mathematics can be seen in the old textbooks used in the colonial countries.

Other population groups find it difficult to relate the mathematics they are taught to their environments and they find it irrelevant to them. They have no sense of ownership of the subject. They try to alienate the subject and it is described as difficult.

Gender differentiation is another reason for the unpopularity of the subject among females. Mathematics is considered a masculine subject (Walkerdine, 1988) and girls are trained to accept this belief by their parents (Ernest, 1996). Downes (1997) identified the way mathematics had been developed as a male subject as one main obstacle to girls' participation and their achievement in mathematics. She further pointed out the absence of role models for girls as another reason for girls not getting motivated to learn mathematics. 'Anyway I am not going to do mathematics once I leave the school' is the attitude most of the girls develop about mathematics. Hence they find mathematics irrelevant to them and they lose interest in the subject by the time they leave secondary school.

The negative attitude towards mathematics is cited as another reason for the unpopularity of the subject. In a review article on attitude towards mathematics, Aiken (1986 as quoted by Cheung, 1988) reports that attitude towards mathematics start developing as soon as children are exposed to the subject. But the junior years (11-15) appear to be particularly important. This is the time when negative attitudes towards mathematics become especially noticeable. Even before students start with their formal education in mathematics, many of them develop a negative attitude towards mathematics. Their parents, elder brothers or sisters or friends might have told them that mathematics was a difficult subject. These children start learning mathematics while being afraid of the subject. Their fear, in most cases, would be confirmed right from the beginning by the poor result either they or their friends get in the tests and examinations in the subject. Gradually the subject will become unpopular with these kids and they drop the subject as soon as it becomes optional in the school curriculum.

All the reasons mentioned above can be described as being true for the unpopularity of mathematics in South Africa also. A country where education was divided along racial differences, mathematics education had stunted growth. According to Goldstein *et al.* (1993),

> In classrooms across the country, in both townships and rural areas, maths and science are viewed as foreign constructs and as integral parts of the structure of oppression. They have been identified as clear markers of the elitist society and the province of the culturally and academically advantaged

Even though the post-apartheid government is trying hard to bring equity into education at all levels, its efforts are hampered by the lack of resources and the shortage of qualified teachers. In 1978 out of the 14389 lower primary teachers responsible for the 'black education' under the apartheid government, only 207 had at least matriculation plus a teaching qualification (Goldstein, Mnisi *et al.*, 1993: 23). Even now the situation has not changed considerably.

Another issue of serious concern in mathematics education in South Africa is the large number of unqualified and under-qualified teachers teaching the subject. Majority of a group of intermediate phase teachers, who took part in a study conducted by Glover and King (2000) in the Eastern Cape, were found to possess misconceptions in algebra. Having taken part in the OBE workshops in MLMMS, I am of the opinion that the level of content knowledge of most of the mathematics teachers in South Africa, especially in the primary schools, is very poor. In one of the workshops I gave the Grade 7 teachers an assessment task on the different types of triangles. The assessment tasks were related to naming of different triangles and their properties. Even though the tasks were very elementary, more than 75% of educators scored less than 8 points out of a total of 15 points. During the discussion about the assessment task, one of the teachers commented, " If this test is so difficult for us teachers, how much more difficult will it be for the learners?". In my opinion majority of these primary school teachers do have serious misconception in almost every aspect of mathematics. Most of these teachers are either under-qualified or unqualified to teach mathematics. Most of these teachers teach those mathematics topics with which

they are reasonably comfortable. They either leave the other topics with which they are uncomfortable or teach those topics wrongly. Even when they teach the topics they claim to be comfortable with, they copy the same examples worked in the textbook on the board without really making the children understand the concepts. Children taught by such teachers will have serious conceptual problems when they reach senior classes.

Through my interactions with some mathematics teachers in the province, I have learnt that there are some high schools where teachers with Primary Teachers Diploma teach mathematics up to grade 12. As a result of the rationalization and redeployment of teachers, either the mathematics teachers in some schools got redeployed to other schools or the school does not qualify for a new teacher in mathematics. In such cases principals of the affected schools indiscriminately ask any teacher to teach mathematics in high school classes even though the teacher is not qualified to teach mathematics. Such teachers always struggle with the subject and resort to, like their primary school counter parts, copying the examples worked out in the textbook. These teachers follow the textbook and are not able to teach the topics prescribed in the syllabus. The failure of most Grade 12 teachers to finish the geometry topics is a proof to this observation. In all textbooks, right through the primary classes, geometry is the last topic and almost all teachers leave this topic. As a result the conceptual knowledge of students in geometry becomes very poor. Generally students score less marks in the geometry section in Grade 12 examinations.

Lack of commitment and low morale among most of the mathematics teachers can also be described as contributing factors to the development of negative attitudes towards mathematics. The Department of Education in the provinces can be held, to a certain extent, responsible for the lack of commitment and low morale among the teachers. There is no proper mechanism to monitor the work done by the teachers in the schools. Also there is no mechanism to give guidance to those teachers who have difficulty in subjects like mathematics. Most of the existing posts of subject advisers in mathematics in the Eastern Cape are vacant.

For example, the post of mathematics subject advisor in the Central Region in the Eastern Cape is vacant for the last 4 to 5 years. This may not be an isolated case. Some of the incumbent subject advisors are not qualified to render any advice to the high school teachers. Moreover those who are occupying the post have to take care of large number of schools in their districts or regions. This situation is correctly portrayed by Pretorius (2001), "Provincial officials are ill-equipped to help. In areas like the Eastern Cape, one maths and science expert has to look after the needs of up to 360 schools". As a result these teachers who struggle with up to sixty students in a class, as Pretorius pointed out, stick to 'theory' and resort to 'spoon feeding'. The students taught by such teachers eventually loose interest in mathematics. This situation does not auger well for a country whose Grade 7 and 8 pupils performed worst out of 45 countries in the TIMSS conducted in 1994/95.

## 9. SOME SUGGESTIONS FOR THE DEVELOPMENT OF MATHEMATICS EDUCATION IN SOUTH AFRICA

Any effort aimed at developing mathematics education should try to address the problems mentioned in the earlier section. The first attempt in the development of mathematics education should be aimed at promoting an alternate view to the absolute nature of mathematics according to which "mathematics is specialist knowledge produced by mathematicians and scientists. The absolute view of mathematics alienates the public from the applications of mathematics that surround them in their daily lives..." (Ernest, 1996: 809). The postmodern philosophies of mathematics, which has been emerging in opposition to the absolutist views of mathematics, should be encouraged as people can have a feeling of ownership of mathematics. This feeling of ownership can attract more people towards mathematics. According to Ernest (1996):

> Post-Modernism proposes a reconceptualised view of the nature of mathematics. It is no longer seen as defined by a body of pure and abstract, which exists in a superhuman, objective realm. Instead mathematics is associated with sets of social practices, each with its history, persons, institutions and social locations, symbolic forms, purposes and power relation.

According to Bishop (1988), the Post-Modern view is that mathematics is an intrinsic part of most people's cultural activities. In order to popularize mathematics, as Ernest (1996) suggested, the cultural origins and uses of mathematics should be recognized as legitimate part of the locus of mathematics and should form part of mathematics courses.

Another important step to be taken to popularize mathematics is removing the euro-centrism around mathematics. It will be possible only by including the contributions of various cultures in different parts of the world in mathematics curriculum and making people aware of these contributions. It is untrue to believe and make others believe that only Europeans contributed in the development of mathematics. According to Zaslavsky (1973), mathematics is in evidence in many aspects of African life. In her book Africa Counts, Zaslavsky looks at the mathematical contributions made by various African cultures. She talks about the various numeration systems that existed in various cultures, their counting systems and various mathematical patterns produced by these cultures. She also describes the geometric patterns and symmetries appear in the beautifully carved and painted masks and in the decorated household things like gourds and baskets. If these contributions form part of mathematical education, more people, especially those in Africa, will develop some ownership in mathematics and will be interested in the subject. As Ghevarghese (1994) suggested:

> The mathematics curriculum must provide opportunities for all pupils to recognize that all cultures engage in mathematical activity and no single culture has monopoly on mathematical achievement. All pupils must be given the opportunity to enrich their mathematical experience by selection of appropriate materials to stimulate and develop knowledge, understanding and skills they will need for adult life and employment in (any country) in the twenty first century.

In a country like South Africa, having different cultures, this approach should be appropriate. The inclusion of the historical development of mathematics (Specific Outcome 3) in the new MLMMS curriculum up to the senior phase in South Africa can be taken as a right step in the right direction. The historical

development of mathematics and mathematics education should form part of mathematics courses in higher education too.

Popularization of mathematics among females is very crucial when gender equality is seriously considered all over the world. One of the main reasons identified for the females to dislike mathematics is the stereotyping of the subject as a masculine subject (Finn *et al*, 1982 as quoted by Dekker and Lemmer, 1996: 16). The popularization programmes should be aimed at encouraging the females to believe that mathematics is not a no-go-area for them. Rather they should believe that they are capable of doing it exactly like their male counterparts. This can be achieved by sensitizing parents, teachers and the wider community including the mass media on the issue and encourage them to desist from the stereotyping of mathematics as a male domain. Care must be taken to make sure that textbooks and other learning materials do not reflect male domination. Learning materials in mathematics should feature women mathematicians who could form role models for girls. Also the learning materials should be made more accessible and user friendly to the females. Moreover certain seats for specialized mathematics courses could be reserved for females. Thus as Downes (1997) suggests "we should develop a situation where girls will feel that they are included in mathematics rather than being excluded from it. We need what is an inclusive rather than an exclusive mathematics".

Another important aspect to be looked at is changing people's attitude towards mathematics. The negative attitude towards mathematics among people could be attributed to their misconceptions about the nature of mathematics, ignorance about its usefulness and relevance and bad publicity. According to the TIMSS study referred to earlier the percentage of students in South Africa who felt that it was important to do well in mathematics and science was only 87% which was lower than the corresponding percentages in achieving countries like Japan (97%) and Korea (98%). This could be one of the reasons for the under-achievement by our learners. Shaw and Shaw (1997) also claim that there is a link between students' performance and their attitude towards mathematics. They

suggest that curriculum designers should design mathematics courses which could improve students' attitudes to the subject as well as to improve their performance in the examinations. Mathematics curriculum should be relevant to the learners and should relate to their environment. Even though every citizen in a country needs mathematics knowledge to a certain level, he/ she does not need all different aspects of mathematical knowledge. The curriculum should cater for the various needs of the different groups of population. Everybody should be given the elementary mathematics. Those who want to specialize in mathematics should be given the opportunity to study the advanced mathematics. Those who want to specialize in the subject will develop positive attitude towards the subject.

As for suggestions to the peculiar problems in South Africa, I support Mogambery's (1997) suggestion of supporting the Mathematics Development Programme (MDP) initiative. AMESA views the MDP as a National Foundation to inspire, develop and coordinate mathematical activity for the overall development of our country, enabling it to compete on an equal footing with the more successful nations of the world. AMESA further suggests that MDP should give attention to issues such as increasing public awareness, teacher and learner development, resource development, education development and research developments in mathematics and mathematics education. All of the above issues are very crucial for the development of mathematics in this country.

I want to conclude this section by looking at the importance of teacher development programmes for effective learner development. It should be generally accepted that to teach mathematics efficiently, like all other subjects, teachers must have sound knowledge in the subject and they should possess an explicit conceptual understanding of the principles and meaning underlying mathematical topics, rules and definitions. Taylor (1999) and Webb (1999) as quoted in Glover and King (2000) highlighted the importance of teachers' subject knowledge and skills. This implies that there is a relationship between the quality of teachers' knowledge of mathematics and quality of lessons in

classroom. In South Africa, where a considerable percentage of the mathematics teachers are either unqualified or under-qualified, there is an urgent need for in-service training to upgrade the qualifications of mathematics teachers. I feel that the main problem experienced by teachers in implementing the new methodology of teaching is their lack of competency in mathematical knowledge.

Together with the in-service training for teachers to improve their mathematical knowledge, incentives should be given to teachers to attract more qualified and committed mathematics people in to the teaching service. It is very difficult to get mathematics graduates to join teaching profession as they can get more attractive jobs with attractive remuneration in industries. In order to attract more qualified people into the teaching service, the government should try to make the teaching profession more attractive by offering more incentives like better conditions of service and better salary. From my experience in Nigeria in the 1970's, I recall the science and maths teachers' allowance given to teachers of those subjects. The science and maths teachers' allowance and some other incentives to people willing to work in the rural areas may help reduce the shortage of teachers in these areas where it is difficult to get qualified teachers.

In order to have enough mathematics and science teachers, Nigerian universities introduced some mathematics and science degree courses like B. Sc (Education) in which some education modules were also part of the course. These graduates had to remain in teaching profession as they were not in high demand in industries like their counter parts who did pure mathematics and science courses in their degree courses. The initiative of Rhodes University to introduce similar programmes, as mentioned earlier, should be encouraged. Other universities in the country should be encouraged to follow the example of Rhodes University. Another strategy worth considering in reducing the shortages of teachers especially in mathematics and science subjects is to introduce compulsory national community service for one year by all fresh graduates from tertiary institutions. Majority of these graduates could render their services in schools

and thus the shortage of teachers can be addressed to a certain extent. The government of Nigeria introduced this programme in the 1970s and it worked well during the period of my stay in that country from 1976 to 1987. Kahn (5 March, 2000) also suggested the introduction of this programme in which all science graduates should be required to spend a year teaching before they are awarded their degrees.

Redirecting teachers with other subject specialization into maths and science subjects could also help in reducing the shortage of teachers in these subjects. During the 90s the colleges of education trained large numbers of teachers in subjects like Biblical Studies, History and Xhosa to mention a few. Many of these teachers are still unemployed. It will be a good idea to offer these teachers some specialized training in priority subjects like mathematics, science and technology. Technology is one of the new learning areas introduced in the new curriculum. Most of the schools do not have teachers for technology. Retraining the unemployed qualified teachers in these priority subjects could alleviate the problem of shortages of teachers in these subjects. It may also reduce the unemployment in the country. It would be a better alternative to importing teachers from overseas to teach subjects like mathematics and science. The government should speed up the process of employing subject experts in district offices where these posts are vacant. The government should also devise mechanisms to make sure that these experts monitor the teaching of the subject in the classrooms and support those teachers who really need assistance.

As part of the learner development programme, more and more learners should be encouraged to learn mathematics. It can be done by developing suitable programmes to make the subject attractive to learners at all levels. Possibility of developing and running enrichment programmes in mathematics for students in all levels should also be looked into. Organizing mathematical competitions and providing support for students who participate in such competitions, especially at international levels may also make more students interested in mathematics. Also special incentives should be offered to students to continue with mathematics

courses at tertiary levels. Government and other organizations should become more serious in this regard by introducing more bursaries and scholarships. The government should also focus its attention on addressing the shortage of relevant learning support materials in schools.

Finally I want to suggest opening some special science schools where learners could specialize in science and mathematics. In the Kano State of Nigeria three special science schools were opened in 1977 (Adamu 1991 as quoted in Bergh, 1996: 469). These Special Science Schools offered a curriculum with special emphasis in mathematics and the sciences for academically bright students selected from the primary schools in the state. A few other states like the Plateau State where I worked from 1979 to 1987 also converted some secondary schools to special science schools. Those schools were able to produce a good number of students for science and mathematics related courses in tertiary institutions in those states. Establishing some special science schools in South Africa, perhaps, could alleviate the problem of decreasing number of students for maths and science related courses at the tertiary level.

## 10. CONCLUSION

In this literature review I tried to unravel the concept of 'mathematics for all'. It was followed by a brief discussion on what mathematics is, together with the reasons for teaching mathematics. The goals of mathematics education were briefly discussed. The present situation of mathematics at international and South African levels was also briefly discussed. Then the reasons for the unpopularity of mathematics among students were also briefly looked at. Towards the end of the paper some suggestions to improve the mathematics education in South Africa is made.

Having seen what mathematics is and the reasons for having it in the curriculum, I want to take you back to the earlier questions: Who should be included in 'All' and what type of mathematics should be taught to 'All'? Considering the

utilitarian and intrinsic values of mathematics and from the moral perspective, I am of the opinion that 'All' should be all inclusive i.e. every citizen of the country should be given the opportunity to learn mathematics. However the type of mathematics to be taught to different sections of the population should be according to their need of the subject. Ordinary citizens need the elementary mathematics or what we call the 'social arithmetic'. What they need is the basic mathematics for simple calculations in handling money, space and time and to interpret and analyze information to cope with their every day needs. Those in 'high level' professions like engineering, architecture, management and businesses need the complex or abstract mathematics. As there is no single citizen who does not use a little bit of mathematics every day, knowingly or unknowingly, I am of the opinion that the concept of mathematics for all is already a reality. But that is not enough. We should have an informed citizenry where every citizen is empowered with the mathematical competence.

In the present South Africa, a lot of efforts are used for the promotion of mathematics education. They are not enough. Our vision should be 'mathematics for all' which will realize the concept of 'mathematics by all'. As people involved in mathematics education, all of us should strive to improve the standard of mathematics education in our country to place it among the leading nations of the world in the field of science and technology. That will be possible by increasing the public awareness of mathematics through popularization efforts and designing a mathematics curriculum which meets the needs of everybody to attract everybody towards mathematics through an effective teaching and learning strategy. All parties involved in mathematics education, the government, NGOs, teachers, parents and even the learners have to be seriously involved in this endeavour. Then only will the vision of 'Mathematics for All' be accomplished.

# LIST OF REFERENCES

Association for Mathematics Education for South Africa. Curriculum Committee. (1997). *Memorandum on issues relating to the implementation of Curriculum 2005.* Johannesburg: AMESA.

Bergh, A.M. (1996). Curriculum reform and reconstruction in Africa and Latin America. In E.I. Dekker and E. M. Lemmer. (Eds.), *Critical issues in modern education.* Johannesburg: Heinemann.

Bishop, A.J. (1988). *Mathematical enculturation.* Dordrecht: Kluwer.

Brombacher, A. (2000). Guest editorial and president's message. Johannesburg: AMESA.

Burton, L. (1986). Women in mathematics – herstory. In L. Burton (Ed.), *Girls into maths can go.* London: Holt Rinehart & Winston.

CASME. (7th October 2001). Mission statement, http://www.und.ac.za/und./casme/mission.htm.

Cheung, K. C. (1988). Outcomes of schooling: Mathematics achievement and attitudes towards mathematics learning in Hong Kong. *Educational Studies in Mathematics, 19*, 209- 219.

Damerow, P., Nebres, B., Dunkley, M. and Werry, B. (1986). *Theme group I: Mathematics for all.* In Carss, M. (Ed.), Proceedings of the 5th International Congress on Mathematical Education. Boston: Birkhauser.

Dekker, E. I and E. M. Lemmer, E. M. (1996). (Eds.), *Critical issues in modern education.* Johannesburg: Heinemann.

Downes, S. (1997). Women mathematicians Male mathematics: A history of contradiction. *Mathematics in School, 26* (3), 26 – 27.

Engelbrecht, S.W. H. (1997). *Preface to TIMSS report: Grade 12 mathematics and science literacy*. Pretoria: HSRC.

Ernest, P. (1996). Popularization: myths, massmedia and modernism. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick and C. Laborde (Eds.), *International handbook of mathematics education (pp 785-817)*. Dordrecht: Kluwer Publishers.

Eves, H. (1953). *An introduction to the history of mathematics*. New York : Holt.

Fitzsimons,G.E., Jungwirth, H., Maab, J and Schloeglmann, W. (1996). Adults and mathematics (Adult numeracy). In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick and C. Laborde (Eds.), *International handbook of mathematics education (pp 755-780)*. Dordrecht: Kluwer Publishers.

Gal, I. (1993). *Issues and challenges in adult numeracy*. Philadelphia: National Centre on Adult Literacy.

Galbraith, P.L., Carss, M. C., Grice, R.D., Endean, L. and Wary, M.C. (1992). Towards numeracy for the third millennium: A study of the future of mathematics and mathematics education. *Educational Studies in Mathematics, 23*, 569-593.

Gheverghese, J. G. (1994). The policies of antiracist/ multicultural mathematics: Common perspectives. *European Education*, 26 (1), 67 - 74.

Glover, H and King, L. (2000). *An analysis of the algebraic misconceptions held by a group of Eastern Cape intermediate phase teachers*. Proceedings of the 8th

Annual Conference of the Southern African Association for Research in Mathematics and Science Education (pp 152 – 157), Port Elizabeth.

Goldstein, C., Mnisi, P. and Rodwell, P. (1999). Changing teaching in a changing society. In B. Jawarski., Terrywood and S. Dawson. (Eds.), *Mathematics teacher education: Critical international perspectives.* London: Falmer Press.

Heard, J. and Pretorius, C. (2000, 2 April). Government to unveil five year plan to solve education crisis. *Sunday Times*, p. 19.

Howie, S. J. (Ed.). (1998). Mathematics and science performance in the middle school years in the Eastern Cape province of South Africa: The performance of students in Eastern Cape province in the Third International Mathematics and Science Study. Pretoria: Human Sciences Research Council.

Howie, S.J. and Hughes, C. (1998). Mathematics and science literacy of final-year school students in South Africa: A report on the performance of south African students in the Third International Mathematics and Science Study. Pretoria: HSRC.

Jacobsen, E. (1996). International cooperation in mathematics education. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick and C. Laborde (Eds.), *International handbook of mathematics education (pp 1235-1256).* Dordrecht: Kluwer Publishers.

Kahn, M., Volmink, J. & Kibi, M. (1995). A proposed comprehensive solution to the cycle of mediocrity in science and mathematics education. *South African Journal of Science*, *91*, 421.

Kahn, M. (2000, 5 March). SA's number will be up if we do not master maths and science. *Sunday Times*, p.21.

Kuiper, J. (2000). New thinking on maths, science and technology. *Reconstruct*, p.7.

Lerman,S. (1990). *Changing focus in mathematics education in cultural perspective on the mathematics classroom*. Dordrecht: Kluwer.

Lewis, C. (2000 October). Provincialisation of education: A review (January – June 2000). *Edusource Data News, 30*, 4 - 6.

Mogambery, M. (1997). *Mathematics development programme should be a national priority*. Johannesburg: AMESA.

Moodley, M. (1992). Teaching/learning mathematics: What counts? In M. Moodley, R.A. Njisane and N.C. Presmeg (Eds.), *Mathematics education for in-service and pre-service teachers*. Pietermaritzburg: Shooter & Shuter.

Naidoo, P. and Lewin, K.M. (1998). Policy and planning of physical science education in South Africa: Myths and realities. *Journal of Research in Science Teaching*, 35 (7), 729-744.

Niss, M. (1996). Goals of mathematics education. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick and C. Laborde (Eds.), *International handbook of mathematics education (pp 1- 45)*. Dordrecht: Kluwer Publishers.

Olivier, A. (2000). *Participate in national mathematics week*! Johannesburg: AMESA.

Paling, D. (1982). *Teaching mathematics in primary schools*. Oxford: Oxford University Press.

Pimm, D. (1987). *Speaking mathematically: Communication in the mathematics classroom*. London: Routledge.

Pretorius, C. (2001, 5 August). Maths and science: What's the solution? *Sunday Times*, p.19.

RADMASTE. (7 October 2001). Mission statements, http:// www.wits.ac.za.

Rhodes University. (2001). Scientific Rhodes opens up for Eastern Cape. *RHODOS*, 13 (12), 1.

Rogan, J. M. and Gray, B. V. (1999). Science education as South Africa's Trojan horse. *Journal of Research in Science Teaching, 36* (4), 373 – 385.

RUMEP. (7 October 2001). Mission statements, http://www.ru.ac.za.

Shaw, C.T. and Shaw, V. F. (1997). Attitude of first-year engineering students to mathematics : A case study. *International Journal of Mathematical Education in Science and Technology, 28* (2), 289 – 302.

Science, Mathematics and Technology Education. (2000). *Annual review*. Port Elizabeth: University of Port Elizabeth.

South Africa (Republic). Department of Education and Training. (1990). *Primary teachers' diploma (senior primary) syllabus for mathematics (Group II subjects: 1990 structure)*. Pretoria: Government Printer.

South Africa (Republic). Department of Education and Culture. (1991). *Core syllabus for mathematics ordinary grade: Standards 5 – 7*. Pretoria: Government Printer.

South Africa (Republic). Department of Education. (1995). *The SYSTEM Initiative: Turning disadvantage into advantage: Pilot projects*. A proposal for consideration by the Heads of Education Department Committee (HEDCOM), submitted by the Task Team on Science, Mathematics and Technology of the Centre for Education Policy Development. Pretoria: Government Printer.

South Africa (Republic). Department of Arts, Culture, Science and Technology. (1996). *White paper on science and technology*. Pretoria: Government Printer.

South Africa (Republic). Department of Education. (1997). *Senior phase policy document*. Pretoria: Government Printer.

South Africa (Republic). (1999/ 2000). *South Africa survey 1999/2000*. Johannesburg: South African Institute of Race Relations.

South Africa (Republic). (2000). *The General Education and Training Certificate (GETC), Discussion document for public comment*. Pretoria: Government Printer.

South Africa (Republic). Department of Education. (2001). *National Strategy for Mathematics, Science and Technology Education in General and Further Education and Training*. Pretoria: Government Printer.

Steen, L.A. (1990a). Numeracy: The new literacy for a data drenched society. Educational Leadership, *57* (2), 8 – 13.

Steen, L.A. (1990b). Mathematics for all Americans. In T.J. Cooney and C.R. Hirsch (Eds.), *Teaching and learning mathematics in the 1990s*. Virginia: National Council of Teachers of Mathematics.

UFH to run matric workshops. (2001, 16 November). *Daily Dispatch*, p.7.

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

Walkerdine, V. (1988). *The mastery reason.* London: Routledge.

Webb, P. (2000). *Science, mathematics and technology education.* First quarterly report, January 2000 – March 2000. A report on the activities of the Department of Science, Mathematics and Technology Education. Port Elizabeth: University of Port Elizabeth.

Wilder, L. (1973). Evolution of mathematical concepts. In C. Zaslavsky. *Africa counts: Number and patterns in African culture.* New York: Lawrence Hill Books.

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

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