IMPLEMENTATION OF AN OUTCOME BASED MATHEMATICS CURRICULUM: A CASE OF A SELECTED SECONDARY SCHOOL IN KAFUE DISTRICT

BY

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A dissertation submitted to the University of Zambia in partial fulfillment of requirements for the award of the degree of master of education in mathematics education.

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DECLARATION

I hereby declare that this project report entitled implementation of an outcome-based mathematics curriculum: A case of a selected secondary school in Kafue district was written by me and was my work and that it has not been submitted for a degree at other Universities.

Author's Signature:…………..………………………………… Date……………………………

APPROVAL

This research report of Janet SILWIMBA was approved as partial fulfillment of the requirements for the award of the degree of master of education in mathematics education by the University of Zambia.

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ABSTRACT

The Zambian curriculum has been objective based since independence until the year 2013 when it was revised to Outcome Based Education (OBE) under the theme “Putting theory into practice.” Therefore, an OBE curriculum aims to produce a learner who can showcase skills, values and competencies in society. The purpose of this study was to ascertain whether the revised mathematics curriculum was implemented by the secondary school mathematics teachers in accordance with the premises and principles underpinning it. The study employed the descriptive design in which qualitative approach was used to gather the data. Purposive as well as chance and willing sampling methods were used to come up with the five respondents which were four (4) mathematics teachers and a curriculum specialist from a selected secondary school and Curriculum Development Centre (CDC), respectively. Data collection methods comprised of interviews, Focus Group Discussions (FGD) and lessons observations. The data gathered through interviews, FGD, and lesson observations were analyzed thematically. Moreover, the data gathered through lessons observation were analyzed using the teaching triad. The findings revealed that mathematics teachers had the knowledge of OBE mathematics curriculum. They were also trained on the implementation of the general curriculum framework. However, the results showed that the mathematics teachers did not implement the design down and clarity of focus principles of the outcome-based curriculum. It is recommended that the Ministry of Education should train mathematics teachers in the implementation of Outcome Based Mathematics Education (OBME) curriculum and the course structure of which among others should focus on Planning and programming in OBME (identification and formulation of outcomes), Teaching and learning in OBME (mathematics lesson demonstration, strategies) and How to use the resources in OBME (text books, syllabus).

***Keywords**: Outcome Based Curriculum, Outcome, implementation, Teachers, CurriculumSpecialist, Mathematics Curriculum.*

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ACRONYMS

CDP	Continuous professional development
DEBS	District Education Board Secretary
ICT	Information Communication and Technology
MOE	Ministry of Education
OBE	Outcome based Education
OBME	Outcome Based Mathematics Education
SPRINT	School programs for in-service for the Term
SBCPD	School based continuous professional development
CDC	Curriculum Development Centre
ECZ	Examinations Council of Zambia

DEFINTION OF KEY TERMS

Outcome Based Education: An approach that derives the teaching and learning strategies, assessment strategies and the content from the learners are to demonstrate.

Outcomes: skills, values, competencies and knowledge learners are able to apply at the end of learning experience.

Implementation: putting into the practice what the system demands.

CHAPTER ONE: BACKGROUND INFORMATION

1.1 Introduction

This study investigated the implementation of an outcome-based mathematics curriculum in one of the selected secondary schoolsof Kafue District. This first chapter provides the background information of the topic under study. Furthermore, it covers the statement of the problem, purpose of the study, objectives of the study, and research questions. After that, the chapter describesthe significance of the study, theoretical frame work, delimitation of the study, limitation of the study, operational definitions and ethical considerations. The chapter ends with the summary.

1.2 Background to the study

Zambia attained its independence in 1964 from Great Britain. In this era, general aims of the primary education curriculum were to produce a self-reasoning learner, who had developed and acquired sufficient skills in primary school courses coupled with an understanding of an environment in which people lived, (MoE, 1962). The teachers then were required to build a concrete foundation for the learners in secondary school mathematics. In implementing the primary education curriculum teachers were required to follow recommended text books that covered the syllabus. Since 1964, three major changes had occurred in the education policy in Zambia.

The first change in the education system occurred in the year 1977. The curriculum was revised due to the kind of education that was being offered. It was viewed to be too academic to meet the demands of the country. As a result, the system was aligned to the ideology of humanism in order to address the challenges that were being faced then by the country. This ideology made education to be linked to the world of work. Implementing this change, the primary schools were changed to basic schools. Thus, covered grade one up to nine, while secondary schools were changed to high schools, that was grade ten to twelve. The idea was to produce a learner at grade nine who was to be self- reliant. The changes in the syllabus to address the new educational vision were affected in 1983. The syllabus was known as “Basic Education Mathematics syllabus: Grade 1-9 self-reliant” (Uchida, Nakamura, and Nkhata, 2007:111).

The basic education mathematics curriculum was aimed at enhancing the relationship between schooling and preparation for working life. Pupils, who underwent this curriculum, did not only acquire knowledge and skills that made them to be productive but also to be self-reliant after completion of grade 9.

In 1991, the education system was again changed. This change was as a result of the influences of the 1990 world conference on education for all in Jomtien, Thailand. Although there was that change, the kind of education was still objective based. The reform focused on primary education with hopes that when implemented, itwould help alleviate poverty, ignorance and promote economic and social development.

There was another change in the education system in1996. This was as a result of the ideology of multi-party system of governance. In this reform, a number of things suggested among others were the significance of mathematics and science in the development of the nation as well as the use of familiar language in Zambian schools, (for example, in Lusaka,chinyanja was used) and to localize the curriculum, include life skills of various categories as well as change to outcome-based education. This curriculum was then implemented where examinations were localized. The country started using its own syllabus. The syllabus incorporated subjects such as Arithmetic and Algebra.

In 2013,the Mathematics education curriculum was revised. However, the major change was from objective based to outcome-based curriculum. The reforms were hoped to address changes in social, economic, political and technology of the nation (MOE, 2014:3). The question was how then was this curriculum being implemented?

1.3 Statement of the problem

The outcome-based curriculum was officially launched in Lusaka at MumanaPleasure Resort under the theme "empowering learners by putting theory into practice" (MOEVTEE 2014:6). This implied that “teachers/trainers should not teach or train, but rather facilitate learning by stimulating creativity, self-learning and critical thinking” (Olivier, 2002:70). How then should mathematics teachers implement it? This curriculum was put in place in order to address some of the concerns in the old curriculum. Some of those were well documented in the (Educating Our Future policy document, (1996:26). Among them were “an excessively compartmentalized, overloaded and inflexible curriculum and a dominant examination system that placed heavy emphasis on factual information that did not assess critical learning areas, and that controlled much of the teaching and learning at the middle basic level". Outcome based education was adopted with the hope that it would address the concerns of teaching not responding to the needs of the society. This therefore meant teaching mathematics in real context, putting the learner at the centre of the learning activities as well as aiming for skills, values, competencies and knowledge as outcomes after a mathematics instruction. It is not known how teachers in mathematics class rooms are teaching or facilitating learning in an outcome-based environment.

1.4 Purpose

The study sought to explore how the revised outcome-based mathematics curriculum was being implemented in secondary school.

1.5 Objectives of the study

The study was guided by the following objectives:

1. To determine the process of change from objective based to outcome-based mathematics education in a school,
2. To establish mathematics teacher's knowledge of outcome-based education, and
3. To establish how mathematics teachers were implementing an outcome-based mathematics education curriculum.

1.6Research questions

The following research questions guided the study:

1. What process of change was affected in schools to adapt an outcome-based mathematics education from objective based curriculum;
2. What knowledge did mathematics teachers have on outcome-based education; and
3. How were mathematics teachers implementing an outcome-basedMathematics education curriculum?

1.7Significance of the study

This study is of vital importance in that the curriculum planners would be provided with information on whether the educators implemented the document in line with the conditions they had put in place. It is hoped that it would enhance the planners with relevant data to sensitize teachers on how to implement it. The school would be equipped with necessary information that would help them plan for the cluster meetings sothat teachers were helped to understand the outcome-based education.

1.8Theoretical frame work

According to Henning, Van Rensberg and Smite (2005), a theoretical framework acts as a mirror where the study is anchored or based. It therefore, enhances the formulation of the assumptions about the study and how it attaches with the world. It replicates the stance adopted by the researcher and thus frames the work; anchoring and facilitating dialogue between the interactive and research.

Therefore, this study was informed by constructivist theory as it had to a great extent what to offer to mathematics education. Besides that, constructivism is one of the theories that underpinned outcome-based education. Constructivism informed the study in that it points out how mathematics classroom should be conducted in an outcome based. It enhanced the researcher to check how the outcome-based mathematics curriculum was being implemented. According to the theory of constructivism:

1. The teacher should use learner centred approach when teaching
2. The teacher should provide pupils with opportunities to discover and learn mathematics processes
3. The teacher should act as a facilitator
4. The learner should construct his or her own knowledge
5. The learner should participate in the learning activities
6. The teaching triad should be the analytical framework for the lesson observation (Jaworski, 1994)

This theory advocates for active participation of learners in the learning activity if they are to construct knowledge. It also posits that knowledge cannot be inactively received. Constructivists are of the view that learners must be provided with an opportunity to discover and learn mathematics processes. Additionally, the teacher plays the role of the facilitator to stimulate the learners to master critical outcomes as revealed in the study of Oliver, (2007). Further, the teaching triad, which embraces the management of learning, sensitivity to student and mathematical challenge, was used to analyze the lesson observed. Jaworski (1994) developed a model which she called the "teaching triad" which was her construct/characterization of the teachers' activities in every aspect of a lesson at hand. The teaching triad is a composition of three categories under which a teachers' lesson can be analyzed: Management of Learning (ML), Sensitivity to Students (SS) and Mathematical Challenge (MC). The three elements are interlinked and interdependent.

ML describes the teacher's roles in the constitution of classroom learning environments and this includes organizing classroom groupings, planning tasks and activity; establishing norms and fostering ways of working. SS describes the teacher's knowledge of students thinking attention to their needs and the ways in which the teacher interacts with individuals and guides group interactions. SS has been shown to relate **Affective** and **Cognitive** dimensions of students' mathematical development. Affective to students include; offering praise, encouraging students to participate and dialogue which is SSA and Cognitive include; judging appropriate questions, inviting explanations, fostering negotiation and inquiry which is SSC. The third category MC, describes the challenges offered to students to engender mathematical thinking and activity in tasks set, questioning posed and metacognitive encouragement, (Jaworski, 2002). This would be used to analyze the lesson if the three components were achieved.

The construction of mathematical knowledge involves the teacher and the learner in a close collaborative process. The teacher designs the learning activities for the learners to construct the intended mathematical knowledge. Teaching as said was more easily observable than learning, however, what teachers actually do and achieve was never obvious, it requires meaningful analysis. Jaworski (1994) asks what she calls an intentionally naïve question to Paul Cobb a well-known mathematics educator and researcher: "If I just ask pupils to construct for themselves, how can I be sure that they will construct what I want them to construct?" Paul Cobb makes some important points in a short answer in response to this question. However, this study would attempt to provide a response to this Jaworski question drawing on what Cobb said as well as Jaworski's teaching characterization of the teaching triad and Vygotsky's Zone of Proximal Development

(ZPD). Construction of mathematical knowledge can take various forms; investigative style in a constructivism paradigm which Jaworski (1994) spent more time observing a number of teachers with various principles leading to investigative style in the quest of making learners construct knowledge.

Jaworski (1994) appears to put across a vital question though seemingly “deliberately naïve” as she had put it not only to Paul Cobb to respond but to the entire mathematics educators who practice investigative style of teaching embedded in a constructivist theory.

Paul Cobb, however, provides an answer in brief as quoted in Jaworski (1981) indicating that teacher tend to think that in a constructivist classroom learner are to be provided with learning materials. Then the teacher goes to attend to other things and comes back some other time expecting that learners have learnt. There is no sense in it because the teacher still remains an authority in the classroom consequently still teaches.

Cobb’s response was rich in a number of ways; firstly, he indicates that constructivism has been misunderstood by many who purport to practice it in a classroom situation by merely thinking that it’s giving learners activities and a teacher forgets and expect learners to construct learning in the right manner. Secondly, he strongly refutes this fact by indicating that after a teacher organizes the learning situation by making provision of teaching and learning materials needed; the teacher controls the classroom activities because he/she has authority on whatever is going on in the classroom and the teacher indeed still teaches.

Cobb’s answer has benefits in a number of ways which we can use to discuss the lessons which were observed in a number of ways. Firstly, a teacher plans the lesson before going to any class and indeed every lesson planned has objectives or outcomes to be achieved after the instructional process, time frame and activities which will lead to attainment of the set goals which the teachers did i.e. lesson planning.

Jaworski (1994) saw the tension between teachers having some particular knowledge which they want pupils to gain and the belief that they cannot give them the knowledge due to the influence of their belief of the philosophy of constructivism. The investigative style of teaching is the most recent version of instruction with minimal guidance which comes from constructivism, which observes that knowledge is constructed by learners and also; Learners need to have the opportunity to construct by being presented with goals and minimal information and Learning is idiosyncratic and so a common instructional format or strategies are ineffective (Steffe and Gale, 1995).

With this at play, the learners are first given instructions, motivated, monitored, assisted, timed and directed with materials to use in the task. These are what Jaworski (1994:182) called "teaching acts which enable students to acquire a principled understanding of mathematical knowledge". Above all, a teacher in any organized formal setting, has a responsibility to deliver the mathematical curriculum and this mathematical curriculum will identify the mathematical concepts which include knowledge such as Pythagoras theorem, Matrices, Probability, Trigonometry, Sets, with boundaries well defined in the syllabus (Jaworski, 1994), which a learner is expected to construct after an instruction regardless of the teaching style employed whether a constructivist approach or an expository teacher-centered approach. Above all, such concepts would be tested by standardized tests or examinations which will also require standard answers and a teacher from a constructivist perspective was, thus, led into a position of having certain knowledge to inculcate or elicit while recognizing the fact that learners can obtain knowledge through shared-meanings and negotiations in a social interaction setting. In this regard therefore, a teacher controls the classroom activities and directs the learning processes despite free environments provide to the learners. After group discussion or any activities, the teacher checks and monitors what the learners are doing and assists those who may stray from the direction of the lesson. The teacher provides a summary at the end to consolidate the diverse views from the learners through shared meaning so that assimilation and accommodation takes place.

In this respect, Jaworski question to Cobb can be answered within the concept of the teaching triad which offers the role of the teacher in any organized formal learning environments. A teacher organizes learning activities in the ML and considers the tasks to give to the students and also considering the social environments surrounding the classroom which are elements of SS and MC.

1.9 Delimitation of the study

O'Leary, (2010:65) considered delimitation as a study's boundaries or how your study was deliberately narrowed by conscious exclusions and inclusions, for example delimiting your study to children of a certain age only or school from one particular region. The study considered only four (4) mathematics teachers inclusive head of mathematics department (HOD) of a Government selected Secondary School in Kafue district and a curriculum specialist. Dueto the fact that the data was triangulated as focus group discussions, observations and interviews were used which resulted at a diffusion point.

1.10 Limitation of the study

O'Leary (2010:65), defineslimitations as conditions or design characteristics that may impact on the generalizability and utility of findings for instance small sample size or restricted access to records. The findings of this study were not generalized to other secondary school in the district resulting from it being purelyqualitative and small sample size.

1.11 Ethical considerations

Before going into the field an introductory letter from the Directorate of Research and Graduate Studies (DRGS) was gotten which was used to seek permission from the District Education Board Secretary (DEBs) to conduct the study in one selected secondary school in the district of Kafue. In turn, the DEBs also issued another introductory letter which was used to get permission from the head teacher to conduct the study in their school. The respondents were assured that the study was purely for academic purposes only. Additionally, they were also assured that the information would be kept confidential. They were also informed that they are free to withdraw if they fill so.

1.12 Summary of the chapter

Chapter one (1) discussed the history of the education curriculum changes from independence era up to date. Moreover, it looked at what necessitated and why conducted the study as well as the importance of the study. The research questions which reflect the objective were also discussed. Further, it converses the tenets of constructivism and the scope including the challenges of the study as well as the ethical issues. Lastly, it explained the key concept used in the study. The next chapter presents the literature review of the study.

1.13 Organisation of dissertation

The dissertation shows how mathematics teachers are implementing the outcome based mathematics curriculum. This was organised as follows: chapter 1 talks about what made the researcher conduct the research study and the tenets of constructivism as it informs the study, as well as underpins the outcome based mathematics curriculum.

Chapter 2 provides the literature reviews revealed in relation to what was done when the mathematics revised curriculum was affected in school. These were teacher training and purchasing of teaching and learning materials. It reveals also a model of change in an education system.

Chapter 3 explains how qualitative methods were used to address the problem. Chapter 4 presents the changes that occurred in school as a result of implementing an outcome based mathematics curriculum education. Moreover, the knowledge those mathematics teachers had on the outcome based mathematics curriculum education. Further, it shows how mathematics teachers were implementing the revised curriculum.

Chapter 5 discusses key findings that are teacher training and procurement of the teaching and learning materials in school. Chapter 6 gives the conclusion that mathematics teachers were not trained on how to implement the revised curriculum due to the kind of training they underwent. Nevertheless, teachers were knowledgeable concerning outcome based mathematics curriculum education.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Creswell (2012:80) defines literature review as a written summary of journal articles, books, and other documents like conference papers and government documents that describes the past and the current state of information on the topic of your research study. Therefore, the writer would review the literature of other researchers which informs the study.

This chapter reviews related literature of the study, under the following: implementationstudy, outcome-based study, continuous professional development on outcomes-based education, change model, mathematics teaching and learning, outcome-based education, and features of the outcome-based mathematics syllabus for secondary schools. These themes are used because they focus on the study and that are driven from the research questions.

2.2 Process of change from objective based to outcome-based mathematics education in a school

2.2.1 Zambia National Education Coalition (2016) found that there was inadequate orientation of teachers and education managers on the revised curriculum and the teachers who were trained on the outcome-based curriculum did not pass on the knowledge to other teachers. However, the duration of the orientation was between one and three days. Furthermore, the teachers did not have clear methodology for the revised curriculum, for instance for teaching numeracy. Teachers are goal keepers in the curriculum implementation. As such this study was relevant in that would help out to check what was done in the process to implement change. The gap was that the study did not look at classroom practice.

2.2.2 Since the introductory of OBE in South Africa there was a need to train teachers in order to prepare them for the implementation of outcome-based education. This was so because outcome-based education was differed from previous practice. However, the training of teachers for outcome-based education was not adequate. As a result, the implementation of outcome-based education and C2005 was seen not to be successful as expected due to a number of factors. Among other factors that deterred or hampered its implementation, insufficient professional development had more than others. The question was, would professional development of teachers produce effective teachers. The question was addressed in the literatures reviewed by Reimers (2003) on international literature of teacher professional development where it was considered to be one of the key elements in most of the educational reforms currently in progress in the world. Therefore, Ferreira (2010) conducted a case study on continuing teacher professional development through lesson study in South Africa. This study encompassed Mpumalanga secondary initiative where lesson study was put into use as well, described and its effectiveness reviewed. The aim of the study or project was to improve mathematics and science learning of secondary school learners using lesson study for teacher development. Therefore, several challenges were faced by most of the South African teachers who had inadequate knowledge, skills and competences and depended on the teacher talk and rote memory as the predominant mode of teaching and learning. The case was serious with mathematics teachers and science teachers, because of inadequate training in the previous political dispensation. The findings were that there were too few teachers qualified in mathematics, science and technology which had resulted in the poor quality of teaching in these subjects in schools coupled with lower learner performance in the subjects.

The study was relevant in that it entails that OBME practices differ from objective based mathematics education practices as such teachers' needs to be trained on how to implement it. Furthermore, inadequate teachers' professional development had negative impact on the implementation of the C2005 than others. As well as continuous professional development were to be held so to equip teachers with necessary knowledge and skills if they were to teach mathematics effectively and consequently produce competent learner. The gap is that the study was conducted in South Africa although it also looked at mathematics and science teachers.

2.2.3 According to the Ministry of General Education (2013), teachers had the professional responsibility to regularly equip themselves with necessary skills and knowledge. While the progression of implementing and embedding the revised curriculum continue, they were required to be up to date with educational developments. Due to the above reason every educator was supposed to be part of an appropriate group in order to grow professionally with the use of lesson study approach. The programme was part of School Programme of In-Service for the Term (SPRINT). Therefore, teachers should prepare and take part in continuous professional development (CPD) meetings that are held either in district, zones or at school level.

The Ministry of General Education, further pointed out that teachers should engage themselves in professional learning communities through social media that was face book, WhatsApp, twitter or face to face in venues like District Resource Centers and just to mention a few (Ministry of General Education, 2013). This creates an opportunity for teachers to discuss with colleagues within the country (Zambia) and around the World.

Additionally, they also alluded to the fact that schools were in better positions to understand the real needs of their students. Therefore, the Ministry pointed out that the school should make sure that the revised curriculum was implemented effectively so that every learner could progress. This could be done through strong leadership, were leaders of the school could develop as well as share good practices. By so doing the revised curriculum would in turn bear good fruit across the whole school. Figure 1 shows the roles of school leaders in ensuring that the revised curriculum is implemented effectively.

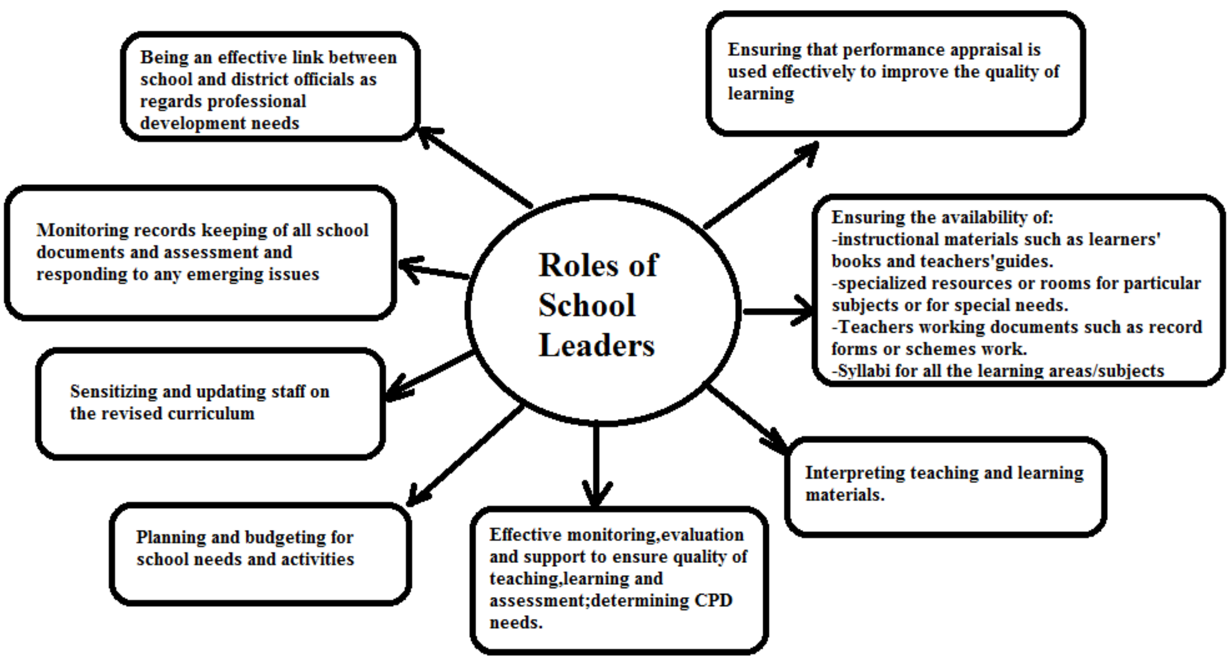


Figure 1: Role of the Headmaster

Source: **Ministry of General Education (2013:18)**

This study was relevant in that it entails that teachers should be taking part in programs such as school programs of in- service for the Term (SPRINT) and continuous professional development (CPD) meeting if there are to accelerate professionally and other communities that was social media through face book and whatsApp. Moreover, leaders should be strong and share good practices if it was to yield good practices

2.2.4 Onwu and Mogar(2007) conducted a study on the professional development for outcome-based education curriculum implementation. Professional development was stated to be one of South Africa's national goals in the continuing reform of its education system. The results of the study were that most of the teachers were not familiar with the teaching of outcome-based education and that there was need to train teachers so as to address the problem. Therefore, the systematic reform initiative for teacher development has been successful in improving the content knowledge, skills and attitudes of teacher participation in the foundation phase of the three years of its implementation. Data was gathered by the use of class room observation, questionnaires, survey and tests. The findings revealed that there was a positive impact of the project on teacher class room practice. The relevance of the study to this study was that it notifies that teachers were not familiar with the implementation of the revised curriculum as a result need for them to be trained. The gap is that the study was done in South Africa and also use of the questionnaires surveys and tests were given to the respondents.

2.2.5Aguerrondo (2008) revealed on the various dynamics of the processes of innovation and change. Therefore, she outlined four (4) phases of innovation in the context of the transformation of education. These were Genesis or Gestation, Setting in Motion, Development and Evolution and Effects and Sustainability. However, the focus would be on the Effects and Sustainability as this relates to objective one of the studies. In that it considers what things where done in the process of change, thus teacher training. In this phase among other things was the concrete ways in which personal training and development participant in the experience. This was of utmost significance when considering the difficulties encountered in non-traditional training strategies in most education reforms, to provide community educators with a sound personal and professional training. Another matter of equal importance was the search for alternative ways to organise educational government and administration. This literature was of utmost important to the study because it enlightens that teacher training was cardinal the process of change.

2.3 Mathematics teacher's knowledge of outcome-based education

2.3.1 Ramoroka (2007) conducted a study on the Educators understanding of outcome-based Education (OBE) and the impact it had on their classroom assessment practices. The study was qualitative where semi-structured interviews, observations, and document analysis were employed. Findings were that Teachers still had little understanding of outcome-based Education grounds and main beliefs. Furthermore, teachers do embrace the premises and principles of outcome-based Education in their classroom practices. This article informs the current study in the sense that if teachers do not understand or have little understanding of outcome based Education, it would be challenging for them to implement the0om OBE because "such understandings are likely to influence how they implement the OBE curriculum'' (Neofa 2010:ii) The study was done in South Africa and it looked at teachers in general and not mathematics teachers in particular.

2.3.2 Brandt (1992) conducted a conversation with Bill Spady on outcome-based education. During this conversation it was revealed that outcome-based education was about preparing learners for life not just for college or employment. They also talked about the definition of outcomes. They defined outcomes as acuminating demonstration of learning. Outcomes are simply demonstrations. It was further revealed, that, outcomes were not the curriculum content. That was, what learners will know. Or what they can recall on a test. But it is the performance that occurs at the end of the learning experience. Outcomes were what the learners were supposed to demonstrate at the end of the learning experience. Mathematics in the framework was an enabling outcome which enables the learner fit in real life roles not an end in itself. Mathematics should be taught or learned by linking it to real life problems, issues and challenges so that it meets the intended purpose. Furthermore, in this conversation, they discussed how outcomes-based education is different. As stated:

> *OBE can be defined in terms of four principles. The first, in shorthand form, is clarity of focus. That means that all curriculum design, all instructional delivery, all assessment design is geared to what we want the kids to demonstrate successfully at the real end not just the end of the week, the end of the semester, the end of the year but the end of their time with us. Principle number two is expanded opportunity. It means expanding the ways and number of times kids get*

a chance to learn and demonstrate, at a very high level, whatever they are ultimately expected to learn. Number three is high expectations, which means getting rid of the bell curve. We don't want bell curve standards, expectations, and results; we want all kids able to do significant things well at the end. The fourth principle is design down: design curriculum back from where you want your students to end up.

The OBE differs from objective based education based on the four principles. Those principles are clarity of focus, expanded opportunity and high expectations. As well as design down, thus, the content, teaching and assessment methods or strategies should be pointed at what the students are supposed to demonstrate not only at the end of the week, semester or the year, but in real life or society.

The study was of vital importance to this study in that it reports to that OBME exists to prepare learners for life apart from collage and employment. As well as outcomes are demonstrations and not the knowledge the learners pose. Moreover, teaching and learning of mathematics should be aligned to practical experiences of the learners. The gap was that it was the conversation with director of the recently established International Center on Outcome-Based Restructuring.

2.3.3 Spady (1994:1) defined outcome-based education as clearly focusing and organizing everything in an educational system around what was 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, then organizing curriculum, instruction, and assessment to make sure this learning ultimately happens. This shows that teachers should first identify the outcomes they want learners to be able to demonstrate. Furthermore, Spady said that Outcomes were not basically things students believe, feel, remember, know, or understand these and other similar things were all internal mental processes, rather than clear demonstrations of learning. Instead, outcomes are what students actually can do with what they know and understand. Subsequently, the content, teaching and assessment strategies should be in line with the outcomes as shown in figure 2.1**.**

THE LEARNING PERFORMANCE PYRAMID

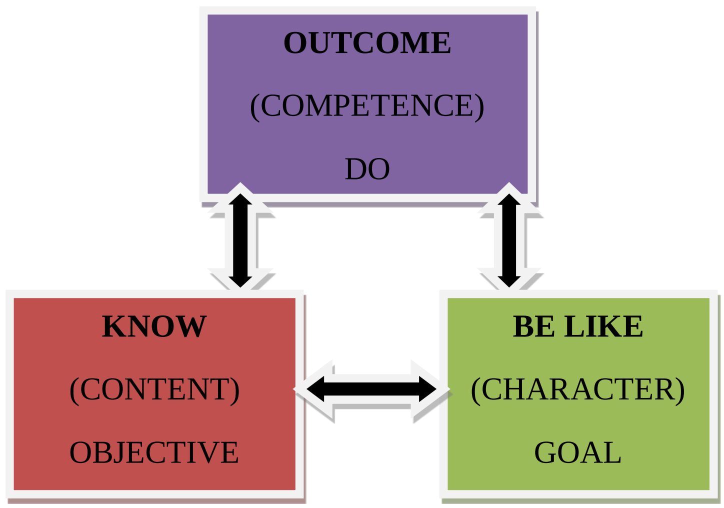


Figure 2.1 The Learning performance pyramid

SOURCE: Spady 1994

Spady (1994) further wrote that there were three premises and four principals underpinning outcome-based education. Those premises are; all students can learn and succeed, but not on the same day in the same way, Successful learning promotes successful learning and Schools control the conditions that directly affect successful school learning.

In the writings of Spady(1994), the premise all students can learn and succeed, but not on the same day in the same way took into consideration the differences in students' learning rates and learning styles therefore, educators should create opportunities for learners to learn and achieve the desired outcomes.

According to Spady (1994:10), the second premise stresses that successful learning rests on students having a strong cognitive and psychological foundation of prior learning success. This points out that when the pupil succeeds in one learning activity, she or might gain courage to take up challenging activities in following lesson with the idea that they would succeed.

The third premise considers schools to control conditions for success as it was the implementer of the curriculum, therefore it's important for the school to create conducive learning environment for students to learn and succeed.

Furthermore, there were four principles according to Spady (1994), namely clarity of focus, high expectations, and design down including expanded opportunity. The clarity of focus means that what the teachers do should be clearly linked to what they want the pupils to demonstrate. Learners should be unveiled with outcomes they were supposed to demonstrate in every learning activity.

Whereas high expectations meanincreasing the level of challenge to which students were exposed and raising the standard of acceptable performance they should reach to be called “finished” or “successful” (Spady,1994:16). This regarded that all learners could learn and succeed and that educators should set high standards for all pupils although slow learners might need more time to achieve them. The design down principle entailed that educators should plan their content, teaching and assessment strategies based on the outcome’s children are expected to demonstrate.

Additionally, expanded opportunity states that learners should be given more than one chance in which to learn and demonstrate their learning. This was combated in five different ways thus Time, Methods and Modalities, Operational Principles, Performance Standards, and Curriculum Access and Structuring are all significant aspects of providing and expanding students’ opportunities for learning and success (Spady, 1994:12).

Learning was not significant unless the outcomes reflected the complexities of real life and gave prominence to the life roles that learners would face after they had finished their formal education. Significant outcomes matter in the future (Spady, 1998:25). This showed that education programs should be based on future needs of the learners and society at large. As well as learners will be expected to demonstrate their achievements in context, thus in real life problem situations. This literature was relevant to this study because it stipulated clearly that OBME planning begin with identification of outcomes where the content, assessment and teaching and learning strategies are aligned. Outcomes are competencies of the learner. It further notifies of the four principles of OBME.

2.3.4 According to Killen (2006) teachers should have had started from where they wanted students to finish with, thus thought of what they want students to learn and reasons why they wanted them to learn those things. By so doing, teachers would have had clear outcomes and purpose of the

lessons. In the writings of Killen, outcome-based education required assessment to be approached differently from content-based curriculum which employed mainly norm referenced assessment. The major change was the emphasis on defining the standards that were required of the students rather than having the upper limit of performance in relation with the highest achieving learner. Another difference was pressed on the aligning of assessment with the outcomes achieved. The most cardinal about assessment was close alignment of outcomes learners were to achieve with the assessment task. However, if there was no correlation between assessment task and outcomes then the assessment results won't be reliable consequently invalid.
Furthermore, clarity of focus alluded to that assessment should link directly to long term outcomes and short-term outcomes which were driven from the long-term outcomes to be achieved by students. This would have been possible to determine which outcome was being tested by each assessment item. This also was another way to up hold the fundamental principles of assessment which stated that all assessment items must measure the intended purpose if they were to have valid results. The relationship between outcomes and assessment items also helped to make them reliable.

Killen (2006) wrote that if the principle of high expectation was to be followed assessment task must be challenging. This task should provide learners with scope to demonstrate deep and high levels of understanding and achievement. Further, alludes to that outcome-based programming made teaching purposeful and systematic. It also allowed pupils to discover, follow their interest and be responsible of their own learning. It as well enhanced learners in personal and academic development. Killen narrated that outcome-based education consist of three distinct but related elements, thus theory of education, systematic structure for education and partial approach to instructional practice. Therefore, there was need to align the systematic structure and the classroom practices with the theory to have the genuine outcome-based education. Furthermore, Killen (2000) states that in an OBE system, teachers or educators should not assume that all students would learn equally well from a strategy such as small-group discussion. Also, that they should not assume that all learners would learn the same things in any fixed period of time. If teachers were to help all learners to achieve the outcomes related to what they teach, they must be flexible in the way that they teach and in the expectations that they have for each student at any particular time. Teachers must accept that, in most lessons, learners would be at different stages of learning and, therefore, that they would be concurrently working towards different short-term outcomes.

The study was important because it revealed that assessment was not to consider the high mark of performance scored by the learner, but rather define the standards required for the learner. Moreover, that assessment be aligned to the outcomes as well as the assessment task be challenging. Furthermore, that teacher should not take it that all learners would learn in the same manner and at the same time in a small-group strategy. Therefore, they are supposed to be flexible and employ other methods.

2.3.5 Willis and Kissane (1995) reviewed literature on outcome-based education. Some of which was by O'Neil (1994:8) who revealed that ''*the futures of many students are compromised because the outcomes held for them are low or unclear...., some students and some schools are held to high standards while others are not'.* This suggests that schools should keep on reiterating the high standards to be achieved by all the learners.
Furthermore, they reviewed the literature by McDonald (1993:485) which stated that, ''*what is wanted is a community of striving in which the standards of achievement are plainly visible and plainly applicable to all, but in which support, time and structure all vary according to need"* This shows that, the school should consider defining same outcomes for all learners, rather than, differential outcomes. Hence, forth, schools will be held accountable for ensuring that the conditions necessary for student success exist in all schools.

The other literature reviewed was for Jasa and Enger (1994: 31) which revealed that '*Outcomes serve as the starting point, defining in broad terms what the student's competencies should be after they have completed the course. Next, assessment is considered. What skills, behaviours, attitudes and understandings signal the mastery of an outcome? These criteria help the teacher construct the course content, which in turn leads to daily instructional Strategies'* The above citation indicates that, in this OBME the teacher should identify the learning outcomes. These outcomes will serve as the starting point for planning. Thereafter, the teaching methods and the assessment strategies will be aligned to the outcomes. This study was cardinal in the sense that it pointed out that schools should keep emphasizing for the high standard for every learner. In addition, the identification of the outcome was the starting point for the teacher planning of the lesson.

2.3.6 Since outcome-based education was launched by the minister of education then Doctor John Phiri in 2013, as the recommended model for teaching and learning in the recent education reform, secondary school mathematics syllabus has been rewritten to follow the outcomes-based format as opposed to objective based syllabus. There were five components in the syllabus for the subject. These were teaching methods, time and period allocation, assessment scheme, rationale and general outcomes, (MoESVTEE 2013: 9). Each of the features was relevant to the study. In that the teacher would be equipped with the kind of teaching methods he or she was supposed to use thus subjective type of strategies and also use of a variety of teaching and learning strategies. The teacher would be capable of providing learning opportunities through time and period allocation as it stipulates hours allocated to the subject per week. Outcomes are cardinal to this study in that teachers would be required to link the assessment strategies, teaching and learning strategies including the content to outcome in their planning. In short, these features are important as they act as a road map to direct the teaching and learning practices in a classroom for teachers are implementers. These features were briefly described.

Teaching and learning methods entailed the teaching as well as the learning strategies that educators used to teach and that learners used to learn the subject. Outcome based mathematics education teaching and learning strategies were aligned with a constructivist theory of learning. The quote from Jaworski(1994:16) states that:

1. *Knowledge is not passively received but actively built up by the cognising subject;*
2. *The function of cognition is adaptive and serves the organisation of the experiential World, not the discovery of ontological reality*.

This entailed that teachers should have employed strategies that would actively engage learners in the learning process of the lesson consequently constructing their own knowledge as opposed to receiving the knowledge passively. The Outcome Based Mathematics Educations OBME promoted a learner-centred approach or pedagogy. This advocated of learners learning Mathematics in context of multipart, comprehensive and practical problems. Under such learning situations learners may be put in groups and required to identify what they already know, what they need to know and how and where to access new information that may lead to resolution of the problem, (MoESVTEE, 2013).

Further, the teacher should have had taken that role of a facilitator to facilitate learning, as well as provide appropriate scaffolding of that process by asking probing questions, providing appropriate resources and leading class discussions plus designing student's assessments. The approach attempted to transform the traditional teacher centred mathematics classroom situation into student centred environment completely where learners were allowed to construct new knowledge through, the specific outcomes learned, thinking processes such as communication, interconnections, reasoning, representations, problem solving and other similar ones: both mathematics and non-mathematical positive as well as universal values (MoESVTEE, 2013). Teachers should link the teaching of mathematics to real life problem situations of the learners. In other words, learners should learn practical applications of mathematics in real world situations. Coupled with the issue of the zone of proximal development (ZPD), where scaffolding through peer to peer by the use of groups should be encouraged. Time and period allocation cover the duration in which the content would be covered for a specific topic.

Assessment scheme comprises school-based assessment and final examination. This scheme should be prepared by the Examinations Council of Zambia (ECZ). Further, the ECZ should also develop examination syllabus in order to provide guidelines to teachers on the objectives to be tested. School based assessment examined whether students had acquired the stated outcomes or not and would contribute towards certification of all learners. This assessment should be in the form of tests. Also, test should be in the form of diagnostic, aptitude, achievement, oral, practice, attitude and performance, exercises, assignments, discussions, investigation, project work etc. (MoESVTEE, 2013). Outcome based mathematics education emphasised continuous assessment that should use various methods of testing according to topics and themes at various levels. Rationale justifies for the subject that establishes the subject importance, relevance and its place in the curriculum.

General and specific outcomes were specific statements that identified the knowledge, skills and values all learners should demonstrate at the end of the learning experience that could be in school, society and world of work.

Table 2.1

Sample of Outcome Based Mathematic Education Syllabus for Secondary School ((MoESVTEE, 2013)

TOPIC	SUB TOPIC	SPECIFIC OUTCOME	KNOWLEDGE	SKILLS	VALUES
12.1 GRAPHS OF FUNCTIONS	12.1.1 Cubic functions 12.1.2 Inverse functions	12.1.1.1 Draw graphs of cubic functions 12.1.1.2 Use graphs to find solutions 12.1.1.3 Determine gradients of curves 12.1.1.4 Estimate areas under curves 12.1.2.1 Draw graphs of inverse functions 12.1.2.2 Application of graphs of functions	• Drawing Graphs of cubic functions • Finding Zeros of the function, Solutions of graphs • Determining Gradients of curves • Turning points and their nature (Maximum and minimum) • Area under the graph (Counting square, Trapezium) • Drawing Graphs of inverse functions • Exponential graphs • Applying graphs of functions	• ***Identification*** of a cubic function. • ***Interpretation*** of gradients and areas under curves. ***Drawing*** graphs of cubic and inverse functions.	• ***Neatness*** in sketching graphs. • ***Logical thinking*** in determining area under the curve. • ***Accuracy*** in finding the turning points.
12.2 LINEAR PROGRAMMI NG	12.2.1 Linear programming	12.2.1.2 Draw graphs of linear equations and inequations in one and two variables (as a recap) 12.2.1.3 Shade the wanted and unwanted regions 12.2.1.3 Describe the wanted or unwanted regions. 12.2.1.3 Determine maximum	• Drawing graphs of linear equations and inequations in one and two variables (as a recap) • Shading the wanted and unwanted regions • Describing the wanted or unwanted region • Finding Values in the feasible region	• ***Interpretation*** of the wanted or unwanted regions. • ***Shading*** of the unwanted region. • ***Determination*** of maximum and minimum values.	• ***Logical thinking*** in finding the wanted region. • ***Planning*** when using graph paper.

9

The other parts of the OBME syllabus are topic, specific outcomes, knowledge, skills and values.

2.4Implementation of an outcome-based mathematics education curriculum.

2.4.1 Zakaria and Iksan(2006) conducted the study titled Promoting Cooperative Learning in Science and Mathematics Education: A Malaysian Perspective. The purpose of this study was to discuss the current shortcomings in science and mathematics education in Malaysia. Two pedagogical limitations were identified as the major shortcomings in traditional secondary education. These were lecture-based instruction and teacher-centered instruction. Lecture-based instruction emphasized the passive acquisition of knowledge. In such an environment, students become passive recipients of knowledge and resort to rote learning. This method was therefore not for conceptual understanding but rather for memorizing and recalling of facts. The use of cooperative learning was emphasized as an alternative to traditional method. Cooperative learning was grounded in the belief that learning was most effective when students were actively involved in sharing ideas and work cooperatively to complete academic tasks Teachers were expected to teach in a way that enables pupils to learn science and mathematics concepts while acquiring process skills, positive attitudes and values and problem-solving skills. A variety of teaching strategies had been advocated for use in science and mathematics classroom, ranging from teacher-centered approach to more students-centered ones. Teachers were also required to create opportunities for learners in class to assess group Promoting Cooperative Learning progress. Group processing enabled group to focus on good working relationship, facilitates the learning of cooperative skills and ensures that members received feedback. Therefore, cooperative learning represented a shift in educational paradigm from teacher-centered approach to a more student-centered learning in small group. It also created excellent opportunities for students to engage in problem solving with the help of their group. The study discussed the difficulties encountered in implementing cooperative learning.

The study was relevance in that it shows cased that lecture-based and teacher-centered instruction had a negative impact in the mathematics teaching and learning in the previous education, as them promote rote learning. However, encouraged cooperative learning as it promotes active learning. Moreover, use of different strategies in mathematics classroom including creation of learning opportunities. The gap was that the study was conducted in Malaysia and not in Zambia.

2.4.2 Another study by Kolawole (2007)was conducted to explore the Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in mathematics. The study aimed to find out which one of the two strategies was more effective learning strategy. It was achieved by comparing the academic performance of mathematics students taught with cooperative learning strategy and those taught with competitive learning strategy. It also compared the academic performance of girls and boy's mathematics students taught with cooperative and competitive learning strategies. The study sample comprised 400 senior secondary school, mathematics students out of whom 240 were boys and 160 girls. Participants were randomly selected from four out of five States in South West Nigeria. The study adopted quasi experimental design. Data was gathered by the use of two instruments thus MathematicsPre-Test Achievement Test (PTAT) and Post-Test Achievement Test (PAT). The data was analyzed by the Z- test at 0.05 level of significance. The findings revealed that cooperative learning strategy was more effective than competitive learning strategy and that boys performed significantly better than girls in both learning strategies. Based on the findings, it was suggested that Cooperative learning strategy should be introduced in the secondary schools in Nigeria.

The relevance of the study was that it enlightens the study that a cooperative learning strategy was more effective than the competitive learning strategy in a mathematics classroom. The gap is that the study was done in Nigeria. It also employed quasi experimental design; analyzed by the Z-test including the instruments for data collections were different that was mathematics pre-test Achievement test and Post-Test Achievement Test.

2.4.3 The study on the Impact of Motivation on Student's Academic Achievement and Learning Outcomes in Mathematics among Secondary School Students in Nigeria done by Tella (2007) revealed that gender difference was significant when there was an impact of motivation on academic achievement as the comparison was done in male and female students. Also other result indicated significant difference when extent of motivation was taken as variable of interest on academic achievement in mathematics based on the degree of their motivation. The purpose of the study was to explain learning outcomes in senior secondary mathematics in terms of motivating students towards academic gains in the subject, thus mathematics. The study design was ex-post facto design. Data was gathered by a modified instrument tagged Motivation for Academic Performance Questionnaire (MAPQ). The study sample comprised 450 secondary school students drawn from 10 schools in two local Governments areas in Ibadan. The participants were randomly selected from the secondary schools. Their age ranged from 15 – 22 years with a mean of 18.6 years and standard deviation of 3.6. The study included male and female students. The data collected were analyzed using inferential statistics which includes; student t-test and analysis of variance (ANOVA). The study was quantitative and questionnaires were used coupled with inferential statistics. The study was relevant in that it enlightens the study that motivation was important if learners are to produce good results. This was done in Nigeria.

2.4.3 Homero Flores (2010) found out that learning mathematics, doing Mathematics was a learner-centred teaching suggestion under development since 1998at the Colegio de CienciasyHumanidades (CCH), a high school system dependant on the National Self-directed

University of Mexico. It looked for the establishment of a Teaching and Learning Environment (TLE) in which learners worked and learnt working together, with open-mindedness, respect and responsibility and according to report of Barrett et al. (2007) to meet learners' needs implies the use of learner-centred pedagogies. The other trend is in the direction of learner-centred and outcomes-based pedagogies. This study was important because it notifies the study that learners are learning mathematics if they actually do mathematics as it was a learner centred approach, consequently meeting their needs. Thestudy was conducted in Mexico.

2.5 Summary of the chapter

The literature on the implementation and outcome-based studies provided that teachers were not adequately trained on that revised curriculum. Hence, they had little understanding of outcome-based education. However, they embraced the premises and principals of outcome based. It was further, pointed out that outcomes were not curriculum content. But they are the demonstrations that occur at the end of the learning experiences.

Moreover, it was discussed in this chapter under the study on continuous professional development and outcome-based education study that teachers need to be trained as they are implementers of that revised curriculum. The training should be done through CPDs in order to prepare teachers for the implementation of outcome-based education. Also, that information could be shared through social media; thus, face book, WhatsApp and twitter or face to face.

With reference to literature on mathematics teaching and learning, outcomes-based education and features of the outcome- based mathematics syllabus for secondary schools respectively, it was noted that the previous curriculum had major shortcomings in its pedagogy. Thus, promoted lecture-based and teacher- centered instructional strategies. These strategies promote passive way of acquiring knowledge which results in rote learning. However, in this revised curriculum cooperative learning is emphasized. Under which learners are enabled to share ideas and work cooperatively to complete academic tasks.

It was also highlighted in this chapter that teaching and learning of mathematics should be linked to real life problem situation as well as the syllabus comprises of the following; topic, subtopic specific outcomes, knowledge, skills and values.

Moreover, literatures reviewed were different from this study. In that others were general survey which did not consider classroom practices. Further, Strategies used to gather the data as well as to analyze the data were also different such as questionnaires, survey, test, conversation, quasi experimental design and Z-Test. Moreover, the studies were conducted in South Africa, Malaysia, Nigeria and Mexico. The coming chapter addressed methodology used to conduct the study.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents the path that was taken by the researcher to collect data. The chapter consists of the research design, study area population, study sample, sampling techniques, data collection instruments, data collection procedures and time line and also data analysis instruments and procedures.

3.2 Research design

Creswell (2009:3) definesresearchdesigns as "plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis''. This shows that research designs are steps followed to solve the problem or to answer the research questions. This study used a descriptive design which entails strategies that the researcher uses to depict the happening in the natural settings. A descriptive designwas employed in order to obtain a picture of how the outcome-based mathematics education (OBME) curriculum was being implemented at a selected secondary school in Kafue District. Consequently, qualitative approach was employed because "it is more than just a collection of data. It involves measurement, classification, analysis, comparison and interpretation of data". (Kombo and Tromp 2006:71) Triangulation was used in order to validate the findings of this study. According to O'Donoghue and Punch (2003:78),Triangulation is a "method of cross-checking data from multiple sources to search for regularities in the research data". Merriam (1995:54) observed that triangulation is where a researcher hears about the phenomenon in interviews, sees it taking place in observations, and reads about it in pertinent documents and he or she can be confident that the reality of the situation, as perceived by those in it, is being conveyed as truth-fully as possible. Therefore, this study used a combination of data collection instruments, sources and with dataanalysismethods.

3.3 Study area

The study was conducted atone secondary schoolin Kafue district. The school was chosen because it was convenient and also that it did not require a lot of funds.

3.4Study population

Bless and Achola (1988:66) defines population as "the set of elements that the research focuses upon and to which the results obtained by testing the sample should be generalized". In this study, thepopulationincluded all the teachers and the Head of departments of sampled secondary school in Kafue District. Additionally, the entire curriculum specialist at Curriculum Development Centre were also consulted for further information.

3.5 Sample size

According to Sidhu (2006: 253), sample refers to a "collection consisting of a part or subset of the objects or individuals of population which was selected for the express purpose of representing the population. Further, Bless and Achola (1988:67) definedsample as "a subset of the population". For this study thesample size consisted of the head of mathematics department, three mathematics teachers from the population study and also one curriculum development officer. The study sample was a total of 5 participants.

3.6 Sampling techniques

The respondents were purposively selected from the population. Purposive sampling was used to select the head of mathematics department and the mathematics teachers from the study population. Whilst the curriculum specialist was first purposefully followed by chance and willing. Since the topic was based on mathematics, mathematics teachers were chosen because they were only likely to be knowledgeable and informative about the topic of discussion,(McMillan and Schumacher, 2001).It is for this reason that Sidhu (2006:265) observed that the investigator or researcher selects a particular group or category from the population to constitute the sample because this category is considered to mirror the whole with reference to the characteristic in question.

3.7 Data collection instruments

3.7.1 Interviews

Data was gathered by means of the interviews, observations andfocus group discussions. All the three means of data collection were recorded. The researcher conducted semi-structured interviews because they wereby and large unrestricted questions that were few in number and proposed to draw out views and opinions from the participants. This view is also supported by Crewell(2009).

3.7.2 Observations

Observations were employed to determine whether the mathematics teacher's opinions were tallying with their practices in their classrooms. Observations were simplytools used to determine how mathematics teachers implemented the curriculum in accordance with the premises and the principles of the OBE in classroom. According to Tuckman (1994) what should be observed, is the event or observable fact in action. He further observed that qualitative educational research observation means sitting in the classroom in an unobtrusive manner as possible and watch educators deliver a programme to students.

3.7.3 Focus Group Discussions

Focus group discussions were also employed to collect data related to the topic forit should"unveil information on the participant's beliefs and perceptions on a defined area of interest" (Komboand Tromp, 2006:96).

3.8 Data collection procedure

For the research objectives to be achieved, interviews, focus group discussions and observations with selected mathematics teachers and curriculum specialist were conducted to gather information on the implementation of an outcome-based mathematics curriculum. Interview schedule with open ended questions coupled with the observation check list were prepared in advance.

The first focus group discussions were conducted with the three mathematics teachers and head of mathematics department making a total of four respondents. This was followed by lesson observations of the three teachers. Additionally, views were conducted with the curriculum specialist. This because the researcher wanted to establish whether what was discussed corresponded with what was observed coupled with data from the interviews. During these interviews, focus group discussions and observations video recordings were done where the respondents consented.

3.9 Data analysis

The data collected in this study was analyzed thematically by categorizing topics that were related together. Only relevant to information to the research questions and objectives was consulted. The coding was done based on the samples of the data collected. Major topics covered were grouped and key quotations were highlighted and interrelated. The major themes were indicated in the margins. Furthermore, the coded materials were placed under the major topics. Lastly, the summary report was written identifying major themes and the relations between them.

During observations, the check list was used to check the data and also the teaching triad was used as the analytical framework. The teaching triad consist of three domains thus management of learning, sensitivity to students and mathematical challenge. Data was analyzed by taking into consideration the three domains. The data from the observation was analysed by the use of the teaching triad. In a constructivist mathematics classroom, lesson observations are analysed using the teaching triad. Also, that constructivism was one of the theories that underpinOBME. Therefore, constructivism theory of teaching and learning links to the principles of outcomes-based mathematics education. The relationship between the three components of the teaching triad and the OBME principles are shown in the Table 3.1.

OBME'S PRINCIPLES

- Clarity of Focus
- Expanded Opportunity
- High Expectations
- Design Down

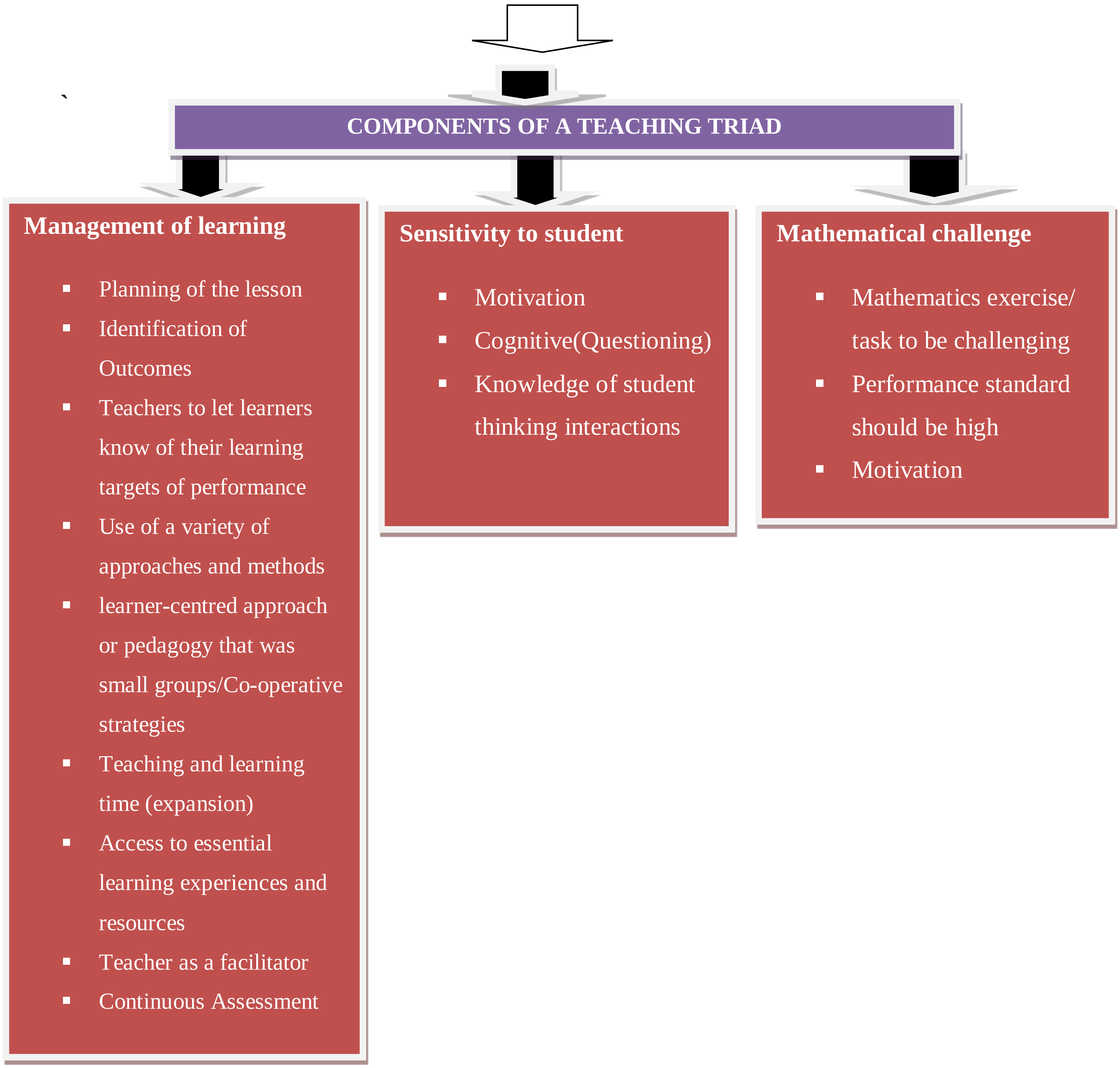


Figure 3.1 Relationships of the Teaching Triad and the OBME Principles

The mathematics teachers need to have a clear picture of what learners are to demonstrate. In other words,the need to identify the learning outcomes, thereafter, links to it the content, assessment and teaching and learning strategies. Teachers also need to create learning opportunities by use of a variety of teaching and learning strategies as time can allow. The things mentioned above feeds in the management of learning, however, ways in which the teacher interacts with the learners as well as issues to do with motivation coupled with how questioning was being done points to the sensitivity of students. Moreover, they set high standards for every learner. For all the learners could learn and succeed though not on the same time and in the same way. Additionally, the tasks prepared by the teachers' feeds in the mathematical challenge. These are of vital importance to the study in that they help out to check if the teachers were conducting the classroom practices in accordance with principals of OBME.

3.10Summary of the chapter

The chapter highlighted that thestudy used a descriptive design. In which the qualitative approach was applied. Consequently, purposive and chance and willing were employed to come up with the five (5) respondents. Further, it was brought to light that data was gathered through focus group discussions, interviews and observations. Additionally, data collected was analysed thematically couple with the teaching triadwhich was an analytical frame for lesson observation.

CHAPTER FOUR: PRESENTATIONOF FINDINGS

4.1 Introduction

The previous chapter presented the methodology used to gather the data. This chapter presents the findings of the study. These findings aim to find out how mathematics teachers implement the outcome-based mathematics curriculum at the selected secondary school in Kafue District.

The study aimed at achieving these three objectives: to establish mathematics teacher's knowledge of outcome-based education; to determine the process of change from objective based to outcome-based education in their school; and to establish whether mathematics teachers are implementing an outcome-based education mathematics curriculum.

In this study, the findings were drawn from the answers given by the 5 participants, of which 4 were mathematics teachers and a curriculum specialist. The data from the 4 mathematics teachers was collected through focus group discussions and lesson observations. Three of the mathematics teachers were observed teaching their classes whileone was not willing to be observed. Another interview was conducted to gather information from the curriculum specialist.

The data from the focus group discussion and interviews were analysed. Themes immerged from the responses of teachers and the curriculum specialist in relation to the research questions. These were; changes in school as a result of OBME introduction, Teacher knowledge of OBMEand Implementation of OBME in a classroom. Twelve (12) observations were conducted in the classroomsafter the focus group discussion. Each teacher was observed four (4) times.

4.2 Changes in school as a result of OBME introduction

The responses from the teachers suggested that the School bought books which were in line with the revised curriculum. The school also paid for internet facilities for staff to access the web resources to supplement the limited textbooks in the school on the revised curriculum. As one teacher stated:

> *''The school has bought copies of books (progress in mathematics text book) to use that are in line with the revised curriculum and we are privileged to have the Local Area Network internet, teachers are able to research for materials that are in line with the revised curriculum'' (Teacher A)*

This was in collaboration with the curriculum specialist from CDC who indicated that schools were free to purchase books from any publisher or bookshop as long as the books were appropriate for the learners and were in line with the revised curriculum. She said:

> "*Government has now liberalized the supply of books. Schools can buy either from a bookshop or private publishers. Materials were not there when they started rolling out the new curriculum. Teachers had no enough textbooks so that they teach effectively in schools. The materials that have been developed depending on this outcome-based curriculum are slightly different from the books that were developed before because these are activity based''* (Curriculum Specialist)

However, she further said that books were not there at the time the curriculum was being implemented. The curriculum specialist's understanding of OBME raises concerns about adequacy of teaching and learning materials. Challenges relating to teaching and learning resources were experienced by teachers at the time the curriculum was introduced. The developed books were different from the old ones in that they were activity based.

Teacher's responses indicated that training was there on the revised curriculum, although, it was not on the specific subject area, for example, mathematics. It would appear orientation was done on a general revised curriculum. This was done by the district. It further suggests that in the Directorate of Open and Distance Education (DODE) meetings through continuous professional meetings CPDs, teachers incorporated the revised curriculum. This was done at the mathematics departmental level. The motive behind was that they should teach each other on how best to implement it. This was stated by head of mathematics department that:

> *''....in the first place some members of staff were invited for a sensitization workshop that was held last year, thus 2016 to create awareness on the revised curriculum which was held by the district and it was I think during the third term but not all went there, but there was a presentation from those that went there, they presented what they learnt to the rest of the teachers in the staff room.'' ''We also have departments in our own DODE meetings; we look at also the syllabi and how best we can implement it so that it is really in full force'' (HOD).*

The responses of the teachers were also in line with those of the curriculum specialist. This suggested that teachers were oriented on the revised curriculum. The orientation was done before the curriculum was implemented, as curriculum specialist said *''before we rolled out the curriculum, we went into schools to actually orient them on the same matters, there was a small number of teachers who were involved in revising the curriculum'' (Curriculum Specialist). However,* she also added that few teachers participated in the development of the revised curriculum.

4. 3 Teacher knowledge of OBME

During the focus group discussions teachers were asked questions pertainingto outcomes-based education. This was to determine teacher's knowledge of OBME. Teachers' answers suggested that they were required to use different methods when teaching. They did not need to use one method of teaching. As teacher B indicated *'we need to give a variety of instructions or methods we don't only need to stick to one methodology in implementing your lesson, use variety of methods'.* The statement of the teachers correlated with that of the curriculum specialist.

The curriculum specialist also pointed out that teachers should use different kind of methods when teaching. The methods suggested could be those that were learner centred. These methods should be those that involved learners to do most of the work by themselves. As the curriculum specialist said *'Different types of methodology of course that has to do with the subjective learning where its most of the work has to be done by the learners'' (curriculum specialist)*

Teachers alluded to the fact that learners were also to be provided with the learning opportunities. This possibly suggested that learners should have hands on activities if they were to assimilate and understand what they were learning. As in the statements of teacher C

> *"provide opportunities for learners to practice what they know, because if that opportunity was not given to them we foresee a situation where it becomes a challenge for learners to really memorize or assimilate what they have just been taught by the teacher, but if they also get involved the opportunities provided for them to practice new knowledge and the way they understand issue I think that can go a long way'' (Teacher C)*

The curriculum specialist suggested as well that this type of education process did not allow teachers to do most of the work by themselves. It demanded mostly the learners to do practical work during the learning process. This would allow learners to develop skills by the end of the lesson. It was revealed in the responses of the curriculum specialist that *'Most of all the work was not based on the teacher alone, but want the learner also to do the practical work. The aim was to have learners who could have a skill at the end of learning''. (Curriculum Specialist)*

The Teachers' response seems to encourage the use of continuous assessment in OBME. That is the learners were to be assessed continuously. The Learners are assessed through the use of class exercises, assignments and questionnaires. These assessments are conducted during the learning process as well as at the end of each topic, for example, the HOD said:

> *'Assessment was continuous, we assess them in class, we assess them through class exercises, at the end of the topic we give them test and also three continuous assessment, in class there you can assess them by questioning them even by giving them class exercises, even by giving them assignment they can come and present' (HOD)*

Furthermore, teachers' response collaborated with what the curriculum specialist said. She submitted that teachers have to change the way they used to assess learners in the objective based mathematics education. In the current education learners are supposed to be assessed differently. She did not state how teachers should assess learners for there are no guidelines for them to follow. Furthermore, she seemed not to know how the assessment must be done. Curriculum specialist advocated that learners should even be assessed using the test prepared by the Examination Council of Zambia(ECZ). Curriculum specialist indicated that secondary schools have not been provided with the worksheet. On this worksheet teachers are required to record the results of the assessment.

> *"we are saying teachers must change the mode of assessing not necessary that we have put some rules which teachers must follow, those rules are not there, may be the way of just giving a test or an exercise and then you record and then at the end of the day you say have taught. So assessment must go on even the examination council type of assessment should be carried out there was a standard that have*

been put in place for recording for the lower level at primary level, known as record sheets, but with the secondary there was nothing, the record sheets have been provided at the primary level where results of the assessment should be written". (Curriculum specialist)

The other response from the teachers suggested that OBME was an education that involved learners in the learning process. The Learners were required to do most of the activities than the teachers themselves. For example, Teacher A said *''An education where by learner activities dominates teacher activities or in simple terms where the pupil learn by doing not whereby they just receive the information they need to be part of the learning''(Teacher A)* . They further pointed out that OBME was an education that centers everything on what they want the learner to achieve at the end of the learning experience that was the learning outcomes. For instance, the HOD said that *''an approach that focuses on what pupils are able to do after they are taught''. (HOD)*

The other responses of the teachers suggested that the previous curriculum considered the learner as a person who came to class without the prior knowledge. Nevertheless, teachers in the old curriculum were viewed to be the source of the knowledge. Learners were non-active as the teacher dominated the learning process. However, in the revised curriculum learners were viewed to have information on every topic as they come to classroom. Teachers were expected to create a conducive learning atmosphere for learners to construct their knowledge. Learners were active in this kind of education as they were involved in the learning process. As Teacher B stated:

''in the previous one we are saying that a pupil was viewed as an empty vessel where teacher will just go in and pump in the knowledge, but under this one is a two way system, a teacher will just create an environment where pupils now take a strategy of actually learning they have something in their mind also on each and every particular topic they are not complete empty, give ideas, create a platform were pupils take part in the lesson and it is believed that when they pick some ideas the same pupils they may not easily forget they believed that they own the lesson''(Teacher B).

Teacher's submission indicated that the previous curriculum was targeting the learner to be able to respond to the exercise after the learning experience in the classroom environment. The Learners did also not see the importance of them undergoing learning at schools. Besides, the learners were required to construct their own knowledge while the teachers were to act as facilitators and also provide learning opportunity in which learners could learn and achieve the outcomes, although it could not be in the same way or at the same time. However, in this current education system, it aims at learners to possess skills and be able to demonstrate what they hadlearnt. For example, the HOD said:

> *‘‘The objective one was just to class room to make sure by the end of the lesson pupils should be able to answer these questions, they do not see the value of what they are learning, we are seeing a situation where the revised one trying to make the product that will value what they are learning based most of the work on the teacher. I understand that with this kind of an approach learners will have to drive their own learning and so for the weaker students when you are there as facilitator and ensure that we give them some catch up work to do so that they also learn what you want them to learn’’ (HOD)*

In relation to what the teachers submitted, the curriculum specialist also indicated that the previous curriculum held teachers as source of knowledge. It did not consider the learner to have had prior knowledge. The revised curriculum put more emphasis on the learners having hands on activities throughout the learning process. As indicated by the curriculum specialist:

> *‘‘The teacher will go to class to teach, treating teacher to have all the information. The teachers at the end of the teaching will be evaluated by her or him over learner’s performance. Whilst outcome based “most of all the work is not based on the teacher alone’’ (Curriculum Specialist)*

4.4 Implementation of OBME in a classroom

Teacher A,B and C were observed in their classrooms. Each teacher was observed four times. The results were tallied as shown in Table 4.1. The results are presented under the themes; class organization, introduction of the lesson, strategies used: learner centered, lesson planning, roles of the educator and assessment of the lesson. As earlier alluded to that the OBME was underpinned by constructivist theory. This stipulates how the mathematics classroom practices should be conducted. These themes were derived from Ministry of Education(2013); Spady(1994)and Killen(2000).They clearly point out that teacher should employ multiple teaching and assessment strategies. The teaching methods should be those that are learner centred. Also conduct continuous assessment in the teaching and learning process. They as well encouraged teachers to apply the OBME approach to small segments of learning and toact as facilitators

Further, teacher was encouraged to use a design down approach in their planning of the lesson.

Table 4.1 Observation Tally Marks

		Teacher A	Teacher B	Teacher C
CLASS ORGANISATION	**Small group**	////	////	////
	Whole class	xxxx	xxxx	xxxx
INTRODUCTION OF THE LESSON	**context**	xxxx	xxxx	xxxx
	Linked To learners real life situations	xxxx	xxxx	xxxx
	Revision of the previous lesson	////	////	////
STRATEGIES USED: LEARNER CENTRED	**Group work**	//	/	//
	Whole class	//	///	//
	Field trip	xxxx	xxxx	xxxx
LESSON PLANNING	**Lesson planning works on a design down principle**	xxxx	xxx /	xxx /
ROLES OF THE EDUCATOR	**Mediator or facilitator**	////	////	////
ASSESSMENT OFTHE LESSON	**Assessment linked to assessment criteria or standard**	xxxx	xxx /	xxx /

Key to Table 4.1

×Means a number of times the teacher did not apply the concept according to the OBME.

/ Means a number of times the teacher applied the concept according to OBME.

4.4.1 Class Organisation

Observations were conducted in the three classes. Two of these were grade eleven (11)classes and there were forty learners in each class. A grade twelve (12)class had 48 pupils. The results from the observations suggested that the classes were organised into small groups as prescribed in the OBME principles which stated that teaching small classes were more effective than large classes. Furthermore, it was observed that in each class pupils were paired; that is on each desk there were two learners despite the desks being a three occupier. Also that none of the teachers A, B and C used whole class sitting arrangement. The learners were not sitting individually, but in pairs.

4.4.2 Introduction of the Lesson

The way the lessons were introduced by teachers A, B and C in the twelve observations suggested that all the three teachers revised the previous lessons in the four observations. For instance, Teacher B revised with the class on the n^{th} term of the arithmetic progression (AP). The teacher established the prior knowledge of the learners before the lesson of the day. The teacher solved the following problems with learners ;*(1) the n^{th} term (T_{n}) of anAP is given by $T_n = 3- 5n$. Find:*

(a)(i)The 8^{th} term,

(ii)The 21^{th} term

(b) What is the first term?

C) What is the common difference?

(2) If x + 1, 2x – 1 and x+ 5 are three consecutive terms of an AP, Find the value of x.

<u>SOLUTIONS</u>

(a)(i)$T_n = 3 - 5n$

$T_8 = 3 - 5\ (8)$

$T_8 = 3 - 40$

$T_8 = -37$

(ii)$T_{21} = 3 - 5(21)$

$T_{21} = 3 - 105$

$T_{21} = -102$

(b) $T_1 = 3 - 5(1)$

$T_1 = 3 - 5$

$T_1 = -2$

(C)$T_2 = 3 - 5(2)$

$T_2 = 3 - 10$

$T_2 = -7$

∴*Common difference* $= T_2 - T_1$

$= -7 - (-2)$

$= -7 + 2$

$= -5$

(2)x + 1, 2*x* –1, *x*+ 5

$(2x - 1) - (x + 1) = (x + 5) - (2x - 1)$

$(2x - 1) - (x + 1) = (x + 5) - (2x - 1)$

$2x - 1 - x - 1 = x + 5 - 2x + 1$

$2x - x - 1 - 1 = x - 2x + 5 + 1$

$x - 2 = -x + 6$

$x + x - 2 + 2 = -x + x + 6 + 2$

$2x = 8$

$$\frac{2x}{2} = \frac{8}{2}$$

$x = 4$

Subsequently, the teacher connected to the lesson for the day which was on arithmetic mean. That was by asking learners what the term mean was. Learners thereafter, responded that it was an average of the two given terms. The teacher consolidated by saying yes, given the sequence3,8,13, 8was the arithmetic mean between3 and 13, as $\frac{3+13}{2} = \frac{16}{2} = 8$and posed a question to learners to solve on the arithmetic mean, of which the learners did. The teacher thereafter, asked one of the learners to come to the front and present the findings of his computation to the class. Thus, find the three arithmetic means between 7and 19.

SOLUTIONS

Let,$a_1 = 7$ and $a_5 = 19$. Then $a_2, a_3$and a_4 are the three arithmetic means

Common difference; $a_5 = \quad a_1 + (n-1)d$

$$19 = 7 + (5 - 1)d$$

$$19 = 7 + (4)d$$

$$19 = 7 + 4d$$

$$19 - 7 = 7 - 7 + 4d$$

$$\frac{4d}{4} = \frac{12}{4}$$

$$d = 3$$

So, $a_2 = a_1 + d = 7 + 3 = 10$

$a_3 = a_2 + d = 10 + 3 = 13$

$a_4 = a_3 + d = 13 + 3 = 16$

∴The three means were 10,13 and16.

Teacher C in one of the four (4) lessons observed introduced the lesson by asking the pupils who were assigned a mathematics research problem (project) to research on to present their findings to the whole class. While in the other three lessons the teacher introduced the lesson by revising. This was either in groups or individually. For example, two pupils were given a mathematics problem on cubic functions where they were required to solve graphically to find the solutions to the problem. The students presented the work accordingly; they worked in pairs. One explained the proceedings; whilst the other drew a graph.

Additionally, teacher C asked other learners to clap for the pair after they had presented the work as a way of motivating them. Thus the teacher introduced the lesson of the day.

Furthermore, in the twelve lessons observed, none of the teachers A, B and C introduced the lesson using a real-life situation or context. However, lesson introduction was done by revising the previous lesson. The teacher asked learners to find the midpoint of A (6,-6) and E (14, 2) before looking at the day's work on gradient of straight line. Learners were asked to do this in five minutes, of which they did. After which one of the learners was asked to present the findings to the class. The learner solved it as follows:

$$m.p = \frac{x_2 + x_1}{2}, \frac{y_2 + y_1}{2}$$

$$m.p = \frac{14 + 6}{2}, \frac{2 + (-6)}{2}$$

$$m.p = \frac{20}{2}, \frac{-4}{2}$$

$$m.p = 10, -2$$

Thereafter, the teacher consolidated and asked the learners to find the answer to the questions:

(a) *If the gradient is 10, of the points (2a, 3) and (1,-2) find the value of a.*

(b) *Find the gradient and y- intercept of the equation* $x - y = 1$.

SOLUTIONS

(a) $m = \frac{\boldsymbol{y_2 - y_1}}{\boldsymbol{x_2 - x_1}}$

$$10 = \frac{-2-3}{1-2a}$$

$$10(1-2a) = -2-3$$

$$10 - 20a = -5$$

$$-20a = -5 - 10$$

$$\frac{-20a}{-20} = \frac{-15}{-20}$$

$$\therefore a = \frac{3}{4}$$

(b) $x - \boldsymbol{y} = \mathbf{1}$

$$\boldsymbol{-y = -x + 1}$$

$$\boldsymbol{\frac{-y}{-1} = \frac{-x}{-1} + \frac{1}{-1}}$$

$$\boldsymbol{y = x - 1}$$

$$\therefore \boldsymbol{m = 1} \qquad \boldsymbol{and} \qquad \boldsymbol{y - intercept = -1}$$

4.4.3 Strategies

The observation tally mark 4.1 indicates that Teacher A andCused group work in two lessons and Teacher B used group work once. For example, Teacher C gave learners the problem on the topic cubic functions and the lesson was on graphical solutions of cubic functions. The task was (a) Draw the graph of the expression: $y = x^3 - 2x^2 - 5x + 6$ for $-3 \leq x \leq 4$. (b) Use the graph to solve the equation $x^3 - 2x^2 - 5x + 6 = 0$.

SOLUTION

$$y = x^3 - 2x^2 - 5x + 6$$
$$y = (-3)^3 - 2(-3)^2 - 5(-3) + 6$$
$$= -27 - 2(9) + 15 + 6$$
$$= -27 - 18 + 15 + 6$$
$$= -24$$

$$y = (-2)^3 - 2(-2)^2 - 5(-2) + 6$$
$$= -8 - 8 + 10 + 6$$
$$= 0$$

$$y = (-1)^3 - 2(-1)^2 - 5(-1) + 6$$
$$= -1 - 2 + 5 + 6$$
$$= 8$$

$$y = (0)^3 - 2(0)^2 - 5(0) + 6$$
$$= 6$$

$$y = (1)^3 - 2(1)^2 - 5(1) + 6$$
$$= 1 - 2 - 5 + 6$$
$$= 0$$

$$y = (2)^3 - 2(2)^2 - 5(2) + 6$$
$$= 8 - 8 - 10 + 6$$
$$= -4$$

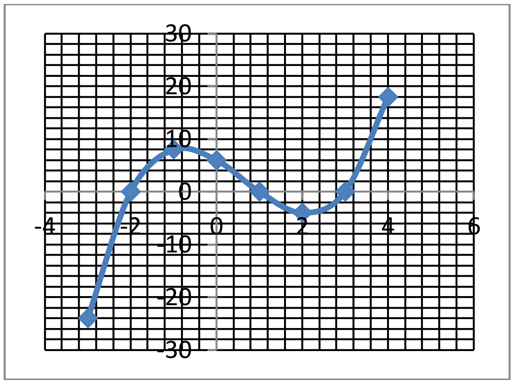
$$y = (3)^3 - 2(3)^2 - 5(3) + 6$$
$$= 27 - 18 - 15 + 6$$
$$= 0$$

$$y = (4)^3 - 2(4)^2 - 5(4) + 6$$
$$= 64 - 32 - 20 + 6$$
$$= 18$$

Table 4.2 x and y values of $y = x^3 - 2x^2 - 5x + 6$ for $-3 \le x \le 4$

x	−3	−2	−1	0	1	2	3	4
y	−24	0	8	6	0	−4	0	18

Figure 4.3 Graphshowing the rootsof the equation x3 – $2x^2 - 5x + 6 = 0$



Or y = $x^3 - 2x^2 - 5x + 6$

$$= 3 \times 1x^{3-1} - 2 \times 2x^{2-1} - 5 \times 1$$

$$f'(x) \;=\; 3x^2 - 4x - 5 = 0$$

$$3x^2 - 4x - 5 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(3)(-5)}}{2(3)}$$

$$x = \frac{4 \pm \sqrt{16 + 60}}{6}$$

$$x = \frac{4 \pm \sqrt{76}}{6}$$

$$x = \frac{4 \pm 8.718}{6}$$

$$x = \frac{4 + 8.718}{6} or \frac{4 - 8.718}{6}$$

$$x = \frac{12.718}{6} or \frac{-4.78}{6}$$

$$x = 2.12 \quad or - 0.8$$

y = $(2.12)^3 - 2(2.12)^2 - 5(2.12) + 6$

y = 9.528128 – 8.9888 – 10.6+ 6

y = −4.06(2.12,-4.06) stationary point

y = $(-0.8)^3 - 2(-0.8)^2 - 5(-0.8) + 6$

y = −0.512 – 1.28+4+ 6

y = 8.208(-0.8, 8.21) stationary point

$$f'(x) \;=\; 3x^2 - 4x - 5 = 0$$

$$f''(x) = 2 \times 3x^{2-1} - 4(1) = 0$$

$$f''(x) = 6x - 4 = 0$$

$$6x - 4 = 0$$

$$\frac{6x}{6} = \frac{4}{6}$$

$$x = \frac{2}{3}$$

$$y = x^3 - 2x^2 - 5x + 6$$

$$y = \left(\frac{2}{3}\right)^3 - 2\left(\frac{2}{3}\right)^2 - 5\left(\frac{2}{3}\right) + 6$$

$$y = \frac{8}{27} - \frac{8}{9} - \frac{10}{3} + 6$$

$$y = \frac{8 - 24 - 90 + 162}{27}$$

$$y = \frac{8 - 24 - 90 + 162}{27}$$

$y = 2.07$ $(\frac{2}{3}, 2.07)$Point of inflection

Pupils solved the problems in groups. Teacher C thereafter, asked the representative from the groups to present the work to the whole class then discussed and concluded.

Besides that, in the majority of the lessons observed the teachers used whole class approach. That is, using every learner in class. For instance, when the teacher posed a question to the class, he or she expected responses from every learner in that class. This was different from assigning questions to pupils in groups. The teacher therefore expected answers from the groups. Teacher A and C used it in two occasions and Teacher B three times. As, Killen (2000) points out that the two approaches to teaching differ in a number of important ways, amongst other ways are what the teacher does, the organisation of instruction, how much the students are involved actively in learning as a well as how much the students are responsible for their own learning.However, in either approach, teachers have a central role as both the planner and the facilitator of student learning. The real difference was in how teachers' structure and mediate their students' learning.

Furthermore, in the observation tally mark on strategies used, it was clear that none of the teachers used field trip. This meant that no teacher had taken the learners out for the mathematics study tour during the period of study.

4.4.4 Lesson planning

As shown in the observation tally mark on the lesson planning, all the teachers planned their lessons before class time. However, teacher A did not follow the design down principle in the planning of the lesson in all the four (4) lessons observed. The designing down principle requires the identification of learning outcomes and any other thing connected to it. For example, Teacher A taught on gradient and equation of the line. The lesson objective was, by the end of the lesson learners are expected to know how to determine the gradient. Also, teachers B as well as teacher C did not abide to the principle of designing down in the three (3) lessons. For example, Teacher Btaught on the topic sequence and series and the lesson was on arithmetic mean. The lesson objective set was: given consecutive terms of an AP TPSBAT insert the arithmetic mean between them. As for Teacher C in one of the lessons observed the stated lesson objective was: given a question on cubic function learners should be able to find solutions graphically; doing so correctly was acceptable performance. According to Spady (1994) outcomes are things learners are able to do at the end of the learning experience. As such the standard criteria set were not outcomes because are not demanding for an action.

But in one lesson plan each of the teachers B and C applied the principle of designing down. For example, Teacher Btaught on the topic sum of an arithmetic progression and the Lesson objective was; pupils are expected to find the sum of an AP. This therefore, suggested that there was confusion in the sense that the lesson plan still reflected objective type of planning and yet what was phrased was an outcome.

Nevertheless, the components of the lesson plans for all the three teachers among other things were lesson objectives. The lesson plans were not composed of lesson outcomes as expected of an outcome-based mathematics education.

4.4.5 Roles of the teacher

All the teachers A, B and C acted as facilitators or mediators in all the 12 lessons observed, for example teacher B assigned learners with the problems in groups to find the solutions.

The questions were on the lesson of the day arithmetic mean. The questions were: (1) Find the value of x and y if $16, x, 6, y$for man arithmetic progression. (2) The numbers $m-1, 4m+1$ and $5m-1$ are consecutive of an AP, find the numbers.

(1) $16, x, 6, y$

$$mean\ x = \frac{16+6}{2}$$

$$x = \frac{22}{2}$$

$$x = 11$$

$$6 = \frac{11+y}{2}$$

$$12 = 11 + y$$

$$12 - 11 = y$$

$$y = 1$$

(2) $m-1,\ \ 4m+1,\ \ 5m-1$

$$4m + 1 - (m - 1) = 5m - 1 - (4m + 1)$$

$$4m + 1 - m + 1 = 5m - 1 - 4m - 1$$

$$4m - m + 1 + 1 = 5m - 4m - 1 - 1$$

$$3m + 2 = m - 2$$

$$3m - m = -2 - 2$$

$$\frac{2m}{2} = \frac{-4}{2}$$

$$m = -2$$

$$\therefore -2 - 1, 4(-2) + 1, 5(-2) - 1$$

$$-3, -7, -11$$

The learners were given the time limit in which to discuss and find the solutions. While the learners were discussing the teacher was going round to check the proceedings as well as provide guidance. For example, one of the pupils was asked to solve this question on the board as shown in table 4: if the gradient was 10 at the line passing line through the points (2a, 3) and (1,-2). Find the value of a.

Table 4 worked Example on finding the gradient of a straight line

x_1 y_1 x_2 y_2

m = 10, (2a, 3), (1,-2)

$$m = \frac{y_2 - y_1}{x_2 - x_1} \text{.........................(1)}$$

$$10 = \frac{y_2 - y_1}{x_2 - x_1} \text{.........................(2)}$$

$$10 = \frac{-2-3}{1-2a} \text{...........................(3)}$$

The learner came to the front and solved the problem on the board. The second (2) step of 4 the teacher guided the learners that the second part could not be equated to ten (10) when the values of the y_1,y_2,x_1 and x_2 have not been substituted. Teacher as well stated that the step was not necessary for it to be included.

After which one of the group representatives from each group came to the front and presented their findings to the whole class. Thereafter, the teacher consolidated and concluded the lesson.

4.4.6 Assessment linked to the criteria/ standard

The observation tally mark 4.1 suggests that the majority of the assessments were not aligned with the assessment criteria or standard. In that the four assessment tasks for Teacher A were not aligning to the criteria. As shown in the example given: (1) Find the gradient of the line passing through the points (3,-2) and (7,-2). (2) Find the gradient and the y- intercept of the following: (i) 2y = -4x + 6 (ii) y = - ½ x. (3) Find the equation of the line passing through (3, -2) and (7, -2). The standard criterion was by the end of the lesson learners are expected to know how to determine the gradient and the equation of the line. These three (3) questions posed to the learners were all demanding for an action. For the word ‘‘find’’ used in the three questions was an observable active verb. Thus, the learners were required to solve the problems such as; question (1) Find the gradient of the line passing through the points (3, -2) and (7, -2). **Solution:**

gradient$= \frac{y_2 - y_1}{x_2 - x_1} \left(3_{x_1}, -2_{y_1}\right), (7_{x_2}, -2_{y_2})$

$$= \frac{-2-(-2)}{7-3}$$

$$= \frac{-2+2}{7-3}$$

$$= \frac{0}{4}$$

$$= 0$$

Consequently, learners were demonstrating what they know thus the competence. This therefore, would enhance the teachers to measure if the learners have grasped the concept or not. However, the criterion that was set does not demand for the action, but points out the content the learner poses. This makes it impossible or difficult for the teacher to rule out whether learners have grasped the concept. As the teacher cannot tell what the learner knows unless he or she demonstrates. Therefore, this shows that the assessment tasks were not linked to the criteria.

Both teachers B and C in the three assessment tasks did not link them to the standard criteria. But only one was aligned to the standard criteria. For instance: Teacher B assigned pupils with exercises, out of the four exercises one was linked to the learning outcomes, although it was written as a learning objective. For instance, the lesson was on sum of an arithmetic progression and the exercise was: (1) find the sum of the first 30 terms of the arithmetic progression (AP): 17, 15, 13, $-, -, \dots \dots$..(2) S_8 of an AP was 116 and S_9 was 117. (a) Find the value of T_9. (b) Calculate the values of a and d. Lesson objective was: pupils are expected to find the sum of an AP. With reference to the questions posed and the standard criteria set, both stipulated for the action. Thus, the learner to demonstrate what he or she knows, nonetheless, this was not an objective but an outcome.

Also, Teacher C gave this exercise to the learners which was linked to the standard criteria: Draw the graph of $y = x^3 - 3x + 5$ for the values of x from -4 to 4. Use your graph to solve the equation $x^3 - 3x + 5 = 0$

Lesson objectives were: Given a question on cubic function, learners should be able to find solutions graphically; doing so correctly was the acceptable performance.

4.5 Summary of the chapter

This chapter shows that teachers were trained on the implementation of the general curriculum framework. Furthermore, an outcome-based mathematics education was an education that focuses on what learners are to demonstrate at the end of the learning experience. Also, those learners were to construct their knowledge. As well as, in the majority of their lesson planning was that of the objective based mathematics education. The following chapter presents the discussion of the findings.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

The previous chapter presented the findings of the study. The purpose of the study was to find out if the school administrators and mathematics teachers implemented the outcome-based mathematics curriculum in accordance with the premises and principles that underpin outcome-based curriculum.

The research objectives of the study were:to determine the process of change from objective based to outcome-based education; to establish mathematics teachers' knowledge of outcome-based education; and to establish whether mathematics teachers were implementing an outcome-based mathematics education curriculum.

This chapter discusses the major themes drawn from the interview, focus group discussion and lesson observations.

5.2 Changes in school as a result of the introduction of outcome the based mathematics education

One of the objectives was to determine the process ofchange from objective based to outcome-based education in the school. The findings in chapter four suggested that something was done to embrace the outcome-based mathematics education in the school. The things that were done in this school to embrace OBME were procurement of the teaching and learning materialsandteacher orientation.

The Curriculum specialist with regard to the information revealed on the availability of the teaching and learning materials indicated that, there were challenges with the teaching and learning materials in schools. There were no books in schools for teachers to use. She further pointed out that the books that were being published were slightly different from the old ones because the books under this outcome-based mathematics education had an activity at the beginning of each topic as a starter activity. The starter activity determined the prior knowledge of the learners.

Furthermore, the school's buying of books could be as a result of the government's liberalisation of supply of books to schools. These books had the outcomes at the beginning of each topic. The findings revealed that teachers deemed themselves to belucky because the school had bought them learners text books called Progress in mathematics textbooks (refer to appendix C). These books were in line with the revised curriculum.

In OBME,one of thepremisesstated that Schools control the conditions that directly affect successful school learning. The study school could control conditions of learning in a number of ways. Some of the ways the school could control the conditions of learning were: making sure that the human resource at the departmental level was adequate, planning was being done and purchasing the teaching and learning materials. (McDonald, 1993 as cited in Willis and Kissane,1995). This was of vital importance as Barrett et al. (2007) also stated that educators and learners need resources such as textbooks. These were the other dimensions of the expanded opportunity in OBME.The OBME principle of expanded opportunity is that teachers would be required to give more chances to learners to learn and demonstrate their learning.

The result of teacher orientation indicated that Teachers were orientated at the Zonal level. The zonal comprised of nearby schools grouped together within the district with the aim of sharing information. The workshops were organised by the District and a few teachers were invited to be trained as trainer of trainers. After undergoing this training, they went back to the school to train others. The content of the training was on the implementation of the general curriculum framework. Teachers were not oriented on the implementation of the mathematics curriculum. At school level, through school based continuous professional development meetings, teachers are trained how to implement topics like computers in their mathematics classrooms.

According to Spady (1994) OBME differs from objective based mathematics education. The four OBME principles make the two types of educations different from each other. This meant that there were changes in the ways the teaching and learning was being done. Therefore, there was need for teachers to be trained in the OBME curriculum.

It should be noted that successful change agents help make the connections between what needs to happen and how people make it happen. Aguerrondo (2008) recognized this fact when she tried to investigatediversedynamics of the processes of innovations and change. It was discovered in this change model that teachers should be trained in order to have the knowledge and skills needed to implement the required change that was from objective based mathematics education to outcome-based mathematics education.

Basing on the findings revealed on procurement of the teaching and learning materialsandteacher orientation, the change process was not smooth. In that teachers were not empowered with the necessary skills as they were oriented on the implementation of the curriculum frame work. The training should have been on the implementation of the mathematics curriculum. Further, the teaching and learning resources were to be provided before the implementation of the revised curriculum.

5.3 Teacher knowledge of OBME

The study objectivewaste establish mathematics teacher's knowledge of outcome-based education. The results in chapter four suggested that in OBME, teachers were required to use different methods in the teaching and learning process, create learning opportunities, and assess learners continuously which was not the case in objective based mathematics education.

The information given by teachers concerning OBMEsuggests that teachers should use different methodologies during lesson delivery which must be learner centred. Learner centred methods incorporate learners in the learning process. Therefore, OBME encourages a learner centred approach or pedagogy (MoESVTEE2013).In these strategies, teacher and learners collaborate so that they create a conducive environmentfor teaching and learning. Teachers were required to implement various strategies of teaching and learning so as to cater for individual differences in learners. Variety of teaching and learning strategies corresponded with the OBME principle of expanded opportunitieswhich teacherswere therefore expected to employ a variety of methods for students to learn. The need to use of several methods and instructional modalities to expand opportunities for successful learning for students was the key philosophy underpinning OBME (Spady, 1994).

Further, the responses to create learning opportunities showed that learners were to be provided with the learning opportunity for them to construct knowledge. Learning opportunity was the philosophical principle of OBME. The learners come to class with different capabilities thus,they work more or less at different times. Therefore, teachers should provide opportunities for each and every student to learn at a high standard. Opportunities could be through expansion of time,and emphasizing on the high standards to be achieved by all the learners(O'Neil 1994 as cited in Willis and Kissane, 1995). The emphasis on high standards would open students' motivational channels and their access to success. Furthermore, the design down would as well provide learners with a clear pathway to pursue and achieve desired learning. Additionally, Clarity of focus also enhances opportunity by creating a clear target for learning performance

The Findings on assessment of learners indicated that learners were to be assessed continuously. It could be in different ways. For instance, it could be in form of a class exercise or test. In OBME continuous assessment was recommended as it reflects teachers' knowledge. The secondary school under study was not provided with the record sheets were the school based assessment results could be recorded. This entails that the Examination Council of Zambia had not started adding the assessment results to the certification of all learners. Therefore, the Examinations Council of

Zambia would prepare detailed procedures on how continuous assessment would be conducted by the teachers. (MoESVTEE,2013).

OBME was an education whereby learner activities dominate teacher activities or where the pupils learn by doing and not just receiving the information. Additionally, it was an approach that focuses on outcomes pupils were expected to demonstrate at the end of the learning experience.Other information revealed that teachers were supposed to create learning opportunities for students to learn by practising. In other words, learning should be linked to real life situations, where teachers only act as facilitators. All these underpin the philosophical principles of outcome-based mathematics education. Basically, the four principles make OBME different from the previous education.

These reflected the knowledge teachers had on the difference of OBME from the previous one. Through engaging with the OBME literature, OBME was considered to be an education that bases everything the school has to do on what they want the learners to demonstrate at the end of the learning experience. That includes the content, teaching methods or strategies and assessment strategies which are linked to the outcomes.

Killen (2000) revealed that OBME was an approach of planning, delivering and evaluating instruction that focuses on the desirable outcomes of the learning experience. Teachers in this study revealed that OBME empowered them with the knowledge in planning; delivery and evaluating instruction that focused on outcomes that pupils were to demonstrate.

During interaction with teachers and the curriculum specialist on OBME, it was noted that they wereknowledgeable on tenets of OBME.One of the teachers pointed out that pupils should construct their own knowledge by actively being involved in the lesson.

Jaworski (1994) stated that knowledge was actively built up by the learner and not the discovery of the ontological world. Teachers reflected OBME tenet of involving pupils in the process of lesson delivery so that they construct knowledge. Learners should be actively involved in the learning process so as to construct his or her knowledge than to passively receive it. Constructivism was one of the theories that underpinned OBME, as it promotes learner participation in the learning process. The curriculum specialist indicated that teachers in OBME were to engage students in the teaching and learning process.

Teachers reflect the key principle of expanded opportunity of OBMEand play a role of a facilitator by creating an opportunity for learners to learn and succeed. Opportunity in OBME covers different dimensions. That was the time for teacher–pupil contact, time given to learners to learn before they are told to stop and the period of time learners are given to learn particular curriculum component. On the other hand, the teacher provides guidance to the learners.

5.4 Implementation of OBME in a classroom

During the twelve (12) lesson observations, a number of things were being checked. Such as class organization,introduction, strategies, Lesson planning, Roles of the teacher and Assessment linked to the criteria/ standard. Findings were tallied on the observation tally marks Table 4.2.1 of chapter four.

The results under class organization suggested that in all the three classes learners sat two per desk, though the desk could allow three learners at a time. Thisindicated thatthe enrolment numbers were considered. OBME promotessmaller classes than large classes because teaching small class was more effective than a large class (Spady, 1994).

The findings in the introductory section of the observation tally marks suggested that none of the teachers introduced the lesson using practical examples or linked it to real-life problem, issues, and challenges so that it becomes the tool it was intended to be and introduced it in context (Brandt, 1992). All of them on a contrary revised the previous lesson.OBME encourages teachers to teach mathematics using real problem situations of learners.

Learners come toclass with different capabilities and misconceptions. During revisions teachers could be in a position to identify the prior knowledge learners could have come with to class.OBME sits on the theory of constructivism in which teachers were required to establish the prior knowledge of the learners in order to link to the lesson of the day.

Teachers in OBME should use cooperative learning where group work should be employed. It was observed that teachers most of the times used whole class in which question and answer, discussion were used. For example, on the observation tally marks Group work was only used five (5) times as compared to whole class which was seven (7) times. This shows that teachers most of the times did not employ group work in their classes. Teachers used different teaching methods to expand learning opportunities for learners to learn and succeed.

However, Killen (2000) states that in OBME, teachers should not take it that all learners would learn equally well in using small group discussion strategy. And they would also not learn the same things in the given time. Therefore, teachers in this study were to be flexible to use whole class strategy during prerequisite time, rather than throughout the teaching process. Thereafter, learners were to be split in different pace groups where they would be given work in accordance with the level of ability in which they receive group or individual instruction. Learners in these groups should not be permanent but once the learner achieves the outcome, he or she move to join the group of the same capability.

Teachers planned their lessons before classes, but the way they were planned was a source of concern if at all principle of designing down was being followed. The principle of designing down means that all planning, teaching, and assessment decisions are made by tracing back to the learning outcomes (Brandt, 1992). One of the components of the lesson plan for all the teachers was learning objectives. This was an indicator of the objective based mathematics education. For example, Excerpt 5.1: by the end of the lesson learners are expected to know how to determine the gradient. However, on one lesson plan for teachers B and C the framing was that of a learning outcome although it was written learning objective. Excerpt 5.2: pupils are expected to find the sum of an AP.

Lesson plan in OBME should have learning outcomes showing that the teachers have a clear picture of what they want learners to demonstrate at the end of the learning experience. Due to the fact that outcomes were not just things learners believe, feel remember, know or understand but were clear demonstrations of learning. The excerpt 5.1 does not demand for the demonstrations due to the word ‘know’ as it was the internal mental processing that the educator could not observe but was rather an objective as it pointed to the knowledge or content posed by the learner. Thus, the word 'know' is non-demonstration action verb.

While Excerpt 5.2 clearly shows that the learner has to demonstrate how to find the sum of an arithmetic progression. Because on this sentence the word find was an observable action verb, which demanded the learner to demonstrate what he or she knows that was the content of the learner. Therefore, outcomes are simply things the student could actually do at the end of the learning experience or competences. In other words, outcomes are forms and ways of applying the mental processing.

Basing on excerpt 5.2 it indicates that the teacher had knowledge on how to frame an outcome as well as was an outcome although it was written like a lesson objective. This could mean that teachers were using the old stencil. However, excerpt 5.1was an objective meaning the teacher had no knowledge on how to form or phrase an outcome even if was using an old stencil.
The researcher did establish that mathematics teachers despite having an idea of OBE, the lesson plans were drawn on an old lesson plan template which reflected objectives other than outcomes. This made the researcher to indicate that the teachers confused the old lesson plan format to the current OBE lesson as they had drawn outcomes on the part reflecting objectives.

In OBME, teachers are encouraged to facilitate the learning. Teachers in this study were facilitating the learning. In that they created an environment which was conducive for learners to learn. Pupils were actively involved in the teaching and learning processes in their classrooms and teachers provided guidance to learners.

In this study, teachers seemed not to use the principle of designing down where the exercise should be traced back to the stated outcomes. This is because the majority of the lessons observed the tasks given to the learners were not linked to the outcomes since the outcomes were not stated but rather the objectives. For example, on the observation tally marks teachers B and C stated the outcomes in one lesson only whilst the other three lessons were objectives. Further, all the four lessons for teacher A were objectives. The assessment task should be linked to the outcome's learners are to demonstrate as well as be challenging Killen (2006).

5.5Summary of the chapter

The chapter highlighted that in the school of study, teacher training was done. This was supported by other literatures which stated that there was need to train teachers on outcome-based mathematicseducation as there was a difference in the teaching and learning practices from the objective based mathematics education.Also,Spady (1994) reflects teachers' knowledge that outcome-based mathematics education is an education that allows teachers to identify the outcomes learners are to demonstrate. Thereafter, align the content, teaching and learning strategies including assessment strategies to the outcomes. Nevertheless, teachers did not plan their lesson according to the principal of design down as proposed by Spady. The next chapter presents the conclusion and the recommendations of the study.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1Introduction

The previous chapter comprised of discussions of the findings. This chapter presents the conclusion as well as the recommendations of the study with regard to the findings and discussions of the implementation of an outcome-based mathematics curriculum at secondary school level in Zambia.

The study was aimed at investigating the implementation of an outcome-based mathematics curriculum at secondary schoollevel inZambia. The study was guided by the three objectives which were; to establish mathematics teacher's knowledge of outcome-based education; to determine the process of change from objective based to outcome-based education in their school; and to establish how mathematics teachers were implementing an outcome-based mathematics education curriculum.

This study employed the descriptive design in which qualitative methods were used. Interviews, focus group discussions, and observations were used to gather data from the sample of five (5) respondents. Four (4) of them were teachers from a government secondary school and a curriculum specialist from curriculum development centre.

6.2 Conclusions

What process of change was affected in schools to adapt an outcome-based mathematics education from objective based curriculum?

During this study it was established that there was a process of change that was put in place to adopt OBME in schools. That was teacher orientation; teachers were orientated on the implementation of the curriculum framework. They were not oriented on the implementation of the OBME curriculum. Furthermore, the school procured teaching and learning materials.

What knowledge did mathematics teachers have on outcome-based education?

The teachers were knowledgeable about OBME.As they pointed out that OBME was an approach that focuses on what learners are to demonstrate at the end of the lesson or learning experience. OBME was an education that promotes learners to construct their knowledge, theirrole in this OBME was to facilitate the learning. Furthermore, they stated that were required to use different methods when teaching. Also, those were required to provide learners with an opportunity to learn.These were selected points from teacher’s responses concerning OBME practices.

How mathematics teachers were implementing an outcome-based Mathematics education curriculum?

Although teachers seemed to have knowledge on OBME, they were not applying the design down and clarity of focus principles of OBME. Furthermore, their lesson plans had lesson objectives instead of outcomes.

Additionally, this study has contributed the knowledge to the existing board of knowledge. Also, that mathematics teacher has been empowered on how to teach as well as plan in an OBME mathematics classroom. Furthermore, curriculum planners have been availed with the necessary information. It enhances them plan for the teacher training workshop on OBME curriculum implementation. Lastly, this study has filled the gaps which were identified in the literature publicized.

6.3 Recommendations

With reference to the findings, discussion and conclusion the study makes the following recommendations:

The Ministry should train teachers in Planning and programming, Teaching and learning as well as on how to use the resources in OBME.

The School should continue Procuring necessary teaching and learning resources

The school should continue training teachers through continuous professional development meetings (CPD) at school level or Zone level.

Future researchers should consider conducting research on assessment and recording in OBME. Because it is not known how teachers are carrying out assessment and recording in this revised

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APPENDICES

APPENDIX A: FOCUS GROUP DICUSSIONGUIDE

1. What do you understand by outcomes-based education?

2. What is the difference between the revised curriculum and previous curriculum?

3. How do you incorporate outcomes based education in you teaching?

- ✓ All student can learn and succeed, but not on the same day in the same way.
- ✓ Success breeds success.
- ✓ Schools control the conditions of success.
- ✓ Clarity of focus- all activities (teaching, assessment) are geared towards what we want students to demonstrate.
- ✓ Expanded opportunity- expanding the ways and numbers of times for pupils to get a chance to learn and demonstrate a particular outcome

- ✓ High expectations- setting standards that all students should achieve at the highest level.
- ✓ Design down- designing the curriculum from the point at which you want students to end up.

4. What strategies do you follow when you facilitate learning?

5. How do you assess learners in your classroom? What assessment strategies do you follow when you are assessing?

6. What process of change has been put in place in your school to adapt the revised curriculum?

7. How is the leadership in your school?

8. How do learners perform in your classroom?

APPENDIX B: Interview Guide (Curriculum Specialist)

1. Do the mathematics teachers have knowledge on outcomes-based education?
2. What process of change have you affected in schools to adapt an outcomes-based education?
3. How do you expect mathematics teachers to implement an outcomes-based education in a classroom?

APPENDIX C: SAMPLE OF A LESSON PLAN

THE UNITED CHURCH OF ZAMBIA

KAFUE BOYS SECONDARY SCHOOL

LESSON PLAN

NAME OF TEACHER: Mr chabwela CLASS: 12 M

SUBJECT: Mathematics DATE: 27/01/2017

TOPIC: cubic Functions NO: OF PUPILS

LESSON: Graphical solutions of cubic functions

LESSON OBJECTIVE(S): Given a question on cubic functions learners should be able find solutions graphically

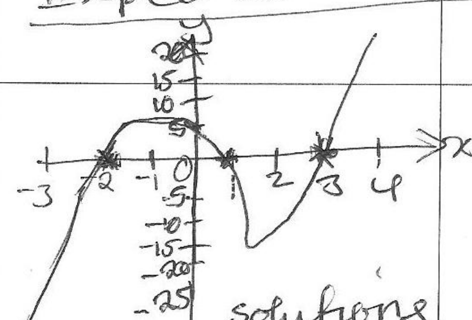
REFERENCES: Mathematics course for secondary school bk 3 page 282

MATERIALS/RESOURCES: Chalk board, board ruler, duster

PHASE/TIME	LESSON CONTENT/ TEACHERS ACTIVITY	METHODS/PROCEDURES	PUPILS ACTIVITY
Introduction 10 min	Ask learners to present their research on their findings on solutions eg of equations graphical ie	Discussion	pupils to present research to the classmates
lesson development	cubic functions. -When a cubic expression is equated to zero or to constant it becomes an equation consider the equation $x^3 - 2x^2 - 5x + 6 = 0$	exposition	pupils to listen attentively
	To solve such an equation graphically proceed as follows (i) Draw the graph		copy ~~comp~~ down lesson notes

of the equation

(ii) To find the values of x at the points where the curve ~~cuts~~ at the points where the curve cuts the axis is when y = 0

20 m	**Example** (a) Draw the graph of the expression: $y = x^3 - 2x^2 - 5x + 6$ for $-3 \le x \le 4$	pair/group work! Teacher going round check.	Pupils to do the work in pairs/groups works.
	(b) Use the graph to solve the equation $x^3 - 2x^2 - 5x + 15 = 0$ **Expected Feedback**		
	 **solutions** The equation $x^3 - 2x^2 - 5x + 6 = 0$ has solutions $x = -2, 1$ or 3		
lesson Evaluation 15 min	**Task** Draw the graph of $y = x^3 - 3x + 5$ for values x -4 to 4; use the graph to solve the equation $x^3 - 3x + 5 = 0$ **Assignment** Draw the graphs	Going round marking	pupils to do the work individually pupils do the Assignment

	of $y=x^3-3x^2+4$ and $y=x^2-2x+3$ on the same axes fo $-2\le x\le 4$ and use a graph to solve the equation'		
	<u>Evaluation'</u>		

APPENDIX D CHECK LISTS

TEACHERS OBSERVATION CHECKLISTS FOR IMPLEMENTATING AN OUTCOME BASED MATHEMEATICS CURRICULUM INA SECONDARY SCHOOL

ENROLLMENT	**Teacher A**	**Teacher C**	**Teacher D**
1-25			
26-45			
46-60			
61-100			
CLASS ORGANISATION			
Small Group			
Whole class			
Small Group Discussion			
INTRODUCTION OF THE LESSON			
Topic linked to learners real life situations			
In context			
STRATEGIES USED: **Learner centered**			
Group work			

Whole class			
Field trip			
LESSON PLANNING			
Lesson planning works on a design down principle.			
ROLES OF THE EDUCATOR			
Mediator/Facilitator			
ASSESSMENT OF THE LESSON			
Assessment linked to assessment criteria/standard			

APPENDIX E: ZAMBIA BASIC EDUCATION COURSE BOOK SAMPLE ON PYTHAGORAS THEOREM/ PROGRESS IN MATHEMATICS LEARNERS BOOK SAMPLE ON PYTHAGORAS THEOREM/ NEW SYLLABUS SAMPLE ON PYTHAGORAS THEOREM

XIII The Pythagoras theorem

1. Squares and square roots

Squares

The *square* of a number is the number multiplied by itself. For instance, the square of 5 is $5\times5 = 5^2 = 25$ and the square of a is $a\times a=a^2$, where a is any number.

Square roots

What is the number whose square is 16? Here, we have to find a number which gives 16 when multiplied by itself. The number is 4 since $4\times4=4^2=16$. We say that 4 is the *square root* of 16. The symbol $\sqrt{\ }$ is used to denote a square root. Therefore, the square root of 16 can be written as $\sqrt{16}$ and

$$\sqrt{16} = 4$$

Consider the number 25. $\sqrt{25} = 5$ because $5^2=25$.
It is also true that $(-5)\times(-5)=25$, therefore $\sqrt{25}$ is $+5$ or -5, but we shall consider positive square roots only.

> The *square root* of a number is the number whose square is equal to the given number.
> The symbol for a square root is $\sqrt{\ }$.
> For instance, $\sqrt{25} = 5$, because $5^2 = 25$.

From the examples above, we see that the square root is an inverse operation for the square. For instance,

$2^2 = 4$, and $\sqrt{4} = 2$
$3^2 = 9$, and $\sqrt{9} = 3$
$4^2 = 16$, and $\sqrt{16} = 4$

Example 1 Find the square of (a) 6 (b) 11 (c) 15.

(a) $6^2 = 6\times6 = 36$
(b) $11^2 = 11\times11 = 121$
(c) $15^2 = 15\times15 = 225$

Example 2 Find the square root of (a) 49 (b) 81 (c) 144.

(a) $\sqrt{49} = 7$
(b) $\sqrt{81} = 9$
(c) $\sqrt{144} = 12$

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Example 3 Find the value of (a) $\sqrt{16+9}$ (b) $\sqrt{10^2-6^2}$

(a) $\sqrt{16+9} = \sqrt{25} = 5$

(b) $\sqrt{10^2-6^2} = \sqrt{100-36}$

$= \sqrt{64}$

$= 8$

Add first, then work out the square root.

EXERCISE 1

1. Copy and complete the following:

$1^2 = 1$

$2^2 = 4$

$3^2 = 9$

$\vdots \quad \vdots$

$30^2 = 900$

2. Find the value of the following:

(a) $4^2 + 3^2$ (b) $12^2 - 9^2$ (c) $10^2 - 7^2$

(d) $25^2 + 24^2$ (e) $8^2 + 6^2$ (f) $25^2 - 24^2$

3. Evaluate the following:

(a) $\sqrt{36}$ (b) $\sqrt{64}$ (c) $\sqrt{81}$ (d) $\sqrt{49}$

(e) $\sqrt{100}$ (f) $\sqrt{225}$ (g) $\sqrt{196}$ (h) $\sqrt{576}$

(i) $\sqrt{729}$ (j) $\sqrt{484}$ (k) $\sqrt{441}$ (l) $\sqrt{10\,000}$

4. Find the square roots of the following:

(a) 1 (b) 9 (c) 49 (d) 144

(e) 625 (f) $25^2 - 24^2$ (g) $8^2 + 6^2$ (h) $64 + 36$

(i) $10^2 - 8^2$ (j) $17^2 - 15^2$ (k) $12^2 + 5^2$ (l) $24^2 + 7^2$

2. The Pythagoras theorem

In a right-angled triangle, the side opposite to the right angle is called the *hypotenuse* and the sides adjacent to the right angle are called *adjacent sides* as in Figure 1.

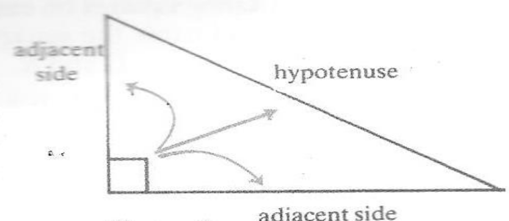


Figure 1

The triangle in Figure 2(a) is a right-angled triangle in which the hypotenuse AC=5 cm and the adjacent sides AB=3 cm and BC=4 cm.

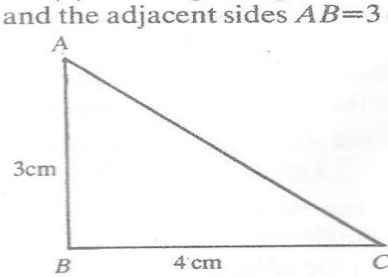


Figure 2 (a)

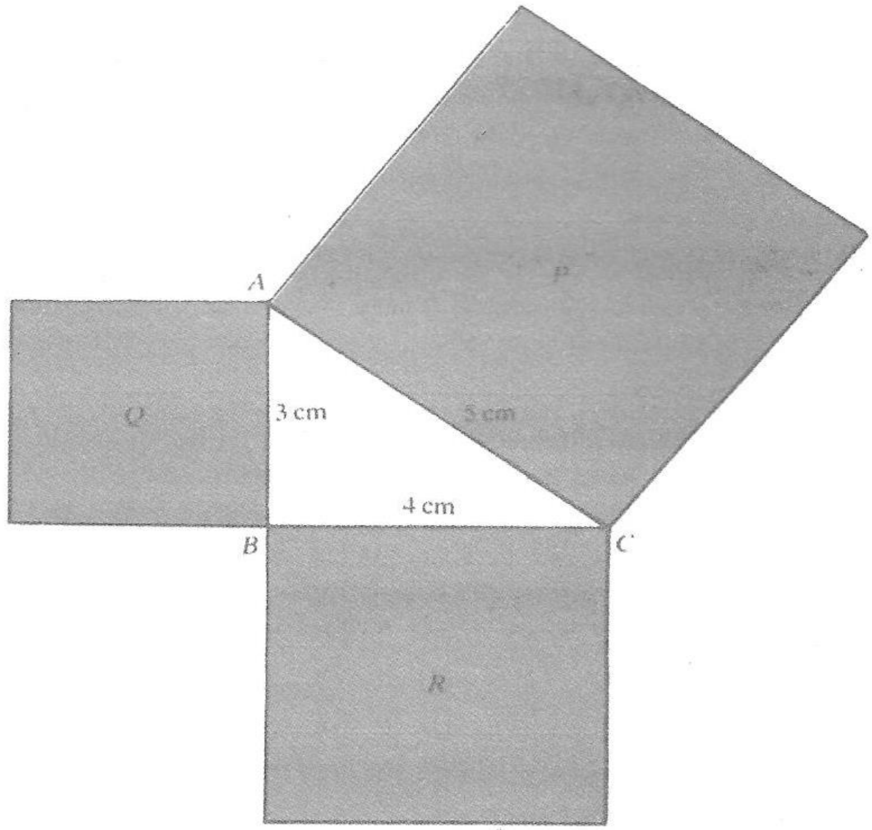


Figure 2 (b)

Draw squares on each side of the triangle ABC, as shown in Figure 2(b), and name the square on the hypotenuse P and the squares on the adjacent sides Q and R.

The sides of the triangle are the sides of the squares, hence:

area of $Q = 3 \text{ cm} \times 3 \text{ cm} = 3^2 \text{ cm}^2 = 9 \text{ cm}^2$
area of $R = 4 \text{ cm} \times 4 \text{ cm} = 4^2 \text{ cm}^2 = 16 \text{ cm}^2$
area of $P = 5 \text{ cm} \times 5 \text{ cm} = 5^2 \text{ cm}^2 = 25 \text{ cm}^2$

You will notice that

area of P = area of Q + area of R
$25 \text{ cm}^2 = 9 \text{ cm}^2 + 16 \text{ cm}^2$
or $5^2 \text{ cm}^2 = 3^2 + 4^2 \text{ cm}^2$

Therefore, the area of the square on the hypotenuse is equal to the sum of the areas of the squares on the adjacent sides.

Since AC=5 cm, AB=3 cm and BC=4 cm, we can also write:

$AC^2 = AB^2 + BC^2$ or $AB^2 + BC^2 = AC^2$

It can be shown that the above statement is true for all right-angled triangles. In Figure 3(a), the hypotenuse of a right-angled triangle is c and the adjacent sides are a and b.

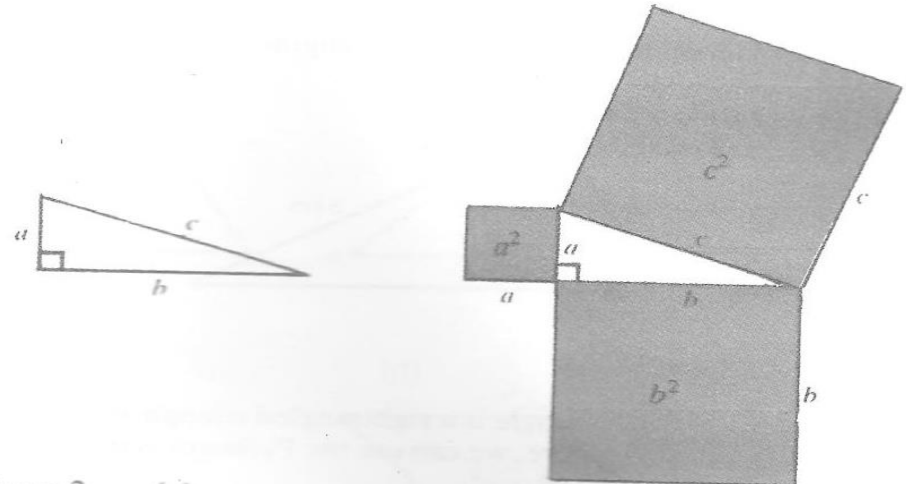
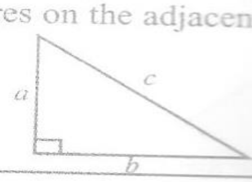


Figure 3 (a) (b)

From Figure 3(b), we get

$c^2 = a^2 + b^2$ or $a^2 + b^2 = c^2$.

This relationship between the square on the hypotenuse and the squares on the adjacent sides is known as the *Pythagoras* theorem.*

> *The Pythagoras Theorem* states that in any right-angled triangle, the square on the hypotenuse is equal to the sum of the squares on the adjacent sides.
>
> 
>
>
> $c^2 = a^2 + b^2$

Example 1 State the Pythagoras theorem for each of the triangles in Figure 4.

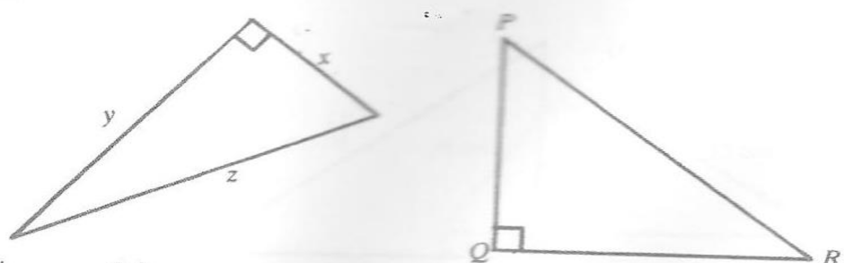


Figure 4 (a) (b)

(a) $z^2 = x^2 + y^2$ (b) $PR^2 = QR^2 + PQ^2$

*Pythagoras was a Greek mathematician who lived about 570 – 505 B.C.

Example 2 Calculate the lengths of the lines marked (a) x (b) y in the triangles in Figure 5.

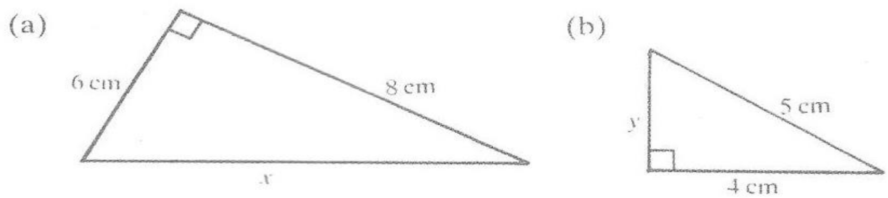


Figure 5

(a) The triangle is a right-angled triangle in which x is the hypotenuse. Therefore, we can use the Pythagoras theorem:

$$\begin{aligned} x^2 &= 8^2 + 6^2 \\ &= 64 + 36 \\ &= 100 \\ x &= \sqrt{100} \\ x &= 10 \end{aligned}$$

> Now, find a number which gives 100 when multiplied by itself; i.e. find the square root of 100.

The hypotenuse is 10 cm.

(b)

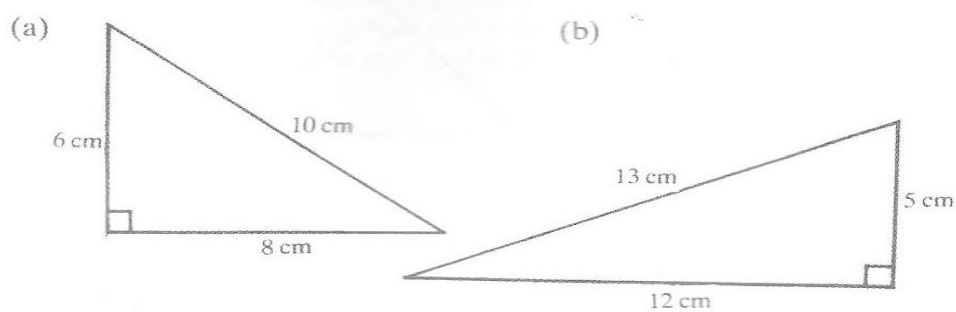
$$\begin{aligned} y^2 + 4^2 &= 5^2 \\ y^2 + 16 &= 25 \\ y^2 &= 25 - 16 \\ &= 9 \\ y &= \sqrt{9} \\ y &= 3 \end{aligned}$$

> y, 4 cm and 5 cm are sides of a right-angled triangle.

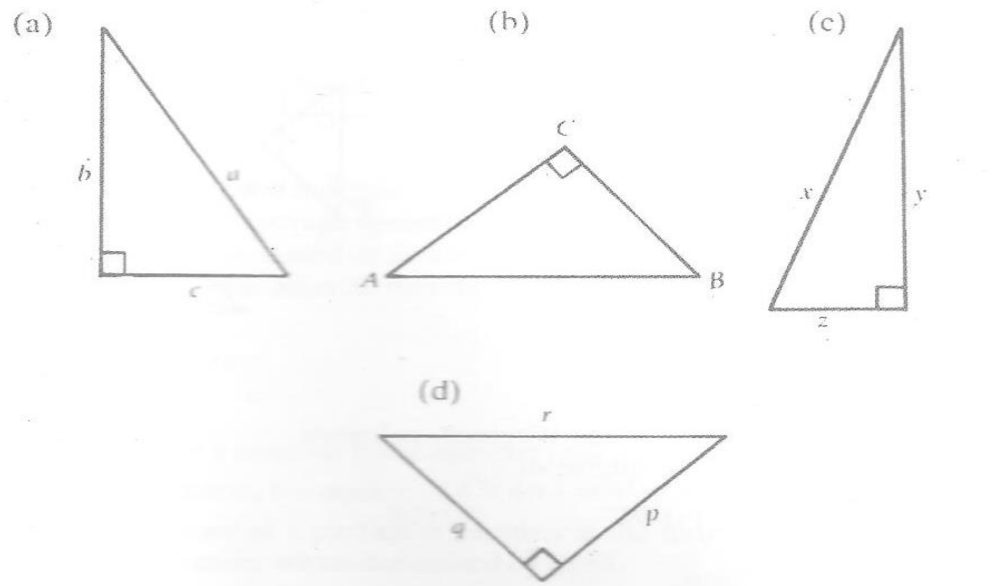
The side is 3 cm.

EXERCISE 1

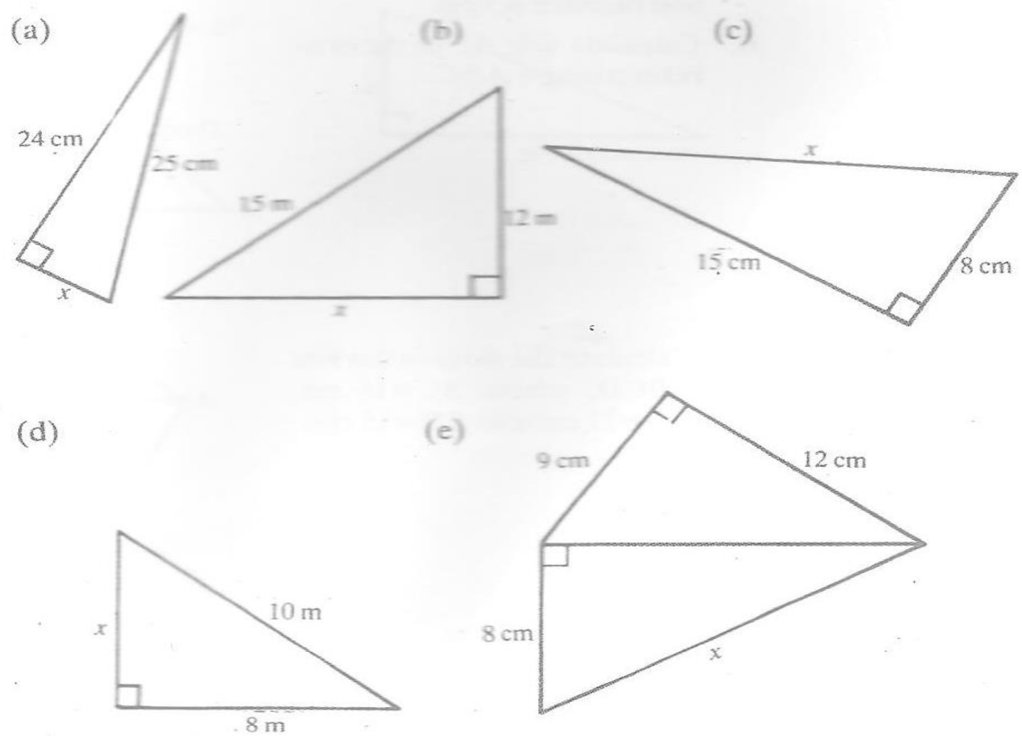
1. The triangles below are right-angled triangles. Calculate the areas of the squares drawn on the sides in each case and show that the Pythagoras theorem is true.



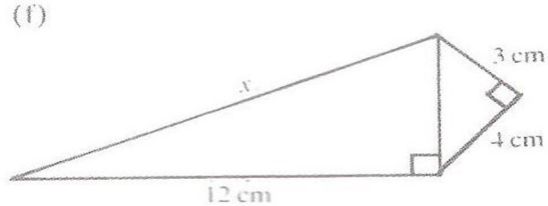
2. Give the formula for the Pythagoras theorem for each of the following right-angled triangles:



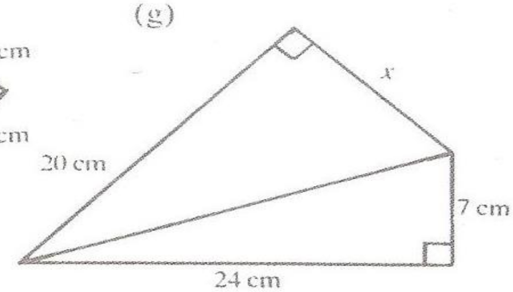
3. Calculate the length of the side marked x in each of the following figures:



(f)

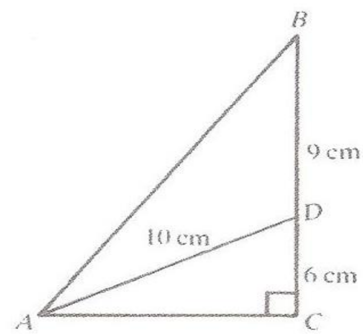


(g)



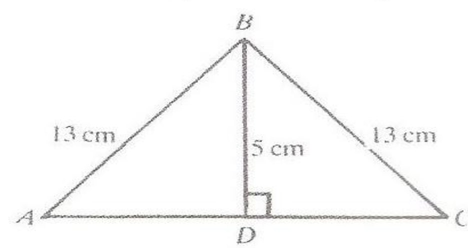
4. From the diagram, calculate the lengths of

   (a) BC (b) AB

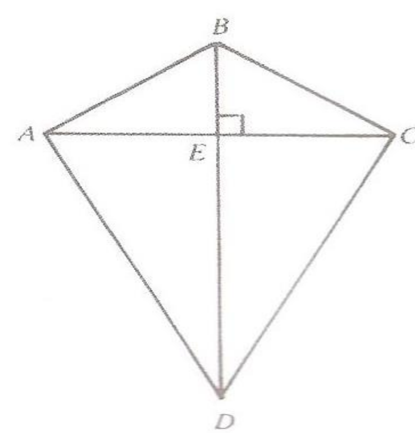


5. Find the length of the diagonal in a rectangle whose length is 4 cm and breadth is 3 cm.

6. Calculate side AC of the isosceles triangle ABC.



7. Calculate the sides of the kite $ABCD$, where $AC=16$ cm, $BD=21$ cm and $ED=15$ cm.



8. Two poles of heights 20 m and 25 m are 12 m apart. Find the length of the wire which connects the tops of the poles.

9. The internal measurements of a cubical box are length: 4 cm; breadth: 3 cm; height: 12 cm. What is the length of the longest straight stick which can (a) rest on the bottom of the box (b) fit into the box?
10. A cyclist and a motorist leave a house at the same time. A cyclist travels at an average speed of 18 km/h east while the motorist travels at an average speed of 24 km/h north. What is the shortest distance between them after 30 minutes?

3. Summary

The *square* of a number is the number multiplied by itself.

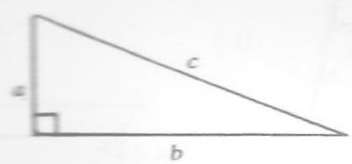
For instance, the square of 4 is $4 \times 4 = 4^2 = 16$

The *square root* of a particular number is the number which gives that particular number when multiplied by itself.

For instance, the square root of 9 is 3 or $\sqrt{9} = 3$, since $3^2 = 9$.

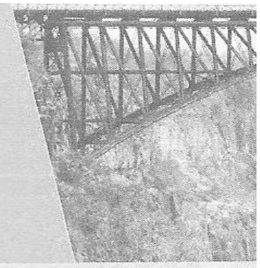
The *Pythagoras theorem* states that in any right-angled triangle, the square on the hypotenuse is equal to the sum of the squares on the adjacent sides.

$$c^2 = a^2 + b^2$$



TOPIC

4 Pythagoras' theorem



Sub-topic	Specific Outcomes
Right-angled triangles	• Identify sides in a right-angled triangle. • State Pythagoras' theorem.
Applications	• Solve real-life problems involving Pythagoras' theorem.

Starter activity

1 Work out the square of each number.

a) 9 b) 12 c) 13
d) 36 e) 54 f) 95
g) 1.2 h) 2.5 i) 3.1
j) 2.75 k) 6.38 l) 9.72

2 If $y = x^2$ then x is the square root of y. Use this fact to find the square root of each number.

a) 144 b) 1.44 c) 0.0144
d) 225 e) 2.25 f) 0.0225
g) 625 h) 6.25 i) 0.0625
j) 729 k) 7.29 l) 0.0729

3 Find the square root of each number without using a calculator.

a) 3.24 b) 1.96 c) 1.21
d) 0.81 e) 0.64 f) 0.49
g) 0.0036 h) 0.0025 i) 0.0016
j) 0.0009 k) 0.0004 l) 0.0001

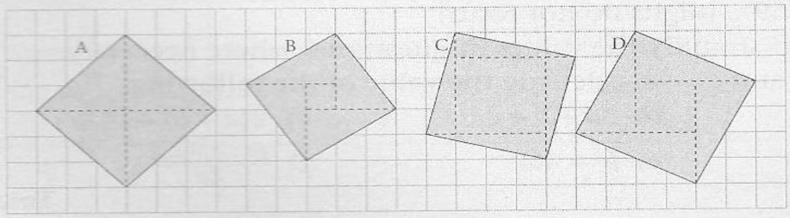
4 If $r^2 = 400$, find the value of r.

5 If $r^2 = p^2 + q^2$, find the value of r if $p = 12$ and $q = 9$.

6 Calculate the following.

a) $\sqrt{1.2^2 + 1.6^2}$ b) $\sqrt{6.25 \times 10^2}$ c) $\sqrt{81r^4}$

7 How many square units of the grid are covered by each square (A to D)?



SUB-TOPIC 1 Right-angled triangles

Identify the sides in a right-angled triangle

Triangles are geometric shapes with three straight sides and three **interior** angles. They can be described according to the length of these sides or the sizes of these angles. For example, in:

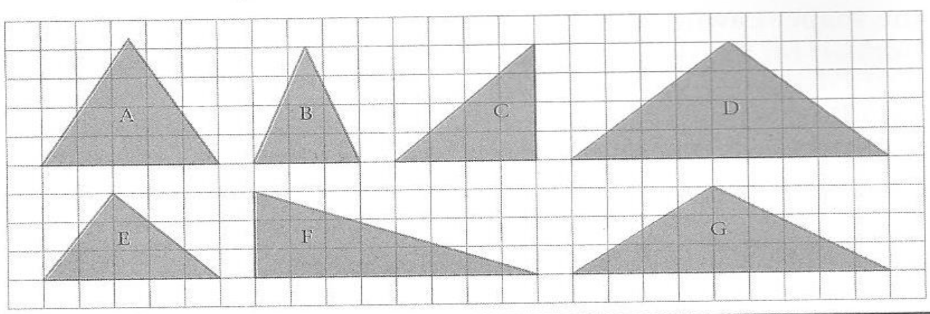
- equilateral triangles, all three sides are equal (the same length)
- isosceles triangles, only two sides are equal
- scalene (skew) triangles, no sides are equal
- acute-angled triangles, three angles are acute
- right-angled triangles, one angle is a right angle and the other two are acute angles
- obtuse-angled triangles, one angle is obtuse and the other two are acute.

New word

interior: inside

Activity 1

Name each triangle below.

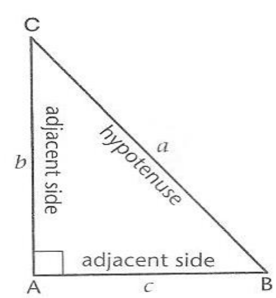


In a right-angled triangle, the side opposite the right angle is called the hypotenuse and the other two sides are called **adjacent** sides because they are next to (adjacent to) the right angle. The right angle is formed where the other two sides meet. It is shown with a small square.

New word

adjacent: next to

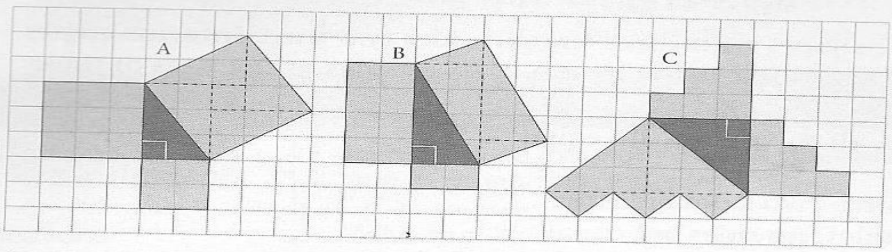
For triangle ABC, we can call the side opposite $\hat{A}$ BC or a, the side opposite $\hat{B}$ AC or b and the side opposite $\hat{C}$ AB or c.



Similar shapes have the same shape, but different sizes. To investigate an important connection between the lengths of the sides of triangles, we will construct similar shapes on the three sides of different triangles.

Worked example 1

Investigate the connection between the areas of the similar shapes drawn on the sides of each triangle. Present your findings in a table.



Did you know?

Similar shapes have the same shape, but they differ in size.

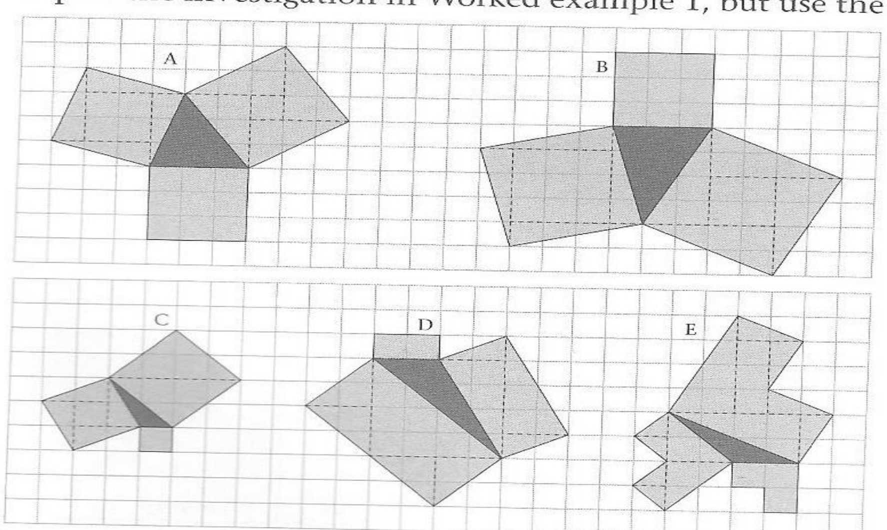
Answers

Diagram	Area covered by the shape on the...			Type of triangle used
	longest side	shortest side	third side	
A	13	4	9	Right-angled triangle
B	10	2	8	Right-angled triangle
C	12	6	6	Right-angled triangle

Note: The area of the shape drawn on the hypotenuse is equal to the sum of the areas of the shapes drawn on the other two sides.

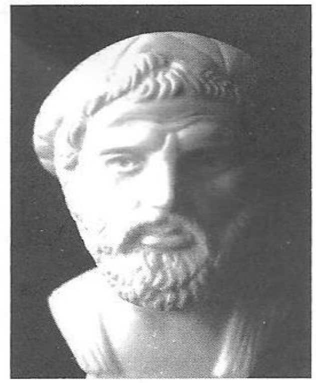
Activity 2

Repeat the investigation in Worked example 1, but use the following diagrams.



State Pythagoras' theorem

The Egyptians, Babylonians and Chinese from long ago knew of a special connection between the lengths of the sides of triangles and they used this relationship. However, the first person to define this relationship was Pythagoras, a Greek mathematician and philosopher (582 BC–500 BC). He established a school of philosophy in Italy where he and his followers expressed views that were considered strange at the time (such as that the earth rotates around its own axis and that the planets revolve around the sun). As a result of these theories, Pythagoras was forced to flee to Egypt.

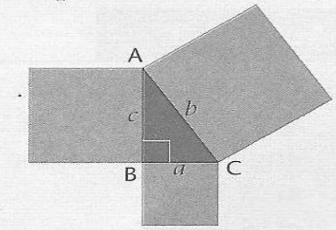

Pythagoras

Pythagoras' theorem states:
In any right-angled triangle, the square on the hypotenuse is equal to the sum of the squares on the adjacent sides.

Note:
- In a right-angled triangle, the area of the shape on the longest side is equal to the sum of the areas of similar shapes on the other two sides (the sides adjacent to the right angle).
- In an acute-angled triangle, the area of the shape on the longest side is smaller than the sum of the areas of similar shapes on the other two sides.
- In an obtuse-angled triangle, the area of the shape on the longest side is larger than the sum of the areas of similar shapes on the other two sides.
- Squares are the easiest similar shapes to construct on the sides of a triangle.
- It is the easiest to calculate the area of squares.

These five discoveries confirm Pythagoras' theorem:
- Description using words: In any right-angled triangle, the square on the hypotenuse is equal to the sum of the squares on the other two sides.
- Description using symbols: If in $\triangle ABC$ $\hat{B} = 90°$, then $AC^2 = AB^2 + BC^2$ or $b^2 = c^2 + a^2$.

Description using a diagram:



We can use Pythagoras' theorem to find out if a triangle is acute-angled, right-angled or obtuse-angled:
- A triangle is acute-angled if the square on the longest side is smaller than the sum of the squares on the other two sides.
- A triangle is right-angled if the square on the longest side is equal to the sum of the squares on the two sides adjacent to the right angle.
- A triangle is obtuse-angled if the square on the longest side is larger than the sum of the squares on the other two sides.

Worked example 2

The sides of a triangle are 3 cm, 4 cm and 5 cm. Use Pythagoras' theorem to find out if the triangle is acute-angled, right-angled or obtuse-angled.

Answer

Determine whether the square on the longest side is smaller, equal to or larger than the sum of the squares on the other two sides.
For the longest side: $(5\text{ cm})^2 = 25\text{ cm}^2$
For the other two sides: $(3\text{ cm})^2 + (4\text{ cm})^2 = 9\text{ cm}^2 + 16\text{ cm}^2 = 25\text{ cm}^2$
$(5\text{ cm})^2 = (3\text{ cm})^2 + (4\text{ cm})^2$
The triangle is a right-angled triangle.

Did you know?

Three numbers that match Pythagoras' theorem are called Pythagorean triplets.

Worked example 3

Prove the following statements.

1 The numbers 10, 24 and 26 are Pythagorean triplets.
2 The numbers 10, 23 and 25 are not Pythagorean triplets.

Answers

1 $10^2 + 24^2 = 100 + 576 = 676$ and $26^2 = 676$
$10^2 + 24^2 = 26^2$, therefore 10, 24 and 26 are Pythagorean triplets
2 $10^2 + 23^2 = 100 + 529 = 629$ and $25^2 = 625$
$10^2 + 23^2 > 25^2$, therefore 10, 23 and 25 are not Pythagorean triplets

Activity 3

1 Each group of three numbers represents the lengths of the sides of a triangle, in centimetres. Use Pythagoras' theorem to work out if each triangle is acute-angled, right-angled or obtuse-angled.

a) 3, 4, 5
b) 4, 5, 6
c) 5, 6, 7
d) 2, 4, 6
e) 4, 6, 8
f) 6, 8, 10
g) 9, 12, 15
h) 5, 12, 13
i) 8, 15, 17
j) 7, 24, 25
k) 10, 24, 26
l) 12, 35, 37
m) 15, 20, 25
n) 20, 21, 29
o) 24, 45, 51

2 Which groups of numbers in question 1 are Pythagorean triplets?

SUB-TOPIC 2 Applications

Solve simple real-life problems involving Pythagoras' theorem

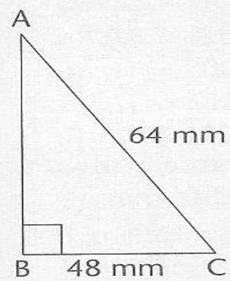
You can use Pythagoras' theorem to:

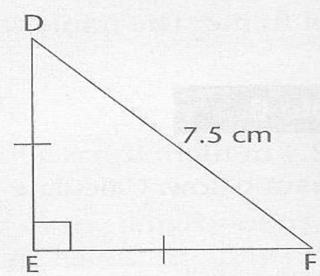
- calculate the length of the unknown side of a right-angled triangle
- find out if a triangle is acute-angled, right-angled or obtuse-angled
- solve simple real-life problems.

The next three examples illustrate these uses of Pythagoras' theorem.

Worked example 4

Calculate the length of the unknown sides in △ABC and △DEF, rounded off to one decimal place.





Answers

In △ABC:

$\hat{B} = 90°$ (given)

$\therefore AC^2 = AB^2 + BC^2$ (Pythagoras)

$\therefore AB^2 = AC^2 - BC^2$

$= (64 \text{ mm})^2 - (48 \text{ mm})^2$

$= 4\ 096 \text{ mm}^2 - 2\ 304 \text{ mm}^2$

$= 1\ 792 \text{ mm}^2$

$\therefore AB = \sqrt{1\ 792 \text{ mm}^2}$

$= 42.3 \text{ mm}$

In △DEF:

$\hat{E} = 90°$ (given)

$\therefore d^2 + f^2 = e^2$ (Pythagoras)

$= (7.5 \text{ cm})^2$

$= 56.25 \text{ cm}^2$

but $f = d$ (given)

$\therefore 2d^2 = 56.25 \text{ cm}^2$

$\therefore d^2 = 56.25 \text{ cm}^2 \div 2$

$= 28.125 \text{ cm}^2$

$\therefore d = \sqrt{28.125 \text{ cm}^2}$

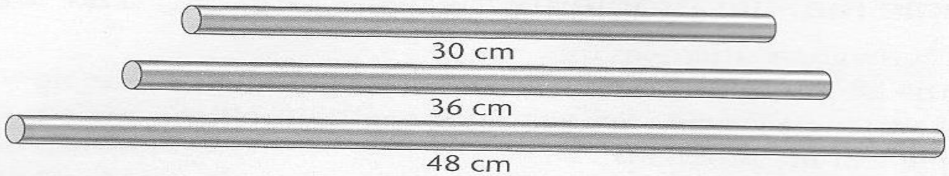
$= 5.3 \text{ cm}$

$\therefore DE = EF$

$= 5.3 \text{ cm}$

Worked example 5

Three iron rods of 48 cm, 36 cm and 30 cm are welded together to make a triangular frame. Will the frame be acute-angled, right-angled or obtuse-angled?



Answer

Square the length of each rod: $(48\text{ cm})^2 = 2\ 304\text{ cm}^2$

$(36\text{ cm})^2 = 1\ 296\text{ cm}^2$

$(30\text{ cm})^2 = 900\text{ cm}^2$

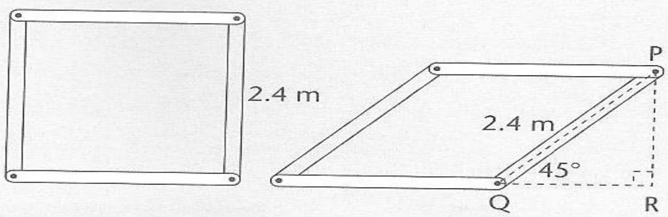
Add the two smallest squares: $1\ 296\text{ cm}^2 + 900\text{ cm}^2 = 2\ 196\text{ cm}^2$

Compare the largest square with the answer: $2\ 304\text{ cm}^2 > 2\ 196\text{ cm}^2$

Identify the type of frame: The frame will be obtuse-angled.

Worked example 6

A square frame is 2.4 m high. It has a hinge at each vertex. The frame is tilted as shown in the diagram below. Calculate PR, the height of the tilted frame.



Answer

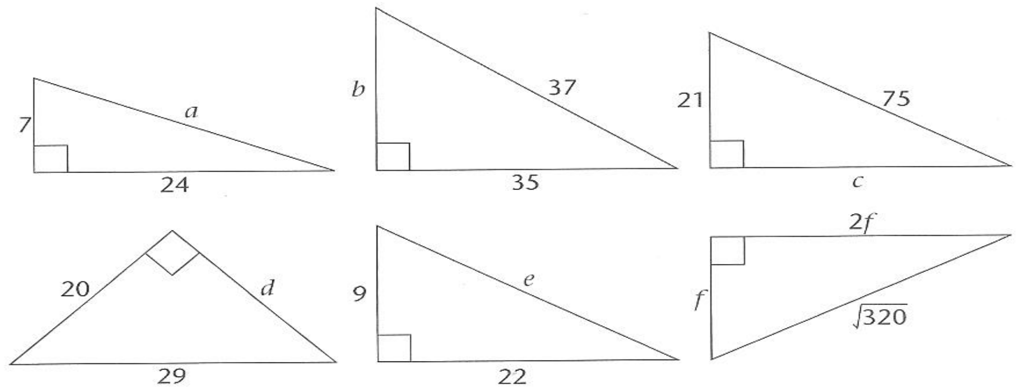
In $\triangle PQR$:

$\hat{R} = 90°$	(perpendicular lines)
$\therefore\ Q\hat{P}R = 45°$	(angles of triangle)
$\therefore\ PR = QR$	(equal base angles)
$PR^2 + RQ^2 = PQ^2$	($\hat{R} = 90°$; Pythagoras)
$= (2.4\text{ m})^2$	
$= 5.76\text{ m}^2$	
$\therefore\ PR^2 = 5.76\text{ m}^2 \div 2$	(PR = QR; proven)
$= 2.88\text{ m}^2$	
$\therefore\ PR = \sqrt{2.88\text{ m}^2}$	
$= 1.7\text{ m}$	(to one decimal place)

Height of the tilted frame: 1,7 m

Activity 4

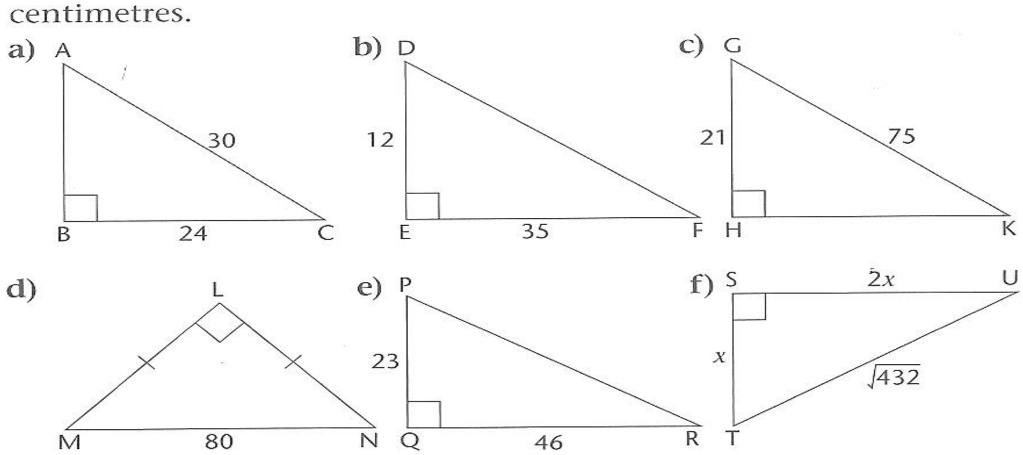
1 Calculate the lengths of the unknown sides (a to f).



2 In △ABC, $\hat{B} = 90°$. Calculate the length of the third side (to one decimal place).

a) AB = 120 mm and BC = 90 mm
b) AB = 200 mm and BC = 150 mm
c) AC = 510 mm and BC = 240 mm
d) AB = 120 mm and AC = 350 mm
e) AB = 100 mm and BC = 260 mm
f) BC = 100 mm and AC = 260 mm

3 The perimeter of a triangle is the sum of the lengths of its three sides. Calculate the perimeter of each triangle below. All dimensions are in centimetres.



Did you know?

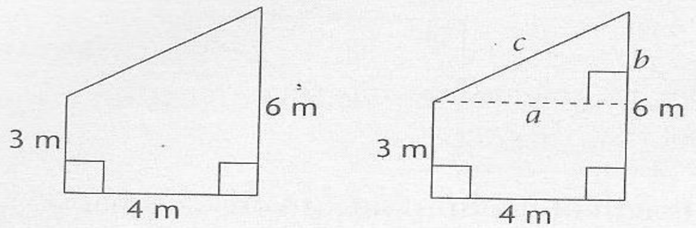
The perimeter of a shape is the distance around the edges of the shape.

Solve complex real-life problems involving Pythagoras' theorem

We can use Pythagoras' theorem to solve real-life problems that involve right-angled triangles in which two sides are given and you need to calculate the third side.

Worked example 7

The first diagram shows the side view of a car shelter. Calculate the length of the sloped section (c).



Answer

Let the length of the sloped section be c metres. In the second diagram, c represents the hypotenuse of the right-angled triangle of which $a = 4$ m and $b = 3$ m. Use Pythagoras' theorem to determine the length of c.

$$\begin{aligned} c^2 &= a^2 + b^2 \quad \text{(Pythagoras)} \\ &= (4\text{ m})^2 + (3\text{ m})^2 \\ &= 16\text{ m}^2 + 9\text{ m}^2 \\ &= 25\text{ m}^2 \\ \therefore c &= \sqrt{25\text{ m}^2} \\ &= 5\text{ m} \end{aligned}$$

Worked example 8

A rectangle is 9 cm wide and the length of its **diagonal** is 41 cm. Calculate the length (l) of the rectangle.

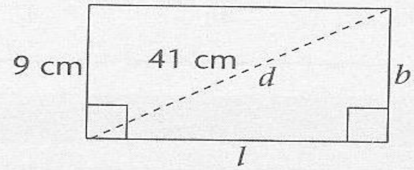
New word

diagonal: line that joins opposite vertices

Answer

Refer to the diagram.

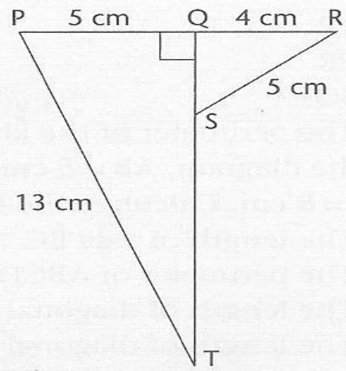
$$\begin{aligned} l^2 + b^2 &= d^2 \quad \text{(Pythagoras)} \\ l^2 &= d^2 - b^2 \\ &= 41^2 - 9^2 \\ &= 1\,681 - 81 \\ &= 1\,600 \\ \therefore l &= \sqrt{1\,600} \\ &= 40\text{ cm} \end{aligned}$$



Worked example 9

In the diagram, PQR is a straight line, $P\hat{Q}T = 90°$, PQ = 5 cm, QR = 4 cm, RS = 5 cm and PT = 13 cm. Calculate the length of ST.

Answer



Using △QRS:

$(QS)^2 + (QR)^2 = (RS)^2$ (Pythagoras)

$\therefore (QS)^2 = (RS)^2 - (QR)^2$

$= 5^2 - 4^2$

$= 25 - 16$

$= 9$

$\therefore QS = \sqrt{9}$

$= 3$ cm

Using △PQT:

$(PQ)^2 + (3 + ST)^2 = (PT)^2$ (Pythagoras)

$\therefore (3 + ST)^2 = (PT)^2 - (PQ)^2$

$= 13^2 - 5^2$

$= 169 - 25$

$= 144$

$\therefore 3 + ST = \sqrt{144}$

$= 12$ cm

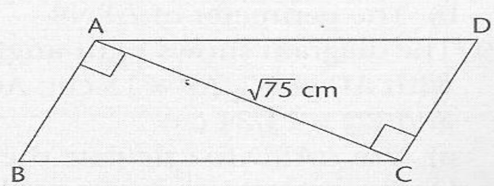
$\therefore$ ST = 12 cm − 3 cm

= 9 cm

Worked example 10

In parallelogram ABCD, the diagonal AC is perpendicular to AB and CD. If AC = $\sqrt{75}$ cm and BC = 2AB, calculate the perimeter of ABCD.

Answer



Let AB = x cm and BC = $2x$ cm

Using △ABC:

$(BC)^2 = (AB)^2 + (AC)^2$ (Pythagoras)

$\therefore (BC)^2 - (AB)^2 = (AC)^2$

$(2x)^2 - (x)^2 = (\sqrt{75})^2$

$\therefore 4x^2 - x^2 = 75$

$\therefore 3x^2 = 75$

$\therefore x^2 = 25$

$\therefore x = 5$ cm

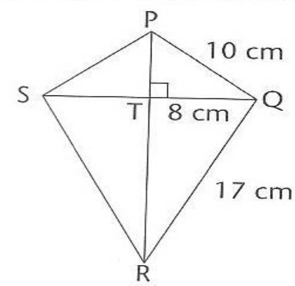
$\therefore$ AB = 5 cm = CD (Opposite sides of a parallelogram are equal.)

and BC = 10 cm = AD (Opposite sides of a parallelogram are equal.)

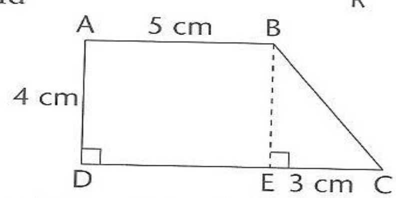
$\therefore$ Perimeter of ABCD = 5 + 10 + 5 + 10 = 30 cm

Activity 5

1 PQRS is a kite with PQ = 10 cm and QR = 17 cm. If TQ = 8 cm, calculate the following.
a) PT
b) TR
c) PR
d) SQ
e) The perimeter of the kite



2 In the diagram, AB = 5 cm, AD = 4 cm and CD = 8 cm. Calculate the following.
a) The length of side BC
b) The perimeter of ABCD
c) The length of diagonal BD
d) The length of diagonal AC



3 The diagonal of a rectangle is 16 cm. One of the sides of the rectangle is 12 cm. Find the length of the other side.

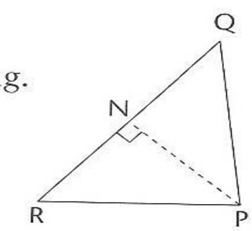
4 A rectangle measures 12 cm by 20 cm. Find the length of its diagonal.

5 Find the length of the diagonal of a square with sides of 10 cm.

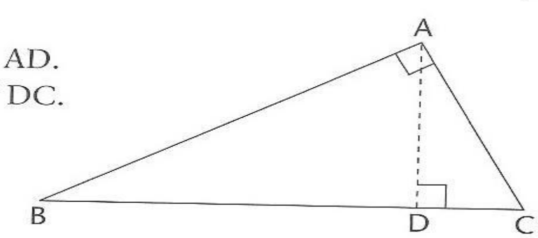
6 A rectangle is three times as long as it is wide. Its diagonal is $\sqrt{490}$ cm.
a) Calculate the dimensions of the rectangle.
b) Calculate the perimeter of the rectangle.

7 Plot the following points on a grid.
a) P(0; 0), Q(8; 0) and R(0; 6). Calculate QR.
b) X(0; 0), Y(8; 0) and Z(0; –6). Calculate YZ.
c) L(–2; –9), M(–2; –3) and N(6; –3). Calculate LN.
d) D(–1; –4), E(–1; –9) and F(11; –4). Calculate DF.

8 The diagram shows isosceles $\triangle PQR$ with $PN \perp QR$. If PQ = PR = 17 cm and QR = 30 cm, calculate the following.
a) The length of PN
b) The perimeter of $\triangle PNR$



9 The diagram shows right-angled $\triangle ABC$ with $AD \perp BC$, AB = 15 cm, AC = 8 cm and BD = 13.24 cm.
a) Use $\triangle ABD$ to calculate the length of AD.
b) Use $\triangle ADC$ to calculate the length of DC.
c) Use $\triangle ABC$ to check your two answers above.



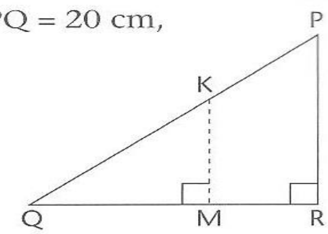
Activity 5 (continued)

10 In the diagram, △PQR is a right-angled triangle with PQ = 20 cm, PR = 12 cm and KM ⊥ QR. Calculate the following.

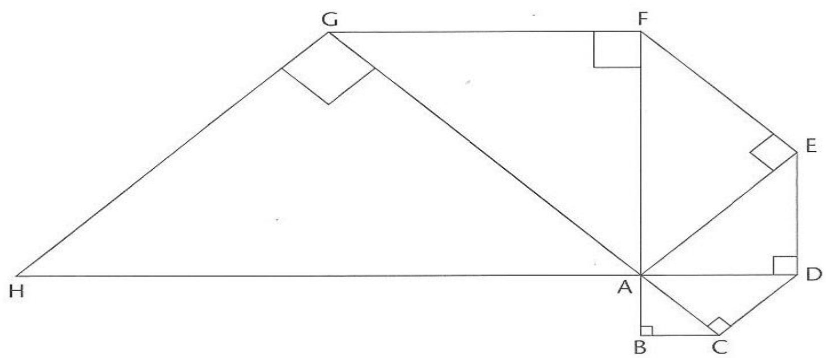
a) The length of QM if MR = 6 cm

b) The length of PK if KM = 7.5 cm

c) The perimeter of PKMR



11 The diagram shows a pattern of isosceles right-angled triangles that start at △ABC. If AB = BC = 1 cm, calculate the following. If necessary, leave your answer in square root form (surd form).

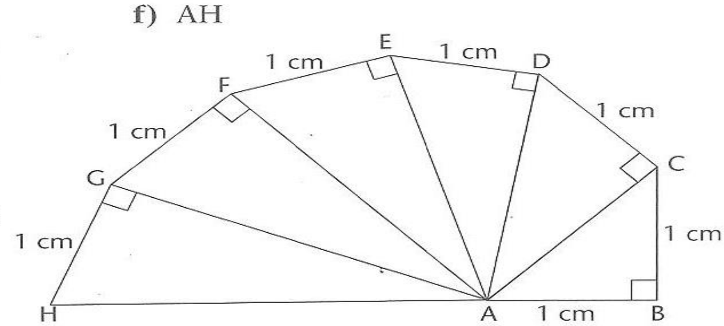


a) AC **b)** AD

c) AE **d)** AF

e) AG **f)** AH

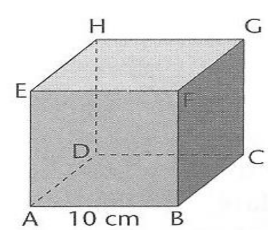
12 The diagram shows a pattern of right-angled triangles that start at △ABC.
If AB = BC = CD = DE = EF = FG = GH = 1 cm, find the length of the hypotenuse of △AGH.



13 The drawing shows a cube with edges of 10 cm. Calculate the following.

a) The distance between vertices A and C

b) The distance between vertices A and G



TOPIC 4

Revision and assessment exercises

Revision exercises

1 State Pythagoras' theorem in the following ways.
   a) Using words
   b) Using a diagram
   c) Using symbols

2 Complete each statement.
   a) If the square on the longest side of a triangle is smaller than the sum of the squares on the other two sides, the triangle is a (an) _____-angled triangle.
   b) If the square on the longest side of a triangle is equal to the sum of the squares on the other two sides, the triangle is a (an) _____-angled triangle.
   c) If the square on the longest side of a triangle is larger than the sum of the squares on the other two sides, the triangle is a (an) _____-angled triangle.

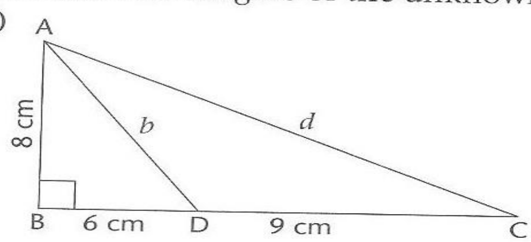
Assessment exercises

1 Complete each statement.
   a) In a right-angled triangle, the hypotenuse is opposite _____.
   b) In a right-angled triangle, the square on the hypotenuse is equal to _____. (4)

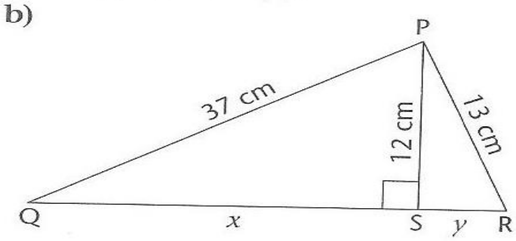
2 Prove that the numbers 9, 40 and 41 are Pythagorean triplets. (3)

3 Calculate the lengths of the unknown sides (b, d, x and y). (12)

a)



b)



4 Calculate the length, to the nearest unit, of the diagonal of the following.
   a) Square ABCD with sides of 40 mm
   b) Rectangle KLMN with KL = 56 mm and LM = 65 mm
   c) A rectangular school hall that is 25 m by 50 m (9)

5 Calculate the perimeter of a square with a diagonal of 80 mm. (3)

6 A ladder is 19.5 m long. It is positioned in a street so that it reaches a window 18 m above the ground. Without moving the foot of the ladder, the ladder is tilted over to the other side of the street where it reaches a window 7.5 m above the ground. Calculate the width of the street. (7)

7 Calculate the exact distance between the opposite vertices of a cube with edges of 60 mm. (7)

Total: 45

TOPICS	SUBTOPICS	SPECIFIC OUTCOMES	KNOWLEDGE	SKILLS	VALUES
9.1 SQUARE ROOTS AND CUBE ROOTS	9.1.1 Square roots 9.1.2 Cube roots 9.1.3 Roots of Squares and Cubes	9.1.1.1 Describe the meaning of square root and its symbol 9.1.2.1 Describe the meaning of cube root and its symbol 9.1.3.1 Find roots of Squares and Cubes	• Describing square root and cube root symbols. • Square and cubes numbers (ONLY PERFECT SQUARES AND CUBES AT THIS LEVEL)	• ***Interpretation*** of root symbol. • ***Evaluation*** of square roots and cube roots.	• ***Awareness*** of root and its symbol. • ***Curiosity*** in using root symbol
9.2 INDEX NOTATION	9.2.1 Indices 9.2.2 Laws of indices	9.2.1.1 Interpret the positive and zero indices. 9.2.2.1 Apply the laws of indices	• Interpreting positive and Zero indices ($5^0 = 1$) • Laws of indices (addition and subtraction of powers)	• ***Interpretation*** of the meaning of zero and positive indices • ***Computation*** of numbers in index notation	• ***Awareness*** of zero and positive indices
9.3 REAL NUMBERS	9.3.1 Rational numbers 9.3.2 Irrational numbers	9.3.1.1 Identify Rational numbers 9.3.2.1 Identify Irrational numbers	• Identifying rational numbers as numbers of the form $\frac{a}{b}$ $(b \neq 0)$ • Irrational numbers such as π, $\sqrt{3}$.	• ***Relating*** rational numbers to irrational numbers. • ***Estimation*** of irrational numbers.	• ***Awareness*** of rational and irrational numbers.
9.4 PYTHAGORAS' THEOREM	9.4.1 Right Angled triangle 9.4.2 Application	9.4.1.1 Identify sides in the Right angled triangle 9.4.1.2 State the Pythagoras' theorem 9.4.2.1 Solve real life problems involving Pythagoras' theorem	• Background to Pythagoras' theorem • Sides in the Right angled triangle (i.e. two adjacent sides and hypotenuse) • Area of squares (i.e. $a^2 + b^2 = c^2$ • Using Pythagoras' theorem to solve problems in real life	• ***Identification*** of sides in a right angles triangle. • ***Application*** of the Pythagoras' theorem.	• ***Curiosity*** in use of Pythagoras theorem. • ***Awareness*** of the Pythagoras theorem. •
9.5 DIRECTIONS	9.5.1 Directions	9.5.1.1 Identify the cardinal points	• Points on the	• ***Identification*** of	• ***Awareness***

APPENDIX F: LETTER OF CONSENT FROM UNZA

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

Telephone: 291381
Telegram: UNZA, LUSAKA
Telex: UNZALU ZA 44370

PO Box 32379
Lusaka, Zambia
Fax: +260-1-292702

Date 22 | 11 | 2016

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: FIELD WORK FOR MASTERS/ PhD STUDENTS

The bearer of this letter Mr./Ms. JANET SILWIMBA ......Computer number 2015130677 ......is a duly registered student at the University of Zambia, School of Education.

He/She is taking a Masters/PhD programme in Education. The programme has a fieldwork component which he/she has to complete.

We shall greatly appreciate if the necessary assistance is rendered to him/her/.

Yours faithfully

THE UNIVERSITY OF ZAMBIA
ASSISTANT DEAN (PG)
22 NOV 2016
SCHOOL OF EDUCATION
P.O. BOX [illegible] LUSAKA

Emmy Mbozi (Dr)
ASSISTANT DEAN POSTGRADUATE STUDIES- SCHOOL OF EDUCATION

cc: Dean-Education
Director-DRGS

APPENDIX G: LETTER OF CONSENT FROM DEBS KAFUE DISTRICT

All Communications should be
Addressed to the DEBS

Telephone / Fax: +260 211 311386
E-mail: debskafue@yahoo.com

In reply please quote

No……………………

REPUBLIC OF ZAMBIA

MINISTRY OF GENERAL EDUCATION

Kafue District Education Board Office
P.O. Box 360296
KAFUE

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
26 JAN 2017
HEADTEACHER
UCZ KAFUE BOYS SECONDARY SCHOOL
P. O. BOX 360023, KAFUE.

DEBS/K/101/4/8

ATT: DEPUTY HEAD

23rd January, 2017

The Head teacher
Kafue Boys Secondary School
KAFUE

RE: AUTHORITY LETTER TO CONDUCT RESEARCH FIELD WORK FOR MASTERS PROGRAMME: MS. JANET SILWIMBA

This serves to introduce to you Ms. Janet Silwimba a student at the University of Zambia, School of Education. Ms. Silwimba has been granted permission to carry out her field work programme in Master of Education at your school for a specific period.

Kindly welcome her and provide necessary information as requested to help her complete the field work component.

T.H. Lungu
DISTRICT EDUCATION BOARD SECRETARY
KAFUE DISTRICT

/mnz