IMPLEMENTATION OF OUTCOMES-BASED MATHEMATICS TEACHER EDUCATION SYLLABUS IN TWO COLLEGES OF EDUCATION IN SOUTHERN PROVINCE, ZAMBIA

BY

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A dissertation submitted to the University of Zambia in partial fulfilment of the requirements for the award of the degree of Master of Education in Mathematics Education

The University of Zambia

Lusaka

2019

DECLARATION

I, **Arthur Mungalu,** do hereby solemnly declare that this dissertation represents my own work, except where otherwise acknowledged, and that it has never been previously submitted for a degree at the University of Zambia or any other university.

Signed: _____ Date: _____

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APPROVAL

This dissertation of …… is hereby approved as fulfilling the requirements for the degree of Master of Education in Mathematics Education by the University of Zambia.

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ABSTRACT

Since the Outcomes-Based Mathematics Teacher Education Syllabus (OBMTES) was introduced at Junior Secondary Teachers' Diploma (JSTD) level in 2016 not much is known regarding how it is being implemented, a scenario which would make it problematic to attribute continued poor competence in mathematics to implementation of poor ideas, or to the inability to implement good ideas in case of Outcomes-Based Education (OBE). Conversely, it would equally be difficult to associate improvement in mathematics results to a well-implemented innovation, or to some extraneous factors. This study sought to assess the implementation of the OBMTES in colleges of education in Southern Province of Zambia. The study employed a qualitative approach and used a case study design to address the purpose of the study. Situated within the diffusion of innovation theoretical lens, the study sought to address the following objectives: determine mathematics lecturers' understanding of the OBE, establish lecturers' practices in mathematics classrooms in view of OBE and to explore the views of trainee teachers on lecturers' practices. From a population of 24 lecturers and 120 students, four lecturers and 40 students were selected purposively by looking at the years of service at college level. Interviews were employed to establish mathematics lecturers' views and understanding of OBE while lesson observations, document analysis and focus group discussions (with trainee teachers) were used to establish lecturers' practices. All data collected was analysed qualitatively by generating themes in line with the objectives of the study. The findings indicated that lecturers were not adequately capacity built in paradigm shift - OBE. Their knowledge of OBE was based on reading curriculum documents such as the curriculum framework, 2013 and the syllabus. This meant that the initiation phase of the diffusion process of the OBMTES was not conducted as required. Beyond that, lecturers exhibited peripheral knowledge of OBE; their comments on OBE were not backed by an understanding of OBE premises and principles. This meant that lecturers' practices would not be rooted in the OBE premises and principles – the basis for implementation of OBE. Moreover, there was lack of alignment between policy and practice – there were little shared meanings between lecturers' views on OBE and their practices. Lecturers consistently used teacher centred approaches to teaching with traces of learner centred methods. Assessment *for* learning was a missing element in assessment practices while limited assessment procedures were applied. Furthermore, it was established that inadequate capacity building, limited time and resources impeded the successful implementation of the OBMTES. The study recommends that sufficient time and resources must be allocated towards building capacity among educators regarding curriculum change in order to build understanding. Additionally, educators who attend capacity building workshops on curriculum change must draft and complete a multiplier effect proposal upon which certification would be done. Moreover, lecturers should model lessons that are learner centred in order to show how learner centred methods of teaching may be used to teach particular concepts in real time. Further research should be conducted in all study areas in general to ascertain the level of implementation of OBE.

Keywords: Outcome, Outcomes-Based Education, curriculum implementation, classroom practice.

DEDICATION

This dissertation is dedicated to the Lord God Almighty for granting me the opportunity to take up this course. Furthermore, I thank Him for granting me good health and for giving me the wisdom to sell through the course.

ACKNOWLEDGEMENTS

I would like to express my heartfelt appreciation and gratitude to Dr. Ndhlovu, Z., my supervisor, for his guidance, encouragement, wisdom and thoughtful criticism throughout this academic journey. I stumbled more often than never along this academic journey but he demonstrated tolerance and with a parental heart you brought me back on track. I may not have lived up to his expected academic standards, but I feel I am a better person academically due to this encounter with him. I would also like to thank the lecturers in the department of Mathematics and Science Education, where my supervisor is a member, for the tireless effort they put in to ensure that I am well grounded in research. The lectures' comments and criticisms rendered during the seminar hours contributed immensely to my success.

In a special way I wish to express my profuse gratitude to the board and management of Charles Lwanga College of Education for sponsoring me throughout the whole program. Without their financial and spiritual support, I would have had divided attention between searching for school fees, providing for my family and focussing on my academic needs. As such, their support impacted positively on my success.

To my kind, caring and loving wife, Melody, who supported me financially, spiritually and morally during this journey, I am indebted. You endured the pain of missing me and having to look after the children for most of the two years when I was out to school for my studies.

To my children Beene, Muleya and Simon, I wish to thank you for enduring life without me even when you needed me most. I sincerely thank you for your understanding and knowing that I have you as my children gave me the impetus to work even harder.

My gratitude would be incomplete without acknowledging the input of the lecturers from the two colleges of education and the student teachers who chose to take part in the study. Without them choosing to participate in this study, this milestone wouldn't have been achieved. I wish, too, to extend my sincere gratitude to the Provincial Education Officer (P.E.O), the District Education Board Secretaries (DEBS) for the districts where

the study was situated, and indeed the management of the two colleges where the study was conducted for granting me permission to conduct the study in the two colleges.

I am indebted to my friend Fumbani Mpande for his encouragement during the whole program. Sincere appreciation also accrue to my classmates for their invaluable insights and critique that shaped me as a researcher.

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ABBREVIATIONS AND ACRONYMS

CDC	Curriculum Development Centre
CPD	Continuing Professional Development
ECE	Early Childhood Education
ECZ	Examinations Council of Zambia
JSSTTC	Junior Secondary School Teacher Training Colleges
MESVTEE	Ministry of Education, Science, Vocational Training and Early Education.
MOE	Ministry of Education
MOGE	Ministry of General Education
NAS	National Assessment Survey
OBA	Outcomes-Based Assessment
OBE	Outcomes-Based Education
OBMTEC	Outcomes-Based Mathematics Teacher Education Curriculum
OBMTES	Outcomes-Based Mathematics Teacher Education Syllabus
OBT	Outcomes-Based Teaching
OBTL	Outcomes-Based Teaching and Learning
PEO	Provincial Education Officer
PTD	Primary Teachers' Diploma
STD	Secondary Teachers' Diploma
UNZAREC	University of Zambia Research Ethics Committee

OPERATIONAL DEFINITIONS

Curriculum implementation	Refers to the planning for and actual use of the OBMTES.
Outcomes-Based Education	Is conceived as a teaching and learning approach which focuses on producing a mathematics teacher who can teach mathematics using authentic contexts.
Outcome	Refers to the ability of the mathematics lecturer to teach using authentic contexts.
Classroom Practice	Refers to planning, teaching and assessment.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter provides the background to the study, statement of the problem, purpose of the study, research objectives, research questions and the significance of the study. Additionally, the limitations of the study, delimitation of the study, theoretical framework, conceptual framework, operational definitions and ethical considerations are presented.

1.2 Background to the study

Teachers are important resources in any educational system world over (Manchinshi, 2013). This is because they facilitate learner's acquisition of desirable knowledge, skills, values and attitudes. Central to raising student achievement in mathematics is improving the quality of mathematics teaching. The issues in mathematics education in Zambia according to Nakawa (2010, 2012) and Nonaka (2013) have indicated that students have very low performance due to teachers' low competence and their limited views on mathematics lessons. Students who receive high-quality instruction experience greater and more persistent achievement gains than their peers who receive lower-quality instruction (Rivkin, Hanushek, & Kain, 2005). To put it differently, teachers are critical determinants of student learning and educational progress and thus must be well trained to use effective teaching practices. The way teachers communicate mathematical knowledge in mathematics classrooms could either promote critical thinking or inhibit learners' thinking which impacts significantly on learners' transfer of learning and consequently, their achievement in mathematics.

For example, the poor results recorded in mathematics over the years in Zambia have been attributed, among other things, to the quality of teaching and learning in mathematics classrooms. The grade 8 and 9 survey conducted by the Examination Council of Zambia (ECZ, 2013), for example, revealed training gaps in teachers in terms of content where teachers performed almost as good as their learners in mathematics. These training gaps could account for the poor performance of learners in the subject as

revealed by the National Assessment reports (NAS, 1999-2012). Arising from the analysis of the survey results, a very weak linkage between the teacher education curriculum and the school curriculum was also observed which was believed to have had a negative impact on the quality of teachers churned out from colleges of education into the schools. It goes without saying, therefore, that any attempt to improve the quality of learning must factor in the need to improve teacher education programs. In line with this, MOE (1996, p. 107) suggested that "the quality and effectiveness of an education system depends heavily on the quality of its teachers…" It was further argued that the quality of teachers was greatly determined by the teacher education regimen that prospective teachers go through. The policy document on education saw the need to focus on the quality of teacher education in order to enhance the quality of teaching and learning in schools.

This is why the Ministry of Education, Science, Vocational Training and Early Education (MESVTEE) did not only revise the school curriculum, but also revised the teacher education curriculum in 2013 and rolled out the revised curriculum for Junior Secondary School Teacher Training Colleges (JSSTTC) in 2016. Notable among the innovations was the paradigm shift from Objective Based Education to Outcomes-Based Education (OBE). It was envisaged that teacher educators would change their practices by designing activities that were outcomes based to engage learners in the lessons by employing learner centered methodologies (MESVTEE, 2013).

It was necessary to establish mathematics lecturers' understanding of the OBE mathematics education syllabus and how they had changed their practices to incorporate OBE premises and principles in their teaching. This was so because the curriculum intent may not always be put into practice by the implementers due to various reasons. In view of this, Waxman (2001) stated that the discrepancy between what a curriculum proposal means to its designers and what it means to the teachers who are being asked to use it was a common and continuing problem in curriculum implementation. Munby (1984) further opined that the teacher sees the curriculum developer's intentions through his or her own perspective so that the viewpoint of the curriculum developer about the nature of learning as well as aims may not be shared by the teacher and are thus

interpreted differently or may not even be reflected in the teacher's practices. What Waxman (2001) and Muuby (1984) suggested was that the implementation of a curriculum largely depends on the implementers' understanding of the innovation; it was not a guarantee that the curriculum intent would be put into practice as it was. The implementers (teachers) adapt the curriculum to suit their feelings, opinions and school environment which might lead to deviation from the expected norm. Principally, without focusing on lecturers' practices as they educate teachers under the OBE paradigm, it would be problematic to ascertain whether the teachers who were churned into the schools really understand teaching and learning under the new paradigm-OBE.

1.3 Statement of the problem

The Outcomes-Based Mathematics Teacher Education Syllabus (OBMTES) was rolled out at Junior Secondary Teachers' Diploma (JSTD) level in the year 2016. From the given background, the problem that was identified was the poor performance of learners in mathematics at all the levels of education which, among other reasons, necessitated the revision of the curriculum from objective based to an Outcomes-Based Curriculum. Beyond that, it was not known whether mathematics lecturers understood the concept of OBE in relation to classroom practice and whether the OBE premises and principles were being applied in mathematics classrooms in order to produce mathematics teachers who were able to teach in an outcomes-based way. Olivier (2002, p.ii) posited that "the success of outcomes-based learning depends on how well it is understood". This implies that understanding of an innovation is critical for successful implementation, meaning that lack of understanding could lead to unsuccessful implementation of the innovation. Without empirical evidence on the implementation of the Outcomes-Based Mathematics Teacher Education Syllabus (OBMTES), it would be problematic to attribute continued failure in mathematics to implementing poor ideas, or to the inability to implement good ideas in the case of OBE. Conversely, it would equally be difficult to associate improvement in mathematics results to a well-implemented innovation, or to some extraneous factors.

1.4 Purpose of the study

The purpose of this study was to assess the implementation of the Outcomes-Based Mathematics Teacher Education Syllabus (OBMTES) in colleges of education granting Junior Secondary Teachers' Diploma (JSTD).

1.5 Study Objectives

The objectives of this study were to:

i. determine mathematics lecturers' understanding of the OBE
ii. establish mathematics lecturers' practices in mathematics classrooms in view of OBE
iii. explore the views of trainee teachers on lecturers' practices.

1.6 Research questions

The study sought to answer the following questions:

i. How do lecturers of mathematics education understand the OBE?
ii. What are the lecturers' practices in mathematics classrooms in view of OBE?
iii. What are the views of trainee teachers on the lecturers' practices?

1.7 Significance of the study

Policy makers in the Ministry of General Education (MOGE) might benefit from the results of the study through insightful information on the status of the implementation of the revised teacher education curriculum. This information might inform future policy implementation in the ministry. Furthermore, the study might inform teachers as well as teacher educators regarding the suitable classroom practices in view of OBE. Moreover, the study may add to literature on OBE in the Zambian context and serve as reference material; it could also be a basis for future research.

1.8 Delimitation

The study was conducted in Southern Province of Zambia in two Colleges of Education; one private and the other government.

1.9 Theoretical framework

The study was underpinned by the diffusion of innovation theory propounded by Rogers (1992). He conceptualized diffusion as a process when new ideas or technology considered relevant by Person A for improvement purposes in a situated context was introduced to Person B. This means that there was always someone who coins or initiates an idea which is later on passed on to another person who must put the idea into practice. The diffusion of innovation theory asserts that there were three broad phases in a diffusion process namely: Initiation, Implementation, and Continuation (Bentley, 2010; Berman & McLaughlin, 1976). The Initiation phase, the first part of a diffusion process, includes all decision making processes, planning for implementation and seeking resources about ideas for new innovations that seem relevant for making differences in societies' practices (Johnson, 1989). Rogers (1995) stresses that initiating change involves short and long term planning and management which, according to Fullan (2007), entail such tasks as needs analysis, lobbying for support, drafting implementation plans, and organising capacity building.

The second phase of the diffusion process was the Implementation phase. Lane (1997) postulated that the term implementation may have two meanings: Policy intentions on one hand and policy results on the other. This study encompasses both - what policy requires and how lecturers, not only understand policy intentions but also have applied them. Thus, implementation concerns initial experiences of attempting to translate policy intentions into practice (Stoller, 2009).

Fullan (2007) argued that "implementation" was evident in the first three years of an innovation project. He adds that during this period, teachers will adapt and modify practices according to their interpretations of the innovation. This time frame was relevant to this study. This is because the initial implementation of the Outcomes-Based Curriculum at JSTD level was in 2016 and this study followed in 2018, two years after the official launch. This phase is critical as many issues are likely to emerge- potential recipients of change may either embrace or reject the innovation during the implementation phase of the diffusion process. In view of this, Stoller (2009) opined that

teachers and change managers should see problems occurring here as learning opportunities rather than as obstacles.

The final phase of the diffusion process was the continuation phase which focuses on the need to sustain innovations for longevity purposes (Rodgers, 1995). For example, incorporating curriculum innovations into teachers' long term practices. This involves institutionalising curricula as part of integral teaching programmes. Prior decisions and activities made in phases one and two will impact on stage three as they are interactively linked. Two possible results may occur here, adoption or rejection (as phase 2). Teachers' choices of curriculum change are said to be influenced by their beliefs, attitudes, and understandings which make up their world views (Borg, 2006). Additionally, teachers could create their own interpretations of the innovation in view of their experiences and knowledge (Carless, 2004). Consequently, the innovation may change into a "weakened" (or strengthened) version of the original (Stoller, 2009, p. 81).

By and large, the diffusion theory suited the study as it related well with the purpose of the study: Assessing the implementation of the Outcomes-Based Mathematics Teacher Education Syllabus. The implementation phase, in particular was relevant to the study as it relates to how the lecturers understood and implemented the OBMTES.

1.10 Conceptual framework

A conceptual framework is a structure which the researcher believes can best explain the natural progression of the phenomenon to be studied (Camp, 2001). Implicit, it is the researcher's explanation of how the research problem would be explored. It is arranged in a logical structure to help provide a picture or visual display of how ideas in a study relate to one another (Grant & Osanloo, 2014). The framework makes it easier for the researcher to easily specify and define the concepts within the problem of the study (Luse, Mennecke & Townsend, 2012). Miles and Huberman (1994, p.18) opined that conceptual frameworks can be 'graphical or in a narrative form showing the key variables or constructs to be studied and the presumed relationships between them.' Figure 1.1 presents the conceptual framework for the study. The framework is built around the OBMTES implementation determinants. It further identifies a number of determinants that are likely to promote or hinder the implementation of OBMTES.

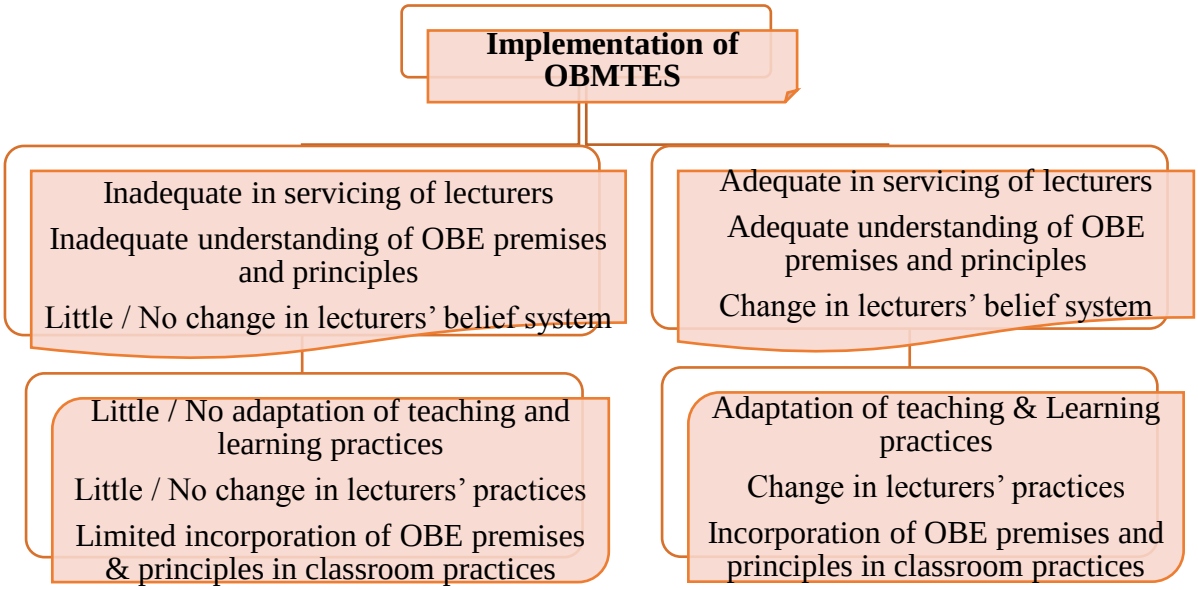

Figure 1.1: Conceptual framework for implementation of OBMTES

Fisher (2007) explained that a good conceptual framework must also be expressed in writing for it to be understood clearly. This means that after a researcher has craftily produced a diagrammatic representation of the main variables of the study, s/he has to explain the relations among them and how their complementation helps in answering the major research problem defined. The framework above shows that understanding of OBMTES is critical for its successful implementation. This underscores the importance of lecturers' in servicing during the initiation phase of OBMTES in order for lecturers to appreciate the necessity of the change and what the change entails for classroom practice. It was necessary for mathematics lecturers to understand the revised syllabus in order for them to change their belief system about teaching and learning hence changing their practices. Without a vivid understanding of the revised syllabus, lecturers' belief system about teaching and learning may not change. This, in turn would perpetuate old classroom practices that are devoid of OBE tenets.

1.11 Ethical Considerations

It was important for the researcher to address ethical issues as they relate to different phases of inquiry: prior to conducting the study; at the beginning of the study; during

data collection and analysis; and in reporting, sharing and sorting of data (Creswell, 2013, p. 232). As such, prior to conducting this study, the researcher submitted the research proposal to the University of Zambia Research Ethics Committee (UNZAREC) for clearance. In view of the same, ethical clearance was granted by UNZAREC. At the beginning of the study, consent was sought from PEO-Southern province, the DEBS for the respective districts where the study was conducted and college management. Beyond that, informed consent was sought from all participants by way of signing consent forms and participants were not asked to write their names to guarantee anonymity. Participants were informed that the research was purely for academic purposes during data collection and that no names of individuals would be used in the study. Apart from that, analysis of data as well as reporting was done in as honest a manner as was reasonably possible by reporting both positive and negative findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter presents a review of scholarly work related to the focus of the study: Implementation of OBE by lecturers of mathematics education. To do this, a critical analysis of educational change will be presented. Moreover, an analysis of the concept of OBE will be presented in order to enhance understanding of it. The definition of the concept, theories associated with it, the premises and principles that underpin it as well as a critique of the concept of OBE will be attempted. Beyond that, the chapter will delve into a synopsis of OBE from the Zambian context. Moreover, the concept of curriculum will be presented and together with the theory that guided the study. Above all, a review of studies on OBE will be done after which the justification for the present study will be made by identifying the gap in literature.

2.2 Innovation seen as educational change

This study focused on innovation but situates the term in the broad topic of education change. Therefore, innovation and change are used interchangeably here. According to the literature, change is inevitable in the twenty first century (Stoller, 2009). Some writers use either "reform" or "innovation" to refer to change (Datnow, Hubbard, & Mehan, 2002; Fullan, 2007). Educational changes are context specific and they can be initiated either internally or externally. The former is instigated by members within social systems whilst the latter is recommended by change personnel outside social systems. For instance, the former could be at school level and the latter as part of the global education reform agenda. Innovations as educational change are deliberate acts aimed to change both goals and practices in education systems (McInerney, Van Etten & Dowson, 2007; Rizvi & Lingard, 2010). Educational change here encompasses reform, improvement, professional development, management, and innovation (Towndrow, Silver, & Albright, 2010). Whenever change occurs in the field of education, policies are developed to guide practice in line with the envisaged change.

Some examples of policies and reforms in education that were developed in Zambia since independence include, but not limited to:

- The Education Act of 1966 which was meant to overhaul the whole system in order to meet the aspirations of an independent African country;
- Introduction of the Zambia Primary Course (ZPC) in 1966 whose focus was to develop competences in students that would enable them teach all primary grades - Grades 1 to 7.
- The educational reform of 1977 which brought further changes in the education system such as Primary School and part of the Junior Secondary School Education (Forms 1 and 2) became Basic School Education while the Senior Secondary Education and part of the Junior Secondary School Education (Form 3) became High School Education;
- Educating Our Future of 1996 which is still binding today (MESVTEE, 2013).

2.3 Diffusion of innovation theory

According to Rogers (1995), diffusion refers to a process when new ideas are introduced by the developers to the people to use or implement those ideas. Diffusion involves various inter-related activities such as decision making and systemic preparation before any new idea is being adopted or rejected by individuals or social systems. The diffusion of innovation theory - or diffusion theory - studies processes of change (Rogers, 1995). This theory asserts that there are three broad phases in a diffusion process (Bentley, 2010; Berman & McLaughlin, 1976). These are: Initiation, Implementation, and Continuation. All stages have different activities which are interactive. These activities include decision making choices, support and putting into practice the required necessities for intending recipients of change.

2.3.1 The Initiation phase

The Initiation phase is the first part of a diffusion process. In education, change can come externally from global influences, or internally from education ministries within countries. This phase includes all decision making processes, planning for

implementation and seeking resources about ideas for new innovations that seem relevant for making differences in societies' practices (Johnson, 1989).

According to the Markee (2001), decision making at policy level involves four areas: (a) decisions about curriculum planning and policy statements, (b) learning aims and means of achieving them, (c) project implementation including materials, resources development, and teacher training, and (d) classroom implementation which refers to teachers' and learners' actions. Most innovations could thrive or fail because of what is done at this stage. Without assembling resources and planning for implementation, innovations may not be actualised. As such, change managers need to take account of pragmatic considerations as they plan and make decisions because these concern time and resources incorporated into curriculum innovation projects.

Rogers (1995) stressed that initiating change involves short and long term planning and management. These entail multiple - tasks, including decisions for proceeding with change in society (Fullan, 2007). Others are: needs analysis, lobbying for support, drafting implementation plans, and organising capacity building. Without building capacity in the implementers, it would be difficult for them to appreciate why the change occurred, what has changed, and the implications of that change on their practices. This is so because not everyone takes part in the development of the innovations.

2.3.2 The Implementation phase

Rogers (1995) described the Implementation phase as the second stage in the diffusion process. The term implementation may have two meanings according to policy perspectives (Lane, 1997). One shows policy intentions and the other implies policy results. For instance, this study encompasses both - what policy requires and how teachers' understand policy intentions and have applied them. Thus, implementation concerns initial experiences of attempting to translate policy intentions into practice (Stoller, 2009).

Fullan (2007) was of the view that "implementation" is evident in the first three years of an innovation project. During this period teachers will adapt and modify practices according to their interpretations of the innovation. This time frame was relevant to this

study because the initial classroom implementation of the Outcomes-Based Education curriculum at STD level was in 2016 and this study followed in 2018, two years after the official launch (MESVTEE, 2013). It is during this crucial phase that issues are likely to arise - potential recipients of change may either embrace or reject the innovation during the implementation phase of the diffusion process. Consequently, Stoller (2009) suggested that teachers and change managers should see problems occurring here as learning opportunities rather than as obstacles.

Some scholars observed that during implementation, recipients of change make surface decisions to adopt innovations without deep reflections about consequences (Cohen & Hill, 2001; Datnow & Stringfield, 2000). Likewise, evidence shows that schools accepted change without realising their full impact (Hatch, 2000). Fullan (2007) argued that accepting change was often due to the influence of lobbying rather than rational thinking. Hence, implementation of a diffusion process may be complex and has consequences for the continuation.

2.3.3 The Continuation phase

Rogers (1995) identified the continuation phase as focusing on the need to sustain innovations for longevity purposes. For example, incorporating curriculum innovations into teachers' long term practices. This involves institutionalising curricula as part of integral teaching programmes. Prior decisions and activities made in phases one and two will impact on stage three as they are interactively linked. Two possible results may occur here, adoption or rejection (as phase 2). Teachers' choices of curriculum change are said to be influenced by their beliefs, attitudes, and understandings which make up their world views (Borg, 2006). Additionally, teachers could create their own interpretations of the innovation in view of their experiences and knowledge (Carless, 2004). Consequently, the innovation may change into a "weakened" (or strengthened) version of the original (Stoller, 2009, p. 81).

2.4 Outcomes-Based Education

Outcomes-Based Education (OBE) has its roots on competency based education which was introduced in the North America during the 1960s in response to educational critics

that voiced the concern of students not being equipped with the necessary competencies while they were in school (Butler, 2004). In other words, the students were graduating from school without the necessary skills needed in the labour market. OBE does not have any single historical legacy. Some trace its roots to behavioural psychology associated with B.F. Skinner; others to mastery learning as espoused by Benjamin Bloom; some associate OBE with the curriculum objectives of Ralph Tyler; yet another claim is that OBE derives from the competency education models associated with vocational education in the UK (Mahomed, 1996).

2.4.1 Outcomes-Based Education defined

William Spardy is deemed to be the leading advocate of OBE and he defined **outcomes** as *clear learning results that we want students to demonstrate at the end of significant learning experiences* (Spardy, 1994, p. 13). He further suggested that outcomes are not values, beliefs, attitudes, or psychological states of mind, but *what learners can actually do with what they know* and have learned. In other words, outcomes are actions and performances that embody and reflect learners' competence in applying content, information, ideas, and tools successfully in novel situations. These learning results that we want students to demonstrate at the end of a learning experience are at the centre of Outcomes-Based Education. Thus, Spardy (1994, p.12) opined that OBE means clearly focussing and organising everything in an educational system around "what is essential for all students to be able to do successfully at the end of their learning experiences". This means starting with a clear picture of what is important for students to be able to do, then organising the curriculum, instruction and assessment to make sure this learning ultimately happens. In his definition, Spardy suggests that the beginning point of learning is not inputs but outputs; the outputs determine the inputs. Simply put, the design of any curriculum, in his view, should start with the identification of the envisaged outcomes then designing the curriculum in such a way that those end results should be achieved. According to Killen (2000), OBE has three types of outcomes: traditional, transitional, and transformational.

- **Traditional OBE** operates within the existing curricula and school system, explicating content and application in terms of outcomes. While teachers may

appear to be more focused, two aspects appear to be problematic: the first is the neglect of the graduate as a total person; in other words, the main concern of this approach is on students' success in school; secondly, the culminating demonstration in traditional OBE is limited to small fragmented segments of instruction (Spady, 1994, p. 7).

- **Transitional OBE** lies between traditional and transformational OBE in terms of scope and purpose. It moves away from the current or existing curricula, cutting across traditional subjects to identify outcomes that reflect higher order competencies. Emphasis is placed on critical thinking, effective communication and technological applications. Concern for students' culminating capabilities at graduation time is strong (Spady, 1994, pp. 8-9).
- **Transformational OBE** is future-orientated, requiring the creation of a whole new system focusing on performance capabilities of young people and their ability to be functional and competent in a multitude of real situations. Therefore, a metamorphosis is required in curriculum and strategic planning, resource allocation and outcomes. The sole purpose of transformational OBE is the students' success after they leave school (Spady, 1994, pp. 10-11). Transformational OBE arises from a sense that the existing educational system and syllabus impedes the development of a new society and fails to meet the needs of learners.

2.4.2 OBE premises

A premise could be a set of assumptions on which something is based or anchored. OBE is based on the following three key assumptions or premises

- All students can learn and succeed, but not on the same day, in the same way.
- Successful learning promotes even inure successful learning.
- Schools control the conditions that directly affect successful school learning. (Spardy, 1994, p. 20).

The first premise explicitly takes differences in students' learning rates and learning styles into account not as barriers to successful learning, but as factors that must be

designed into any sound instructional process. It is a very optimistic view of the learning potential of all students. This principle acknowledges that all learners have inert potential which the teacher or educator needs to evoke during the learning process. The implication of this premise for classroom practice is that educational planning must take into account the myriad needs of learners so that each learner's needs may be taken into account with a view to help them to reach their full potential. Bloom (1976) suggested that every child, given sufficient time and proper assistance, can be expected to learn. In the same vain, Carroll (1963) explained that differences in student scores on aptitude and intelligence tests are measures of time required for different students to learn the same material – not, as previously believed, measures of students' innate capabilities to learn. The point here is that all students can and will learn given sufficient time and proper assistance.

The second premise stresses that successful learning rests on students having a strong cognitive and psychological foundation of prior learning success. The stronger schools can help make both foundations, the easier it will be for students to continue learning successfully. For classroom practice, this means that mathematics educators should ensure that learners' pre-requisite knowledge is adequate for them to comprehend the next concepts in the syllabus. Mathematics educators could assess this prior knowledge before introducing a new concept so that learners' readiness to handle the new concept may be determined.

Finally, those who implement OBE believe they are capable of changing how they operate to allow and encourage all students to be successful learners. Schools can function differently than in the past if educators and others who work with them choose to implement needed changes. This entails that the school environment should be conducive for enhancing learners' success by providing the needed resources such as the library, reference books and teaching resources. Spardy further opined that these three premises serve as the rationale on which the actual implementation of OBE - guided by its four principles described on pages 15 and 16 - ultimately rests.

2.4.3 Principles of OBE

In order to operationalise the three premises of OBE, Spardy identified four principles which guide action as: Clarity of Focus, Expanded Opportunity, High Expectations, and Design Down (Spardy, 1994).

- *Clarity of focus:* This principle entails that the focus or centre of any educational program or activity should be learner success; a clear view of the learning outcomes provides lecturers with a clear picture of the learning they wish to demonstrate. In this sense, the envisaged learning outcome becomes the turning point for planning, teaching and evaluation
- *Design Down:* This principle entails that curriculum design should begin with envisaged learning outcomes to determine what is to be learnt and how it is to be learnt. Furthermore, designing back encompasses planning, teaching, and assessment decisions to be considered by teachers. These teaching and learning activities all have to align with the intended learning outcomes identified in principle one.
- *Expanded opportunities:* Since the first principle of OBE acknowledges that 'all students can learn and succeed, but not on the same day, in the same way', it is necessary to provide opportunities for all learners to achieve. Implicit, more opportunities and learner support should be provided for successful learning to take place. To achieve this, Spardy (1994) posited that, among other things, teachers must use a variety of teaching and learning methods, assessment methods as well as engaging learners in learning activities and access to resources. According to Killen (2000) expanded opportunities involve teachers accommodating different teaching strategies to enhance students' learning irrespective of cognitive abilities. This principle appeals to teachers' knowledge of instructional strategies for purposes of lesson delivery. Some examples include: problem solving methods, student-centred lessons, whole class teaching, integrated teaching, research and exploratory learning. Killen (2000) acknowledged that working in a systemic structure with time constraint is

challenging, but emphasized that teachers need adapt to the students' needs, rather than students adapting to teachers and institutions.

- *High Expectations:* This principle entails raising the levels of expectations which learners are exposed to. As the teacher and the learner work towards the achieving outcomes, the expected standard of performance is increased in order to allow learners to aim higher. According to Spady (1994), high expectation refers to motivation from both teacher and students. It involves teachers setting high standards of performance in order to motivate students to be co-learners in the learning process (Killen, 2000). Evidence from an OBE context in Queensland, Australia showed that when students engage deeply with their classroom learning successful learning is promoted (Queensland School Reform Longitudinal Study, 1999). When this happens, students' confidence develops and gives them experiences to accept further challenges**.**

The principles and premises of OBE were critical for the study as they form the basis for the implementation of the OBMTES. The study sought to assess the incorporation of these premises and principles in mathematics lecturers' practices. A thorough understanding of OBE premises and principles by mathematics lecturers was equally checked. Arising from the aforementioned premises and principles, it is evident that OBE can be viewed not only as a theory of learning, but also as a systemic structure as well as an instructional strategy.

2.4.4 Principles of OBE in the Zambian context

The revised mathematics teacher education syllabus was premised on Spady's version of OBE whose implementation was based on the following principles: *clarity of focus, reflective designing, setting of high expectations for all learners and appropriate opportunities*. Reflective designing is what Spady calls design down while appropriate opportunities refers to expanded opportunities in Spardy's model.

- **Clarity of focus**

  This means that everything that the teacher and teacher-educator do must be focused on what learners want to know, understand and be able to do successfully. When teachers and teacher-educators plan and teach, they should

focus on helping learners acquire the necessary knowledge, skills and dispositions that will enable them achieve the desired outcomes.

- **Reflective designing**

  The starting points for all curriculum design are clearly defined learning experiences that learners are to achieve during the programmes. Therefore, all instructional decisions should be made by **tracing back from the desired end result** and identifying the `building blocks' that will be required to achieve that end. This entails that there should be direct and explicit links between planning, teaching, assessment decisions and the outcomes that learners should achieve.

- **Setting high expectations for all learners**

  Teachers and teacher-educators must establish challenging standards of performance for all learners to encourage them engage in successful learning. When learners experience success, it reinforces their learning, builds their confidence and encourages them to accept further learning challenges.

- **Appropriate opportunities**

  Intellectual ability is something expected of all learners. It is not a preserve of a few learners. Therefore, teachers and teacher-educators must provide expanded opportunities for all learners including those with Special Educational Needs. This principle is based on the understanding that not all learners can learn the same thing in the same way and at the same pace in spite of the fact that they all have to complete a specific level in a stipulated time. (MESVTEE, 2013).

2.4.5 OBE as a theory of learning

Outcomes-Based Education encompasses and affiliates with certain assumptions about learning, teaching, and the systemic structures within which teaching and learning occur. Similar to the other teaching and learning models, it defines interactions of learners as being pivotal for meaning creation in social environments (Creswell, 2007). Assumptions about who should be active during the lesson, what and how to learn characterize OBE. Furthermore, Killen (2000) described OBE as a collaborative approach in an education system that needs administrators, teachers, and students to aim for "desired results of change" (p. 2), whereby outcomes of students' learning are

expressed individually against a set of criteria. As such, OBE as a theory of learning may be used as a basis for planning curriculum. For example, the Zambian revised curriculum is said to be Outcomes-Based.

This perspective of OBE (as a theory of learning) was critical for the study as it formed the basis for anticipated lecturers' practices in mathematics classrooms. Theories of learning inform lecturers' belief system about teaching and learning which, by and large, influence their decisions about teaching and learning activities.

2.4.6 OBE as a systemic structure

According to Spady (1994), a genuine OBE system requires holistic changes to the whole system. The systemic structure of society is complex with multiple layers and functions (Markee, 1997). Moreover, Killen (2000) argued that for OBE to be successful there should be alignment of systemic structure, and the classroom practice with the theory. This ensures that the argument for quality of education be judged from three perspectives: the inputs into the system, the actual events within the system, and the outputs from the system. These three categories provide a frame for describing education quality, rather than perceiving education quality through only one lens (Spady, 1994).

The study focused, among other things, on classroom practice which was expected to be aligned to the systemic structure and the theory of learning. The actual events within the OBE system would only be understood by observing lessons conducted by the lecturers of mathematics.

2.4.7 OBE as an instructional strategy

Other than simply being used as a theory of learning and a systematic structure, OBE, it is believed, can be used as an instructional strategy for classroom practices (Killen, 2000). The emphasis is on teachers having a clear picture of what is important for learners' education, and then developing curriculum instruction, and assessment to make sure that learning does happen. OBE as an instructional strategy was adopted by the Ministry of Education, Science, Vocational Training and Early Education, moving away from the transmission mode of teaching (MESVTEE, 2013). That being the case, this perspective of OBE was relevant to the study as it spelt out the importance of focusing

on envisaged learning outcomes during lecturers' planning for teaching/learning activities as well as assessment procedures. Moreover, with the thrust towards use of learner centered approaches in the teaching process, OBE as an instructional strategy was key to the study; Lecturers' use of learner centered approaches was among the practices that the study sought to establish.

2.5 Outcomes-Based Education in Zambian context

Curriculum world over should be responsive to the needs of the society – It must address the critical needs of the society ranging from social – economic, political and labour market needs. Since knowledge, skills and technology advance rapidly, it is necessary to revise educational policy to suit the changes in society. It is for this reason that the Zambian government developed the curriculum framework, 2013 to provide a clear articulation of the direction the Zambian education ought to take in this modern world. Through a consultative and participatory approach, the Ministry revised the curriculum for education in the year 2013. Notable among the changes to the curriculum was the paradigm shift from objective based education to Outcomes-Based Education. This is contained in this statement:

> *Outcomes-Based Education (OBE) is an approach to learning that the Ministry of Education, Science, Vocational Training and Early Education has adopted, moving away from Behavioural Approach. The approach seeks to link education to real life experiences as it gives learners skills to access, criticize, analyse and practically apply knowledge. Learners are given practical experiences during the teaching and learning processes that help them gain life skills. In the recent years, there has been a concern that teaching was not responding to the needs of the society*. *Hence the focus on OBE* (MESVTEE, 2013, p. 16).

It may be deduced from the above statement that the Ministry of Education's view of OBE was that of it being an instructional strategy (an approach to learning) which aimed at linking teaching to real life. This meant that, for example in teacher education, trainee teachers would be given more opportunities to learn how to communicate mathematical knowledge to the understanding of learners other than simply knowing the content to be taught. thus, Outcomes-Based Teaching and Learning (OBTL) - signifies a paradigm

shift from the traditional teaching and learning approach which is teacher-centred and objectives-based, to a student-centred approach under which students are given more autonomy in determining their own learning trajectories and learning goals so that students' learning experiences can be more dynamic (McDaniel, Felder, Gordon, Hrutka, & Quinn, 2000). Table 2.1 shows the differences between objective-based teaching and Outcomes-Based Teaching (OBT).

Table 2.1: Comparison between objective based teaching and OBT.

Objectives-Based	**Outcomes-Based**
Purpose	
• Deliver/provide instruction • Transfer knowledge from lecturer to student • Achieve access for diverse students • Improve quality of instruction	• Produce learning • Elicit students' discovery and construction of knowledge • Achieve success for diverse students • Improve quality of learning
Criteria for success	
• Inputs, resources • Quality of enrolled students • Quantity and quality of resources	• Learning and students' success outcomes • Quality of exiting students • Quantity and quality of outcomes
Teaching and Learning structures	
• Time held constant, learning varies • End – of – course assessment • Classes start/end at the same time • Independent disciplines/departments	• Learning held constant, time varies • Pre/during/post assessments • Environment ready when student is • Cross discipline/department collaboration
Learning theory	
• Knowledge exists "out there" • Knowledge comes in "chunks" and "bits" delivered by instructors • Learning is teacher centred and controlled • "Live" teacher, "live" students required • The classroom and learning environment are individualistic	• Knowledge exists in each person's mind and is shaped by individual experience • Knowledge is constructed and created • Learning is student centred and controlled • "Active" learner required, but not "live" teacher • Learning environment and learning are cooperative, collaborative and supportive.

Adopted from Barr and Tagg (1995).

The above table could be better understood when viewed in this sequence: Learning theory – purpose – teaching and learning structures – criteria for success. The learning theory impacts the teacher's belief about teaching and learning. The teacher's belief about teaching and learning (Influenced by his/her held learning theory) has an effect on the purpose, whether teaching or learning which determines the structures for teaching and learning and consequently the criteria for success.

Barr & Tagg (1995) suggested that under the objective-based paradigm, the classroom and learning environment are individualistic. However, it is not absolutely true that learning under this paradigm was teacher centred and individualistic; rather, teachers in Zambia, for example have been using learner centred methods such as group work, field trips and discovery methods. The contention may be a matter of degree of use of learner centred methods compared to teacher centred methods. Moreover, pre/during/post instruction assessment is not peculiar to OBE as it has been used in mathematics classrooms prior to the advent of OBE.

2.5.1 Curriculum changes in the revised curriculum

The revision of the curriculum cut across all the levels of education, from Early Childhood Education (ECE) to Tertiary level. Some developments that came with the adoption of an OBE system were as follows: Linkage of the education system from ECE to tertiary level, the use of familiar Zambian languages as the official languages of instruction in the Pre-Schools and early Grades (Grades 1-4), introduction of two **Career Pathways - Academic and Vocational** in Junior Secondary School Education (JSSE) level as well as Senior Secondary School Education (SSSE) level and linking the Teacher Education curriculum with the then school curriculum in terms of content. The harmonisation of the school curriculum and the teacher education curriculum is in line with what the education reform (1977) envisaged as is evident in the quotation below:

> *The curriculum should concentrate on enabling trainee teachers to understand the objectives of the school curricula and the underlying principle of learning in the choice and use of teaching materials (MoE, 1977:67)*

However, knowledge of content to be taught in and of itself is necessary, but insufficient for enhancing teaching and learning in the classroom. The teacher should be equipped with knowledge of pedagogy in order to be able to communicate that knowledge to the understanding of the learners. In view of that, the policy document suggested that:

> *The teacher should communicate knowledge in a manner that helps children and young people to develop both the desire and ability to learn. The teacher should, therefore, have good command of the subjects he teaches and be resourceful in translating his knowledge into effective learning experiences for his/her students (MoE, 1977:61)*

What the Reforms were referring to could only be possible if the teacher had acquired the right knowledge and skills for the job of teaching in schools. This is why the revised curriculum specifies that in order to successfully implement the curriculum, teaching methodologies, assessment procedures, availability of physical resources and planning are cardinal.

2.5.2 Teaching methodologies in OBE

The ministry acknowledges that the curriculum development process should take a global view of the new trends, strategies and practices, and embrace indigenous heritage and thoughts that could fit in the local and national situations (MESVTEE, 2013, p. 56). Among the global trends that the curriculum embraced (besides OBE) is the social constructivist theory which, among others, influenced the choice of teaching methods and techniques. The following statement depicts the policy intent with regard to teaching methodologies:

> *It is important that teachers and teacher-educators use a variety of teaching methods and techniques in order to cater for the range of learning needs taking into account the available local resources. The teachers and teacher-educators should as much as possible, use methods that promote active learners' participation and interaction. In addition, they should use methods that encourage learners to reflect, think and do rather than reproduce from rote learning. In this regard, teachers and teacher-educators are strongly advised to*

use the Learner-Centred Approach (LCA) in the teaching and learning process (p. 56).

The use of a variety of teaching methods is a response to the OBE – *all students can learn and succeed but not on the same day or in the same way*.

The concept of learner centeredness also draws from the social constructivist view of learning which holds that learners construct their own meaning through interaction with materials, peers and knowledgeable others. Wertsch (1991) highlighted *that social interaction*, *cultural tools*, and *activity shape* individual development and learning. Cultural tools here mean language and other physical objects within the learning environment. As such, Chin (2007) stated that in the classroom "knowledge was constructed through language and other semiotic means" (p. 816).

2.5.2.1 The concept of Student Centred Learning (SCL)

Over the past century, strong educational movements to shift away from an emphasis on teaching to an emphasis on learning have occurred; this shift encourages the movement of power from the teacher to the student. This paradigm change was founded on the premise that students should be actively constructing their own meaning through interaction with materials, peers and knowledgeable others. The theoretical standing of SCL is primarily grounded in the constructivist view of learning (Landau, 2001, p. 22). Constructivist learning models require active input from students and require intellectual effort and aids retention. The role of the teacher in student-cantered learning is to facilitate the students' learning by providing a framework (i.e. activities for students to complete) that facilitates their learning. For example, the teacher posts activities or questions that students complete. Projects include: writing papers, essays and reports, publishing webpage, conducting research, answering open-ended questions, creating artwork and organizing events.

The term 'student-centred learning' is widely used in the educational literature. Many terms have been associated with SCL (flexible learning, active learning, experiential learning and self-directed learning (Burnard 1999; Taylor 2000). SCL also includes

direct instruction (When the teacher wishes to introduce and cement a new concept), hinting and collaboration.

In view of this study, it was necessary to address the concept of SCL as it was envisaged in the policy document that classroom teaching and learning under the OBE paradigm would be learner centred (MESVTEE, 2013). Illuminating this concept was indispensable since it was at the core of the study; learner centred teaching was one of the elements that was looked for in lecturers' practices, particularly in mathematics lessons.

2.5.3 Outcomes -Based Assessment

In education, the terms assessment, measurement, evaluation and testing mean very different things, yet they are often used interchangeably by different stakeholders (teachers, parents, schools, educational authorities and students).

Assessment is a broad term that includes measurement, evaluation and testing. It is defined as a process of gathering information for making decisions to facilitate teaching and learning (Kabilan, Khairani & Lian, 2012). Examples of assessment practices include tests, assignments, projects and portfolios.

Measurement refers to the process of assigning numbers to certain constructs or attributes. The number is usually called a score, which describes the degree to which a student is acquiring the attribute while *evaluation* is a process where a value judgment is made about a student's performance. It is the basis for the course of action that should be taken next. For instance, when a group of students scores higher than 90% on a calculus test, the students are considered to be exceptionally good at calculus. Thus, they may be encouraged to take part in a mathematics competition at the national level. They may also be assigned to help their friends improve. Figure 2.1 depicts the connections between the major concepts related to assessments that are briefly discussed above.

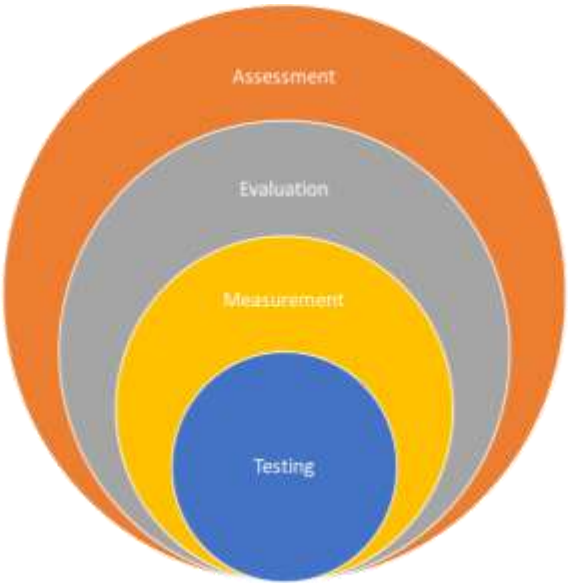

Figure 2.1: The connection between assessment, evaluation, measurement and testing

Educators should understand the links between these concepts for them to distinguish between them and to use them appropriately in the planning and delivering of their lessons.

Assessment is an important tool in the teaching and learning process and is used to determine whether teaching and learning have taken place or not. In fact, it is not possible to separate teaching and learning from assessment – they are inextricably bound together. Assessment may be formative – *assessment for/as learning* (On-going assessment that informs learning), Summative – *assessment of learning* (done at the end of a unit or topic to determine the level of understanding of the concepts) and Diagnostic – *assessment for learning* (used to find out what learners know, their difficulties and strengths with a view to inform teaching and learning). Thus, educators should strike a balance between the assessment *for, as* and *of* learning in their classrooms.

Since OBE is based on the assumption that all learners can learn and achieve, but not in the same way and at the same time, the policy prescribed that teachers and teacher-educators should employ varying types of assessments. This should not only be as a way of measuring the learners' strengths and weaknesses, but it should also help learners to get used to the assessment procedures and environment (MESVTEE, 2013, p. 57). The following assessment procedures are recommended:

- Standard-based projects and assignments that require learners to apply their knowledge skills, positive attitudes and values;
- Clearly defined rubrics (or criteria) to facilitate a fair and consistent assessment of learner's work and;
- Clearly defined performance targets at key stages of learning.

A scoring rubric can be defined as a scoring guide or scheme that consists of specific performance criteria or standards that assist teachers in assessing student work. There are two types of scoring rubric: holistic and analytic. In holistic scoring, a single grade is given to a student based on the overall judgment of his/her performance. In analytic scoring, a student's performance is scored separately for different parts or characteristics of the performance and then these partial scores are added to obtain a total score (Kabilan et al, 2012. P. 29). An example of a holistic scoring rubric is presented in Table 2.2.

Table 2.2: Sample holistic rubric

Score	Description
4	Makes accurate estimations. Uses appropriate mathematical operations with no mistakes. Draws logical conclusions supported by graph. Sound explanations of thinking.
3	Makes good estimations. Uses appropriate mathematical operations with few mistakes. Draws logical conclusions supported by graph. Good explanations of thinking.
2	Attempts estimations, although many are inaccurate. Uses inappropriate mathematical operations, but with no mistakes. Draws conclusions not supported by graph. Offers little explanation.
1	Makes inaccurate estimations. Uses inappropriate mathematical operations. Draws no conclusions related to graph. Offers no explanations of thinking.
0	No response/task not attempted.

Source: 'Designing Scoring Rubrics for Your Classroom' by Craig A. Mertler (2001), Practical Assessment, Research & Evaluation, 7(25). Available online: http://www.pareonline.net/getvn.asp?v=7&n=25

The area of assessment was very critical for this study because the implementation of OBE in the institution level would entail restructuring of relevant systems and procedures to constructively facilitate the attainment of the desired outcomes of education (Macayan, 2017). This includes the critical restructuring of assessment methods and procedures employed by educators and institutions in evaluating student performance, which serves as evidence of the attainment of outcomes. It was necessary to establish how lecturers of mathematics had changed their assessment practices to accommodate OBE premises and principles. Without a vivid consideration of OBA, the study would have been incomplete as teaching/ learning and assessment are inextricably linked together – a lesson is not taught until it is learnt. Conversely, assessment informs teaching and learning. The scoring rubric was necessary for the study as policy prescribed it as one of the instruments to be used in OBA.

2.6 Studies related to OBE

This section explores and reviews literature on the implementation of the Outcomes-based curriculum. The literature was purposely selected and reviewed based on its relevance to the main theme of the study – the implementation of the Outcomes-Based Mathematics Education syllabus. As such, the studies reviewed are not exhaustive considering how broad the subject of OBE and curriculum implementation is. A critical review of literature shows that not much has been done to assess the implementation of the Outcomes-Based Curriculum particularly in mathematics education at STD level since the OBE curriculum was launched (in 2013 at school, ECE, PTD level and in 2016 at STD level).

The closest study to the current study was done by Musonda in 2009, who reviewed the implementation of the Learner – Centered Approach in the teaching of mathematics at Nkrumah and Copperbelt Secondary Teachers Colleges. The qualitative study established that lecturers of mathematics were implementing LCT approach in their teaching. Findings of the study also indicate that the lecturers' methods of teaching can impact students' performance positively or negatively. Beyond that, it was found out that lecturers of mathematics still needed more training in LCT approach. The study was relevant to this study as it equally focused on use of learner centered approaches in

teaching mathematics in colleges of education, a concept which was investigated in this study. While the study was conducted in secondary teachers' colleges among mathematics lecturers, it targeted those lecturers who were trained in LCT approach during the VVOB project. The current study was conducted among lecturers of mathematics who may or may not have undergone any training by the CDC regarding OBE.

Mugaji (2014) assessed the implementation of mathematics curriculum in senior secondary schools in Kano state. Findings of study revealed that Mathematics curriculum contents in Senior Secondary Schools in Kano State were not fully implemented. In addition, it was discovered that some internal factors i.e. those inclusive aspects within the curriculum, and other external factors such as provision of teaching and learning facilities, Qualified Teachers were influential to effective implementation of Mathematics curriculum. This study was relevant to the current study as it focused on implementation of mathematics curriculum thus providing background information on the purpose of the study. However, the qualitative descriptive study did not only focus on curriculum contents, but was also conducted in secondary schools. The current study focused on the pedagogy aspect and was conducted in secondary teacher education colleges.

Another study by Ramoroka (2007) explored 'educators' understanding of the premises underpinning Outcomes-Based Education and its impact on classroom assessment practices' in Pretoria, South Africa and elicited data from observations, structured interviews and document review. The findings of the study revealed that educators still have little understanding of OBE premises and principles despite having undergone capacity building. They do not accommodate OBE premises and principles in their practices. Ramoroka's study was relevant to the current study as it focused on premises and principles underpinning OBE as they related to assessment practices. Thus, it provided some good footing in view of the concept of OBA. However, the study was conducted in primary schools and was not subject specific. The current study was conducted in colleges of education among lecturers of mathematics.

In his Masters study in 2000, Williamson did a comparative analysis of Outcomes-Based Education in Australia and South Africa. Findings were that Australia is a country found to be well resourced and politically and economically stable, with at least 10 years' experience in OBE. Furthermore, small classroom sizes, support structures and teacher aides have enhanced the implementation of OBE in Australia. However, the findings indicated that similar problems had emerged in Australia and South Africa regarding the structure of OBE, assessment and reporting and the extra workload associated with the implementation of OBE. This study was reviewed because it provided useful information on OBE and its implementation from countries that were among the pioneers in implementing OBE. Despite that, the study was conducted in schools and was done in countries which, then, had 10 years' experience in OBE. The current study was done in colleges of education within two years of implementation of the OBMTES.

Additionally, Gutema (2013) explored the Implementation of Outcomes Based Teaching and Learning at Misrak Technical-Vocational Education and Training College in Ethiopia. The survey findings revealed the level of teachers' and students' understanding of OBTL is very low. So, it is difficult to determine how the teachers accommodate premises and principles of OBTL in their class room practices. Furthermore, the issue of unsuccessful student's certification and competent on the basis of achieving intended exit graduate outcomes during the Occupational competency assessment resulted from different problems. As the study finding revealed, from Students/trainees themselves, Trainers/teachers, Materials, Managements, Industry, and Assessment need the attention. In addition to these, low understanding of OBTL and practices, Teaching and learning activities, delivery systems, effectiveness of teaching practice, aligned curriculum to students desired outcomes changing in short time, assessment task, lack of good leadership of the college, insufficient training facilities and availability of resource were the core problems for students success and implementation of OBTL. The study was relevant to the current study as it focussed on Outcomes-Based Teaching and Learning (OBTL) which was, among other things, the focus of the study. As such, it provided valuable information on OBTL. While the present study focussed on the teaching of mathematics, this study focused on technical and vocational subjects.

In his Doctoral thesis, Joskin (2013) investigated the implementation process of a curriculum in Papua New Guinea using a case study design. Using focus group discussions, structured interviews, participant observations, and document analysis, the study findings revealed that curriculum change was challenging as policy expectations failed to align with practices. There were little shared meanings between teachers' views and classroom practices; this lack of connection contradicted policy intentions. There also appeared to be no connection by policy makers of the inbuilt tensions inherent in the outcomes-based model of education adopted for PNG. This study was relevant to the current study as it focussed on implementation process of a curriculum. It provided information regarding general conduct of implementation of a curriculum. The study was conducted in secondary schools and focussed on the English curriculum. The present study focused on the Mathematics curriculum and was situated in colleges of education.

Finally, Vallente (2016) evaluated Outcomes-Based Education Integration in Home Economics Program of a State University in the northern part of the Philippines. Descriptive survey and qualitative design were deployed to gather, analyse, and interpret data, which were deemed significant to the study. These research methods involved questionnaires, interviews, observations, and document investigations. Results disclosed that there is little understanding of the new paradigm shift—OBE; there are limited instructional resources for the faculty; laboratory equipment were inadequate; and physical facilities available do not maximize the competencies required by OBE. While the study was critical by focussing on integration of OBE premises and principles in Home Economics, the present study focussed on integration of OBE premises and principles in mathematics lessons. The current study used a case study design to address the purpose of the study while the reviewed study used a descriptive survey.

The studies reviewed were mainly done outside the Zambian context. Moreover, the studies (except one which focused on mathematics curriculum content) did not focus on the pedagogy aspect, the gap that the current study hopes to contribute to. As such there is need to replicate such studies in the Zambian context to establish if same results will

be found. The study reviewed in the Zambian context did not specifically look at the paradigm shift – OBE.

2.7 Summary

The chapter has discussed innovation as educational change and has highlighted some of the educational policies and reforms that have taken place since independence. It has been noted that whenever new ideas are developed, there was need to pass them on to the people who are supposed to implement them. The process by which these new ideas are introduced by the developers to the people who are supposed to use them was said to be the diffusion process. The introduction of OBE as a paradigm shift from objective based teaching is presented as the key issue in the revised teacher education syllabus as well the whole education system. It was observed that the diffusion of the OBMTES had to pass through three phases: initiation, implementation and continuation. OBE was not only depicted as a theory of learning, but also as a systemic structure as well as an instructional strategy, the orientation which underpins the revised Teacher Education Curriculum other than alignment of topics to school syllabus. The chapter has also shown that the premises of OBE were the basis for its implementation. The conception of OBE has also been discussed from the Zambian context with the thrust towards enhancing learner centeredness. A review of studies related OBE has been presented and most of the studies were relevant in informing the study as they provided basic information on the implementation of OBE. There was scarcity of literature on OBE in the Zambian context especially focusing on Teacher education, a gap which the study sought to contribute to. The next chapter presents the research methodology that was used in the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This chapter discusses the research methodology that was used in the study. Methodology is important as it provides a sense of vision, in terms of what it is that the researcher wants to do in the research process (Strauss and Cobin, 1998). In this chapter, the researcher explains how a qualitative method of inquiry was selected as the methodology in the research study. Additionally, the research design for the study is explained and justified. Further, the chapter discusses the study population, study sample, sampling procedure, data collection procedure and instruments. Beyond that, methods of data analysis, limitations of the study and rigor are explained.

3.2 Research Approach and design

The study employed a qualitative approach to address the purpose of the study. *Qualitative research* is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem (Cresswell, 2014). The study sought to understand the meaning that lecturers ascribed to OBE and how they changed their practices to suit the paradigm shift – OBE. A case study design was used to generate data for analysis. Yin (2003) noted that case study research has been effectively used for decisions, programs, *implementation processes*, and organizational change. Since the focus of this study was to assess the implementation of a curriculum (Innovation), the use of a case study approach is justified. A case study method relates to perusal for understanding and meaning of an issue under contention. It is defined as examining a specific phenomenon such as an event, person, process, institution, or social group (Merriam, 1998). Furthermore, Yin defined case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident" (2009, p. 18).

Yin (1994) suggested that there are three different types of case studies. Depending on the type of research question, there are exploratory, descriptive, and explanatory case

studies. He explained that if the research is mainly focused on "what" questions, it may call for exploratory study. An explanatory case study deals with "how" or "why" questions. A descriptive case study focuses on covering the background information and accurate description of the case in question. This study was an explanatory case study because it attempted to establish *how* the OBMTES was being implemented in real life context.

3.2.1 Rationale for using case study

The case study approach suited the study because it addresses interpretive questions that seek to explore, explain, or portray in-depth descriptions of social phenomena (Stake, 1995). Furthermore, the approach allows the investigator who is the main instrument of data collection and analysis to observe events as they eventuate and to probe participants about those events (Merriam & Associates, 2002). In view of this, the study sought to understand and describe mathematics lecturers' practices in view of OBE. Because their practices were embedded in their college contexts. Moreover, a case study enables multiple data sources such as focus group discussions, interviews, direct observations, and analysis of written documents which need to be validated using triangulation (Merriam, 1998; Yin, 2009). These techniques were used for collecting data in this study. Put differently but meaning the same thing, Stake (2006) suggested that a case study approach allows for triangulation of findings from various data sources and processes to corroborate each other where the different data connect. Lastly, since only a single unit of analysis was considered (Mathematics Teacher Education Syllabus), a case study was deemed suitable for the study.

3.3 Study population

Study population is defined as the entire group of individuals or objects in which researchers are interested in generating the conclusions (Patton, 2002). Kombo and Tromp 2006) also explained that a population is the entire set of objects, events or group of people which is the object of research and about which the researcher intends to determine some characteristics. A total of two (2) government colleges and four (4) private colleges offering JSTD mathematics courses constituted the study population with twenty-four (24) lecturers of mathematics education being part of the study

population. Moreover, one hundred twenty (120) student teachers of mathematics education were part of the study population.

3.4 Study sample

A sample is a small proportion of the entire population selected for observation and analysis (Creswell, 2014). Bless and Achola (1988) also construed that a sample is a sub-set of the whole population which is actually investigated by a researcher and whose characteristics will be generalized to the entire population. From the population, 2 colleges (1 government & 1 private) were selected and 4 lecturers of mathematics education (2 per college) were included in the study sample. Additionally, 40 student teachers (10 from each of the four classes visited) were selected. The demographic details of the participants are presented below in order to highlight their characteristics. The following categories were mainly considered from the lecturers: work experience and professional qualifications while gender distribution and year of study were considered on the side of student teachers.

3.4.1 Demographics of students

This section presents the demographics of students who took part in the study. Two categories, gender distribution and year of study were identified as being vital for the study. Table 3.1 below shows the distribution of student teachers by gender.

Table 3.1: Frequency distribution of student teachers by gender.

Variable	**College**		**Total**
Gender	**C1**	**C2**	
Male	45	61	**106**
Female	21	32	**53**
Total	**66**	**93**	**159**

Source: Field data, 2018

As can be seen in the table above, college one (C1) had low enrolment levels than college two (C2) with a ratio of approximately 2:3. Worth noting too is the fact that both

colleges had relatively low enrolment for female students than male students where the number of male students was twice that of female students. In particular, the number of female student in the four classes visited totalled 53, accounting for 33% of the sampled students while male students were 106 altogether accounting for 67% of the sampled students. The percentage distribution of students by gender is shown in Figure 3.1 below.

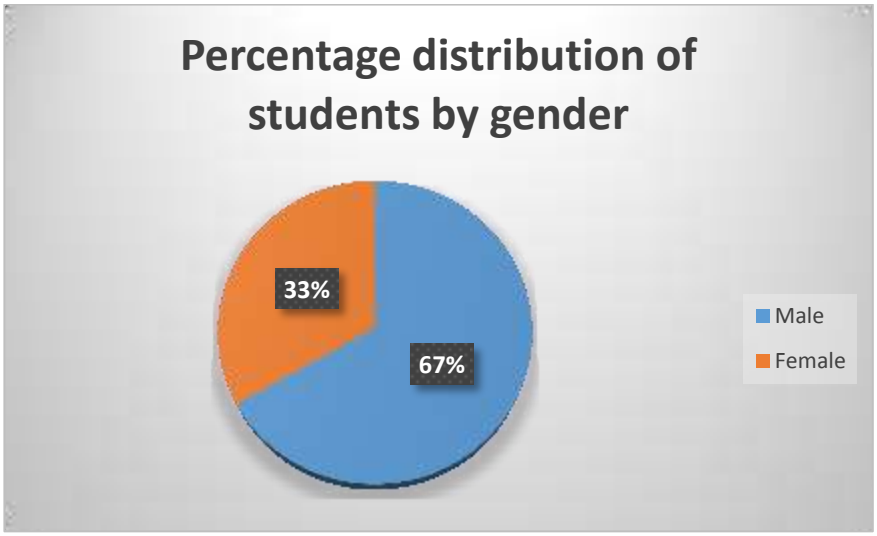

Figure 3.1: Percentage distribution of students by gender

Source: Field data, 2018

In terms of year of study, the classes visited comprised one first year class, one second year class and two third year classes. This was done in order to have a myriad of experiences from different groupings of students.

3.4.2 Demographics of lecturers

The lecturers who took part in the study were asked to indicate their gender, professional qualifications and years of experience in teaching at college level. The gender distribution of lecturers is shown in the Table 3.2.

Table 3.2: Gender distribution of participant lecturers

Variable	**College**		**Total**
Gender	**C1**	**C2**	
Male	1	2	**3**
Female	1	0	1
Total	**2**	**2**	4

Source: Field data 2018

The gender distribution of lecturers shows that only one out of the four lecturers identified herself as female. The female lecturer was from C1 while C2 had only male lecturers available as shown in Table 3.2 above. In a like manner, one lecturer had a masters degree while the rest had first degrees in mathematics as shown in Figure 3.2 below. Moreover, no lecturer was found to have a Doctor of Philosophy degree.

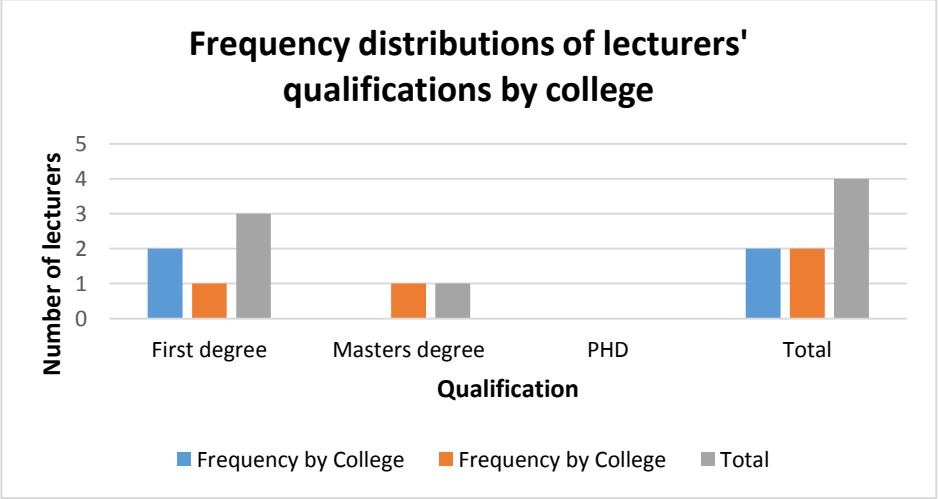

Figure 3.2: Frequency distributions of participant lecturers' qualifications by college.

Source: Field data, 2018

The above characteristics of lecturers suggests that all the sampled lecturers had the minimum qualification for them to teach diploma programs at their colleges.

Apart from the professional qualifications of lecturers, their years of experience in teaching at college level were established. This category of participant demographics was critical for the study as it helped the researcher to know whether the participants were already serving at their stations at the time the revised syllabus was rolled out in colleges. Table 3.3 below shows the qualifications of the lecturers who took part in the study.

Table 3.3: Categorization of lecturers by years of experience at college level.

Variable	**Frequency by College**		**Total**
Years of experience	**C1**	**C2**	
0 to 2 years	0	0	**0**
3 to 5 years	2	1	**3**
Above 5 years	0	1	**1**
Total	**2**	**2**	**4**

Source: Field data, 2018.

Among the sampled lecturers, no one had served two years and below while three lecturers indicated that they had served between 3 and 5 years. One lecturer served more than five years at college level as shown in Table 3.3 above. These statistics imply that all the sampled lecturers were already teaching at college level at the time the Outcomes-Based Curriculum was introduced.

3.5 Sampling techniques

Purposive sampling was used to select the two colleges where the study was conducted. To do this, consideration was given to how established an institution was in order to select colleges that potentially could give rich information. The number of years that the college had been offering the JSTD programs was one of the considerations given. In view of the aforesaid, Putton (2002, p. 230) suggested that "the power and logic of purposive sampling lies in selecting information-rich cases for study in depth". The lecturers' years in service constituted the selection criteria for lecturer participants. This

information was accessed from the Heads of Sections. Besides that, students were asked to volunteer to participate in the Focus Group Discussion (FDG).

3.6 Data collection instruments

Data for the study was collected using the following instruments: interview guide, observation schedule, document analysis guide and FGD guide. The interviews were semi – structured to allow the researcher to probe emerging issues during the interview and lesson observation. Three kinds of data collection are critical in generating data for case studies: in-depth, open-ended interviews, direct observations and written documents (Putton, 2002 & Creswell, 2014).

3.6.1 Interviews

Putton (1990, p. 278) stated that "the purpose of interviews is to find out what is in or on someone's mind…, people are interviewed in order to determine from them those things which cannot be directly observed". In this study, mathematics lecturers' understanding of OBE mathematics education syllabus was probed using the interviews to respond to objective one. Semi-structured interviews were used since some questions (those that guided the study) were planned prior to the interview while some questions were posed to probe the emerging issues from lesson observations and document review. Patton (1990) argued that people are interviewed in order to determine from them those things which cannot be directly observed as everything cannot be observed.

The interviews were conducted at the end of the lesson observation session (after observing three lessons for each lecturer). This was done in order to avoid pre – emptying some issues on OBE which, potentially, could have interfered on the lesson observation and document review data. Implicit, each lecturer was interviewed once during the whole data collection process. The interview included, among other things, questions on the lecturers' understanding of OBE as well as questions on the emerging issues from lesson observation and document review. A sample of the interview schedule is given in Appendix 5.

3.6.2 Lesson observation

Lesson observations were conducted to establish whether the mathematics lecturers' opinions on OBE were in tandem with their practices. Observations further enumerated data pertaining to lecturers' incorporation of OBE premises and principles in their practices (Planning, teaching and learning and assessment). Each lecturer was observed three times during the data collection process. Tuckman (1994, p.378) observed that "what should be observed is the event or phenomenon in action…". Furthermore, Burstein et al (1995) suggested classroom observation is the 'gold standard' for assessing curriculum implementation and pointed out that researchers must observe student-teacher interactions in order to measure some aspects of instruction. The assessment of the implementation of OBE cannot be effectively done without classroom observation.

The Incorporation of OBE principles and premises was the focus of lesson observation and was to be reflected in the following:

- Number of learners in a classroom
- Classroom setting
- The use of resources
- Classroom interaction (Lecturer-Student, Student-Lecture, Student-Student)
- Assessment strategies followed
- Learner participation

Based on these, an observation checklist was prepared and used during observation. (See Appendix 4 attached).

3.6.3 Document analysis

Literature describes document analysis as a systematic approach for reviewing or evaluating documents (Bowen, 2009). Documents can include both printed and electronic materials. Wellington (2000) defined data gathered from documents as secondary sources, while observations and interviews are primary sources. In this study

official records from documents used by the four observed Mathematics Education lecturers were analyzed to determine the extent of the OBE policy intentions in classroom practice. The lecturers' teaching files were requested for and the documents that were filed there such as schemes of work, lesson notes, records of work, assessment tools and mark schedules were reviewed. This was done concurrently with the lesson observation. The Document analysis guide is given in Appendix 7.

Prior (2003) opined that documents are useful in making visible the phenomena under study, but have to be used in conjunction with other factors occurring simultaneously. As such, one rationale for using documents was to help to validate data through triangulation (Yin, 2003). In this study, document review findings were triangulated with the three other sources (interviews, FGDs and observations) to check for consistency and or inconsistencies.

3.6.4 Focus Group Discussions

The purpose of focus group discussion was to establish the views of student teachers on lecturers' practices in view of OBE. Maykut & Morehouse (1994) argued that the purpose of focus groups is to bring several different perspectives into contact to understand what people experience and perceive about the focus of inquiry, through a process that is open and emergent' (p. 103). A focus group often consists of between 6 to 12 people (Patton, 1990). In this study, the researcher conducted a structured focus group discussion in both colleges (See Appendix 6). In each college, two FDGs were conducted bringing the total number of FDGs to four.

Each class that was observed had five male and five female students who voluntarily took part in the FDG. The FDG was conducted at the end of the lesson observation session. Data from the focus groups were coded into themes and triangulated against the other three data sources (interviews, observations, and document analysis).

3.7 Data collection procedure

As alluded to above, data was collected using in-depth semi structured interviews (to capture direct quotations about people's personal experiences), lesson observations (to obtain detailed and thick descriptions) and document analysis to allow for triangulation

of results (Patton, 2002). Apart from that, FGDs were done (to establish students' views on lecturers' practices). The FGDs with student teachers were conducted on the last day of lesson observations. This was done in order to allow for non-participant bias of student teachers during lesson observation. Interviews were conducted with lecturers after lesson observations so as to establish their understanding of OBE as well as to address the emerging issues from the lesson observation and document review. Apart from that, some questions in the interview schedule would have given clues to the lecturers as to what the researcher was looking for in the classroom had the interview been conducted prior to lesson observations and document analysis.

3.8 Limitations of the study

The limitations of this study were mainly inherent in the data collection procedures that were used. Lecturers may have stage managed their lessons to suit the purpose of the study. People do better when they know that they are being observed. To mitigate for the foreseen limitations, documents were analyzed for consistency in applying OBE premises and principles. Moreover, the number of mathematics lecturers in the colleges was limited thus making selection of participants to be limited. Most of all, the fact that lecturers were not adequately capacity built entailed that their practices in view of OBE had negative implications on the findings of the study since thorough understanding of OBE is critical for successful implementation.

3.9 Data analysis instruments and procedures

The process of qualitative data analysis includes (but is not limited to) data organisation, data description and data interpretation (Awoniyi et. al, 2011; Putton, 2002). The constant comparative data analysis approach was used. Data generated from the field was read carefully and coded (by assigning a word/statement to a category of data). The common codes were grouped into categories which led to themes identification.

3.10 Rigor

It is important for any research to guarantee trustworthiness of the results to the users of the generated results. To achieve this, triangulation of data sources was done in order to compare the findings from each data source for consistency. Furthermore, data was

subjected to expert review to examine evidence that justifies the themes (Creswell, 2012). Beyond that, data were subjected to member checking by availing the themes or specific descriptions to participants for verification of the accuracy of the descriptions.

3.11 Summary

The qualitative approach employed in this study helped to collect data from the two settings – College one and College two. Triangulation of research procedures (Interviews, lesson observation, document analysis and FGDs) enhanced the rigor of the research. The data sources supplemented each other. The next chapter presents the research findings.

CHAPTER 4

PRESENTATION OF FINDINGS

4.1 Overview

This chapter provides a presentation of findings based on the data collected through interviews, lesson observation, focus group discussion and document analysis. The data was collected from lecturers and student teachers. Presentation of data was done according to the research questions. A summary of the chapter is given at the end of the chapter. In this chapter, lect. 1 and lect. 2 refer to the lecturers sampled from college 1 (C1) while lect. 3 and lect. 4 refer to the lecturers sampled from college 2 (C2). Further, FG1, and FG2 represent focus group discussions with student teachers from C1 while FG3 and FG4 represent focus group discussions with student teachers from C2.

4.2. Findings

4.2.1. Teaching versus learning

The researcher sought to establish lecturers' understanding of an objective and an outcome. Where the lecturer was addressing the issue of difference, the corresponding code was assigned 'difference' as the issue. All codes with the issue 'difference' were compiled into a single table. A comparison of the codes allowed the researcher to form categories, which in turn formed a basis for identifying themes. The following theme was identified as being related to the difference between an objective and an outcome: *Teaching versus learning.*

The difference arising from the analysis of data was that an objective related to teaching in terms of what the teacher intended to teach and achieve while an outcome was the ability of learners to use and apply the acquired knowledge in real life situations. The theme which gave rise to this definition was *teaching versus learning*. The codes and categories related to this theme are shown in Table 4.1.

Table 4.1: Teaching versus learning theme: codes and categories

Codes	Category	Theme
What teachers hope to achieve *versus* what learners do with knowledge	Teacher intentions versus Application of acquired knowledge	Teaching versus Learning
Learners reciting facts versus application of knowledge		
Flexibility when teaching	Teaching versus learning	
Thriving on background information		

Examples of participant comments related to this theme are as follows:

> *An objective is what the teacher wants to teach in a lesson…what he or she wants to achieve within a planned lesson while an outcome reflects what learners should do with that knowledge* (Lect. 4, interview - May 2018).
>
> *An outcome has to do with the application of the acquired knowledge to solve problems in real life but an objective simply focuses on the learners being able to recite what the teacher taught them* (Lect. 1, interview - March 2018).
>
> *There is not much difference except that under Outcomes there is a bit of flexibility in that if the aim is not achieved there is room to implement other methods in order to achieve it* (Lect. 3, interview - May 2018)
>
> *I think objectives were more of behavioral where you have to give a stimulus and wait for the response but for the outcomes you thrive on the background information they (learners) have* (Lect. 2, interview - March 2018).

Overall, participants were of the view that objectives reflected teachers' intentions irrespective of whether learning took place or not while outcomes reflected what learners would actually do with the knowledge acquired. They believed that objectives were for teachers while outcomes were for students. Worth noting is the view by lecturer 2 who explained that objectives were rigid and aimed at coverage of content while outcomes were flexible and attuned towards promoting learning.

4.2.2 Promotion of learner centeredness and relevance for practice

Lecturers' views regarding what necessitated the paradigm shift to OBE were explored. This was necessary because for any change in belief system of lecturers to occur, there must be a sound understanding and appreciation of why the change was effected. From the analysis of interview data, two themes were identified: (i) Leaner centeredness (ii) relevance for practice. Table 4.2 shows the codes and categories for the two themes.

Table 4.2: Learner centeredness and relevance for practice themes: Codes and categories

Codes	Categories	Themes
To avoid teacher dominance To give learners opportunities to learn Learner centeredness	Role of teacher and learner	Learner centeredness
Matching teacher ed. Content with school content To harmonise syllabi Whether syllabus was Outcomes-Based or not	Content for syllabus	Relevance for practice

Promotion of learner centeredness

The first theme that emerged was that of promoting learner activity during mathematics lessons as opposed to teacher dominance. Participants believed that the OBMTES was introduced in order to redefine the role of the teacher and the learner in the classroom to that of facilitator and active participant respectively. The comments related to this theme are given below:

> *OBE was introduced to avoid selfishness from us teachers where we feel we are the source of knowledge…It is not us to learn but the learner so learners should be given opportunities* (Lect. 2, interview - March 2018).

> *I am aware of the part where it (Curriculum Framework, 2013) says that government has shifted from previous whatever it was to now Outcomes-Based which is more learner centred…But whether the syllabus that came out is outcomes-based that's another issue* (Lect. 3, interview - May 2018).

Worth noting is the feeling of doubt as to whether the syllabus that came out was Outcomes-Based expressed by lecturer 3 (*But whether the syllabus that came out is outcomes-based that's another issue*). This shows that he feels that whether or not the STD curriculum was Outcomes-Based was a subject of debate. This comment relates to the content of the syllabus leading to the second theme.

Relevance for practice

The second theme that emerged relates to relevance of syllabus content for practice. Lecturers were of the view that the OBMTES was introduced in order to ensure that the content for teacher education was in tandem with that of the school where the trainee teacher would eventually teach. The participants' comments are given below:

> *Under objective based paradigm there was a mismatch between what students learn and the world of work but under OBE, there is a match between what is learnt and the world of work whereby learners are able to apply what they learn in their work* (Lect. 1, interview - March 2018).

> *The curriculum was revised in order to bring harmony between what is taught at college and what students are actually going to teach…* (Lect. 4, interview - May 2018).

Overall, there are two broad ideas that were expressed as to why OBE was introduced. The first one suggests that the revised syllabus was introduced with a view to promote active learning as opposed to passive learning. The last thought deals with preparing student teachers to be able to teach mathematics effectively by interacting with the material that they would later be teaching.

4.2.3 Lecturers' knowledge of OBE premises

As alluded to in literature, Spardy (1994) specified three premises underlying OBE and suggested that they are the basis for implementation of OBE. It was therefore necessary to establish whether mathematics lecturers had knowledge of these premises and their classroom implications. Participants (Lecturers) were asked to state the premises of OBE in order to establish whether they had knowledge of the premises underpinning the revised curriculum.

Interview data revealed that participants had no knowledge of the premises underlying OBE. None of them could state the premises of OBE. The comments below are some examples of participants' responses:

> *Ummmm, I may not be very sure of those (Premises)… Is there another way of putting it?* (Lect. 2, interview - March 2018).

> *I beg your pardon…, oh I may not really be sure of what those are* (Lect. 3, interview - May 2018).

As a way of probing their understanding, the OBE premises were stated and the lecturers were asked to give the implication of each premise for classroom practice.

First premise: *All learners can learn and succeed, but not at the same time and pace*.

Lecturers generally subscribed to the assumption that all learners can succeed; a myriad of views were expressed by the participants regarding the first premise with the

following theme 'Variation in learning pace, style and ability' emerging. Table 4.3 shows the codes and categories that account for the themes identified.

Table 4.3: Variation of learning pace, style and ability theme: Codes & Categories

Codes	Categories	Theme
Learners don't learn at same pace Some learners are fast, others slow Learners learn differently We must use different methods to cater for all learners	Pace and style of learning	Variation of learning pace, style and ability
Students have different abilities Some students cannot achieve what others can do	Ability to learn	

Variation of learning pace, style and ability

As can be seen in the table above, analysis of participant responses showed that learners vary in terms of ability as well as how and when they learn. This theme was derived from two categories: ability to learn and pace and style of learning. Although participants agreed that all learners can learn, they did allude to the fact that learners vary a great deal in such dispositions as ability, pace and style of learning. Some examples of participant remarks are given below:

> *Quite alright all learners can learn but they differ a lot in terms of their abilities…some can handle tough material while others cannot* (Lect. 2, interview - March 2018).

> *Although all learners can achieve, the level of achievement is different from one learner to another* (Lect. 3, interview - May 2018).

Yes every student has the ability to learn but they don't have the same ability. For example the speed at which they grasp mathematical concepts is different… (Lect. 1, interview - March 2018).

We must use a variety of teaching methods because learners differ in the way they understand or learn; some learn well in groups, others want the lecturer to explain in detail and so on (Lect. 4, interview - May 2018).

Second premise: *Success breeds further success*

Lecturers generally subscribed to the notion that success thrived on prior knowledge. Analysis of interview data suggested that for a student to succeed, there must be a firm foundation of existing knowledge upon which the new concept would be built. Implicit, lecturers' understanding of the OBE premise '*success breeds further* success' was that Outcomes-Based Teaching and Learning (OBTL) as being dependant on learners' prior knowledge. The codes and categories for the theme 'Prior knowledge' are shown in table 4.4.

Table 4.4: Prior knowledge theme: Codes & categories

Codes	Categories	Theme
Success in task aids comprehension of next concept Mathematics concepts build on each other Basis for learning new concepts	Connection between concepts	Prior knowledge

The quotations below attest to that notion:

It is true that when a learner succeeds in one task, he or she may succeed in the next activity (Lect. 3, interview - May 2018).

Concepts in mathematics build on each other. So if the student is not well grounded in the lower level concept, it is not likely that he will understand the next concept (Lect. 1, interview - March 2018).

> *Success truly builds further success… for a student to grasp a concept in mathematics, they may need to apply what they learnt already in order to do well in the concept at hand – prior knowledge is the basis for learning new concepts in mathematics* (Lect. 2, interview - March 2018).

However, while recognising the importance of prior knowledge for learning novel concepts in mathematics, one lecturer believed that success in a given concept depended on the nature of the topic. The following statement represents the meaning:

> *Even if prior knowledge is important, learners' success also depends on the topic at hand whether problems are straight forward like* ***solve for this*** *or maybe problems are not given explicitly, like in word problems…some students may have the prior knowledge but fail to interpret problems that are not explicitly stated* (Lect. 4, interview - May 2018).

This view seems to suggest that despite having prior knowledge on a given topic, success may not be guaranteed due to the nature of the topic and the learners' thinking patterns.

Third premise: *Schools control conditions for success*

Lecturers were of the view that the school physical environment impacts success of learner. Analysis of interview data showed that *provision of necessary physical resources* was key to promoting learner success coupled with *monitoring* of lecturers' and students' activities. Table 4.5 shows the codes, categories and themes arising from the analysis of interview data. The theme that emerged was: *provision of physical resources*.

Table 4.5: Resources theme: Codes & categories

Codes	Categories	Themes
Need for facilities Availability of resources No meaningful learning without TLAs	Provision of resources	Resources

Lecturers indicated that factors within the school environment impacted on the learners' success. They believed that availability of physical infrastructure as well as teaching and learning materials was critical for success of learners. The comments below depict the meaning:

> *Schools should have necessary facilities such as laboratories and library and resources such as text books and mathematical instruments in order for effective teaching and learning to take place* (Lect. 2, interview - March 2018).

> *Without necessary teaching and learning aids, it is difficult to make learners understand concepts in mathematics hence hindering their success* (Lect. 4, interview - May 2018).

While acknowledging the importance of teaching and learning resources in enhancing meaningful teaching and learning, one lecturer suggested that monitoring of teaching and learning activities was a necessary ingredient as expressed in this remark:

> *For the school environment to promote success, management should monitor teaching and learning activities as well as students' prep. If teachers do not attend classes and learners just write notes, success may not be guaranteed* (Lect.3, interview - May 2018).

The lecturer here felt that management had a role to play in enhancing the success of learners by ensuring that teaching and learning activities are monitored for conformity to and adherence to policy. Worth noting is the sentiment by lecturer 1, who posited that other than the school environment, the home environment contributed towards the success of learners. This is expressed in the quote:

> *It is not only the school environment that matters for learners to succeed. The home environment also plays a major role because some learners stay in overcrowded boarding houses that are not conducive for studies…some parents may or may not help learners with assignments and learners may be involved in too much work to concentrate on school* (Lect. 1, interview - March 2018).

Here, lecturer one suggested that not all students are in boarding; some come from home while others live in boarding houses (rented rooms) away from their parents. This was a common practice in colleges where not all students were in boarding houses.

4.2.4 Inadequate capacity building

On the whole, lecturers indicated that their knowledge of OBE was based on reading curriculum documents such as the curriculum framework, 2013 and the revised syllabus while only one lecturer did attend a CPD meeting on OBE. This massage was best represented by the following comments:

> *The dissemination was not good…actually I am talking about having knowledge about OBE through reading the Curriculum framework, 2013 but I may be the only one…some colleagues were involved in the development of the syllabus* (Lect. 4, Interview - May 2018).
>
> *I knew about OBE through CPD at my secondary school where the person who attended a workshop on OBE shared to us what it is all about but from this place (College) there has been no workshop* (Lect. 2, interview - March 2018).

Some salient aspects of the dissemination of the revised syllabus include the fact that capacity building of lecturers was inadequate and that not all lecturers attended a workshop on curriculum dissemination. Of the three lecturers, only one had an opportunity to take part in a departmental Continuing Professional Development (CPD) workshop organized by the Head of Department who attended a workshop of OBE. This was a part time lecturer who was also teaching at a named secondary school.

4.3 Mathematics Lecturers' practices.

The implementation of the OBMTES could not have been examined without establishing mathematics lecturers' practices. These practices included (but not limited to) planning, teaching and assessment. To collect data in response to this research question, lesson observations and document analysis were conducted with a view to ascertain whether lecturers accommodated OBE premises and principles in their practices.

4.3.1. Planning

Lecturers' teaching documents such as schemes of work, lesson plans, lesson notes and records of work were checked to establish whether they accommodated OBE premises and principles. Analysis of the content of the documents revealed that schemes of work were prepared by all the lecturers that took part in the study. Among other things that were evident in the schemes of work are: content to be covered, general outcomes and specific outcomes. The methods of teaching were not indicated on the schemes of work.

Apart from schemes of work, lecturers prepared lesson notes which mainly showed the content of each lesson from start to end with examples and exercises embedded. The lesson notes were devoid of details such as lesson outcomes, teaching and learning aids and the duration of the lesson. Lesson notes were mainly extracted from the modules. When asked why he only prepared notes without key details such as specific outcomes, methods of teaching, teaching and learning materials, he had this to say:

> *Lesson notes are a guide during lesson presentation because they contain carefully selected examples that cover the content in depth. …for me that is what is important. The way we teach is such that we tell students the intended learning outcomes at the start of the lesson and we use different methods and strategies in a lesson even when they are not reflecting in the notes* (Lect. 3, interview – May 2018).

A sample of the lesson notes obtained from lecturer 3 is given in Appendix 8.

4.3.2 Teaching

Each lecturer was observed three times on different days and interviewed once at the end of the three lessons to, among other things, probe the lecturers on the emerging issues in the three lessons. The lesson observation mainly focussed on the following broad areas: lesson flow, interaction during the lesson, use of teaching and learning resources and forms of assessment used. Classroom one, two, three and four refer to classes for lecturer one, two, three and four respectively.

4.3.2.1 Revision, examples and demonstration by students

Generally, the classroom setting was the same in all the four classes visited where learners sat in rows and columns with the lecturer being in front nearer to the board. The lessons observed consistently showed a similar flow comprising revision of previous work, demonstration by teacher of the day's concept and student demonstration on chalk board. An example of the observations is given in Table 4.6.

Table 4.6. Description of lesson presentations observed in classroom one.

Lesson No.	**Introduction**	**Development**	**Conclusion**
1	Quiz: Revision of differentiation of Trigonometric functions	Delivery of new concept- Integration by parts. Demonstration by student and lecturer. .	Emphasis of key points: mastery of differentials and integrals of trigonometric and logarithmic functions; Prep work given for students to practice.
2	Definition of a definite integral by the lecture as an integral with limits of integration denoted by $\int_a^b fx$, where a and b are the limits of integration and $f(x)$ is the function.	Example given involving a definite integral…; Students asked to solve some problems on the board involving definite integrals.	Students given questions to attempt during their free time.
3	Revision of previous assignment was done; Then the lecturer introduced the concept of finding area under the curve.	Demonstration by the teacher on how to find the area bounded by the curve and two given points; Another example was given involving three regions of integration.	Lecturer emphasized the key points in the lesson; Two problems were given to the students for them to attempt at their own time.

Source: *Field observation data, March 2018.*

Table 4.6 presents a summary of the lessons conducted by lecturer 1 at C1 and was generic in two other classrooms except one. The key practices comprised: revision of previous work, examples (Demonstration by lecturer) and demonstration by students.

Revision of previous work

Data from lesson observation revealed that lecturers commenced their lessons by revising previously learned concepts. This was observed consistently in all the four classrooms that were visited. The revision was done mainly by asking students to solve problems on the chalk board while others contributed in the whole class discussion. An example depicting revision of previous work is given in the excerpt from lesson 2 conducted by lecturer 1. In this excerpt, **T** represents teacher led talk, **St** represents individual student talk while **Cr** represents chorus response by students.

1.	*T*	*Good morning*
2.	*Cr*	*Good morning sir*
3.	*T*	*Sorry we have lost some minutes. However we continue. I hope we all did the exercise I gave you yesterday.*
4.	*Cr*	*Yes*
5.	*T*	*Now let us refresh and go through two of the questions. Which ones can we do?*
6.	*St*	*b and c….No, b and d*
7.	*T*	*Okay let's quickly do b and d. Can anyone volunteer to work out b? Yes..*
8.	*St*	*Our equation is* $y^2 = -16x$. *So here, to find the focus, we divide* -16 *by 4. What is the answer?*
9.	*St*	*Chorus…* -4
10.	*St*	*Okay, so the focus is* $(-4,0)$. *Remember that the focus is* $(a,0)$ *and our* a *is* -4.
11.	*St*	*So the direxrix is* $x = -(-4); x = 4$. *The vertex is* $(0,0)$. *Then the parabola will appear like this (Draws the parabola)*
12.	*T*	*Very good. Can someone do the other question? A lady now. Okay yes!*
13.	*St*	*The equation we are given is* $y^2 - 10x = 0$. *The first thing I did was to write it like this* $y^2 = 10x$.
14.	*T*	*Explain why you did that.*
15.	*St*	*Sir, mmmm so that it is standard.*
16.	*T*	*Yes. Very important. Continue.*
17.	*St*	*So to find the focus, I did* $4a = 10$, *so* $a = 2.5$. *Then the focus is* $(2.5, 0)$. *The directrix I got* $x = -2.5$ *and the vertex is* $(0,0)$.
18.	*T*	*Okay, thank you very much. Am sure you all drew the parabola. I hope we are now okay. Let's go further and look at this situation.*

As can be seen from the above excerpt, the lecturer did not confirm whether students had drawn the parabola correctly but only assumed that they did. This is contained in line # 18. Immediately after going through the questions, the lecturer drew the students' attention to day's concept.

Introduction of day's concept

The flow of the lessons in the observed lessons was such that after revision of previous work, the lecturer introduced the day's concept to the class through didactic means. Students were not challenged to investigate mathematical ideas using the prior knowledge but were simply presented with the concepts by the lecturer as is evident in the excerpt from lesson 2 conducted by lecturer 1 at college 2 below.

19. T *We have dealt with the parabola of the type* $y^2 = 4ax$ *and concluded that the focus is* $F(a,0)$ *as long as Vertex is* $(0,0)$. *The equation of the directrix is* $x = -a$ *and the line of symmetry is* $y = 0$.

20. T *Now suppose we have a parabola of the type* $x^2 = 4ay$ *with vertex at origin. Then the focus is* $(0,a)$*....Check that it is the opposite of what we did.*

21. T *the equation of the directrix is* $y = -a$ *and the axis of symmetry is* $x = 0$.

22. T *Note: If* $a > 0$, *the parabola opens upwards and if* $a < 0$, *the parabola opens downwards.*

23. T *Example: A parabola has the focus at* $(0,4)$ *and its directrix is the line* $y = -4$. *(i) Write down the equation of the parabola. (ii) Find the equation of the axis of symmetry and the coordinates of the vertex.*

24. T *Solution… Let* $P(x,y)$ *be a point on the parabola. The distance from P to the focus (0,4) is the same as from P to the directrix. Using the distance formula, we say that* $\sqrt{(x-0)^2 + (y-4)^2} = |y+4|$*; After squaring both sides, we have* $x^2 + y^2 - 8y + 16 = (y+4)^2$ *... Is that right?*

25. Cr *Yes sir*

26. T *Right, from this, we get* $x^2 + y^2 - 8y + 16 = y^2 + 8y + 16$ *which, after terminating the common terms will give us (Remember that here we can put like terms together and in doing so some terms will be cancelled like* y^2 *and* 16*).*

27. T *So we shall get* $x^2 = 16y$. *Compare our equation* $x^2 = 16y$ *with the standard equation* $x^2 = 4ay$, *this will give us* $4a = 16$ *meaning that* $a = 4$.

28. T *Thus, the axis of symmetry is the* $y - axis, x = 0$ *and the vertex is* $(0,0)$.

29. T *Are we alright?*

30. Cr *Yes sir*

In line 19, the lecturer gave a synopsis of the previous lesson and then introduced the day's lesson in line 20. Worth noting is that the lecturer gave the focus, the equation of the directrix and the equation of the line of symmetry in line 20, 21 and 22 respectively instead of challenging students to attempt to find those variables by relating to the previous work.

Demonstration by students

Once the lecturer had given an example, students were called upon to solve some problems on the chalkboard. This was commonly seen in classroom 1, 2 and 4 while in classroom 3, students solved problems in groups. An example from a lesson conducted by lecturer 2 from college 1 is given below.

24. T	*Very good…, so we always have to remember that when dealing with the pie chart, the sum of angles in a circle is* 360^o.
25. T	*Aha,,, so we can say, like for football,* $\frac{12}{20} \times 360°$. *So we can cancel 20 here and in* 360 *we get what?*
26. Cr	*18*
27. T	*And then we multiply* 12 *by* 18. *What do we get?*
28. Cr	216
29. T	*Yes, so the angle for football is* 216°.
30. T	*Can someone find the sector angle for volleyball? Yes you.*
31. St	*For Volleyball, there are 5 students. So we write* $\frac{5}{20} \times 360°$. $5\ into\ 5\ is\ 1, 5\ into\ 20\ is\ 4. Then\ 4\ into\ 360\ goes\ 90\ times$. *So the angle for volleyball is* 90°.
32. T	*Is he correct?*
33. Cr	*Yes*
34. T	*Can we find the angle for Table tennis? I'll give you 2 minutes.*

One prominent characteristic of the student demonstration session was the chorus responses that students gave during the question – answer sessions. This means that whole class teaching was a prominent feature in the lessons observed. However, while this was the case in lessons conducted by lecturers 1, 2 and 4, lecturer 3 consistently used pair work and group work during his lessons as a way of establishing whether students had grasped the concept being discussed. Figure 4.1 shows the lecturer mediating during group activity.

Figure 4.1 Lecturer mediating during group discussion

Source: Field observation data, 2018

While students discussed the given questions in their respective groups, the lecturer took time to see what they were doing and where need arose, he provided mediation for the students. An example of mediation is given in the excerpt below:

65. T	*Let's imagine that we have …this is the origin and this is the* $x-axis$ *and this is* $y-axis$*. Let us suppose the coordinates of the focus is* $(a,0)$ *meaning from the point* $(0,0)$ *to "*a*" how many units are there?*
66. St	*(Quiet…)*
67. T	*If it was 4 in place of "*a*" how many units are here?*
68. Cr	4 *(Chorus)*
69. T	*There are 4…, What if it was* $(7,0)$*?*
70. Cr	7
71. T	*Now am writing* $(a,0)$*. So how many units are here*
72. Cr	"a"
73. T	*And let's suppose also that the directrix is* $x=-a$*, meaning that from here (focus) to here it's "*a*" units isn't it?*

However, the conduct of group work was such that students were not given an opportunity to present their solutions to the whole class and to critique each other's ideas. During the interview the lecturer was asked to comment on the conduct of his lesson. He was quick to mention that:

> *I am a strong believer in learner centred approach…that is why if you saw I tried to ask them to work in pairs and groups though it wasn't done very well but I always like asking them to think, pair and share* (Lect. 3, Interview - May 2018).

The above comment shows that the lecturer was aware that group work and pair work were not done as expected.

4.3.2.2 Lecturer dominance during lessons

The lessons observed showed a similar pattern of interaction where the teacher did most of the talking while learners answered lecturers' oral questions. Communication was mainly tilted towards the lecturer who dominated the classroom discourse (Presenting facts, asking questions and demonstrating solutions). The excerpt of the lesson by lecturer 2 from college 1 is shown below. In the excerpt, **T** – represents teacher talk, **St** – represents student individual response and **Cr** – represents chorus answers from two or more students.

Example one

1. *T* *Find the coordinates of the centre to the circle* $x^2 + y^2 - 4x + 8y + 15 = 0$.
2. *T* *This is just a warm up from what we did last time.*
3. *T* *I will give you 3 minutes then you'll tell us what you did after you get the answer.*
4. *T* *You have a question?*
5. *St* *I have finished.*
6. *T* *Oh, you have already done it? The coordinates to the centre already?*
7. *Cr* *Yes*
8. *T* *3 Minutes…, Let us wait for others who do not know.*
9. *T* *Let us say "Find the radius and the coordinates of the centre to the circle* $x^2 + y^2 - 4x + 8y + 15 = 0$. *So now there is also the radius.*
10. *T* *So I'll do this then you'll compare with what you have done then we'll discuss afterwards because I know what some of you did. That's what I want to talk about.*
11. *T* *We said this equation is in general form. So to find the centre we have to factor out and complete the square.*
12. *T* *Pay attention you who did not do it.*
13. *T* *So it's x minus… half of this is?*
14. *Cr* *Two (2)*

The above example is an excerpt from an introductory lesson on the parabola; the lecturer took time to derive the equation of the parabola. Students were asked to work on a given problem individually (Lines 1, 2 and 3) and the lecturer indicated that the students would tell the class the answer they got. However, that did not happen as the

lecturer demonstrated solving the given problem on the chalkboard (Line 10, 11, 12 and 13) while students answered oral questions posed by the lecturer (Line 14).

Other than that, the lecturer did not give students an opportunity to share their ideas with others during the classroom discourse as is evident in the excerpt on page 61.

Example two

25. T *Now what some of you did which I also talked about last time is: Immediately you see an equation, as you can see this is* -4 *the centre is* $+2\ldots, +8, -4.$

26. T *It is easy to see what the centre of the circle is when you see the general equation before you calculate.*

27. T *If say* $x^2 + y^2 - 10x + 6y - 7 = 0$, *Immedaitely you look at it you'll be able to tell that the* $x - coordinate$ *will be...,* $-\frac{1}{2}$ $of\ this$?

28. Cr $+5$

In the above example, Line 25 and 27 showed that the lecturer demonstrated how to find the centre by inspection instead of allowing the student who got the centre within a minute (in example one) to explain how he got the answer fast. Coupled to this finding is the observation made in lesson two conducted by participant two at C2, who dominated the classroom discourse as shown in example three below:

Example three

1. *T* *Today we shall look at the application of exponential and logarithmic functions.*
2. *T* *So, where do we normally apply this one?*
3. *T* *We said this topic can be applied in business (not so?).*
4. *Cr* *Yes*
5. *T* *It can be applied in business that is for planning purposes.*
6. *T* *Also for decision making …do you know what it means decision Making?*
7. *Cr* *Yes (No).*
8. *T* *To enable people to make decisions.*

As can be seen in line 2, the lecturer asked a question to the class and in line 3, 5 and 6, he answered his own question without allowing time for students to think and respond. Moreover, in line 6, the lecturer asked students a question and they gave two different

responses in chorus form, some saying yes others no. However, in line 8, the lecturer responded to the question posed in line 6 instead of asking those students who knew the meaning to attempt answering the question. During the interview, the lecturer indicated that it was not possible to cater for individual learners' needs. This is contained in the comment on page 62.

> *We may not cater for every learner's need in the classroom but we normally ask then to consult us at the tutorial block (Offices) for more clarifications* (Lect. 2, Interview - May 2018).

The same thought was expressed by lecturer 1 who indicated that time was limited to address individual differences in learners' pace of grasping mathematical concepts as indicated in the comment below.

> *Since learners differ in terms of the pace and how they learn, time is limited to individualize teaching in order to address individual needs and preferences of each learner* (Lect. 1, Interview - March 2018).

4.3.2.3. Inadequate use of teaching and learning resources

With regards to teaching and learning resources, the study established that all lecturers used the chalkboard to illustrate mathematical concepts and for demonstration. Other than the chalkboard, no other resources were used in the lessons observed. Additionally, lecturers did not incorporate Information Communication Technology (ICT) in the teaching of mathematics. Notable, among many lessons was the lesson conducted by participant two from C1 on the presentation of data on a pie chart. The lesson went on without the teacher and the students measuring any angle in the process. The scenario under which this happened is shown in Figure 4.2.

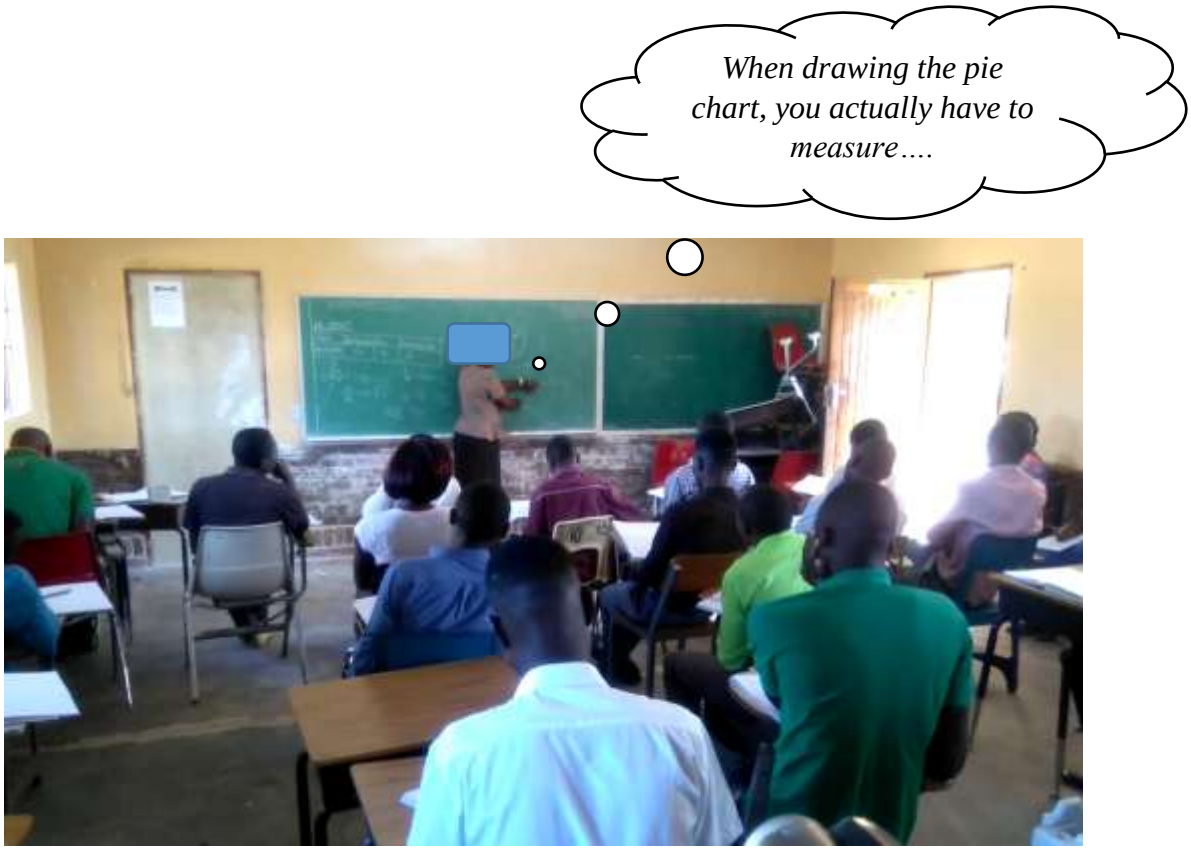

Figure 4.2 Lesson on the pie chart.

Source: Field data, March 2018.

When she was asked which part of the lesson she could have done better, the lecturer had this to say:

> *Where I could have done better is when dealing with presenting data using a pie chart. I feel it was important for me to come with teaching aids such as a campus and a protractor…, It was difficult to know whether students drew the angles correctly because they did not have instruments as well so I just emphasized to them that they actually have to measure* (Lect. 2, Interview - March 2018)

The above statement confirmed that during the lesson, students had no mathematical instruments either. The teacher further indicated that the department had no board instruments like protractor, board ruler and compass for use in such topics.

4.3.3. Limited application of OBE premises and principles in assessment

The forms of assessment that lecturers used during lessons and outside lessons were probed during lesson observations and interviews as well as document review. Data

from lesson observation revealed that lecturers assessed learners as the lesson progressed by asking questions based on the concepts at hand. After demonstration by the lecturer, students were given some questions to attempt either individually or in some cases in pairs and groups while some lecturers accorded students an opportunity to demonstrate on the chalkboard. This was evident in excerpts from lessons given in section 4.3.2.1.

Data from document analysis showed that lecturers kept teaching files which included, among other things, assessment documents such as assignments, tutorial sheets, test papers and marking guides and mark sheets showing the marks obtained by each student in each piece of work given. Further analysis showed that two lecturers consistently gave students some questions to attempt outside class in form of tutorial questions. From those tutorial questions, one lecturer asked students to submit solutions to certain marked questions as part of their continuous assessment while the rest of the questions were for them to practice. Furthermore, overnight tests were observed in C1 while (regular) tests were also a common feature. The test and assignment results were recorded in mark sheets by each lecturer for the purpose of determining whether a student would be eligible to write the final examination or not.

One common feature in the assessment tools was the lack of authentic contexts; the questions were simply put without any real life situations that required students to figure out and model mathematical sentences before applying appropriate formulae to solve the problem (See Appendix 9). The questioning techniques where such that they did not promote critical thinking; the questions were explicitly given and did not require students to think deeply and critically before solving the given problem.

Furthermore, interview findings revealed that lecturers had limited knowledge about Outcomes-Based Assessment (OBA) as may be deduced from the following comments:

> *I think on that part I wouldn't say we are responding in line with OBE (referring to assessment)… I may not know whether we are responding in line with that one (OBA) or in line with the old way of doing it (Objective based Assessment) I may not know* (Lect. 4, Interview - May 2018).

We normally assess learners on what we have taught to find out whether the intended concepts have been understood by the learners; we do not assess outside what we have taught them (Lect. 2, Interview - March 2018).

The comment by lecturer two clearly suggested that he was not sure whether he was applying OBA strategies or the traditional methods of assessment.

4.4 Student teachers' views on lecturers' practices

For each of the classes observed, a group of ten students comprising five males and five females were requested to voluntarily take part in the FGD. This was necessary in order to establish from the students the practices of lecturers over time since the data from lesson observations was limited to the period of observation.

4.4.1 Commonly used teaching methods

The methods of teaching were listed and students were asked to select *three* which are mostly used by their lecturers. This was done before they were interviewed. The results are shown in the Figure 4.3.

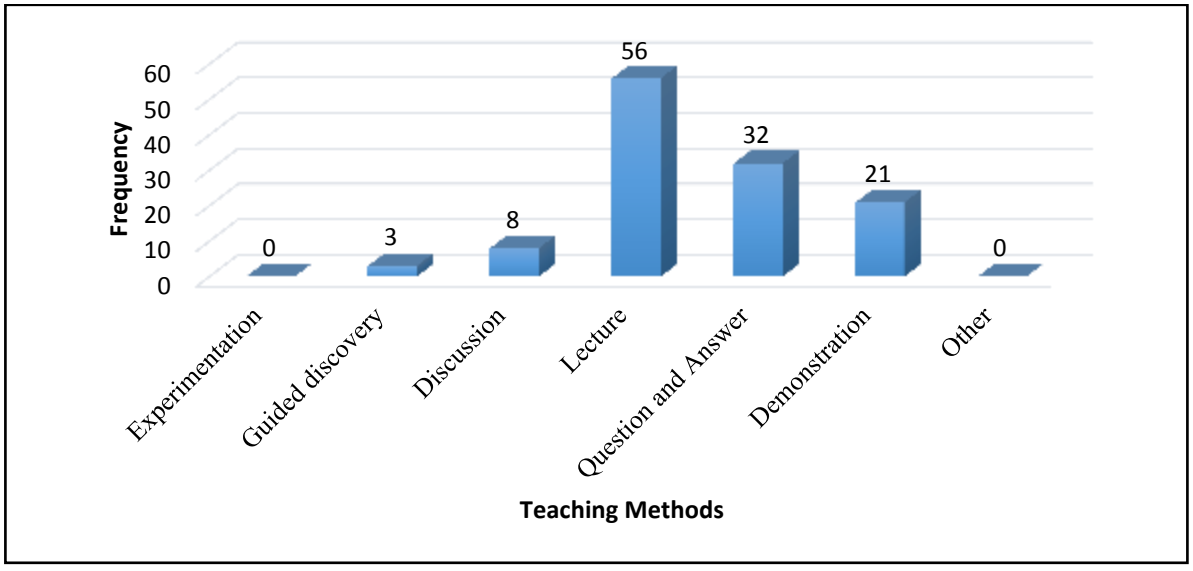

Figure 4.3. Frequency distribution of methods of teaching

Source: Field data, 2018

Figure 4.3 shows that lecture method was the dominant method of teaching followed by question and answer, demonstration, demonstration, discussion and guided discovery.

None of the student teachers chose experimentation as one of the methods used in mathematics classrooms. Some examples of participant responses are as follows:

> *Some lecturers make mathematics simple the way they explain but others it's like they are talking to themselves…*o*thers it's like they are only concerned with lecture method just because we are students they will just lecture and say make use of the library* (FGD 3, May 2018).

> *For me I would say lecturers use different methods like lecture method and then they ask you some questions to solve on the board. Our lecturer tries to involve us during her lectures so that we are not bored* (FGD 2, March 2018).

> *Lecture method is used more but group discussion is also used where in pairs of two or three we share ideas...* (FGD 4, May 2018).

> *Lecturers demonstrate to us how to solve problems and allow us to try some questions on our own* (FGD 1, March 2018).

Although project method was not listed, one participant stated that lecturers use it during lessons. When asked to explain how it was used, he had this to say*: Sometimes they give us work to do then ask us to bring the answers in the following lecture to share with the other members* (FGD 4, March 2018).

4.4.2. Students' preferred way of learning

Apart from stating the methods of teaching that are often used by lecturers, student teachers were asked which methods of teaching they favoured most and why? Their responses suggested that students like interactive methods where they are involved in the lesson. The quotations below contain the meaning:

> *For me I would say (I favor) learner centered, say group discussion, because the mathematics that we are learning at this level some of us we did not do it at senior level… but when we get involved then it becomes very easy for us to learn rather than lecture method where by you find this lecturer is just talking to himself and most of the time he is just writing things which you do not understand. But when you are taught in a group discussion where the lecturer*

gives you questions, you solve and give feedback that way it's very easy to remember mathematics (FGD 1, March 2018).

As said what you hear might be easily forgotten but what you do sticks… if I just copy then I might not know how we arrived at the answer (FGD 3, May 2018).

But others still felt that demonstration method was favourable especially to slow learners who needed more examples in order to grasp the concepts. This view was expressed in the comment below:

We'll never ran away from this fact that there are slow learners and fast learners. When a lecturer is just writing and speaking using one method of teaching which lecture method there are some students who are very fast like to follow the lecturer but it is a disadvantage to those slow learners; they need more solving for them to understand (FGD 4, May 2018).

The views of students suggested that not one method of teaching may fit all; different methods of teaching may be desirable to cater for their various needs and capabilities.

4.5 Summary

This chapter has presented findings of the study based on the research questions. Findings of the study revealed that all lecturers (except one) did not receive any capacity building in view of the paradigm shift-OBE. While lecturers gave sound views regarding the implication OBE premises and principles to classroom practice, their views were inconsistent with their practices and devoid of the knowledge of the premises and principles. While teacher centred methods characterised mathematics classrooms, student teachers suggested that they learnt well when they were involved in the lessons through learner cantered methods. Furthermore, lecturers exhibited limited knowledge of OBA and mainly used assignments and tests to assess students. Beyond that, the study established that inadequate training, lack of teaching and learning materials and time are potential barriers to successful implementation of the OBMTES. The next chapter is dedicated to the discussion of the findings highlighted in this chapter.

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1 Overview

This chapter presents a discussion of the themes that emerged from the analysis of data of the study. The themes are discussed in relation to the diffusion of innovation theory which underpins the study as well as the literature reviewed. The findings revealed the following themes: Lack of capacity building, peripheral knowledge of OBE, lack of alignment between policy and practice and threats to successful implementation. The four findings will help answer the two main research questions of this study. The theme on lack of capacity building will be discussed in section 5.1 while section 5.2 will discuss peripheral knowledge of OBE. Section 5.3 will delve into the theme on lack of alignment and the threats to successful implementation of OBE will be discussed in section 5.4. A summary of the chapter will then be given at the end of the chapter.

5.2 Peripheral knowledge of OBE

The study established that lecturers understood objectives to be a reflection of teachers' intentions irrespective of whether learning took place or not while outcomes reflected what learners would actually do with the knowledge acquired. They believed that objectives were for teachers while outcomes were for students. For example, participant 2 was of the view that objectives were rigid and aimed at coverage of content while outcomes were flexible and attuned towards promoting learning.

Moreover, lecturers believed that OBE was introduced to promote learner centered teaching as well as to align the content for teacher education to that of the school curriculum. These ideas are in line with the policy intentions as contained in the curriculum framework, 2013 where it posited that study areas in the tertiary (Teacher Education) curriculum had been linked to school curriculum so that the student teachers would become familiar with school curriculum while at college and while teachers and teacher-educators were strongly advised to use the Learner-Centred Approach in the teaching and learning process. This finding entails that participants could have read through the policy document in order to appreciate why the curriculum was revised.

Furthermore, the study established that participants had no knowledge of the OBE premises. When asked what premises OBE was anchored, none of the participants could state them. However, when the premises were stated for them, their interpretation in relation to classroom practice was in line with the policy on teaching and learning under the OBE paradigm. For example, in explaining the principle: *all learners can learn and succeed but not at the same time and pace*, participants stated that there was need to use a variety of teaching methods. The policy, through the curriculum framework 2013 spelled out the principles of the revised curriculum as being: Clarity of focus, reflective designing, setting high expectations for all learners and appropriate opportunities. Spardy (1994, p. 21) explained that the three principles of OBE (all students can learn and succeed, but not on the same day, in the same way; successful learning promotes even more successful learning and schools control the conditions that directly affect successful school learning) were the rationale on which the actual implementation of the curriculum would rest.

As such, the lack of knowledge of the OBE principles by the lecturers was an indication that their practices may not be fully aligned to the tenets of OBE. There was need for mathematics lecturers to be well grounded in the premises and principles of OBE in order to better appreciate its implementation. Thus, lecturers' views on the implications of OBE premises and principles for teaching mathematics may be meaningless without the knowledge that the said premises and principles undergird practices. Implicit, lecturers' knowledge of OBE could be said to be peripheral knowledge; one that is not grounded in the core premises and principles of OBE.

5.3 Inadequate capacity building

This section discusses the lack of capacity building among the mathematics lecturers. Despite the importance of training the implementers on an innovation to prepare them for implementation, findings here revealed that out of four lecturers who took part in the study, only one had an opportunity to attend a CPD workshop on the OBMES (Section 4.4.1). While this was the case in this study, Musonda, (2009) and Ramoroka (2007), in their respective studies, established that educators had undergone in-service training through workshops in order to implement SCL approach and OBE in their classroom

practices respectively. The study by Musonda involved lecturers who underwent training on SCL approach under a project by VVOB framed 'Better Secondary School Trained Teachers (BeSSTT). It is clear that since this project was funded, the training of lecturers was inevitable as it was the whole essence of the project. The other study by Ramoroka was done in South Africa which is relatively well resourced compared to Zambia. As such, while capacity building workshops were conducted to equip teachers to implement OBE in South Africa, it was not the case in the Zambian setting because of financial constraints. This was confirmed by the Mathematics curriculum specialist who indicated that the ministry could not reach everyone due to lack of resources.

The diffusion of innovation theory (Section 2.3.1) asserts that all decision making processes, planning for implementation and seeking resources about ideas for new innovations must be done during the first phase of the diffusion process (Rogers, 1995). Markee (2001), further argued that decision making at policy level involves, among other things, decisions about curriculum planning and policy statements, learning aims and means of achieving them, project implementation including materials, resources development, and teacher training. The finding here showed that the diffusion process of the Outcomes – Based Mathematics Teacher Education Syllabus (OBMTES) was not systematically and effectively managed and followed by the Ministry of Education. Fullan (1993) suggested that effective curriculum change and implementation requires time, personal interaction, in-service training, and other forms of people-based support.

Unlike building capacity in all lecturers of mathematics countrywide through provincial or district workshops, the ministry trained a few lecturers with the hope that they would train the rest of the members at the stations. This method did not work well as no such local CPD workshop was recorded in the visited colleges to educate members of the department regarding OBE. For example, Musonda (2007) recommended that colleges needed to organise orientation workshops for new lecturers in order to enhance LCT. This is an indication that despite being among lecturers who were trained in LCT, new lecturers were not capacity built. There seemed to be a lack of willingness to share innovations by the people who are privileged to attend workshops on new developments in education.

Educational change, as Fullan (1993) observed, involves changing teachers' beliefs and understanding as a prerequisite to improving teaching practices. He further postulated that teachers require a thorough understanding of the meaning of educational change before there is an acceptance and adoption of new programs and approaches. As such, the inadequate capacity building of lecturers was a threat to successful implementation of the OBMTES since the successful implementation of an innovation largely depended on the clarity to the implementer of what the innovation meant in practice.

5.4 Lack of alignment between policy and practice

Section 5.2 showed that lecturers had peripheral knowledge of OBE since their knowledge was not backed by corresponding knowledge of the underlying premises and principles. This section addresses the emergent theme on lack of alignment. This was based on data triangulation (interview, lesson observation, FGDs and document analysis).

5.4.1 Direct transmission vs Learner centred approach

The first factor accounting for lack of alignment between policy and practice was the dominance of teacher centred approaches in the observed lessons. This was confirmed by the findings from FGD where students indicated that the lecture method was the most used teaching method followed by question and answer, demonstration and discussion respectively. Although lecturers demonstrated how to solve mathematical problems on the chalkboard and accorded students an opportunity to solve problems on the chalkboard these practices were not novel in the teaching of mathematics. Moreover, lecturers consistently exhibited traits of transmission mode of teaching in most parts of the lessons as is evidenced in examples one, two and three (Section 4.3.2.2) where the lecturer did most of the talking while students only came in to confirm what the lecturer was saying in response to questions like "*isn't it*?." Example three depicted a scenario where the lecturer was responding to his own questions without giving enough wait time for students to respond to his question.

The methods of teaching that were deemed to be interactive such as group work were only observed consistently in classroom 3 at college 2. This provided contexts in which

to use mathematical language, negotiate meanings and scaffolding would be applied. However, the version of group work that was exhibited in the classroom discourse was a weaker one as the students were not accorded an opportunity to report their results and critique each other's knowledge. Participant three showed the characteristics of a late adopter of change when he stated that he was *a strong believer in learner centred approach and always liked asking students to think, pair and share* yet he did not allow students to share. The teachers' choices for delaying the adoption process of the OBE curriculum change here is related to his attitudes and belief systems (Borg, 2006) which provide reasons for the lack of alignment argument between policy and practice here.

By and large, traits highlighted above indicated that lecturers were still rooted in the transmission mode of teaching while exhibiting some traits of learner-centred teaching practices. This finding comes in spite of the policy direction that emphasised learner activity during lessons. In view of the same, Wertsch (1991) highlighted *that social interaction*, *cultural tools*, and *activity shape* individual development and learning. Thus, without them taking an active role in the construction of mathematical knowledge, students may be at a loss in terms of grasping the concepts being taught.

This finding is not peculiar to this study as Ramoroka (2007) found out that educators did not accommodate OBE premises and principles in their practices. Despite that, Musonda (2009) established otherwise, that lecturers of mathematics were implementing LCT approach. This discrepancy could be attributed to lack of capacity building of participants in the current study while the participants in the other study were trained through the VVOB project.

5.4.2 Inadequate use of resources

The findings from lesson observation indicated that other than the chalkboard, there was no evidence of use of TLA's in all the lessons for the four participants. In as much as it may be difficult to think of TLAs for use in certain topics like those observed on logarithmic and exponential functions, integration and conic sections, the use of work sheets, and instructional media could come in handy. The acute situation with regards to the use of TLAs in mathematics lessons arose in lesson two conducted by participant two in college one who was teaching on the pie chart. That particular lesson on the pie

chart went on without use of mathematical instruments (pair of compass, ruler and protractor). It was interesting to note that the lecturer knew the importance of TLAs in mathematics lessons in general and in that lesson in particular despite not having evoked their use (Section 4.3.2.3).

The teacher assumed that students were all the same – having the capacity to measure and draw angles contrary to the first premise of OBE and the principle of design down where the outcome should have dictated the input in the lesson. Most of the concepts in mathematics are abstract in nature and require the use of concrete and/or semi-concrete objects to help in explicating them. For example the concept of number can be well understood when attached to things at the least. This points to the importance of using Teaching and Learning Aids (resources) (TLAs) in mathematics lessons. In this lesson on the pie chart measuring and drawing angles was the key expected outcome which should have necessitated the use of hands - on considering how confusing reading the protractor can be. Figure 5.1 shows a protractor with a reading of an angle of 40°.

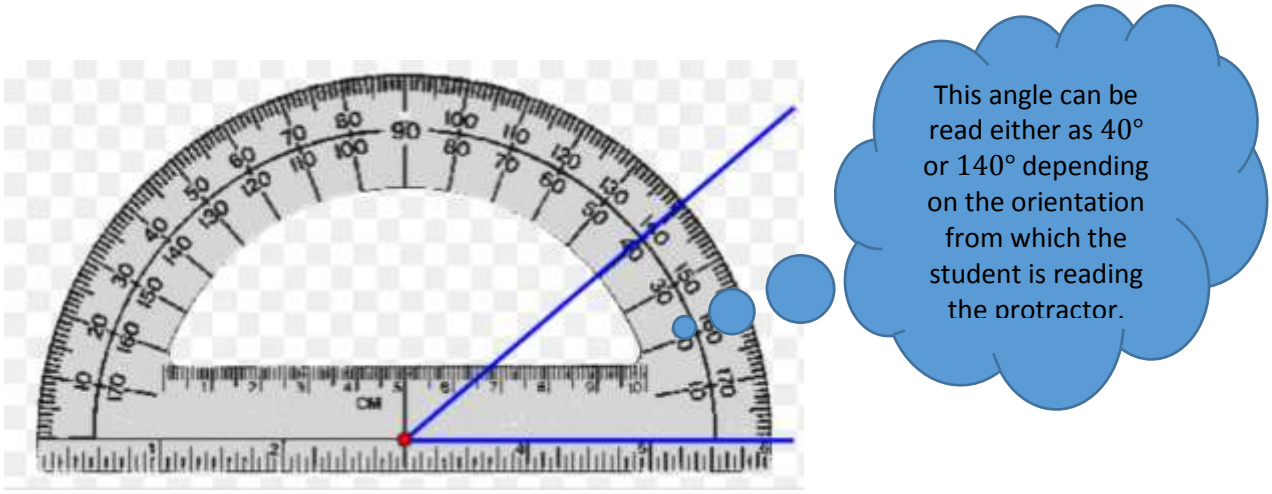

Figure 5.1: Snapshot of an angle on a protractor.

Source: *NCERT, 2010.*

In Figure 5.1 above, the protractor bears a reading of 40° yet it is possible for a student to read it as 140°. This depends highly on where the student takes the reading from (Clockwise or anticlockwise). The use of a protractor to measure and draw angles is a skill that requires close attention and the teacher should have asked students to carry

mathematical instruments with them as well as source board instruments to illuminate the concept.

This policy guiding the implementation of OBMTES spelled out that learners should be given expanded opportunities to learn. In this case, like the lecturer rightly observed, it was difficult to know whether learning had taken place or not because they did not have mathematical instruments for them to do the actual measurements. In fact, MOE (1996, p.40) recognized that:

> *Quality education requires the availability and use of textbooks and other educational materials. Without these aids to the learning process, effective teaching and learning in the modern sense cannot take place. Suitable materials enable pupils to acquire and apply knowledge, to learn at their own pace and to assess their own progress*.

This indicates that teaching aids are valuable tools that lecturers should use to explicate mathematical concepts.

Additionally, the finding did not resonate well with the diffusion of innovation theory, the theory underpinning the study (Section 3.2). The theory holds that during the initiation stage of the diffusion process, planning for project implementation including materials, resources development is critical. What this entails is that college two did not prepare adequately to implement the Outcomes-Based Curriculum by assembling resources in all departments, mathematics inclusive. This lack of alignment to policy points to the fact that the lecturer in question is a late adopter of change, knowing what the policy requires (since she agreed having been capacity built in the paradigm shift-OBE) and having knowledge of the importance of mathematical instruments for that particular topic but could not use them in the lesson. Furthermore, this finding is not peculiar to this study as Vallente (2016) also reported that there was scarcity of use of teaching and learning resources in Home Economics Lessons. This means that the challenge of lack of resources is a common and continuing problem in curriculum implementation.

The implication here was that since students were taught without any teaching and learning resources, it was likely that they may not have been well grounded in the concept of drawing angles, for example, thereby making it difficult for them to teach the same concept to the understanding of the learners when they went out to teach.

5.4.3 Limited assessment procedures

Data triangulation from document analysis and interviews showed that there was limited use of assessment procedures in mathematics classrooms. Interview data revealed that lecturers had limited knowledge of Outcomes-Based Assessment (OBA). This pointed to a lack of understanding of policy intentions regarding OBA. This lack of alignment could be attributed to inadequate knowledge of OBE assessment. For example, one lecturer expressed scepticism as to whether he was applying premises and principles of OBE in his assessment (Section 4.3.3). This uncertainty could be attributed to inadequate capacity building in OBE.

The above finding shows a lack of alignment of policy to practice. Assessment is an important tool in the teaching and learning process and is used to determine whether teaching and learning have taken place or not. As such, before the teacher sets out to teach a given concept in mathematics, there may be need to determine students' capabilities as well as challenges through a diagnostic test; also, as the lesson is ongoing, the readiness of the students to move on to the next part of the lesson is determined through assessment and finally the overall attainment of learning outcomes is done through assessment.

MESVTEE (2013, p. 57) explained that the following assessment procedures are recommended:

- Standard-based projects and assignments that require learners to apply their knowledge skills, positive attitudes and values;
- Clearly defined rubrics (or criteria) to facilitate a fair and consistent assessment of learner's work and;
- Clearly defined performance targets at key stages of learning.

This statement takes cognisance of the OBE premises and principles (Section 2.4.2 & 2.4.3) and acknowledges that not one form of assessment fits all students given their varying needs and the need to provide for them expanded opportunities for them to succeed.

Analysis of assessment tools showed that the problems given to students were mainly of recall and application of formulae to evaluate, integrate, and estimate the population increase with little or no reflection of real life problems which would require students to identify which concept to use in resolving the given problem. Appendix 10 shows an example of a test item. The use of rubrics was equally a missing component in assessment practices of lecturers.

5.4.4 Inadequate application of OBE premises and principles in planning

Findings of the study elicited through document analysis, showed that lecturers prepare schemes of work, lesson notes and records of work. However, there was little evidence of the application of OBE premises and principles in those documents. As an example, lesson notes did not reflect the learning outcomes, the teaching methods and strategies for various parts of the lesson, TLAs among others. Without documenting such variables, the lecturer is not likely to think about them prior to the lesson, especially TLAs which may need to be organised well before the lesson.

Planning is an essential ingredient in defining success in achieving desired learning outcomes. This planning must be informed by the envisaged learning outcomes so that it is tailored towards the attainment of the same outcomes. MESVTEE (2013, p. 57) highlighted that "*Planning is important in the work of a teacher and teacher-educator. This works as a guide for the effective delivery of lessons and other activities in and outside the classroom*." This planning should be such that it takes into account the OBE premises and principles in documents such as scheme of work, lesson plans/notes, record of work.

This finding indicates a lack of alignment between policy and practice as observed by Joskin (2013). It also resonates with Ramoroka (2007) who established that OBE principles and premises were not accommodated in teachers' practices. Data from

interviews (Section 4.2.1) also showed that personal belief systems and attitudes influenced participants' actions (Borg, 2006). When related to the diffusion of innovation theory, the participants showed the 'resistor of change' attitude whereby he relied so much on his teaching experience and downplayed the importance of incorporating OBE premises and principles in his documents.

By and large, the findings showed that participants were still rooted in their old practices while exhibiting some traits of change. This lack of alignment between policy and practice was anticipated according to literature (Section 2.2.2). Educational change involves changing teachers' beliefs and understanding as a prerequisite to improving teaching practices. Lecturers required a thorough understanding of the meaning the paradigm shift to OBE before there was an acceptance and adoption of Outcomes – Based teaching and learning approaches.

5.5 Threats to successful implementation of OBMTES

The study established potential threats to successful implementation of the OBMTES namely inadequate capacity building, time and lack of resources. These were identified through data triangulation where interviews, lesson observations and FGDs where participants intimated the threats to implementation of OBE. Since none of the lecturers was capacity built in OBE, all lecturers had no knowledge of the premises and principles of OBE which undergird its implementation. As such, their understanding of OBE and consequently their practices were not informed by the OBE premises and principles. With regard to the aspect of time, participants indicated that time was not sufficient to cater for the myriad needs of all students. For example, participant 4 explained that he asked students to consult further at the office in case of any clarifications on the covered material because it was not possible to cater for all their needs within the lesson. In the same vain, literature suggests that given sufficient time, every child can be expected to learn adding that differences in student scores are measures of time required for different students to learn the same material (Bloom, 1996; Carroll 1963).

The achievement of learning outcomes should and is not limited to classroom interaction; as such it was a good indication by the lecturer that time would be set aside for the students to seek clarity as and when need arises. However, it is one thing to say

that students are free to consult, and another to be available and attend to their individual needs outside classroom time. It may be necessary to have timetabled tutorial hours where students' concerns could be addressed. Still on the aspect of time, lecturer 4 could not apply group work effectively by not giving students a chance to critique each other's knowledge. It may be deduced from this statement that the lecturer was focused on completing the day's planned content at the expense of allowing students to present their solutions and critique one another's ideas.

It was also observed that lack of teaching and learning aids had the potential to hinder attainment of learning outcomes. There was a general lack of use of other teaching and learning aids other than the chalk board to illustrate mathematical concepts. The acute situation was observed in a lesson conducted by participant 2 who could not demonstrate how to measure angles due to non-availability of mathematical board instruments such as protractor, campus and board ruler. Unfortunately, students too did not have instruments. Vallente (2016) also established that limited instructional materials impeded the maximization of competencies required for OBE. Further, Gutema (2013) stated that material availability, among other things, was a core problem for students' success and implementation of OBTL. While the institutions should provide the necessary teaching and learning materials, educators must organise such whenever they are not available or postpone the lesson until such are available so as to ensure that meaningful learning occurs.

5.7 Summary

The chapter has discussed the emerging themes from the findings presented in chapter four. The notable points of reflection are: lack of capacity building regarding the paradigm shift – OBE, participants' peripheral knowledge of OBE and general lack of alignment. The lack of alignment was reflected in the dominance of transmission mode of teaching with traces of learner centred teaching; inadequate use of teaching and learning aids; limited application of assessment procedures and inadequate application of OBE premises and principles in planning. The next chapter presents the conclusion the whole study.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Overview

This final chapter attempts to show that the research questions raised in chapter one have been answered. An attempt has been made to highlight the purpose of the study and a summary of the main research findings as answers to the research questions. Beyond that, the chapter presents the theoretical and practice related implications of the results of the study and its contribution to the body of knowledge. Finally, the conclusion will be given followed by the recommendations of the study.

6.2 Main Findings

The study was motivated by a lack of adequate empirical data regarding the implementation of the OBMTES which, potentially, makes it problematic to attribute continued failure in mathematics to implementing poor ideas (OBE), or to the inability to implement good ideas. Conversely, it would equally be difficult to associate improvement in mathematics results to a well-implemented innovation, or to some extraneous factors. A summary of the main research findings is presented below according to research questions.

6.2.1 Peripheral knowledge of OBE

The first research question sought to elicit data which provided answers on the lecturers' level of understanding of OBE. The results of lecturers' interviews clearly showed that the lectures only had peripheral knowledge of OBE as it was not undergirded by their knowledge of OBE premises and principles, the basis for implementation of the OBE curriculum. Interview data further illuminated that there was inadequate capacity building of lecturers which could account for the limited knowledge of the change.

6.2.2. Lack of alignment between policy and practice

Research question two was meant to establish whether lecturers' practices incorporated OBE premises and principles. Data triangulation from lesson observations, document analysis and FGDs indicated that the practices of lecturers were not aligned to policy

intent meaning that there was a mismatch between what policy desires and what lecturers were actually doing in their classes. Many areas of interest were considered such as planning, teaching and learning as well as assessment and these were checked for consistency with policy and OBE premises and principles.

6.2.3 Lecturers' use of teacher centred approaches

Research question three sought to elicit data on the lecturers' practices as observed by student teachers. This was mainly for the purpose of triangulating data from lesson observation and document analysis in view of objective two. Data from students' FGDs showed that lecturers teaching was predominantly teacher centred with some traces of Student-centred methodologies. There were few activities that engaged students deeply during the lessons. This finding was in agreement with the findings from the classroom.

6.3 Theoretical Implications of the Study

The findings of this study are consistent with the diffusion of innovation theory presented in chapter two which suggests that the diffusion of any innovation passes through three phases: Initiation, Implementation, and Continuation. For example, the inadequate training of lecturers by the Ministry of Education entails that the first phase of the diffusion of the OBE curriculum did not happen as intended. Moreover, the lecturers' peripheral understanding of OBE is attributed to inadequate capacity building workshops organised by the ministry. This entails that according to the diffusion theory, the curriculum was launched at a time when the ministry was not yet fully prepared to do so. This situation already entails a weak expectation of implementation of the Outcomes-based Mathematics syllabus. Therefore, a vivid attempt to address planning issues during the diffusion process must be given priority before launching any curriculum innovation. In view of this, Markee (2001) explained that decision making at policy level involves four areas: decisions about curriculum planning and policy statements; learning aims and means of achieving them; project implementation including materials, resources development, and teacher training; and classroom implementation which refers to teachers' and learners' actions.

The study makes an important contribution to the field's understanding of the implementation of Outcomes-Based Curriculum at teacher education level. There is limited literature, if any, on this subject particularly at teacher training level. Hence, the study makes a contribution to the body of knowledge on the practices of lecturers within the context of mathematics teaching and learning in Southern Province of Zambia.

6.4 Conclusion

Based on the findings presented in chapter 4 of this study, it can be concluded that lecturers were not adequately capacity built in the paradigm shift – OBE. Their understanding of OBE was based on reading the curriculum framework, 2013 and the revised syllabus. Even though lecturers' interpretations of OBE premises and principles were in line with the intended meaning as per the policy, they did not have knowledge about them. This meant that their implementation of OBMTES was not backed by a vivid knowledge of the premises and principles that undergird practice.

Beyond that, lecturers exhibited traits of Outcomes-Based Teaching such as use of prior knowledge, hinting, demonstration and in scarcely negotiation of meaning. Notwithstanding these worthwhile OBE implementation strategies used by lecturers, the traditional methods of teaching continue to outweigh the good practices in view of OBE. There was a general lack of alignment between policy and practice in the implementation of the OBMTES in the two colleges of education that were surveyed. Initially, lecturers did not incorporate OBE premises and principles in their planning. Moreover, lecturers consistently used teacher centred methods in the teaching of mathematics with traces of learner centred strategies. Furthermore, there was limited application of TLAs and assessment procedures in the teaching of mathematics. This was seen as limiting students' opportunities to succeed contrary to OBE is premises and principles.

6.5 Recommendations

In view of the foregoing, the following recommendations are made:

For policy and practice

i. Given the reality of challenges of the economy in Zambia, it may be necessary for the Ministry of General Education (MoGE) to enshrine a regulation that compels every teacher or lecturer who attends a capacity building workshop to develop and execute a multiplier effect. This will ensure that curriculum innovations reach all the intended people thus improving the quality of education.
ii. Since the content for teacher education and schools was harmonised, lecturers of mathematics need to model lessons that are learner centred in order to demonstrate in real time, how the methods of teaching can be applied to explicate mathematical concepts.

For Further Research

The following areas are recommended for further study:

i. There is need to carry out a research in other study areas to establish the level of implementation of the Outcomes-Based Curriculum.
ii. The area of assessment under the OBE paradigm is quite broad. There is need for a study to be conducted particularly on assessment in colleges of education or schools in general.

REFERENCES

Awoniyi, S. A., Aderanti, R. A., & Tayo, A. S. (2011). *Introduction to Research Methods*. Sango: Ababa Press Ltd.

Barr, R. B. & Tagg, J. (1995). From teaching to Learning: A New Paradigm for Undergraduate Education. *Journal of change, 27 (6), 13 – 26.*

Bentley, T. (2010). Innovation and Diffusion as a Theory of Change. In A. Hargreaves, A. Lieberman, M. Fullan & D. Hopkins (Eds.), *Second International Handbook of Educational Change (pp. 29 - 46). London: Springer.*

Berman, P., & McLaughlin, M. (1976). Implementation of educational innovation. *Educational Forum, 40 (3), 345 – 370*

Bless, C. and Achola, P. (1988). *Fundamentals of Social Research Methods: An African Perspective*. Lusaka: Government Printers.

Bloom, B. S. (1976). *Human characteristics and school learn.* New York: McGraw-Hill.

Borg, S. (2006). *Teacher cognition and language education*. London: Continuum.

Bowen, G. A. (2009). *Document Analysis as a Qualitative Research Method. Qualitative Research Journal, 9 (2).*

Burnard, P. (1999). Carl Rogers and postmodernism: Challenged in nursing and health sciences. *Nursing and Health Sciences, 1, 241–247*

Burstein, L., McDonnell, L. M., Van Winkle, J., Ormseth, T., Mirocha, J., & Guitón, G. (1995). *Validating national curriculum indicators (RAND Document No. MR-658-NSF).* Santa Monica, CA: RAND.

Camp, W. G. (2001). Formulating and Evaluating Theoretical Frameworks for Career and Technical Education Research. *Journal of Vocational Educational Research, 26 (1), 27-39.*

Carless, D. (2004). Issues in teachers' reinterpretation of a task based innovation in primary schools. *TESOL Quarterly, 38, 639 - 662.*

Carroll, J. B. (1963). A model of school learning. *Teachers College record 64(8):723 – 33.*

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching, 44(6), 815-843*.

Cohen, D., & Hill, H. (2001). *Learning policy*. New Haven, CT: Yale University Press.

Creswell, J. (2007). *Qualitative Inquiry and Research Design Choosing Among Five Traditions.* Thousand Oaks California: Sage.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Creswell, J.W (2012). *Research Design: Qualitative and Quantitative Approaches*. New Delhi: Sage Publications.

Creswell, J.W (2014). *Research Design: Qualitative and Quantitative Approaches* (4th ed). New Delhi: Sage Publications.

Datnow, A., Hubbard, L., & Mehan, H. (2002). *Extending educational reform: From one school to many*. London: Routledge Falmer Press.

Fisher, C. (2007). Researching and Writing a Dissertation: A Guidebook for Business *for Developing Grounded Theory*. Thousand Oaks, California: Sage.

Framework for Doctoral Students. *International Journal of Doctoral Studies, 7, 143-152.*

Fullan, M. (2007). *The New Meaning of Educational Change* (4th ed.). New York: Teachers College Press.

Fullan, M.G. (1993). *Change forces: Probing the depths of educational reform.* Bristol, PA: Falmer Press.

Grant, C. & Osanloo, A. (2014). Understanding, Selecting, and Integrating a Theoretical

Gutema, G. (2013). The Implementation of Outcomes Based Teaching and Learning at Misrak Technical – Vocational Education and Training College. *A Thesis submitted to the Institute of Educational Research in partial fulfilment of the*

requirements for the Degree of Master of Arts (Educational Research and Development). Addis Ababa, Ethiopia.

Hatch, T. (2000). *What happens when multiple improvement initiatives collide?* Menlo

Johnson, R. K. (1989). A decision making framework for the coherent language curriculum In R. K. Johnson (Ed.), *The Second Language Curriculum*. Cambridge: Cambridge University Press.

Johnson, R. K. (1989). A decision making framework for the coherent language curriculum In R. K. Johnson (Ed.), The Second Language Curriculum. Cambridge: Cambridge University Press.

Joskin, A. M. (2013). *Investigating the implantation process of a curriculum: A case Study from Papua New Guinea.* A thesis submitted to the Victoria University of Wellington in fulfilment of the requirements for the degree of Doctor of Philosophy in Education.

Kabilan, M. K., Khairani, A. Z. & Lian, L. H. (2012). *Module 6: Assessment in Student – Centred Learning (SCL)*. Pinang: CDAE.

Killen, R., (2000). *Outcomes-based education: Principles and possibilities*. Unpublished manuscript, University of Newcastle, Faculty of Education.

Kombo, D. K. and Tromp, D. L. A. (2006). *Proposal and thesis writing: An Introducation.* Nairobi: Paulines Publication Africa.

Kombo, D.K and Tromp, D.L. A., (2006). Proposal and Thesis Writing: An Introduction.

Landau, V. (2001). *Developing an effective online course.* California: California Community Colleges.

Lane, J-E., (1997). *Implementation, accountability and trust*. In Hill. M. (Eds.) The Policy Process (pp 297 – 313). Harvester, Wheatsheaf: Prentice Hall,

Learning. Lusaka: University of Zambia Press.

Luse, A., Mennecke, B., & Townsend, A. (2012). Selecting a Research Topic: A Framework in Dissertation Research: Creating the Blueprint for 'House'. *Administrative Issues Journal: Connecting Education, Practice and Research, Pp. 12-22 DOI: 10.5929/2014.4.2.9*

Macayan, J. (2017). Implementing Outcome – Based Education (OBE) framework: Implications for Assessment of students 'performance. *Educational Measurement and Evaluation Review 8 (1). Philippine Educational Measurement and Evaluation Association*

Magaji, A. B. (2014). *Assessment of the Implementation of Mathematics Curriculum in Senior Secondary Schools in Kano State.* A Thesis submitted to the Department of Educational Foundations and Curriculum, Ahmadu Ballo University Zaria, in partial fulfilment of the requirements for the award of the Masters Degree in Education.

Manchishi, P.C. (2013). Reforming Zambian Pre-service Teacher Education for Quality

Markee, N. (2001). *The diffusion of innovation in language teaching*. In D. R. Hall & A. Hewings (Eds.), Innovation in English Language Teaching (pp. 118 - 126). London : Routledge.

Maykut, P. & Morehouse, R. (1994). *Beginning qualitative research: a philosophical and practical guide*. London: Falmer Press.

McDaniel, E. A., Felder, B. D., Gordon, L., Hrutka, M. E., & Quinn, S. (2000). New faculty roles in learning outcomes education: The experiences of four models and institutions. *Innovative Higher Education, 25(2), 143-157.*

McInerney, D., Van Etten, S., & Dowson, M. (Eds.). (2007). *Standards in Education.* Charlotte, NC: Information Age.

Merriam, S. B. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey Bass.

Merriam, S., & Associates. (2002). *Qualitative Research in Practice Examples For Discussion And Analysis*. San Francisco: Jossey Bass.

Mertler, C. A. (2001). Designing scoring rubrics for your classroom. *Practical Assessment, Research & Evaluation, 7(25).* Retrieved Sept 1, 2011, from http://www.pareonline.net/getvn. asp?v=7&n=25

Mertler, C. A. (2001). Designing scoring rubrics for your classroom. *Practical Assessment, Research & Evaluation, 7(25).* Retrieved Sept 1, 2011, from http://www.pareonline.net/getvn. asp?v=7&n=25

Miles, M. B. & Huberman, M. A. (1994). *Qualitative data analysis: an expanded source book* (2nd ed.). Thousand Oaks, California: Sage.

Ministry of Education (1996). *Educating Our Future.* Lusaka: MOE.

Ministry of Education (1999). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (1999). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2001). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2001). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2003). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2003). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2006). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2006). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2008). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education (2008). *Zambia's National Assessment Survey Report of Learning Achievement at the Middle Basic Level*. Lusaka: MOE.

Ministry of Education, Science, Vocational Training and Early education (2013). *Zambia's National Assessment Report 2012: Learning Achievement at the Middle Primary School level*. Lusaka: MoESVTEE.

Ministry of Education, Science, Vocational Training and Early education (2013). *Zambia Education Curriculum Framework*. Lusaka: Curriculum Development Centre.

Munby, H. (1984). A qualitative approach to the study of a teachers beliefs. *Journal of Research in Science Teaching, 21*(1), 27-38.

Musonda, A. (2009). *Reviewing the Learner-Centred Approach in the Teaching of mathematics at Nkrumah and Copperbelt Secondary Teachers Colleges.* A thesis submitted to the University of Zambia in Fulfilment of the requirements for the Master of Education in Mathematics Education.

Nakawa, N (2012). "Growth and Challenges Two Basic Schools Teachers under the Practice of lesson Development Based on Substantial Learning Environment (SLE) in the Republic of Zambia" *Journal of JASME Research in Mathematics Education, 18(2),* pp.13-21.

Nonaka, T. (2013). "Current Status and Issues of Child-centeredness of Mathematics at Basic Education in Zambia", *Journal of JASME Research in Mathematics Education, 19(2) pp.45-52.*

Olivier, C. (2002). Let's educate, train and learn outcomes – based. *Ifafi, Pro Technology, Jul – Dec 2000, 24 (1).* Park, CA: Carnegie Foundation for the Advancement of Teaching.

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods.* New Delhi: Sage Publications.

Patton, M.Q. (1990). *Qualitative Evaluation and Research.* (2nd Ed). London: Sage.

Prior, L. (2003). Using Documents in Social Research. New Delhi: Sage Publications.

Ramoroka, N. J. (2007). *Educators' understanding of the premises and principles underpinning Outcomes – Based Education and its impact on their classroom Assessment practices*. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Education in Assessment and Quality Assurance. University of Pretoria, South Africa.

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. *Econometrica, 73(2), 417–458.*

Rizvi, F., & Lingard, B. (2010). *Globalizing education policy.* London: Routledge.

Rogers, E. M. (1995). *Diffusions of innovations* (4th Ed.). New York: The Free Press.

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

Stake, R. E. (1995). *The Art of Case Study Research.* Thousand Oaks, California: Sage.

Stake, R. E. (2006). *Multiple Case Study Analysis.* New York: The Guilford Press.

Stoller, F. L. (2009). Innovation as the Hallmark of Effective Leadership. In M. Christison & D. E. Murray (Eds.), *Leadership in English Language Education Theoretical Foundations and Practical Skills for Changing Times (pp. 73-97)*. New York: Routledge.

Strauss, A., & Corbin, J. (1998). *Basic Qualitative Research Techniques and Procedures*

Taylor, P. G. (2000). Changing expectations: Preparing students for flexible learning. *The International Journal of Academic Development*, 5(2), 107–115.

Towndrow, P. A., Silver, R. E., & Albrigh, J. (2010). Setting expectations for educational innovations. *Journal of Educational Change, 11(4), 425 - 455.*

Tuck man B.W. (1994). *Conducting Educational Research* (4th ed). Harcourt brace College: publishers.

Vallente, J. P. C. (2016). Outcomes-Based Education Integration in Home Economics program: An Evaluative Study. *Journal of Education Issues, 2(1), 289-304*.

Waxman, H. C. (2001). Research on school-based improvement programs: its implications for curriculum implementation. *Education, 15*(3), 318-322.

Wellington, J. (2000). *Educational research: Contemporary issues and practical approaches.* London: Continuum.

Wertsch, J. V. (1991). *Voice of the mind: A social-cultural approach to mediated action*. Cambridge, MA: Harvard University Press.

Williams, B. (2004). Self-direction in a problem-based learning program. *Nurse Education Today, 24*, 277-285. http://dx.doi.org/10.1016/j.nedt.2004.01.008

Williamson, C. M. (2000). *A comparative Analysis of Outcomes Based Education in Australia and South Africa*. Pretoria: South Africa. A dissertation submitted in accordance with the requirements for the degree of Masters of Education in Comparative Education.

Yin, R. (2003). *Case study research design: Design and methods* (3rd Ed.). California: Sage.

Yin, R. K. (2009). *Case Study Research Design and Methods* (4th ed.). Thousand Oaks: Sage.

Yin, R., (1994). *Case study research: Design and methods* (2nd ed.). Beverly Hills, CA: Sage Publishing.

APPENDICES

Appendix 1: Information Sheet for Participants

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province, Zambia.

Information sheet for participants

Researcher: Mungalu Arthur

I am a Masters student at The University of Zambia and am kindly requesting you to participate in my research.

My research seeks to assess the implementation of the Outcomes-Based Mathematics Teacher Education Syllabus in Colleges of Education. The study will seek to suggest how the implementation of a curriculum can be enhanced.

The study is a qualitative one and data will be collected using semi-structured interviews, lesson observations, focus group discussions and document analysis. All data collected will be available only to me, my supervisor and examiners and will be used for the purpose of the study only.

The University of Zambia requires that ethical approval be obtained for any research. This research was subjected to scrutiny by The University of Zambia ethics committee after which approval was granted.

I would like to seek your permission to be observed, video recorded and audio recorded. Furthermore, I would like to request that you grant me access to your teaching documents.

The research will contain no names; only pseudonyms will be used unless the participant so wishes. Names of institutions will remain anonymous unless the institution so wishes.

Should you be prepared to participate, kindly fill in the consent form attached and return it to me.

Thank you for choosing to participate in this study.

.....

Mungalu Arthur

c/o The University of Zambia

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Appendix 2: Consent Form

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province, Zambia.

Informed consent for lecturers

I have read the information provided in appendix one and do hereby agree to take part in the above study. By virtue of agreeing to take part in the study, I am willing to:

(Kindly tick √ all boxes)

- □ Be observed
- □ Be audio recorded and video recorded
- □ Grant the researcher access to my documents as may be required

I understand that:

- □ All information obtained for the purpose of this study is confidential.
- □ My participation is voluntary and I can choose to withdraw my participation at any point.
- □ The information I will provide cannot be used for any other purpose other than for this study.
- □ The research materials will be stored in a secure place and destroyed after a period of 3 years.
- □ I consent to be involved as a participant in this study.

Lecturer #:.....

Signature:.....

Date: .....

Appendix 3: Consent Form

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province, Zambia.

Informed consent for students

I have read the information provided in appendix one and do hereby agree to take part in the above study. By virtue of agreeing to take part in the study, I am willing to:

(Kindly tick √ all boxes)

- □ Take part in the focus group discussion
- □ Be audio recorded

I understand that:

- □ All information obtained for the purpose of this study is confidential.
- □ My participation is voluntary and I can choose to withdraw my participation at any point.
- □ The information I will provide cannot be used for any other purpose other than for this study.
- □ The research materials will be stored in a secure place and destroyed after a period of 3 years.
- □ I consent to be involved as a participant in this study.

Name:.....

Signature:.....

Date: .....

Appendix 4: Classroom Observation Guide

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province of Zambia.

[This instrument will be completed by the researcher for each classroom session, on each of the days of the observation (1 hour-2hours sessions)]

Teacher number:.....

Number of learners:.....

How often did you observe each of the following in a classroom session? Tick in the relevant box.

	None	Little	Much
1. Collaborative problem solving.			
2. Activity based learning.			
3. Authentic contexts used			
4. Teacher led questions.			
5. Learner pose and identify problems			
6. Teacher provides individual attention to learners.			
7. Learners are given opportunities to demonstrate what they learn.			
8. Learners given opportunities to construct knowledge (meaning).			
9. Learners reflect on solutions and build consensus			
10. Teaching pedagogy promotes self-regulated learning			
11. Variety of teaching resources used			

12. Describe fully the critical incidents in the classroom (incidents that exemplify or contradict OBE principles).

Appendix 5: Lecturers' Interview Guide

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province, Zambia.

The purpose of this interview was to get the lecturers' views on how the OBE mathematics education syllabus was introduced to them as well as their understanding of OBE premises and principles.

1. Why do you think Outcomes Based Curriculum was introduced?
2. How was the curriculum introduced to you lecturers?
3. What has Teacher Education and Specialised Services (TESS) and the Curriculum Development Centre (CDC) done to equip you to implement the OBE syllabus in the classroom?
4. Please tell me the **three** premises and **four** principles of OBE and their implications for teaching mathematics.
5. What is the difference between an *objective* and an *outcome*?
6. How does teaching and learning under the OBE paradigm differ from teaching and learning under the objective-based paradigm?
7. Have you had to change any of the following as you implement the Outcomes Based mathematics education curriculum? Explain.
    - Teaching methods.
    - Assessment criteria.
8. With regard to the lessons that were observed, what are some of the critical moments when OBE premises and principles were applied?
9. What are some of the strengths of the lessons?
10. Where could you have done better and why?

Appendix 6: Students' Focus Group Discussion

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province, Zambia.

The purpose of this discussion was to get students' views on lecturers' practices.

1. Please, indicate three methods of teaching which are commonly used by your lecturers in mathematics classrooms by ticking in the boxes against the chosen methods.

Method of teaching	Tick
Experimentation	
Guided discovery	
Discussion	
Lecture	
Question and Answer	
Demonstration	
Other (Specify)	

2. Considering your experiences of learning mathematics at this college,
    - What methods are used frequently by your lecturer?
    - Are the lessons interesting and why?
    - Do they promote a particular way of teaching? Specify.
    - To what extent do they influence the way you will teach when you go in the field?
3. Do you have a preferred way of learning? Explain.
4. Do you know anything about Outcomes Based Education? If your answer is yes, what is Outcomes Based Education?

Appendix 7: Document Analysis Guide

Title: Implementation of Outcomes-Based Mathematics Teacher Education Syllabus in Two Colleges of Education in Southern Province, Zambia.

The purpose of this instrument was to establish whether or not lecturers' documents reflect OBE premises and principles.

Do the lecturers' documents contain OBE premises and principles? What OBE tenets are reflecting in the following documents?

a) Schemes of work

.....

.....

.....

b) Lesson plans

.....

.....

.....

c) Assessment instruments

.....

.....

.....

d) Records of work

.....

.....

……

Appendix 8: Sample of Lesson Notes

1.0 CONIC SECTIONS

1.1 THE PARABOLA:

A parabola is a locus of points in a plane which are equidistant from a given point and a given straight line. The given point is called the **focus** and the given line is called the **directrix.**

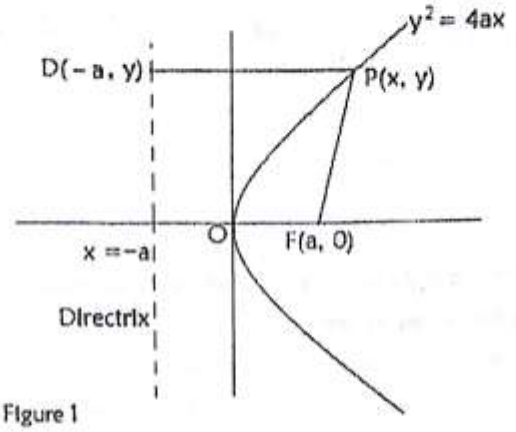

Figure 1

In Figure 1, Let F be a point (a, 0) and let a straight line $x = -a$, be a straight line. The point P(x, y) is a locus of points which are equidistant from the point F(a, 0) and the straight line $x = -a$.

i.e. PF = PD,

$\Rightarrow \sqrt{(x-a)^2+(y-0)^2} = \sqrt{(x+a)^2+(0-0)^2}$

$\Rightarrow (x-a)^2 + y^2 = (x+a)^2;$

$\Rightarrow x^2 - 2ax + a^2 + y^2 = x^2 + 2ax + a^2;$

$\Rightarrow y^2 = 4ax;$

The equation $y^2 = 4ax$ is the standard equation of a parabola with the **Focus** at F(a, 0) and the **Directrix** $x = -a$.

The straight line through the focus and perpendicular to the directrix is called the **Axis** of the parabola. The axis of the parabola intersects the parabola at the point O, the midpoint of DF, called the **Vertex**

1.2 Features of the graph of the parabola

1.2.1 When the vertex is at the origin and the axis coincides with the x-axis, the equation of the parabola is $y^2 = 4ax$, where:

Coordinates of Focus:	$x = a$, and $y = 0$
Coordinates of Vertex:	$x = 0$ and $y = 0$
Equation of Directrix:	$x = -a$
Equation of axis of symmetry:	$y = 0$.

If $a > 0$, the parabola opens to the right; If $a < 0$, the parabola opens to the left.

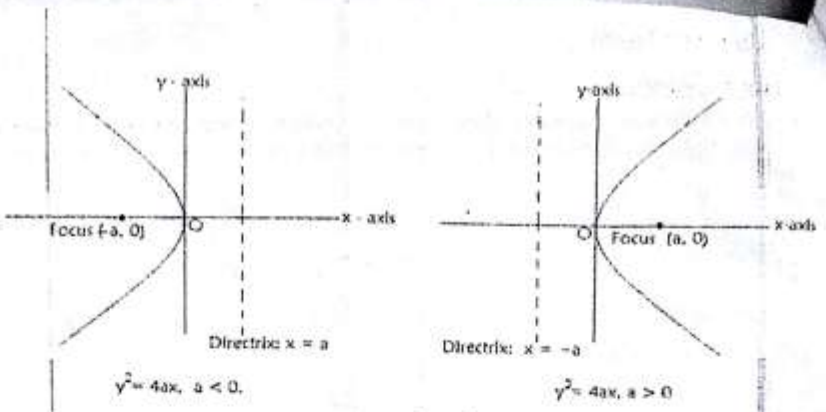

Figure 2

1.2.2 When the vertex is at the origin and the axis coincides with the y-axis, the equation of the parabola is $x^2 = 4ay$, where:

Coordinates of Focus:	$x = 0$, and $y = a$
Coordinates of Vertex:	$x = 0$ and $y = 0$
Equation of Directrix:	$y = -a$
Equation of axis of symmetry:	$x = 0$.

If $a > 0$, the parabola opens upward; if $a < 0$, the parabola opens downward.

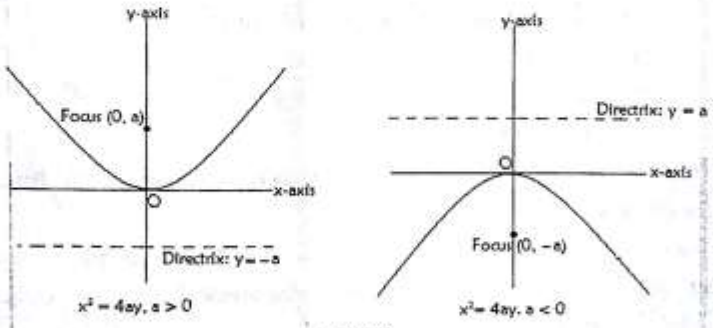

Figure 3

Example 1

A parabola has the focus at (3, 0) and its directrix is the line $x = -3$.

(a) Write down the standard equation of the parabola.

(b) Find the equation of the axis of symmetry and the coordinates of the vertex.

Solution

Let P (x, y) be an arbitrary point on the parabola. The distance from P to the focus (3, 0) is the same as that from P to the directrix $x = -3$.

Appendix 9: Sample of Test Paper

EXAMINATION COUNCIL OF ZAMBIA

IN ASSOCIATION WITH

DEPARTMENT OF SCIENCES

Mathematics section

Third year Test one (internal)

Instructions

Answer all the questions

Marks are shown for each question

Show your working clearly to obtain full marks

Time: 1h50m

1. If $a = 9i - 2j - 6k$ $b = 2i - 6j + 3k, c = 2i - j + 2k$. Find;
   (a) $a.b$ **(1mark)**
   (b) The angle between a *and* b (to the nearest degree) **(5marks)**
   (c) bxc **(3marks)**
   (d) If the vectors $2si - 3j$ *and* $si + 6j$ *are perpendicular, find the values of* s **(3marks)**
2. OA and OB are two vectors that OA= $a + 2b$, OB= $2a - b$ and OA is perpendicular to OB. show that $a.b = \frac{2}{3}b^2 - a^2$ **(3marks)**
3. If $f(x) = 3x - x^2$, find $f'(x)$from first principles and hence evaluate $f'(4)$. **(6marks)**
4. Find the points on the curve $y = x^3 + 3x^2 + 6x - 10$ where the gradient is 3. **(3marks)**
5. Find the x coordinates and nature of the stationary points for the function

   $7 - 6x - x^2$. **(4marks)**

6. Find $\frac{dy}{dx}$,
   (a) $y = 3x^6 - 2x^2 + 6x - 8$ **(2marks)**
   (b) $y = (5x - 3)^6$ by chain rule **(3marks)**
   (c) $y = \frac{2x-x}{3x+1}$ by quotient rule **(4marks)**
   (d) $y = x^2 sin3x$ by product rule **(4marks)**
7. Find the equation of the tangent to the curve $y = x^2 + 5x - 2$ *at the point where this curve cuts the line* $x = 4$ **(3marks)**
8. If $x = \frac{1+t}{1-2t}$ and $y = \frac{1+2t}{1-t}$,where t is variable find the value of $\frac{dy}{dx}$ when $t = 0$ **(5marks)**

END