

**PROJECT-BASED LEARNING FOR NAMIBIA SENIOR SECONDARY
CERTIFICATE ORDINARY ALGEBRA IN SELECTED SENIOR SECONDARY
SCHOOLS IN KAVANGO WEST REGION IN NAMIBIA**

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APPROVAL PAGE

This research has been examined and approved as meeting the required standards for partial fulfilment of the requirements of the degree of Master of Education.

Internal Examiner Date

External Examiner Date

Dean: Faculty of Education Date

DECLARATION

I, Robert Lusungo Mukelabai, hereby declare that this study on “*Project-Based Learning for Namibia Senior Secondary Certificate Ordinary Level Algebra in Selected Senior Secondary Schools in Kavango West Region*” is a true reflection of my research, and that this work, or any part thereof has not been submitted for a degree at any other institution.

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ABSTRACT

This study investigated the effects of Project-Based Learning (PBL) for Namibia Senior Secondary Certificate Ordinary (NSSCO) algebra in selected senior secondary schools in Kavango West region. The study employed a quantitative approach. Furthermore, a quasi-experimental non-equivalent (pre-test - post-test) control research design was used to collect data from one school for two weeks. A sample of 80 learners was randomly selected from the poorest performing school (school E) and from the class lists of all Grade 11 learners. From this sample, 11 A, of 40 learners belonged to a control group and the other class, 11 D, belonged to the experimental group. Furthermore, lessons on algebra were conducted for two weeks for both groups (experimental and control). The experimental group learners were presented with real-life activities such as working on a project (designing a budget), outdoor practices such as field trips, small-group interactions, group work activities, simulations activities and watching videos, to enable them to learn algebra in a more project-based learning setting. In addition, the learners had an opportunity to interview people in their communities and do a research, with the use of internet and reading books, newspaper and other educational journals. The control group was taught the same lessons but using a different teaching strategy; chalk and talk, question and answer, lectures, as well as whole class discussions.

The groups were given a pre-test on the first day and a post-test on the last day of the lessons. The non-equivalent (pre-test-post-test) scores were used to establish the cause and effect relationship between the use of Project-Based Learning (PBL) and learners' performance on the topic of algebra. Descriptive statistics was used to analyse the

quantitative data from the pre-test and post-test scores and a t-test analysis was conducted for both. The mean results indicated that the post-test scores for the experimental group (17.085714) were higher than the post-test scores from the control group (13.314286). Both the experimental and control groups had similar mean scores in the pre-test prior to the intervention. In addition, no significance difference ($t_{\text{calculated}} < t_{\text{critical}}$) was found between the experimental and control group. This indication suggests that the two groups were equivalent before the intervention. After the intervention, the experimental group had outdone the control group in the post-test. The test was used to test for the significance difference in performance between the two groups, found a significance difference ($t_{\text{calculated}} > t_{\text{critical}}$) in the algebra post-test performance of the experimental and control group at 99% confidence level. The findings suggested that project-based learning improved learners' performance in algebra. Therefore, the recommendations were made based on the findings of the study. Mathematics teachers to be encouraged to use PBL approach when teaching algebra topics i.e. linear equations, quadratic equations, factorisation and inequalities. In addition, teachers should be encouraged to use practical examples that are associated to real life situation. Finally, the study recommends that, the Ministry of Education, Arts and Culture in collaborations with National Institute for Educational Development, should improve the capacity of the teachers to plan and execute projects.

DEDICATION

This thesis is dedicated to my late mother, Peggy Namasiku-Mukupi Lilungwe and my late aunt Magret Chaze Mukanwa-Mashewani. Thank you for the upbringing and may your soul continue to rest in God's hand. To my beloved sons Benjamin Eden Chika Mukelabai and Robert Lusungo Junior Mukelabai, this is for you!

LIST OF ACRONYMS AND ABBREVIATIONS

DNEA	Directorate of National Examinations and Assessment
ICT	Information Communication and Technology
IUM	International University of Management
LC	Learner-Centered
LCE	Learner-Centred Education
MEAC	Ministry of Education, Arts and Culture
MOE	Ministry Of Education
NIED	National Institute for Educational Development
NSSCO	Namibian Senior Secondary Certificate Ordinary
NTA	Namibia Training Authority
NUST	Namibia University of Science and Technology
PBL	Project-Based Learning
PBLA	Project-Based Learning Approach
RVTC	Rundu Vocational Training Centre
SBS	School Based Studies
UNAM	University of Namibia

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CHAPTER 1: INTRODUCTION

1.1 Background of the study

Mathematics is all around us and in order to be successful in this world there is a need for individuals prepared to absorb new ideas, perceive patterns and solve unconventional problems. Hence, the aim is to enable learners to develop an ability to apply mathematics, in the context of everyday situations. Additionally, it is important that learners develop their ability to analyse problems logically, recognise when and how a situation may be represented mathematically, identify and interpret relevant factors and where necessary, select an appropriate mathematical method to solve a problem (NIED, 2010).

Project-Based Learning (PBL) is constructivist instructional methods which are learner-centred, in which learners are presented with a problem and through discussion within their group, activate their prior knowledge. In addition, PBL engages learners in gaining knowledge and skills through an extended inquiry process structured around composing, authentic questions and carefully designed products and tasks (Thomas, Michaelson & Mergendoller, 2002). PBL has authentic content and purpose, uses authentic assessment, utilises the teacher as a guide, has explicit educational goals and aims to make the teacher learn continuously (Ozdemir, 2006). Moreover, PBL can be beneficial if employed in science subjects especially mathematics (Algebra).

The teaching and learning of mathematics in the school curricula is of vital importance in achieving Vision 2030. In addition, in order to learn mathematics well, conceptual structures and strategies of problem solving and attitudes towards appreciation of mathematics is needed (NIED, 2010). Learners today live in a world that is dominated by technology such as computers, smart phones, the internet and global economy (NIED, 2010) that require an extensive use and understanding of mathematics; hence sound mathematical knowledge is necessary to survive in the modern technological world.

In order to achieve the above set goals, learners need to be actively involved in their learning and meaning making in the classroom. Haimbondi (2012) argues that this type of learning is a true learner-centered learning approach where learners are the main driving force behind knowledge construction in the classrooms and teachers facilitate the learning process.

Therefore, due to the lack of learner-centered education (LCE) in classrooms learners tend to be bored. Moreover, educators realised that when learners are bored and unengaged, they are less likely to learn (Blumenfeld, Soloway, Marx, Krajcil, Guzdial & Palinscan, 1991). In addition, if teachers could implement ways to involve learners in their own learning, learners would be more motivated to learn. This would improve mathematics results in schools. Consequently, the introduction of PBL to assist learners and teachers to be actively involved in the teaching and learning of mathematics could provide an opportunity to improve results and this needs exploration.

PBL allow learners to engage in real world activities that are similar to the activities that adult professionals engage in. “ Project-based learning is a form of situated learning and is based on the constructivist theory that students gain a deeper understanding of material when they actively construct their understanding by working” (Krajcik & Blumenfeld, 2006, p.2). Hence, there is a need to explore the effects of incorporating PBL as an approach or strategy in the teaching and learning of mathematics.

According to the Directorate of National Examinations and Assessment’s (DNEA) Annual Examiner’s Report for Mathematics Ordinary Level (DNEA, 2013), trigonometry and algebra are topics identified as difficult to the learners. The examiner’s report (DNEA, 2014, p.311) states that “teachers must concentrate on topics that prove to be difficult for the learners: Geometry, Trigonometry, Algebra and Probability”. The reports further state that learners had difficulties to simplify algebraic equations and solve simultaneous equations that involve two unknowns. Also, other questions on algebra were poorly answered (DNEA, 2014).

The Namibian Senior Secondary Certificate Ordinary level (NSSCO) Mathematics 2014 results analysis done by the Kavango Education Directorate shows that, more than five secondary schools in the region performed with an average of below 50%. This performance is based on the national grading criteria. These school results range from 19.55% to 27.24% in 2014 as shown in Table 1.1 and from 27.8% to 45.5% in 2015 for Kavango West as shown in Table 1.2.

Table 1.1: Statistical analysis of the NSSCO Mathematics 2014 results in Kavango

Region

Name of secondary schools	NSSCO-Mathematics (%) 2014
A	27.24
B	26.62
C	24.81
D	20.53
E	19.55

Source: www.dnea.gov.na//archive?2014,exams

Table 1.2: Statistical analysis of the NSSCO Mathematics 2015 results in Kavango

West Region

Name of secondary schools	NSSCO-Mathematics (%) 2015
A	45.5
B	41.3
C	41.3
D	33.0
E	27.8

Source: www.dnea.gov.na//archive?2015,exams

These results indicate a significant problem in the teaching and learning of mathematics topics such as Geometry, Trigonometry, Algebra and Probability in the region. In this study the focus was on algebra as an area of performance measure. DNEA reports

indicate consistently that questions on algebra are poorly answered. It is against this background that the researcher chose to investigate whether a PBL approach to algebra teaching might result in an improved learner performance in the area of algebra specifically in expressions, equations and inequalities.

1.2 Statement of the problem

Since 2009, many learners have failed to achieve a D symbol or better in mathematics. This indicates that 60% of learners who sit for mathematics examinations, obtained symbols between E (40%) and U (<20%). In 2014, in Kavango West region only 26% of learners who wrote the national examinations obtained A-D symbol (DNEA, 2014). Moreover, a C symbol is a minimum entry requirement to science related fields at the University of Namibia (UNAM), the Namibia University of Science and Technology (NUST) and the International University of Management (IUM). It therefore means that in the year 2014, 74% of the learners who wrote examinations in the Kavango West region did not qualify for any science related field at any of the three universities in the country.

Recent studies (NIED, 2010; & Nambira, Kapenda, Tjipueja & Sichombe, 2009) investigated reasons for poor performance in mathematics and listed lack of proper teaching methods as a major cause of poor performance in mathematics. According to the Annual Examiner's Report for Mathematics Ordinary Level (DNEA, 2014) the algebra topics were consistently identified to be performed badly. Furthermore, the statistics on the components of the four papers (NSSCO Mathematics) written in 2014,

indicate that more learners failed the questions on the topic of algebra (DNEA, 2014). Questions based on algebra were poorly answered. In addition, the statistics on the components of the four papers (NSSCO Mathematics) written in 2015 states that “the following topics proved to be difficult to most of the candidates therefore teachers must put more emphasis on them: Rate, Ratio, Algebra, Graphs and Geometry” (DNEA, 2015, p.369).

Following the above explanation and reasoning, the study investigated the effects of a PBL approach in learning and teaching algebra in selected secondary schools in the Kavango West region.

1.3 Hypothesis

The study was guided by the following null and alternative hypotheses as it sought to determine the effects of PBL on learners’ performance in algebra. The hypotheses were tested at $\alpha = 0.01$ significance level.

H₀- There is no significant difference in the learners’ performance in algebra when taught using the PBL approach.

H₁- There is a significant difference in the learners’ performance in algebra when taught using the PBL approach.

1.4 Significance of the study

The outcomes of this study could be helpful in informing policy makers and Ministry of Education, Arts and Culture (MEAC) officials in Namibia about the usefulness of PBL methods in teaching and learning algebra in mathematics classrooms. The results might also help to inform education policy and decisions-makers about setting up policies that could assist mathematics teachers in effectively implementing PBL. The results of the study provided information on the effects that a project-based learning approach has on the performance of learners in algebra and in mathematics as a subject. These results would benefit mathematics teachers in the Kavango West educational region by providing them with a PBL approach which has a positive influence on the academic performance of learners. The results might also help educators in the Kavango West region as a new teaching method and strategy.

1.5 Limitations and delimitations of the study

The success of data collection of this study depended heavily on the cooperation and willingness of both learners and teachers to participate. Without their full cooperation, there would hardly be any relevant and reliable data collected. The results of the study could only be generalised to the schools with similar characteristics to the selected school. This study was only carried out with the Grade 11 Mathematics learners at one selected secondary school in the Kavango West education region in Namibia.

1.6 Definition of terms

It is important to define terms that could be misinterpreted in order to establish a frame of reference in which the researcher approached the problem (Best & Kahn, 1998). Accordingly, the following terms are used in this study and should be understood as defined here:

Project-Based Learning (PBL): The term “project-based learning” describes a concept and practice in which learners go through an extended process of inquiry in response to a complex question, problem, or challenge. In this study, PBL refers to the method of teaching that involves active participation of learners in mathematics through working on real life activities, projects, small-group discussions and outdoor practices in particular, to enable them to learn algebra in a more project-based way (Mergendoller, 2006).

Learner-Centred Education (LCE): Are methods of teaching that promote active learner participation, encourage self-initiated learning; involve the process of inquiry and discover and promote understanding of what is being presented in the teaching/learning process (Henson, 2003).

Performance: Refers to the academic accomplishment of a given task measured against preset known standards of accuracy, completeness and speed (Cobb, 2005). In this study, the term was used to refer to the learners’ results and outcomes from mathematics pre-test and post-test activities given to them to complete.

Students and Learners: Are terms used interchangeably in this study and understood to mean those trying to gain knowledge or acquire a skill in something through studies or experience in a school.

Teacher-Centred Methods: Are methods of teaching where attention and activities focus on the teacher. Learners often only sit quietly, passively and listen to the teacher. In teacher-centred methods of teaching, the teacher is expected to have the knowledge required for the teaching/learning process which he/she has to pass on to the learners. As a result, the teacher does most of the talking and thinking during lessons (Henson, 2003).

1.7 Summary

This chapter has given a general overview of the principles of PBL and how other studies have investigated the different topics in mathematics. Based on the information above, the study cannot conclude whether PBL has an effect on the performance of the learners in algebra. Therefore, it is against this background that this study was conducted to address the Namibian context investigating the effects of project-based learning in learning algebra in a selected secondary school in Kavango West region. The next chapter reviews the literature on the topic.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter presents the theoretical framework from which the research findings are reviewed. The review of literature is primarily focused on Project-Based Learning (PBL) and the teaching of mathematics. It addresses the existing gaps in the literature and presents the following sections: PBL and how it relates to the learning of mathematics, PBL and its relation to Learner-Centred Education (LCE), and the importance or benefits of incorporating PBL in teaching and learning of mathematics for Namibian learners. The researcher was unable to find studies on PBL done in Namibia.

Therefore, the study sought to investigate the effects of a project-based learning approach in the learning and teaching of algebra at a selected secondary school in the Kavango West region. The study further wants to prove the following hypotheses:

H₀:- There is no significant difference in the learners' performance of algebra after using the PBL approach.

H₁: - There is a significant difference in the learners' performance of algebra after using the PBL approach.

2.2 Theoretical framework

The study is viewed through the lens of the social constructivist theoretical framework. In Vygotsky's (1978) theory, the learner is viewed as an active participant in constructing his/her own knowledge within the community (Kiboss, 2001). Moreover, "constructivism is a theory of knowledge and learning based on the idea that individual learner constructs their knowledge, building on their prior knowledge" (Moursund, 2003, p.15). In addition, learning is seen as involving the altering of learners' existing theoretical framework as a result of their exposure to new experiences. The constructivist perspective on concept learning draws on the idea that knowledge is actively constructed (Kibett, 2002). This is an approach for learners to construct knowledge through teamwork and problem-solving with scientific methods (Krajcik, Czeniak & Berger, 1999). Project-based learning has been a category of pedagogical practice for years, and involves a wide range of scientific areas where learners usually concentrate on group learning and presentation of various outcomes. In this study, social constructivism implies that the learners construct new knowledge through project-based learning and teaching methods which include collaborations, sharing experiences, projects, learning by doing and discussions among learners and between the teacher and the learners. There are 8 Elements of constructivism of which project-based learning fits well into. Every aspect of PBL meets the requirements listed below:

1. Learning is an active process in which the learner uses sensory input and constructs meaning out of it.

2. People learn to learn as they learn: learning consists both of constructing meaning and constructing systems of meaning.
3. The crucial action of constructing meaning is mental: it happens as reflective activity in the mind. Physical actions, hands-on experience may be necessary for learning, especially for children, but it is not sufficient; there is a need to provide activities which engage the mind as well as the hands.
4. Learning involves language: the language used influences learning.
5. Learning is a social activity: learning is intimately associated with people's connection with other human beings, teachers, peers, family as well as casual acquaintances.
6. Learning is contextual: learners learn in relationship to what else they know and believe.
7. One needs knowledge to learn: it is not possible to assimilate new knowledge without having some structure developed from previous knowledge to build on.
8. It takes time to learn: learning is not instantaneous. (Excerpted from <http://www.artsined.com/teachingarts/Pedag/Dewey.html>).

2.3 Definitions of project-based learning and its relation to the learning of mathematics

Krajcik and Blumenfeld (2006) define PBL as an approach to the learning environment that supports the learning activities appropriate to achieving learners in the investigation of authentic problems. Mergendoller (2006) also defines PBL as a teaching methodology that utilises learner-centred projects to facilitate learner learning. It is different from the

traditional teaching methods as it improves problem solving and thinking skills, and learners are actively involved in their learning (Holm, 2011). Moreover, a PBL approach focuses on organising self-learning in an experiential project (Tseng, Chang, Lou & Chen, 2011). These can be achieved through practical activities, interactive discussions and cooperation; learners reach the planned target and establish their own knowledge (Tseng et al, 2011).

Railsback (2002) argues that PBL is an authentic instructional model or strategy in which learners plan, implement and evaluate projects that have real-world applications beyond the classroom. Mostly, learners find projects fun, motivating and challenging because they play an active role in choosing the project while involving them in the entire planning process. PBL can be defined as a learner-centred instruction that takes place over a long period, in which a learner selects, designs, investigates and produces a product, presentation or performance that answers a real-world question (or problem) or responds to an authentic challenge (Holm, 2011; Grant, 2011; Krajcik & Blumenfeld, 2006). Blumenfeld and Krajcik (2006) add that “PBL is an overall approach to the design of learning environment” (p.2). Grant (2011) argues that “the production of a learning object is what consequently distinguishes PBL from problem-based learning” (p.38). Furthermore, Bell (2010) defines “PBL as a student-driven, teacher-facilitated approach to learning” (p.9). During the process, the learners pursue knowledge by asking questions that have piqued their curiosity. Learners develop a question and are monitored through research activities of their own by their teachers. Effective PBL leads learners to investigate important ideas and questions and is framed around the inquiry process. PBL is also focused on the learner’s needs and interests. PBL requires the use

of creative thinking and information skills to investigate, draw conclusions about, and create content that connects to the real world as well as authentic problems and issues (Klein, Taveras, King, Commintate, Curtis-Bey & Stripling, 2009). There are five features of PBL (Thomas, 2000, p.1-4):

- The use of projects that focus on content central to the curriculum.
- Projects are based on questions of importance or driving questions. Driving questions should foster learner involvement and promote active intellectual pursuit of solutions.
- Projects involve learners in ways that require them to identify problems, develop and design solutions, and create an end product such as a presentation, report, invention or model.
- Projects are learner-centred to the greatest extent possible. Teachers serve as facilitators and guides, but it is the learners, who define, choose and carry out their projects.
- Projects are developed from reality-based ideas and problems rather than on academic exercises and pursuits. The project represents authentic efforts in solving or investigating real-world dilemmas.

Karaman and Celik (2008) describe PBL in the literature as:

PBL is a model that organises learning around projects. Learners decide how to approach a problem and what activities to pursue. They gather information from a variety of sources and synthesise, analyse and derive knowledge from it. Their learning is inherently valuable because it is connected to something real and involves adult skills such as collaboration and reflection. In the end, students

demonstrate their newly acquired knowledge and are judged by how much they have learned and how well they communicate it (p.204).

Therefore, there must be a paradigm shift in the roles of teachers and learners, away from traditional teaching methodology. To sum up, the teachers' involvement and guidance and the learners' involvement are needed for optimal learning.

2.4 The learning of algebra

“Algebra is a set of letters and numbers connected by addition, subtraction, multiplication and/or division” (D’Emiljo, 2012, p.38). Wu (2009) adds that “algebra is about what is true in general for all numbers, all whole numbers and all integers” (p.3). Algebra is an important part of school mathematics but is challenging for most learners. Algebra is also a powerful mathematical tool that is used to solve real-world problems in science, business and many other fields. In the Namibian syllabus algebra is divided into the following topics: algebraic representation and formulae, algebraic manipulation, polynomials, equations and inequalities, sequences, indices and logarithms (NIED, 2010). Any equation in algebra is a statement that indicates that two quantities are equal. All equations have an equal sign.

Usiskin (1995) outlines the difficulties that learners may face without knowledge of algebra:

- Learners lose control over parts of their lives and rely on others to do things for them.

- Learners are most likely to make unwise decisions, financial and otherwise.
- Learners are not able to understand many ideas discussed in chemistry, physics, earth sciences, economics, business, psychology and many other areas.

Algebra is important in everyday life. Usiskin (1995) states the importance of algebra as:

- The language of generalisation. Algebra is the language through which we describe patterns.
- Algebra enables a person to answer all the questions of a particular type at one time.
- Algebra is the language of relationship between quantities.
- Algebra is a language for solving certain kinds of numerical problems. It is used to solve problems involving age, motion, coins, work and mixtures (p.32-34).

One of the important uses of algebra is to develop mathematical models for understanding real-world phenomena. In order to solve an application problem, relevant information must be extracted from the wording of problem and then translated into mathematical symbols. This skill requires practice and the key is to stick with it and not get discouraged (Usiskin, 1995).

Problem-Solving Flowchart for Word Problems

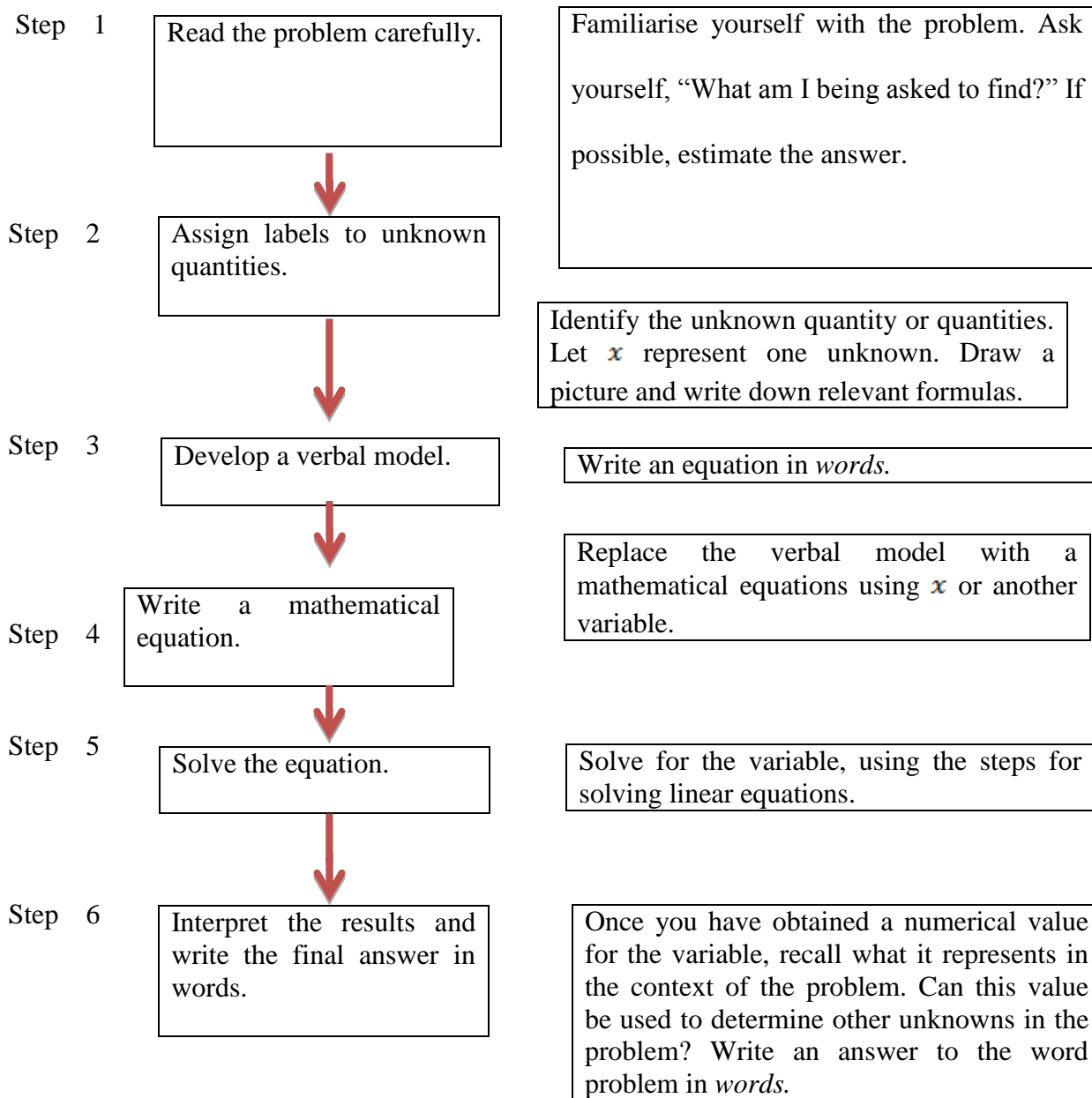


Figure 2.1: Flowchart on the process of dealing with word problems

Using the steps in Figure 2.1, look at a scenario. The sum of two numbers is 39. One number is 3 less than twice the other. What are the numbers?

Step 1: Read the problem carefully.

Step 2: Let x represent one number.

Let $2x - 3$ represent the other number.

Step 3: (One number) + (other number) = 39

Step 4: Replace the verbal model with a mathematical equation.

(One number) + (other number) = 39

$$x + (2x - 3) = 39$$

Step 5: Solve for x .

$$x + (2x - 3) = 39$$

$$3x - 3 = 39$$

$$3x = 42$$

$$\frac{3x}{3} = \frac{42}{3}$$

$$x = 14$$

Step 6: Interpret your results. Recall step 2.

One number is x : \longrightarrow 14

The other number is $2x - 3$:

$2(14) - 3$ \longrightarrow 25

Therefore, the answer: The numbers are 14 and 25.

2.5 Phases in the application of projects

Chard (2001) reports that application of projects need to consist of three phases; the beginning, middle and the end. In the initial stage, the teacher selects the topic of study based on the learner's interests, the curriculum objectives and the availability of resources and materials. The teacher also brainstorms his or her own experience, knowledge and ideas, representing them in a topic web. The teacher discusses the topic with the learners to find out what experiences they have had and what they already know about it (Blumenfeld, 2000; Moursund, 2003). The learners represent their experiences in a variety of ways and show how well they understand the concepts involved in explaining their observations. The teacher helps the learners develop questions about what their investigation will answer. The teacher encourages the parents to talk with their children about the topic and to share any relevant special expertise.

In the second or middle phase, it is important to construct the project. The learners have opportunities for them to do field work and talk to experts. The teacher provides resources to the learners by helping them with their investigations; real objects, books and other research materials. Each learner is involved in representing what they have learnt and each learner can work at his or her own level in terms of basic skills, drawing, music, construction and dramatic play. The teacher enables the learners to be aware of all the different work done through class or group discussions and display. The topic web designed earlier provides a shorthand means of documenting the progress of the project (Chard, 2001).

The last phase involves the product of the project and evaluation of the product, for both the learners and the teacher. The teacher arranges a culminating event for the learners to share what they have learned. The learners may need help in telling the story of their project to others. The teacher helps the learners to select material to share and by so doing it involves them purposefully in reviewing and evaluating the whole project. The teacher also offers the learners imaginative ways of personalising their new knowledge through art, stories and drama. Finally the teacher uses the learner's ideas and interests to make a meaningful transition between the project being concluded and the topic of study in the next project (Chard, 2001).

At the beginning phase of the project, the teacher, who will also be the researcher, will discuss the topic with the learners to find out what experiences they had and what is already known to them, then, learners will work on the project in groups.

2.6 The benefits of using project-based learning

A PBL offers a wide range of benefits to both learners and teachers especially in mathematics and other science related subjects. PBL assists learners with an in-depth understanding of concepts rather than memorisation (Grant, 2011). This helps learners to become self-directed are able to apply sound higher-order thinking skills (Holm, 2011).

PBL prepares learners for the workplace. Learners are exposed to a wide range of skills and competencies such as collaboration, project planning, decision-making and time management (Blank, 1997; Dickinson et al., 1998). PBL increases the motivation of the learners. Teachers often note improvement in attendance, more class participation and

greater willingness to do homework (Bottoms & Webb, 1998; Moursund, Bielefeldt & Underwood, 1997). PBL helps learners to connect learning at school with reality.

Learners gain more knowledge and skills when they are engaged in stimulating projects. With projects, learners use higher order thinking skills rather than memorising facts in an isolated context without a connection to how and where they are used in the real world (Blank, 1997; Bottoms & Webb, 1998; Reyes, 1998). In addition, PBL improves the learning of the learners. After completing a project, learners understand the content more deeply, remember what they learn and retain it longer than is often the case with traditional instruction. Due to this, learners who gain content knowledge with PBL are better and able to apply what they know and can do to new situations. A teacher in the Washington State who used project-based learning in his maths and science classes reports that many learners who often struggle in most academic settings find meaning and justification for learning by working on projects (Nadelson, 2000). The teacher also notes that by facilitating learning of content knowledge as well as reasoning and problem-solving abilities, PBL can help students prepare for state assessments and meet set standards (Nadelson, 2000).

Mathematics is a doing subject, full of formulae and equations and learners need to understand and apply to solve real problems. In addition, PBL offers learners skills such as guidance and management as well as monitor their learning through self-direction and self-regulation (Worthy, 2000). Moreover, it also increases learner attendance and improve attitudes toward the learning of mathematics (Thomas, 2000). PBL also has the potential to integrate collaboration and cooperation meaningfully (Lou & MacGregor,

2004). Furthermore, lessons that use PBL use different resources, tools and the media. According to Blumenfeld and Krajcik (2006), “in project-based mathematics, students engage in real, meaningful problems that are important to them and that are similar to what scientists do. Project-Based Learning in mathematics allow students to explore phenomena, investigate questions, discuss their ideas, challenge the ideas of others and try new ideas” (p.4).

PBL provides learners with opportunities to develop complex skills such as higher-order thinking, problem-solving, collaborating and communicating (SRI, 2000). Moreover, PBL builds success skills for college, career and life. In the 21st century workplace and in college, success requires more than basic knowledge and skills. In a project, learners learn how to take initiative and responsibility, build their confidence, solve problems, work in teams, communicate ideas and manage themselves more effectively. Furthermore, PBL provides access to a broader range of learning opportunities in the classroom, providing a strategy for engaging culturally diverse learners (Railsback, 2002).

PBL provides opportunities for learners to use technology. Learners are familiar with and enjoy using a variety of technology tools that are a perfect fit with PBL. With technology, teachers and learners cannot only find resources and information and create products, but also collaborate more effectively and connect with experts, partners and audiences around the world (BIE, n.d). In addition, PBL provides a practical, real-world way to learn to use technology (Kadel, 1999; Moursund, Bielefeldt & Underwood, 1997).

Many teachers feel that project-based learning is an important and effective part of their teaching, especially algebra topics. A project-based learning lesson provides learners with the opportunity to learn in an authentic, challenging and multidisciplinary environment to learn how to design, carry out and evaluate a project that requires sustained effort over a significant period of time, to learn to work with minimal external guidance, both individually and in groups, to gain self-reliance and personal accountability (Moursund, 2003). As a result of these prospects, PBL provides many advantages that emerge from a learner's point of view. Firstly, PBL provides the LC approach and uses intrinsic motivation. Secondly, it encourages collaboration and cooperative learning. Thirdly, it allows learners to make incremental and continual improvement in their products, presentations or performances. Fourthly, it actively engages learners in 'doing' things rather than in learning 'about' something. In addition, it requires learners to produce a product, presentation or performance. Lastly, it challenges learners with a focus on higher-order skills (Moursund, 2003).

Moursund (2003) gave an analysis on the advantages of project-based learning based on the teacher's point of view. PBL has authentic content and purpose, uses authentic assessment, utilises the teacher as guide, has explicit educational goals, stems from constructivism and aims to make the teacher a learner (Moursund, 2003). Moreover, teachers report that PBL overcomes the separation between knowledge and thinking, helping learners to both "know" and "do". It supports learners in learning and practicing skills in problem solving, communication and self-management while encouraging the development of habits of the mind associated with lifelong learning, civic responsibility

and personal or career success. It integrates curriculum areas, thematic instruction and community issues, assesses performance on content and skills using criteria similar to those in the work world thus encouraging accountability, goal setting and improved performance. It creates positive communication and collaborative relationships among diverse groups of students, meets the needs of learners with varying skill levels and learning styles, and engages and motivates bored or indifferent students (Moursund, 2003).

Studies done by ChanLin (2008) and Karaman and Celik (2008), indicate that learners in PBL performed better in skill development, general ability and knowledge compilation than those who did not use PBL. In addition, it is argued that PBL helps to increase the learners' positive learning attitudes towards technology (Mioduser & Betzer, 2007) and mathematics (Catherine & Barry, 2008).

In conclusion, PBL lessons make use of reflections (Grant & Branch, 2005), such as short reflections at the end of the period. Hence, this study tests the effects of this approach in teaching of algebra in one selected secondary school in the Kavango West region.

2.7 Project-based learning 21st century skills

PBL could have the potential to positively impact student engagement in the learning process, and the facilitation of student acquisition of 21st century life and learning skills. Twenty-first century skills comprise of a variety of technology, collaboration and thinking skills. Specifically, the Partnership for 21st Century Skills identified five broad

categories, including: (a) information, media and technology skills; (b) learning and innovation skills; (c) life and career skills; (d) global awareness; and (e) financial, health, civic and environmental literacy (The Partnership for 21st Century Skills, 2009).

Mergendoller, Markham, Ravitz and Larmer (2006) argue that PBL practices vary depending on the grade level and subject area. Projects should allow for some degree of the learners' voice and choice, and should be carefully planned, managed and examined to connect rigorous academic content to 21st Century skills (such as collaboration, communication & critical thinking) through learner development of high-quality, authentic products and presentations. Learners need to develop skills that will enable them to become independent life-long learners who can access, organise, synthesise and interpret information. Through PBL, learners' are provided both the structure and flexibility to develop those skills in addition to communication, information, civic awareness and self-regulatory skills. Because, "self-concept is the way people describe themselves based on the roles they play and the personal attributes they think they possess," (Beane et al., 1980, p.86), it could be reasonably suspected that PBL and the acquisition of 21st Century skills could contribute to improved learner performance in algebra.

Furthermore, learners participating in PBL engage in ongoing development of communication, research, organisation, self-regulation and presentation skills which offers them the opportunity to continuously reinvent themselves. In addition, it is conceivable that the learners' self-concept could be impacted by the skills and opportunities inherent in the constructivist PBL model. Hence, the PBL link with 21st

Century skills development is rooted in the social process involved in project development and product or artefact presentation. By engaging learners in problem-solving, authentic experiences in which they utilise technology, collaborate with peers and present their findings, students build 21st Century skills.

The Partnership for 21st Century Skills (2009) summarised that learning and innovation skills (creativity, communication, collaboration and critical thinking) are recognised as the skills that separate learners who are prepared for the complex life and work environments of the 21st century, from those learners who are not. Table 2.1 displays McGrath's (2004) summary of the four skills sets of 21st Century skills identified by the *enGuage 21st Century Skills Report*.

Table 2.1: McGrath's Four Skill Sets Related to 21st Century Skills

21st Century Skills	
Digital Age Literacy	-Basic scientific, economic and technological literacy -Visual and informational literacy -Multicultural literacy and global awareness
Inventive Thinking	-Adaptability, managing complexity and self-direction -Curiosity, creativity and risk taking -Higher-order thinking and sound reasoning
Effective	-Teaming, collaboration and interpersonal skills
Communication	-Personal, social and civic responsibility, as well as interactive communication

High Productivity	-Prioritising, planning, and managing for results -Effective use of real-world tools, and the ability to produce relevant high-quality products
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As learners progress through a PBL project, they must demonstrate to varying degrees, the acquisition of these 21st Century skills (McGrath, 2004). Thus, PBL provided the educational environment that enabled learners to learn in relevant, real world contexts through collaboration, creative learning practices, human support and individual exploration of authentic questions (The Partnership for 21st Century Skills, 2009). This is important because these are skills learners can use in the world of work and throughout their lives. Hence, conclusively, it can be assumed that using the 21st Century Skills and

PBL enable learners to perform well in algebra. The stated literature does not state whether the 21st Century Skills have effects on the performance of learners in algebra.

2.8 The relationship between learner-centered education and project-based learning in Namibian the system

It is of benefit to Namibian teachers to analyse the motions of learner-centred education (LCE) within the context of PBL. How does it fit together and how does it make sense as an approach to consider for teaching and learning, and then look at the relationship of LCE and project-based learning. The term LCE is a very old concept in the education setting. Its origin could be traced back to the work of some well-known philosophers and educators such as Confucius, Socrates and Jean-Jacques Rousseau, just to mention a few (Cuban, 1984; Henson, 2003). LCE is deeply rooted in the theory of social constructivism because it takes into account the social nature of the learning environment as a collaborative atmosphere between the teachers and learners (Gergen, 1995; Murphy, 1997; McCombs & Whistler, 1997).

Social constructivism emphasises the importance of learners learning through interaction with the teacher and other learners (Maypole & Davies, 2001). This means learning is a social process. Social constructivism also recognises the role of shared experiences and discussions between people in the way that builds their sense of meaning (Kilgore, 2001).

Ministry of Education (2014) defines LCE as:

An approach to teaching and learning that comes directly from the National goals of equity (fairness) and democracy (participation). It is an approach that means that teachers put the needs of the learner at the centre of what they do in the classroom, rather than the learner being made to fit whatever needs the teacher has decided upon. This means that learning must begin by using or finding out the learners' existing knowledge, skills and understanding of the topic. The teacher is responsible for developing different activities to find out what the learners already know about the topic. Then teachers develop more activities that build on and extend the learners' knowledge (p.13).

Qhobela and Moru (2014) also proposes that LCE should focus on the learning process and that all the actions in a classroom must focus on what the learners are doing and not what the teacher is doing. The natural curiosity and eagerness of learners to learn to investigate and to make sense of a widening world must be nourished and encouraged by challenging and meaningful tasks. The learners' perspective needs must be appreciated and considered and learners should be empowered to think and take responsibility - not only for their own, but also for other learning and total development. Learners should be involved as partners in, rather than receivers of, educational growth (Ministry Of Education, 2014). In the LCE, the focus is on the learner and not the teacher.

O' Neill and McMahan (2005) highlighted several themes related to the definition of LCE as follows: some people view LCE as the concept of the learners' choice in their education; others see it as being about the learner doing more than the teacher; while

others have a broader definition which includes both of these concepts but, describe the shift in the power relationship between the learner and the teacher.

LCE has advantages during the teaching and learning process. LCE focuses on the following advantages (Ministry of Education, 2014):

The curriculum and syllabus objectives should be expressed in terms of what the learner will achieve, not what the teacher will teach. Secondly, the learning should be from the learner's own experience. The learner's prior knowledge should be taken into consideration, during the learning process. Thirdly, learners learn from pairs and group activities. Fourthly, learners learn by doing. The teacher and learners can bring a large number of materials in class to be looked at, examined, drawn, painted, copied, read and analysed. The next advantage is that learners learn from useful materials, materials that guide and stimulate learning. Hence, these materials encourage self-study and self-learning in an environment where the teacher is ready to support. In addition, there is a shift in the role of the teacher. The teacher becomes a facilitator of learning (Ministry of Education, 2014).

The LC approach also has advantages for the teachers. The teacher has time to develop a personal interest and can establish a proper relationship with each learner. Secondly, teachers have time to observe the usefulness of the materials, and how they are working in class. This includes the formal materials and the one developed by the learners. Lastly, the teacher assesses each learner individually, that includes oral work, written

work, activities, reading skills, classroom interaction and personal development. The fast and slow learners are given attention.

A number of methods are associated with LCE (Adejoke, 2007). No single method is superior, particularly in terms of student performance. Consequently, in LCE, the methods of teaching must be matched to objectives and intended tasks for efficiency and effectiveness. Some learner-centred methods of teaching which were mostly relevant to the teaching and learning Mathematics particularly algebra are as follows: Individualised method, group work, interactive method (the discussion technique), project work, practical and experimentation, problem solving and discovery learning, peer tutoring, debate, simulation and field trips.

2.8.1 Project work

This is a technique where learners can be given a topic to do some studies on. The topic can be chosen by the teacher or by the learners depending on the school subject or the desired topic. In the case of algebra, a teacher can get learners to choose a topic and then do an investigation or research using different resources. This approach is learner-centred as learners would use their own initiative to gather and analyse information and demonstrate their writing skills in the learning process through the project they would be doing (Katz & Chard, 1990; Henry, 1995; Kagan, 1995; Imasiku, 1999). Project work could be individualised for learners and it could also be in form of a group project, but whichever the case is, the aim of the two is the same; to foster better learning and

encourage active learner participation. It requires careful planning and evaluation techniques. It is very useful at higher levels of learning (Johnson et al., 1993; Chipeta, 1997; Dunne & Wragg, 1997; Engelbrecht, 2000).

The PBL approach takes learner-centredness to a higher level (Bilsborough, 2013). Bilsborough (2013) further outline four elements which are common to all project-based activities and LCE:

- A central topic from which all the activities derive and which drives the project towards a final objective.
- Access to means of investigation (the Internet has made this part of project work much easier) to collect, analyse and use information.
- Plenty of opportunities for sharing ideas, collaborating and communicating. Interaction with other learners is fundamental to PBL.
- A final product (often produced using new technologies available to us) in the form of posters, presentations, reports, videos, web pages, blogs and so on.

Holm (2011) define PBL as learner-centred instruction that occurs over an extended time period, during which learners select, plan, investigate and produce a product, presentation or performance that answers a real-world question or responds to an authentic challenge. In addition, PBL is an innovative approach to learning that teaches a multitude of strategies critical for success in the twenty-first century. Learners drive their own learning through inquiry, as well as work collaboratively to research and create projects that reflect their knowledge. From gleaning new, viable technology skills,

to becoming proficient communicators and advanced problem solver, learners benefit from this approach to instruction (Bell, 2010). As is in the case with LCE, the teacher serves as a facilitator, providing scaffolding, guidance and strategic instruction in the process of learning. A project or pursuit, undertaken by the learner, has four distinct, learner-centred phases: purposing, planning, executing and judging. Ideas such as these, combined with the model for scientific inquiry, have contributed to a variety of student-centred methods such as problem-based, case-based, discovery learning and expeditionary learning (Knoll, 1997; Thomas, 2000; Prince & Felder, 2007).

Thomas (2000) emphasises the depth of learning and intrinsic motivation as key benefits of this methodology, as well as a focus on learner-centred, systematic inquiry. LCE and PBL are not arguably, different concepts. The goal of these methodologies is to move education towards more learner-centred, inquiry-based, active learning methods. The intent is to help learners become self-directed learners who can apply sound higher-order thinking skills. Moreover, Meyer (2004) describes three broad inquiry-based approaches that emerged as a response to the rise of constructivist ideas about learning in the 1960's: inquiry on the basis of understanding problem-solving rules based on the work of Jerome S. Bruner; in the 1970's, Jean Piaget's conservation of strategies applied to problem solving and Seymour Papert's contributions to discovery learning applied to computer programming concepts.

2.9 Recent research in Namibia on mathematics and educational technology

Haimbodi (2012) looked at the effects of cooperative learning on motivation and performance of Grade 11 learners in the Oshana education region and found that cooperative learning improves learner performance in mathematics and also increases their motivation of learning mathematics. In educational technology, Kamerika (2006) investigated the teachers and learner's perceptions and challenges that affected the implementation of Computer Practice in schools and discovered that teachers were not initially trained as Computer Practice teachers but few of them were trained to teach the subject at schools. Other studies were done on the integration of ICT in the preparation of teachers at the colleges of education in Namibia (Ipinge, 2010) and found that majority of teachers and educators expressed interest and willingness to integrate ICT in their teaching and learning situations. On Principal's perceptions on ICT implementation in secondary schools in the Khomas educational region (Quest, 2014) it was found that principals in the Khomas educational region had positive attitude towards ICT irrespective of the challenges they faced in managing the implementation of ICT in the school environment. In a study on Hifikepunye Pohamba Unam campus primary student teachers of Information and Communication Technology use and integration practices during school-based studies (Henocho, 2015), it was found that student teachers mostly used 2 and 3 dimensional ICT materials during school based studies (SBS) because they were commonly available and easy to prepare. Thus far, no study was done on the use of project-based learning in mathematics focusing on algebra teaching and learning. Therefore, there is a clear gap and motivation to investigate PBL within the setting of the Namibian classroom.

2.10 Aims of mathematics in Namibian schools

The Subject Policy Guide for Mathematics grades 5-12 outlines the aims and elaborates the educational purpose of a course in mathematics for the primary, junior and secondary school levels for Namibian schools. It indicates that mathematics should be continuous for the learners during the time at school. This will assist the school management, teachers and learners to gain a better insight in the ways of handling the subject within their school environment. The aim of the mathematics syllabus is universal for all learners in Namibian schools. The aims allow them to:

- Make provisions for a well-organised, uniform and practical-oriented programme of activities in teaching of mathematics in schools;
- Set a uniform standard to maintain a consistent approach in the teaching, evaluation and control of activities in mathematics throughout the country;
- Guide teachers in organising their administrative duties and in planning teaching and learning to meet the expectations of the national standards and performance indicators;
- Guide teachers in the methods to follow in the preparation of the lesson units to be taught;
- Provide guidelines for the collective involvement of learners in teaching-learning processes;
- Guide heads of departments, principals, advisory teachers and inspectors in exercising proper, democratic control and advice the teaching of the subject.

(National Subject Policy Guide for Mathematics grades 5-12, 2008)

With reference to the Subject Policy aims mentioned above, the mathematics syllabus should enable learners to acquire knowledge through an inquiry approach.

2.11 Summary

The review literature supported the use of PBL in mathematics and other science subjects. The common statement found is that PBL enhances performance in some subjects. In addition, most literature reviewed indicates the use of project-based learning in science, engineering and technology. In the Namibian context, based on the literature review, no study was conducted on the PBL approach. It is against this background that this study was conducted to address the Namibian context by investigating the effects of the PBL approach in the teaching and learning of algebra in a selected secondary school in Kavango West region.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter outlines the research design and methodology undertaken for this study. The research instruments, sampling and data collection procedures as well as the data analysis methods are also presented. The ethical considerations are discussed at the end of the chapter.

3.2 Research design

This research employed a quantitative approach in the form of a quasi-experimental research design that was used to investigate the influence of the PBL approach in algebra teaching for the Grade 11 learners at a selected secondary school in the Kavango West education region. “This design provides control of when and to whom the measurement is applied, but because random assignment to experiment and control treatments has not been applied, the equivalence of the group is not assured” (Best & Kahn, 2006, p.183). In addition, “quasi-experiments include assignment, but not random assignment of participants to groups. This is because the experimenter cannot artificially create groups for the experiment” (Creswell, 2012, p.309). In a quasi-experimental study, the researcher manipulates an independent variable, controls the other variables and then observes the effect on the dependent variables (Gay, Mills & Airasian, 2009). Under quasi-experimental design, a non-equivalent (pre-test and post-test) control group design was used to establish the cause and effect relationship between the use of the

Project-Based Learning Approach (PBL) and the learners' performance in the topic of algebra. Moreover, to identify the effect of the PBL approach, a control group and an experimental group was selected. The two groups were given a pre-test, followed by different treatments and then the post-test in order to measure the effects of project-based learning approach (an independent variable) on learner's performance in algebra (dependent variable).

The study used a non-equivalent control group design by studying the intact classrooms (Creswell, 2012), the reason is that the class groups already existed in the school and the researcher could not split up the classes. The researcher did everything possible to control other variables. Both groups were taught by the researcher, who gave the same teaching materials, and assignments during the duration of the study. A project-based learning approach was used for the experimental group and whereas a traditional teaching approach was used for the control group. It is important to note that perceptions of PBL is not used this study as it is not part of the scope of the study.

3.3 Population

The population of the study consisted of the all five poor performing senior secondary schools in mathematics as identified by DNEA in Kavango West region (as indicated in Table 1.1&1.2 in Chapter 1). The Grade 11 learners were chosen as participants because they had lessons on the topic of algebra, which is mostly taught in Grade 11 and because the Grade 12 learners were busy with final examinations during the data collection period.

3.4 Sample and sampling procedures

According to Best and Kahn (2006), “a sample is a small proportion of the population selected for observation and analysis” (p.13). A sample of 80 learners was randomly selected from the poorest performing school (school E) and from the class lists of all Grade 11 learners. Hence, from this sample, 11 A, of 40 learners belonged to a control group and the other class 11 D, belonged to the experimental group. Intact classes were randomly selected by writing class names on pieces of papers and randomly picking them from a container (Cohen, Manion & Morrison, 2011).

3.5 Research instruments

The research instruments that were used to collect data from the participants was a pre-test and post-test. The instruments were also given to the supervisors who made changes and rectifications which were included in the final instruments.

3.5.1 Tests

The pre-test-and post-test were created using the Themes and objectives from the NIED curriculum. Through following the objectives of the NIED NCCSO syllabus as guide, validity and reliability of the instruments is ensured.

Johnson and Christensen (2004) say that a test enables the researcher with information about what a student has learnt and what he or she can do. It can also provide the

researcher with information on how well one student has achieved in comparison with another, enabling rank orderings of performance and achievement to be constructed (Johnson & Christensen, 2004).

In this study, a pre-test (See appendix A) was given to both the control and experimental group at the beginning of the study as both learners had similar level of understanding in relation to the topic of algebra. The intervention (projects) was made by allowing the experimental group opportunities to learn lessons 1,2,3,4 (See appendix I) and work on the project (See appendix C), in algebra in a more project-based learning environment. However, the control group was taught the same lessons (in the afternoons), with the same notes and in the same duration of two weeks but with a different approach. Each lesson was 1 hour 20 minutes. Secondly, a post-test (See appendix B) was then given to both groups on the last day after the intervention (project).

During these lessons, the experimental group learners were presented with real-life activities such as working on a project (designing budget), outdoor practices such as field trips, small-group interactions, group work activities, simulation activities and watching videos to enable them to learn algebra in a more project-based learning setting. Moreover, the learners had an opportunity to interview people in their community and do a research, with the use of internet, books, newspapers and other educational journals. The groups were rotated in different venues in order for the learners to have a different exposure and different settings. In each venue there were workstations where the learners could work on different activities and the researcher only facilitated the process of learning. On the seventh day, the learners were given an opportunity to present their project to the rest of the class. The mathematics teacher was used as a judge, using the

requirements as stipulated in the rubric (See Appendix D). On the last day, a post-test was administered.

The learners in the control group taught the same objectives on algebra using traditional teaching methods such as teacher-centred learning, class discussions, question-and-answer techniques, as well as demonstrations for duration of 1h 20 minutes for seven consecutive days. The researcher, arranged class desks in rows in order to minimise discourses and the learners were encouraged to work on problems individually. During each session, the objectives were stated at the beginning of each lesson in order to create a level of expectations for learning. The content was presented and discussed with the learners as the researcher consistently used the questions to actively involve learners in the learning process. A post-test was administered on the eighth day. To control for extraneous factors such as the researcher variables, the researcher taught both groups in the presence of a mathematics teacher at the school to observe lessons.

3.6 Data collection procedures

After obtaining permission from the Permanent Secretary, Director of Education, Principal and teachers at the school, the purpose of the study was explained to the participants and how the tests were to be administered. On day one, the researcher divided the participants into the control group and the experimental group and explained the rules of participation. Furthermore, a pre-test on algebra to both groups after school hours was administered. Thereafter, the researcher taught the topic on algebra specifically on equations and inequalities to the experimental group in the afternoon

using various technologies such as projects, presentations, computing, interactive lectures, video clips and collaboration group work for two weeks. The control group was taught using some traditional teaching methods namely, teacher-centred method or lecture style with question and answer summative assessment and whole class discussions for eight consecutive days. A post –test was administered to both groups at the end of the teaching sessions on the last day of teaching.

3.6.1 Lessons

Both the experimental and control groups were taught separately, algebra (equations and inequalities). An equation is a mathematical statement indicating that the quantities on either side of the equal sign (=) have the same value (Greenes, Larson, Leiva, Shaw, Stiff, Vogeli & Yeatts, 2005). The Namibia Senior Secondary Certificate (NSSC) Ordinary level syllabus has the following objectives listed under equations and inequalities:

1. *solve simple linear equations in one unknown*
2. *solve simultaneous linear equations in two unknowns*
3. *solve quadratic equations given in factorised form, e.g.*

$$(x - 2)(x + 3) = 0$$

4. *solve quadratic equations by factorisation, by completing the square and by use*

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

5. *solve equations with fractions, e.g. $\frac{x-2}{x-1} - 1 - \frac{x+8}{x+14}$*

6. *solve simultaneous equations, one linear and one quadratic*

7. *solve simple linear inequalities*

The lessons were taught according to the order of objectives in the syllabus. As stated earlier, the lessons were structured in a PBL approach, by using driving questions, that is, related practical and real- life scenario. Lessons built from the known to the unknown. The learners' prior knowledge was taken into consideration for them to assimilate the new concept.

The lessons ran for two weeks as “short time period minimises the history threat to validity” (Gay et al., 2009, p.243). The post-test was administered immediately after the intervention. The tests were written by all the participants at the same time and in the same room to minimise external influences on the performance of the learners by allowing them to write under the same environmental conditions. Two teachers at the school where the study was conducted invigilated the pre-test and post-test.

3.7 Data analysis

The analysis of data starts from the specific and builds towards general patterns, and the researcher's responsibility is to look for relations among the different dimensions in the data collected (Johnson & Christensen, 2012). The study, employed descriptive statistics (mean, standard deviation and variance) to analyse quantitative data from the tests. A t-

test was used to determine whether the use of project-based learning had any significance effect on the performance of the learners in algebra.

3.8 Ethical consideration

To ensure adherence to the research ethics, the researcher first obtained clearance from the University of Namibia Centre for Research and Publications (See Appendix E), thereafter, from the Permanent Secretary in the Ministry of Education, Arts and Culture (See Appendix F). Further permission was requested from the Director of Education in Kavango West region (See Appendix H), and from the school principal of the selected school.

The participants were asked to give consent and for minors assent (See Appendix G) was obtained from their parents to allow them to participate in the study after school hours. The respondents were assured of confidentiality by informing them not to write their names on the test items. The participants were also informed that they were free to withdraw at any time during the study, without discrimination. Data collected would be stored in a locked brief case to which only the researcher have access and kept for a period of not more than five years after completion of the study. Thereafter the hard copies would be destroyed by using a shredder while the soft copies would be deleted from memory sticks and hard drives.

3.9 Summary

The study was embedded in a quantitative paradigm following quasi-experimental design. Two classes from the same school were randomly selected. Each class was taught differently with a different teaching approach. The pre-test and post-test were used to determine if there was significant difference in performance of learners in Algebra and the teaching approach. Descriptive analysis and t-test were used to analyse the quantitative data. The next chapter presents the findings and discussions.

CHAPTER 4: PRESENTATION AND DISCUSSION OF RESULTS

4.1 Introduction

In this chapter, the data collected from the pre-test and post-test are presented and discussed. The study sought to determine the effects of a PBL approach in learning and teaching algebra in a selected secondary school and expounding the differences in performance of learners in the selected secondary school in the Kavango West region, Namibia. The study further wants to examine the following hypothesis:

H₀: -There is no significant difference in the learners' performance of algebra after using PBL approach.

H₁: -There is a significant difference in the learner's performance of algebra after using PBL approach.

4.2 The effects of project-based learning in learning algebra

In order to determine the effects of PBL on the performance of learners the experimental group scores in both test items were compared to establish the cause and effect relationship. The study used ratio scale of measurement. Both the pre-test and post-test were marked out of 35.

As stated in chapter 3, the theme for the study is: algebra focusing specifically on equations and inequalities. In the Namibia Senior Secondary Certificate (NSSC) Ordinary level syllabus, has the following objectives listed under equations and inequalities:

1. *solve simple linear equations in one unknown*
2. *solve simultaneous linear equations in two unknowns*
3. *solve quadratic equations given in factorised form, e.g.*

$$(x - 2)(x + 3) = 0$$

4. *solve equations with fractions, e.g. $\frac{x-2}{x-1} - 1 - \frac{x+8}{x+14}$*

5. *solve simple linear inequalities*

The pre-test and post-test scores are shown in Table 4.1, below

Table 4.1: Experimental group tests results

Descriptive Statistics		Pre-test	Post-test
N	Valid	40	35
	Missing	0	5
Mean		8.875000	17.085714
Median		9.000000	16.000000
Mode		9.0000	14.0000 ^a
Std. Deviation		2.9193211	4.5592274
Variance		8.522	20.787
Range		13.0000	18.0000
Sum		355.0000	598.0000
<i>a. Multiple modes exist. The smallest value is shown</i>			

The results displayed in Table 4.1 shows the mean scores, median, mode, standard deviation, variance, range and sum for both the pre-test and post-test. Table 4.1 also indicates that, five participants did not write the post-test. The participants withdrew during the course of the intervention. The means, medians and mode all indicate significantly higher values for the post-test; providing strong evidence that PBL was responsible for improving results.

The **Mean**, which provides the average scores for each group, indicates the two tests show a significant shift, causing a difference of 8.210714 ($17.085714 - 8.875000 = 8.210714$) in the mean scores showing that the favour is on the post-test. Hence, it can be concluded that the change was brought as a result of the implementation of PBL that was used.

The **Median**, which inform us about the middle score of the entire group when the scores are arranged in order of magnitude (either ascending or descending). The results of the median of the two tests indicates another shift after implementing PBL; that is 9.000 in the pre-test and 16.000 in the post-test this shows a 7.00 scores increase ($16.000 - 9.000 = 7.000$) due to the use of PBL.

The **Mode** indicates the most occurring score within the whole group. Thus, the results in Table 4.3 show that, in the pre-test, most learners scored 9 out of 35 marks, while after implementing the PBL, the modal value had changed from 9 to 14, 18, 23 and 25 (multiple modes existed), but the lowest mode of the post-test is specifically chosen as 14. This was in order to avoid compromising the validity of the results.

The **Sum** illustrates the total of all scores obtained in the test items for each group. In the Table the pre-test sum was 355.000 while the post-test sum was 598.000. This demonstrates a large increase of 243.000, indicating that the increase was possibly brought by the intervention used (PBL), so signifying an improvement in the performance.

The **Range** shows the difference between the maximum and the minimum scores. Therefore, the table displays that the range of the pre-test was 13, whereas for the post-test it was 18.

Standard Deviation tells us how measurements for a group are spread out from the mean (average). A low standard deviation indicates that most scores are close to the mean, while a high standard deviation indicates scores are spread out far from the mean. The results in Table 4.1 display pre-test scores have a mean of 8.8750 and a standard deviation of 2.9193211, while on the post-test the scores have a mean of 17.085714 and a standard deviation of 4.5592274. A high standard deviation was obtained in the post-test, which shows that scores were spread out from mean in the post-test as compared to the pre-test scores.

4.3 Comparison in the learners' performance in algebra

In order to determine the differences between the performances of the grade 11 learners, which took part in the study, both the pre-test and post-test results were compared and analysed as shown in the tables 4.2 and 4.3:

Table 4.2: Experimental Group Results

Statistics		Pre-test	Post-test
N	Valid	40	35
	Missing	0	5
Mean		8.875000	17.085714
Median		9.000000	16.000000
Mode		9.0000	14.0000 ^a
Std. Deviation		2.9193211	4.5592274
Variance		8.522	20.787
Range		13.0000	18.0000
Sum		355.0000	598.0000
<i>a. Multiple modes exist. The smallest value is shown</i>			

Table 4.3: Control Group Results

Statistics		Pre-test	Post-test
N	Valid	40	35
	Missing	0	5
Mean		10.625000	13.314286
Median		10.500000	12.000000
Mode		12.0000	10.0000
Std. Deviation		3.5423265	4.7882910
Variance		12.548	22.928
Range		16.0000	20.0000
Sum		425.0000	466.0000

Concentrating on the measure of central tendencies in Table 4.2 and 4.3 above, there appear to be clear differences in performance between the control group and experimental group. Moreover, in the control group the mean scores there was a slight difference in the absolute values of the pre-test (10.625000) and post-test (13.314286). The mean scores in the experimental group for pre-test was (8.875000) and post-test (17.085714) with a difference of 8.210714. This demonstrates that there was no change in the performance of learners when the learners were taught using the traditional methods as in Table 4.3. In Table 4.2 there was a significant improvement in the performance of learners when the PBL was employed as a method of teaching.

In Table 4.2 the mode scores in the experimental shifted from 9 in the pre-test to 14 in the post-test. This means more learners scored 9 out 35 in the pre-test, whereas in the post-test taken by the same learners after the intervention PBL, most learners scored 14 out 35.

In Table 4.3, the mode score for the control group decreased from 12 in the pre-test to 10 in the post-test. This means that more learners scored 12 out of 35 in the pre-test and in the post-test more learners scored 10 out of 35. The sum in both the pre-test and post-test scores in Table 4.2 differs greatly in the experimental group, compared to the sum in the both the pre-test and post-test in the control group.

4.3.1 Comparison in pre-test results of the Grade 11 learners in the selected secondary school

The selected secondary school consisted of a sample of 80 learners (40 from each group). The selected school was given a pseudonym, namely school E. A randomly sampling was performed, where 40 learners belonged to the control group and another 40 learners belonged to the experimental group. As mentioned previously, the two classes had similar characteristics, and the pre-test was given on the first day of the study at the same time. Table 4.4 below shows their results:

Table 4.4: Paired Samples Test: Experimental and Control group pre-test scores

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	99% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-test	1.750000	4.7542154	.7517075	-.2855585	3.785585	2.328	39	.025

Table 4.4 indicates how the pre-test scores from the two groups (experimental and control) were paired. In order to find the difference in performance between the two; Groups, a t-test was used to determine whether two means were significantly different from each other at a given $\alpha = 0.01$ level. In the table the $t_{\text{calculated}}$ is 2.328; while the table value t_{critical} is 2.712 and the degrees of freedom (df) = 39. The $t_{\text{calculated}} = 2.328$ is less than $t_{\text{critical}} = 2.712$. These results indicate that there was no significant difference in the pre-test scores between the experimental and the control group.

4.3.2 Comparison in the post-test performance of grade 11 in the selected secondary school

The experimental and control groups were both given a post-test on the last day of the eight-day interventions. Lessons in both groups had the same duration of 1hour 20 minutes, the same notes and handouts were used but a different approach was used to deliver the lessons. Teaching and learning methods were different. In the experimental group, their focus was on projects and real life activities.

Table 4.5: Paired Samples Test: Experimental and Control group post-test scores

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	99% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post-test	-3.7714286	6.53595	1.1046774	-6.7854241	-.7574330	-3.414	34	.002

Table 4.5 indicates how the post-test scores from the two groups (experimental and control) were paired. In order to find the difference in performance between the two groups, a t-test was used to determine whether two means were significantly different from each other at a given $\alpha=0.01$ level. In the table the $t_{\text{calculated}}$ is -3.414; while the table value t_{critical} is 2.718 and the degrees of freedom (df) =34. The $t_{\text{calculated}} = -3.424$ (the sign notwithstanding) is more than $t_{\text{critical}} = 2.718$. Therefore, the H_0 (Null hypothesis) is rejected and an alternative hypothesis (H_1) is accepted, which states that: “There is a significant difference in the learners’ performance in algebra when taught using the PBL approach.”

4.4 Discussion of the results

This section discusses the findings presented in this chapter according to the headings:

1. The effects of PBL approach on the performance of Grade 11 learners in algebra.
2. Comparison of Grade 11 learners’ performance in algebra.

4.4.1 The effects of Project-Based Learning approach on the performance of Grade 11 learners in Algebra

Based on the results presented in Table 4.1, the PBL approach has a positive influence on the performance of learners in algebra. There is a change and an improvement between the pre-test and post-test in terms of the mean scores, standard deviation and

sum (Table 4.1). After implementing PBL, the learners scored higher results in the post-test compared to the pre-test scores.

This is consistent with the results of previous studies that confirmed the effectiveness of PBL to improve students' academic achievement in mathematics (Van Ryzin & Newell, 2007; Blumenfeld, Soloway, Marx, Krajcil, Guzdial & Palinscan, 1991; Boaler, 2002). There was also a significant improvement in the mode and performances of both tests, that is 9 in the pre-test and 14,18, 23 and 25 (multiple modes existed) in the post-test. This is an indication that most learners performed well after the PBL intervention.

In Table 4.2, the post-test mean scores increased from 9 (26%) to 17 (49%) and this is attributed to use of PBL, affirming the learners' growth in terms of the subject content. This concurs with the results of the previous studies (Baumgartner & Zabin, 2008; Duncan & Tseng, 2010; Geier, Blumenfeld, Marx, Krajcik, Fishman & Soloway, 2008; Kaldi, Fillipatou & Govaris, 2011; Mioduser & Betzer, 2007), that the students in project-based classrooms exhibited greater gains in content knowledge than their traditionally taught peers. Learners performed well in the post-test as a result of the conditions to which they were exposed during the PBL, allowing them to learn better.

4.4.2 Comparison of Grade 11 learners' performance in algebra

The comparison of the pre-tests of both the experimental and control groups (Table 4.2 and Table 4.3), indicates that there is no significant difference between the experimental

and control groups. This implies that the experimental group and control group had similar knowledge in algebra at the beginning of the study.

Comparing the averages mean scores of the control group ($10.62500+13.314286 = 23976786/2 = 11.98839$) and the experimental group ($8.875000+17.085714 = 25.96071/2 = 12.980355$), while the difference in the mean is ($12.980355-11.98839 = 0.991965$) between the control group and the experimental group tests. This implies that, the experimental group mean is 0.991965 higher than the control group mean. Thus, it shows a clear indication that the experimental group learners performed better than the control group learners. Thus, one can conclude that the difference was brought as result of using PBL (cognisant of the fact that perhaps other factors could have influenced the increase, but because it was not in the scope of the study it does not impact results). These findings agrees with several other research studies indicating that through a variety of tests and observations in these studies, researchers found that when projects are planned with high-quality teaching pedagogy, learning in this way can add meaning and deeper understanding for students, which then increases engagement and academic performance in school (Boaler, 2001; Maxwell, Mergendoller & Bellisimo, 2005; Wenglinsky, 2004). The findings also agree with recent research that shows that students are more engaged and motivated when teachers are using instructional approaches that promote experimentation and real life context (Boaler, 2006; Horn, 2006).

Table 4.4 indicated the comparison of the pre-tests for the experimental and control groups. This showed that $t_{\text{calculated}} = 2.328$ is less than $t_{\text{critical}} = 2.712$. This result

indicates that there was no significant difference in the pre-test scores between the experimental and control group. On the other hand, Table 4.5 compared the post-test of the experimental and control groups. In the table the $t_{\text{calculated}} = -3.414$ (the sign notwithstanding) greater than $t_{\text{critical}} = 2.718$. Kress (2005) confirms that using a PBL approach to learning will enhance achievement and engagement for students. This result showed that “There is a significant difference in the learners’ performance in Algebra when taught using the PBL approach”.

4.5 Summary

This chapter presented the data on the effect of a project-based learning approach in teaching and learning of algebra. The findings indicated that there was no significant difference in the scores of both the experimental and control groups in the pre-test before the intervention of PBL. There was a significant difference in the post-test score in both the experimental and control group after the intervention of PBL at significance level $\alpha = 0.01$. The results of this study seemed to suggest that using the PBL approach enhances the learners’ performance in algebra.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter discusses the findings from the study in relation to the conceptual framework and presents possible recommendations and concludes with a summary and what a follow-research could focus.

5.1 Discussion

This study investigated the effects of the PBL approach in the teaching and learning algebra. The study proved that (hypothesis testing results) there is a significant difference in using the PBL as a pedagogical approach in teaching algebra. This means that there is benefit in further exploring various aspects of a PBL approach in teaching mathematical concepts. The contribution of this study to Namibian education literature is significant as it proves that training institutions and professional development workshops should ensure that specific focus be placed on PBL as a pedagogical approach along with other approaches within the teacher training programmes. Institutions such as the National Institute for Educational Development (NIED) who also take on the responsibility for in-service training of teachers should focus on providing more training in the PBL pedagogical approach in order to improve teaching presentation and performance of learners.

PBL would also be used in Namibian schools, not only in mathematics, but in many other subjects such as History, English just mention a few. The impact of using PBL

appears to show significant increase in learner performance which would impact overall performance across the country. According to Blumenfeld and Krajcik (2006) found that PBL allows learners to explore, investigate questions, discuss their ideas, challenge ideas of others and try new ideas. Learners are able to think critically and analyse every situation independently. In addition, PBL awards opportunities to learners to develop complex skills, such as higher-order thinking, problem-solving, collaborating and communications. (SRI, 2000). The studies done by ChaLin (2008) and Karaman and Celik (2008), discovered that learners in PBL performed better in areas of skill development, general ability and knowledge compilation than those who did not use PBL. In the same relation, PBL helps learners to increase positive attitudes in learning mathematics (Catherine & Barry, 2008).

This study used the social constructivist framework as the lens and the discussion below unpacks the relevance of each element of social constructivism in relation to the study findings.

- 1. Learning is an active process in which the learner uses sensory input and constructs meaning out of it.*

This study focussed on learners actively participating in the designing of the projects and doing interviews during the cause of the data collections. Kibett (2002) makes an observation that knowledge is actively constructed through active participation of the learners and in this study, learners appeared more active than traditional teaching. There was a continual questioning and answering interaction between peers and the teacher-facilitator. Learners interacted with their peers and collaborating with each other in terms of sharing prior knowledge.

- 2. People learn to learn as they learn: learning consists both of constructing meaning and constructing systems of meaning.*

General observations from this study revealed that the change in approach caused confusion at first, but eventually students were getting increasingly comfortable with the approach. The specific methodology of PBL used in this study, was aimed at creating ease for the learner in adapting to the new teaching approach. Results show that the learners performed well in the post-test than in the pre-test. This indicates that PBL approach yield positive results as a learning and teaching pedagogy in algebra.

- 3. The crucial action of constructing meaning is mental: it happens as reflective activity in the mind. Physical actions, hands-on experience may be necessary for learning, especially for children, but it is not sufficient; there is a need to provide activities which engage the mind as well as the hands.*

The aspect of meaning-making was outside the scope of this study and would be a good recommendation for future studies in the field. The study could only prove that there was an aspect of understanding as revealed in the increase in performance from the experimental group in the post test. Piaget proves that learning needs to be active and through this approach where learners are engaged in activity to apply concepts and principles in an authentic real-world example, the act of meaning making and understanding is assumed.

- 4. Learning involves language: the language used influences learning.*

It is commonly understood that mathematics and all the science subjects is equated to learning a new language. Learning new languages can be challenging, In a PBL approach learning of the “new language” is essentially a peer-to-peer activity where understanding is shared from one learner to another. As facilitator in this PBL approach

it is crucial that the correct understanding of the concepts be conveyed and it is also evident in the final product presented. The participants were bound to subsequently learn new concepts in the PBL approach and specifically how to navigate within the new way of learning.

5. Learning is a social activity: learning is intimately associated with people's connection with other human beings, teachers, peers, family as well as casual acquaintances.

In this study, the result indicates there was significant difference in the performance of the learner's performance using the PBL approach. The learners interacted with other learners, community and teachers as per the underlying aim of PBL learning. Knowledge is constructed through interaction and learning from the experience of others.

6. Learning is contextual: learners learn in relationship to what else they know and believe.

Using examples that learners can relate to is a key component of any successful PBL approach. The activity needs to make sense to the learner and peek his or her interest as something relevant to their lives and environment they are in. In this study the focus was on earnings which are relevant to the age the learners. At this grade many are thinking of careers and are curious as to the earning of these professions within the Namibian market. Many of the learners are making life decisions of applying for university of other higher learning institutions and needed to plan and think about the kind of lifestyle they want to lead. Very little life skills are conveyed about the reality of living on a salary and budgeting.

7. *One needs knowledge to learn: it is not possible to assimilate new knowledge without having some structure developed from previous knowledge to build on.*

The study attempted to invoke prior knowledge through the pre-test phase. It was important to establish a baseline whereupon the facilitator teacher could build upon. PBL allows learners connected the prior knowledge with the new knowledge. Learners are able to think critically and independently and know that whatever previous knowledge they have in the field are to be engaged.

8. *It takes time to learn: learning is not instantaneous.*

This element of the social constructivism framework requires further exploration. More time was needed in order for PBL to be fully implemented. Continuous exposure of the PBL approach to the participants will not only allow for ease but create opportunities for deeper learning.

In conclusion, the following challenges were experienced. The learners were more accustomed to traditional methods of teaching, in order to transform them to carry out self-directed learning activities, from memorizing and repeating to discovering, integrating and presenting, it took time and was exhausting. The participants relied mostly on the textbooks, teacher notes, peer-knowledge and various other materials available. Time of the data collection was of the factor especially that it was in the afternoon. Despite the significant increase in learner performance, learners had problems with concentration. It can be assumed that a long school day and again a school session in the afternoon can be stressful and can easily have changed the results of the study. In further speculation it could be that if the approach was done during the school day performance could have increased even more.

5.2 Summary of the research findings

This section presents the key research findings of the study. The findings are presented with reference to the hypothesis of the study.

The study tested the following hypothesis:

H₀- There is no significant difference in the learners' performance in algebra when taught using the PBL approach.

H₁- There is a significant difference in the learners' performance in algebra when taught using the PBL approach.

The results of this study suggested positive effects of PBL approach on the learners' performance compared to the performance of those taught using the traditional methods of teaching. Both the Experimental and Control groups had similar mean scores in the pre-test prior to the intervention (Table 4.2 and Table 4.3). In addition, no significance difference ($t_{calculated} < t_{critical}$) (Table 4.4) was found between experimental and control group. This indication suggests that that the two groups were equivalent before the intervention. After the intervention, the Experimental group had outdone the Control group in the post-test. The test was used to test for the significance difference in performance between the two groups, found a significance difference ($t_{calculated} > t_{critical}$) (Table 4.4) in the Algebra post-test performance of the Experimental and Control group at 99% confidence level.

The findings of this study support Nadelson (2000) that use of PBL as a teaching learning tool results in better performance of learners in Mathematics, since PBL was interactive learners found meanings and justification for learning by working on projects. In addition, the teacher also notes that by facilitating learning of content knowledge as well as reasoning and problem-solving abilities, project-based instruction can help learners prepare for external examinations and meet requirements (Nadelson,2000). The findings also concur with Edelson, Gordin and Pea (1999) that use of PBL provide opportunities for learners to improve their understanding of scientific and mathematical practices by problematizing various situations, placing a demand for knowledge, discovering new principles, refining preexisting understanding, and applying understanding while pursuing answers to research questions. Furthermore, the findings of this study supports Bruner's (1961) Constructivist Theory that proposes that learners' construct their own knowledge and do this by organizing and categorizing information using a coding system, this leads to more effective learning and good performance in subjects. The concept of discovery learning implies that students construct their own knowledge for themselves (also known as a constructivist approach) (Brunner, 1961).

The findings of the study agree with the study of other researchers such as Baumgartner and Zabin (2008), Chu, Tse and Chow (2011), Faris (2008) and Hmelo-Silver, Duncan and Chinn (2007).

5.3 Recommendations

The following recommendations are made based on the findings of this study:

1. Mathematics teachers should be encouraged to use PBL approach when teaching Algebra topics i.e. linear equations, quadratic equations, factorisation and inequalities.
2. Mathematics teachers should incorporate project-based activities in their planning.
3. Teachers should be encouraged to use practical examples that are associated to real life situation. This should be done through the use of projects, using small group discussions, real life practical examples, allowing learners to explore and discovery through research, this will improve their performance.
4. The Ministry of Education, Arts and Culture (MEAC) and NIED, should improve the capacity of the teachers to plan and execute projects.

5.4 Conclusion

This study investigated the effects of a project-based learning approach in learning and teaching algebra in the Kavango West Education Region.

The t-test shows a significant difference in the performance of the learners when using the PBL approach. The experimental group that used the intervention of PBL had significantly higher scores than the control group that used teacher-centred approach. There was no significant difference on the performance of the control group learners when algebra was taught using the teacher-centred approach. The results seem to suggest that using the PBL approach in schools might improve the results in the Kavango West region in algebra. The study used is a small sample of learners and can in no way be generalised. A larger sample and from other educational regions in Namibia could be

used in order to find out the effects of using PBL approach in learning on their performance in Mathematics and other subjects. It is imperative for the Namibian Ministry of Education to focus on empowering teachers with new pedagogical approaches that increase learner performance and teach 21st century skills of communication, collaboration, critical thinking and creativity.

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APPENDICES

Appendix A: Pre-Test

Algebra Pre-Test

Participant Code

Instructions: **Do NOT** write your name on this paper.

Answer ALL the questions and show your working.

Write your answers in the spaces provided after each question or part question.

-
1. The enrolment in Rundu Senior Secondary school was 695 students. This year there are 748 students. If n represents the number of new students, the equation $695 + n = 748$ results. Find the number of new students.

Answer..... [4]

2. Solve the simultaneous equations

$$2y + x = 11,$$

$$2y - 3x = -1.$$

Answer x =.....

y =..... [3]

3. In 2015, University of Namibia profit from school's enrolment was 10 times from the previous year. If the profit from enrolment was about N\$ 40 million, approximately how much was the income from the school enrolment in 2014?

Answer..... [4]

4. Solve $-7 \leq 3x - 10 \leq -1$.

Answer (a) $\leq x \leq$ [2]

5. Rundu Secondary Scholl enrolls x learner during a school registrations.

(a) Noordgrens Secondary school enrolls 3 learners more than Rundu Secondary School. Write down the number of learners that Noordgrens Secondary School enrolled in terms of x .

Answer (a)..... [1]

(b) Kaisosi Combined School enrolls 2 times as many learners as Rundu Secondary School. Write down Kaisosi Combined School's learner in terms of x .

Answer (b)..... [1]

(c) (i) Write down and simplify the total number of learners enrolled by the three schools in terms of x .

Answer (c) (i)..... [2]

(ii) The average number of learners was 9.

Show that $4x + 3 = 27$.

[1]

(iii) Solve the equation $4x + 3 = 27$

Answer (c)(iii) $x =$ [2]

(d) How many learners did Noordgrens Secondary School enroll?

Answer (d)..... [1]

6. Margret was making a curtain for her room. She had $9\frac{1}{2}$ m of material. It took 7m for the curtain. How much material was not used for the curtain?

Answer..... [2]

7. Kasanga ordered three novelty T-shirts from a catalogue to be used during the enrolment. The total price including shipping was N\$ 50. If the total shipping cost was N\$ 5, how much did each T-shirt cost?

Answer [2]

8. (a) In 2001 St Boniface College was x years old.

Elia Neromba Secondary school is **34 years younger** than St Boniface College.

(i) Complete the table, in terms of x , for St Boniface College and Elia Neromba School's ages.

	2001	2013
St Boniface College	x	
Elia Neromba SS		

[3]

(ii) In 2013 St Boniface is **three** times as old as Elia Neromba Secondary School.

Write down an equation in x and solve it.

Answer (d)..... [4]

9. Solve for q in the equation $-7q = -3$.

Answer..... [1]

10. Mr. Seponde has 232 seedlings to be planted in the school garden with 8 plants in each flowerpot. How many flowerpots will he need to plant the seedlings?

Answer [2]

Total: 35

Appendix B: Post-Test

Algebra Post-Test

Participant Code

Instructions: **Do NOT** write your name on this paper.

Answer **ALL** the questions and show your working.

Write your answers in the spaces provided after each question or part question.

1. Solve the simultaneous equations

$$2y + x = 11,$$

$$2y - 3x = -1.$$

Answer $x =$

$y =$ [3]

2. In 2015, University of Namibia profit from school's enrolment was 10 times from the previous year. If the profit from enrolment was about N\$ 40 million, approximately how much was the income from the school enrolment in 2014?

Answer..... [4]

3. Solve for q in the equation $-7q = -3$.

Answer..... [1]

4. Rundu Secondary Scholl enrolls x learner during a school registrations.

(a) Noordgrens Secondary school enrolls 3 learners more than Rundu Secondary School. Write down the number of learners that Noordgrens Secondary School enrolled in terms of x .

Answer (a)..... [1]

(b) Kaisosi Combined School enrolls 2 times as many learners as Rundu Secondary School. Write down Kaisosi Combined School's learner in terms of x .

Answer (b)..... [1]

(c) (i) Write down and simplify the total number of learners enrolled by the three schools in terms of x .

Answer (c)(i) [2]

(ii) The average number of learners was 9.

Show that $4x + 3 = 27$.

[1]

(iii) Solve the equation $4x + 3 = 27$

Answer (c)(iii) $x =$ [2]

(d) How many learners did Noordgrens Secondary School enroll?

Answer (d)..... [1]

5. Margret was making a curtain for her room. She had $9\frac{1}{2}$ m of material. It took 7m for the curtain. How much material was not used for the curtain?

Answer..... [2]

6. (a) In 2001 St Boniface College was x years old.
Elia Neromba Secondary school is **34 years younger** than St Boniface College.

- (iii) Complete the table, in terms of x , for St Boniface College and Elia Neromba School's ages.

	2001	2013
St Boniface College	x	
Elia Neromba SS		

[3]

- (iv) In 2013 St Boniface is **three** times as old as Elia Neromba Secondary School.

Write down an equation in x and solve it.

Answer (d)..... [4]

7. Mr. Seponde has **232** seedlings to be planted in the school garden with 8 plants in each flowerpot. How many flowerpots will he need to plant the seedlings?

Answer [2]

8. Solve $-7 \leq 3x - 10 \leq -1$.

Answer (a) $\leq x \leq$ [2]

9. Kasanga ordered three novelty T-shirts from a catalogue to be used during the enrolment. The total price including shipping was N\$ 50. If the total shipping cost was N\$ 5, how much did each T-shirt cost?

Answer [2]

10. The enrolment in Rundu Senior Secondary school was 695 students. This year there are 748 students. If n represents the number of new students, the equation $695+n=748$ results. Find the number of new students.

Answer..... [4]

Total: 35

Appendix C: Building a Budget

BUILDING A BUDGET

In this project learners are to pursue what they have learnt to create a personal budget to help them meet financial goals. Learners have to choose the job, which is interesting to them. Investigate and determine rent, utilities, and transportation and grocery costs. Learn about effective decision making for building a budget and make and use a monthly spreadsheet. Learners will have to do a 3-5 minute presentation.

Driving question: How can algebra be used to build/plan a cost-effective budget?

Step 1 Brainstorm

In groups of three or four learners.

LIST OF CAREERS

Careers	Annual salary	Monthly salary
School principal	N\$ 366 974	
Engineer	N\$	
Teacher	N\$ 202 594	
Nurse	N\$	
Medical doctor (officer)	N\$ 438 0734	
Lecturer	N\$	
Human Resource Practitioner	N\$	
Secretary	N\$ 135 308	
Geologist	N\$	
Police Officer	N\$	
Lawyer	N\$	
Waitress	N\$ 48000	
Pilot	N\$	
Building Inspector	N\$	

Chef	N\$	
Teller (Bank)	N\$	
Paramedics	N\$ 180 000	

- ❖ From the list choose one careers that interest you.
- ❖ Calculate the monthly income.
- ❖ Brainstorm monthly living expenses, monthly fixed expenses, and annual expenses. Include rent, transportation, and groceries. The expense should, based on the inflation rate.
- ❖ Find out what is the inflation rate in Namibia.

Step 2 Research

- ❖ Use the Internet and/or newspapers to search for more jobs openings in your chosen career.
- ❖ Estimate and research the cost of monthly living expenses, monthly fixed expenses, and annual expenses in your home city.

Step 3 Explore Your Community

Interview about four to six adults in your community about the decision-making process they use when developing a personal budget. And determine their budget in next 3 months. Formulate equations. Ask them how they prioritize expenses and to share any tips they might have fore sticking to their budgets.

Step 4 Create Your Budget

- ❖ Calculate your monthly net income. Assume your annual gross pay is N\$40,000 you are unmarried, and paid monthly, and have no exemptions. Use the tax tables in the text book on page 33.
- ❖ Use Excel and create a Monthly spreadsheet to determine your monthly budget

- ❖ Adjust personal spending, entertainment, and other expenses as needed to live with your monthly net income.
- ❖ Develop a pie chart showing your monthly expenses.
- ❖ Formulate equations and determine the unknown spending on entertainment in the next month.

Step 5 Develop Your Presentation

- ❖ Use Word to write a one page report
- ❖ List the job you chose and explain why
- ❖ Summarise your conversations about a budget
- ❖ Describe any adjustments you might have make to personal spending, entertainment, and other expenses
- ❖ Share your thoughts or observations about the experience of preparing a budget
- ❖ Create a 3-5 slide presentation to share with the class. Include your pie chart. Print your completed Monthly spreadsheet or include it in your presentation.

Appendix D: Rubric

RUBRIC ON BUILDING A BUDGET

Driving Question:	How can algebra be used to build/plan a cost-effective budget?
Product Description:	Learners will create a personal budget to help them meet financial goals in groups. Learner will choose the job, which is interesting to them. They will investigate and determine rent, utilities, and transportation and grocery costs.
Presentation Description:	Groups will have to do a 3-5 minutes presentation.
Before presenting, you must have:	A complete and proficient product.

Category	1	2	3	4
Research	Learner has conducted little Or no research. Unable to use internet or media to search for more jobs in addition to the lists.	Slight understanding of the budge and slightly use of internet or media.	Information is taken from some sources; learner can at most estimate and research the cost of monthly living expenses, monthly fixed expenses, and annual expenses in your home city.	Information is taken from multiple sources; including various websites and media are used to search for more jobs. Learner estimate and research the cost of monthly living expenses, monthly fixed expenses, and annual expenses in your home city.

Interview	Learner conducted no or little interview. No equations were formulated on determining the budget in the next 3 months.	Learner conducted interview with less than three people in their community. Few equations were formulated.	Learner interviewed about five people in their community, concerning the decision-making they use. Equations were formulated, the budgets for two months were determined.	Learner interview about four to six adults in their community about the decision-making process they use when developing a personal budget. And determined their budget in next 3 months. Formulate equations.
Completed budget	Group did not stay within the budget. The tax was not calculated. Excel was not used to create a monthly budget. The budget is not built based	Group did not stay within the budget, slightly over. The budget formulated was for one week, instead of a month. They could not adjust the personal spending, entertainment and others.	Group formulated a budget somehow based on the guidelines/plan given. Formulated equations and determined the unknown spending on entertainment in the next month.	Stayed within the guidelines/plan layout. Excel was used to determine a monthly spending. Pie charts were developed, that displays the monthly expenses. Proper equations were formulated, and the unknown spending on entertainment in the next month

				was calculated. Budget was authentic and pleasing.
Teamwork	All tasks were not completed. Two or more learners did not follow assigned tasks. Tension within the group.	Some tasks were completed. Some ideas were incorporated into designing and building a budget.	Most members completed their tasks. Most ideas were incorporated into designing and building a budget.	All members completed their tasks. They listened to each other's ideas and incorporated them into designing and building a budget.
Creativity	The budget reflects little or no creativity	The budget reflects elements which are made by the learners, but are based on the designs or ideas of others.	The budget reflects some degree of learners' creativity in their creation and display.	The budget reflects an exceptional degree of learners' creativity in their creation and display

Appendix E: Ethical Clearance Letter from the Research and Publication Office



UNAM
UNIVERSITY OF NAMIBIA

ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: FOE/157/2016

Date: 9 December, 2016

This Ethical Clearance Certificate is issued by the University of Namibia Research Ethics Committee (UREC) in accordance with the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval is given in respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the Faculty/Centre/Campus Research & Publications Committee sitting with the Postgraduate Studies Committee.

Title of Project: Project-Based Learning for NSSCO Algebra in Selected Senior Secondary Schools in Kavango West Region

Nature/Level of Project: Masters

Researcher: R.L. Mukelabai

Student Number: 200636405

Faculty: Faculty of Education

Supervisor: Dr. P. Boer

Take note of the following:

- (a) Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the UREC. An application to make amendments may be necessary.
- (b) Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the UREC.
- (c) The Principal Researcher must report issues of ethical compliance to the UREC (through the Chairperson of the Faculty/Centre/Campus Research & Publications Committee) at the end of the Project or as may be requested by UREC.
- (d) The UREC retains the right to:
 - (i) Withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected,
 - (ii) Request for an ethical compliance report at any point during the course of the research.

UREC wishes you the best in your research.

Prof. P. Odonkor: UREC Chairperson

Ms. P. Claassen: UREC Secretary

Appendix F: Permission Letter from the Permanent Secretary (MoEAC)



REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION, ARTS AND CULTURE

Tel: +264 61-2933262
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Enquiries: Ms. Rauna Shiipepe

Luther Street Government Office Park
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WINDHOEK
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
Mr. Robert L Mukelabai
PO Box 2497
RUNDU

Dear Mr. Mukelabai

RE: PERMISSION TO CONDUCT A RESEARCH.

1. Your letter dated, 07 February 2017 is hereby acknowledged and bears reference.
2. Kindly be informed that your request has been considered and permission is granted for you to conduct research interview for the requested period.
3. The Ministry wishes you the best in your study.

Yours sincerely,


SANET D. STEENKAMP
PERMANENT SECRETARY
Windhoek, Namibia

Ministry of Education, Arts and Culture
Office of the
Permanent Secretary
2017-06-13 17

All official correspondences must be addressed to the Permanent Secretary

Appendix G: Consent Form for Parents

Instruction: Please fill out this consent form and return it.

I, _____, the
parent of _____ a grade
11 _____ learners at
_____ hereby
give consent for my child to be a subject in the study entitled “*effects project-based
learning on the teaching and learning Algebra*” by attending the sessions and sit for the
tests.

I understand that:

1. My child is under no obligation to participate, and may withdraw from the study at any point prior to the publication or presentation of research results.
2. Anonymity will be maintained through the use of pseudonyms. The name of my child will not be reported.
3. The research will be used for academic and professional presentations and publications.

___/___/2017

Signature

Date

Appendix H: Permission from the Director of Education, Kavango West



**REPUBLIC OF NAMIBIA
KAVANGO WEST REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE**

Private Bag 2134, Rundu, Namibia Tel. 264 66 256090 Fax: +264 66 258 9213/267070

Enquiries: Teopolina Hamutumua

Email: kavangowestec@yahoo.com

Mr. Robert Lusungo Mukebabai
P.O. Box 2497
Rundu, Namibia


1 March 2017

Dear Mr. Mukebabai

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN KAVANGO WEST REGION.

1. Your letter dated 15th February 2017 on the above subject bear references.
2. Permission is granted to conduct research at schools in Kavango West on "*Project- based learning for NSSCO algebra in selected senior secondary schools*" provided that the research activities will not interrupt or negatively affect normal teaching and learning.
3. Should there be any question on the matter please do not hesitate to contact this office.

Sincerely


.....
Dr. Mpasi E. N. Katewa
Chief Regional Officer
Kavango West Regional Council



2017/03/01
.....
Date

All official correspondences must be forwarded to the office of the Chief Regional Officer

Appendix I: Lessons

Lesson 1: Equations and Expressions: Writing And Solving Expressions

Teacher: Mr. Robert L Mukelabai

Grade 11

Duration: 1 hour 20 minutes

Date:

Specific Objectives

- ❖ use letters to express generalized numbers
- ❖ express basic processes algebraically
- ❖ substitute numbers for words and letters in formulae

Goal:

Today's Goal:

Write and evaluate expressions

Instructional outcomes:

1. Given words, learners will translate into a mathematical expression.
2. Given an algebraic expression, students will evaluate based on provided variables.

I plan to meet these instructional outcomes using a variety of learning strategies throughout the lesson. I will use guided practice, practice with partners, and individual practice. Learner learning will be assessed in a variety of ways as well. I will know if my instructional outcomes are met by facilitating my learners throughout the lesson.

Materials:

- ❖ Black board
- ❖ Worksheets

- ❖ Scientific Calculator
- ❖ Posters

Procedure:

1. Warm Up:

Students will work on the warm-up activity before class begins.

2. Notes :

Each learner is given a copy of the skeleton notes that they are expected to use during the lesson.

3. Partner Practice: Writing and Evaluating Expressions

The learners will be put into groups of 3 to 4 for the activity.

4. Homework: Evaluating Expressions with Exponents

This independent practice will be an opportunity for learners to practice what they learnt today.

Name: _____

Date: _____

Class work: Notes

EQUATIONS AND EXPRESSIONS

Algebraic Expressions and Exponents



Why learn this?

You can use algebraic expressions to help you make predictions based on patterns. If you know how far you can swim in one minute, you can estimate how far you can swim in 5 minutes.

Variable: a _____ that represents a number.

Ex:

Expression: A mathematical phrase.

Ex: Place each key word in the bank with the correct operation.

Addition (+)	Subtraction (-)
Multiplication (\times)	Division (\div)

Key Word/ Phrase Bank

Product
Difference
Sum
Quotient
Total
Fewer than
Times
Per
Decreased by
More than
Every

Less than
Increased by

Writing Algebraic Expressions

You will need to be able to translate words into math!

Pick a variable that will represent “a number”.

Word Phrase	Algebraic Expression
3 more than a number	
3 less than a number	
The product of a number and 3	
A number divided by 3	

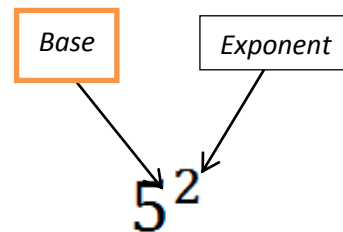
Do them! Translate the following word phrases into an algebraic expression.

1. A temperature(t) decreased by seven
2. Ten times a number(n)
3. Sixteen more than five times a number(n)
4. One more than the quotient of x and four

Solving with Exponents

Exponent:

When a number is represented in the form x^y



The exponent tells you the number of times the base is multiplied by

Simplify by first writing each exponent in expanded form:

1. $3^4 =$	2. $2^3 =$
3. $1^8 =$	4. $8^0 =$

In your scientific calculator, there is a button that is used for exponents. When we have an exponent that is very large, instead of multiplying the base by itself over and over, you can use the exponent button. This button looks like an upside down “V” and we call this exponent button the “carrot”.

Using your Calculator to Solve:



Solve the following by using your calculator.

1. $(10)^5$	2. $(3)^7$	3. $(2)^2$
4. $(-1)^4$	5. $(-5)^5$	6. $(-9)^8$

Name: _____

Date: _____

Writing and Evaluating Expressions Practice

WRITING EXPRESSIONS

Directions: Write each phrase as an algebraic expression.

1. A number (n) increased by five.
2. Four more than a number (x).
3. The product of a number (y) and ten.
4. Write an algebraic expression that represents the product of a number (x) and five, decreased by fifteen.

Then, evaluate the expression when $x = (-2)$

Answer: _____

5. Write an algebraic expression that represents the product of a number (x) and ten, increased by negative twenty.

Then, evaluate the expression when $x = (5)$

Answer: _____

EVALUATING EXPRESSIONS

Directions: Evaluate each expression when $x = 2$, $y = -3$, and $z = 0$. Show all of your mathematical thinking.

6. $(z + y) \times x$	7. $5y^z$
8. xyz	9. $(xy)^z$

Lesson 2: Linear Equations

First name and Surname	Robert L Mukelabai
Date	
Subject	Mathematics
Grade	11
Syllabus theme(s)/ topic (s)	Lesson 2: Linear equations
Driving Questions	How is equality maintained when solving an equation?
Learning objectives	<ul style="list-style-type: none">• solve simple linear equations in one unknown• solve equations with fractions
Introduction (5 minutes)	<p>Tell learners that, I am a mind reader. Tell the learners to think of a number, any number, and to write the number down. Will tell them to mentally add 5 to the number; then subtract 5. Let them give their answers. Then, will tell them their original number. Will repeat the exercise, having them multiply their number by 4, and then dividing by 4. Repeat several times, each time changing the operations they perform, but always having them perform inverses. Start with a number (x), perform some operation, and then perform the inverse operation that we will end with that number (x).</p>
Prior Knowledge	<p>Will give some linear equations to the learners:</p> <ul style="list-style-type: none">❖ $x + 5 = 11$❖ $x - 8 = 6$❖ $4x = 20$❖ $\frac{x}{3} = 5$ <p>Give learners some time to answer and let them use the</p>

	board to give explanation.
Investigate/Explore	<p>The teacher will begin the investigation with a “human balance”, a learners with arms outstretched. Learners will have to use their imaginations, as weights will not actually balance, etc., but the activity will give learners a “picture” of what happens when we solve an equation.</p> <p>Example 1: Addition equations: In one hand, place a container with several small same-sized objects in it (x) and 5 additional objects; in the other hand place 11 of the same objects. If Lab Gear is available, place an x and 5 ones in one hand; in the other hand, 11 ones. Ask learners how we would go about finding out how many objects are in the container, or what x is. Demonstrate that we write what we did like this:</p> $x + 5 = 11$ <p>What we started with on each side of balance.</p> $x + 5 - 5 = 11 - 5$ <p>We took 5 off each side</p> $x = 6$ <p>(Example 1 is matched the launch and activating prior knowledge, so that it can be referred to. Make the connection that we can use the inverse operation to get the x by itself; that when we solve the equation we want to keep it in balance; and that, as they did when they solved informally, we do end up subtracting 5 from 11.)</p> <p>Have learners model and write:</p> $x + 8 = 17$

$$x + 8 - 8 = 17 - 8$$

$$x = 9$$

As well as additional examples as needed.

Example 2: Multiplication Equations: In one hand, place 4 containers (or 4 x) and in the other, place 20 ones. Ask learners how we would go about finding out what is in each container or what x is. Learners give answers.

Demonstrate that we write this:

$$4x = 20$$

$$\frac{4x}{4} = \frac{20}{4}$$

$$x = 5$$

Have students model and write:

$$3x = 18$$

$$\frac{3x}{3} = \frac{18}{3}$$

$$x = 6$$

Subtraction and division equations do not easily lend themselves to demonstrating with the “human balance.”

$$x - 8 = 6$$

$$x - 8 + 8 = 6 + 8$$

$$x = 14$$

$$\underline{x} = 5$$

$$3$$

$$3 \cdot \underline{x} = 5$$

$$3$$

$$x = 15$$

	<p>Monkey See/Monkey Do:</p> <p>For the rest of the Investigate/Explore time, learners will practice solving equations with a partner. Using dry-erase boards, each learner should write one side of the equation. The learner, who has the “left-hand” side of the equation, should “undo” the given operation to get the unknown by itself. Then, the partner should perform the same operation on the other side.</p>
Materials:	<ul style="list-style-type: none"> ❖ Teacher’s notes ❖ Practice problems ❖ Quiz

Teacher Notes

Begin the investigation with a “human balance”, a learner with arms outstretched. Two additional learners can be used to hold the “weights” on each side if necessary. Learners will have to use their imaginations, as weights will not actually balance, etc., but the activity will give learners a “picture” of what happens when we solve an equation.

Example 1: Addition equations: In one hand, place a container with several small same-sized objects in it (x) and 5 additional objects; in the other hand place 11 of the same objects. If Lab Gear is available, place an x and 5 ones in one hand; in the other hand, 11 ones. Ask learners how we would go about finding out how many objects are in the container, or what x is. Hopefully they will say that if we take 5 off each side, the x

will balance with the amount on the other side. (Have a learner model this.) Therefore $x = 6$.

Demonstrate that we write what we did like this:

$$\mathbf{x + 5 = 11}$$

What we started with on each side of balance.

$$x + 5 - 5 = 11 - 5$$

We took 5 off each side

$$x = 6$$

(Example 1 is matched the launch and activating prior knowledge, so that it can be referred to. Make the connection that we can use the inverse operation to get the x by itself; that when we solve the equation we want to keep it in balance; and that, as they did when they solved informally, we do end up subtracting 5 from 11.)

Have learners model and write:

$$\mathbf{x + 8 = 17}$$

$$x + 8 - 8 = 17 - 8$$

$$x = 9, \text{ as well as additional examples as needed.}$$

Example 2: Multiplication Equations: In one hand, place 4 containers (or 4 x) and in the other, place 20 ones. Ask learners how we would go about finding out what is in each container or what x is. Hopefully they will say that if we divide both sides by 4, we'll find that each x balances with 5 ones. Demonstrate that we write this:

$$\mathbf{4x = 20}$$

$$\underline{4x = 20}$$

$$4 \quad 4$$

$$x = 5$$

Again, the example is matched to the launch and activating prior knowledge. Have learners model and write:

$$\mathbf{3x = 18}$$

$$\underline{3x = 18}$$

$$3 \quad 3$$

$$x = 6$$

Subtraction and division equations do not lend themselves to demonstrating with the “human balance.” Based on what they learned from addition and multiplication equations, have students demonstrated how to solve these equations:

$$x - 8 = 6$$

$$x - 8 + 8 = 6 + 8$$

$$x = 14$$

$$\underline{x} = 5$$

$$3$$

$$3 \cdot \underline{x} = 5 \cdot 3$$

$$3$$

$$x = 15$$

Monkey See/Monkey Do:

For the rest of the Investigate/Explore time, learners should practice solving equations with a partner. Using dry-erase boards, each learner should write one side of the equation. The learner, who has the “left-hand” side of the equation, should “undo” the given operation to get the unknown by itself. Then, the partner should perform the same operation on the other side. (Work should alternate from one partner to the next as they work toward the solution.) Learners should take turns so they have a chance to work through each side of the equation. (For equations to use, see the attachment “Practice Problems.” Equations are grouped by operation, but should not be done in order. “Steps” are shown for the first problems in the sets; solutions are given for all.)

Practice Problems

Name : _____

Date : _____

Addition Equations

1. $x + 5 = 16$

2. $x + 25 = 138$

3. $16 = x + 4.2$

4. $x + \frac{1}{4} = \frac{2}{3}$

5. $16 + x = -18$

Division Equations

1. $\frac{x}{4} = 100$

2. $\frac{x}{3} = -6$

3. $\frac{x}{5} = 22$

4. $\frac{3}{4}x = 12$

5. $\frac{2}{3}x = 18$

Subtraction Equations

1. $x - 10 = 3$

2. $x - 3 = -7$

3. $x - \frac{5}{9} = \frac{2}{3}$

4. $x - 15 = 25$

5. $x - 2.5 = 3.5$

Multiplication Equations

1. $5x = 75$

2. $7x = 140$

3. $-4x = 32$

4. $6x = 21$

$x = 3.5$

5. $4x = -76$

Lesson 3: Real life problems of linear equations

First name and Surname	Robert L Mukelabai
Date	
Subject	Mathematics
Grade	11
Syllabus theme(s)/ topic (s)	Lesson 3: Real life problems of linear equations How Old and Rich are You?
Driving Questions	How can algebra help us solve seemingly difficult problems simply?
Learning objectives	<ul style="list-style-type: none">• solve simultaneous linear equations in two unknowns• solve quadratic equations given in factorized form, e.g. $(x - 2)(x + 3) = 0$
Introduction (5 minutes)	<p>Will divide the class into two groups. One group will be presented with this problem:</p> <p>In my change purse I have a lot of coins. I have some quarters and some nickels. I actually have twice as many nickels as quarters. I also have some pennies and dimes. There are two less pennies than nickels and five more dimes than quarters. I know that I have \$5.65. How many of each coin do I have?</p> <p>To the other group, will present this problem:</p> <p>I know you are always wondering how old I am, so I decided that today I will just tell you. First I'll have to tell you a little bit of my family history. My sister has a son, my nephew, Eddie. I was 15 when he was born. 31 years ago, I was 4</p>

	<p>times his age. So, by the way, how old am I?</p> <p>Let the two groups solve both problems.</p> <p>Let the learner present the solutions to the different scenarios.</p>
Prior Knowledge	<p>As learners are working in small groups, observe to see how they are approaching the problem. Those with little algebra background will most likely use a guess and check method, or might put the information in some kind of table.</p>
Investigate/Explore	<p>As the discussion of the solutions to the problems in the launch unfolds, lead the learners toward seeing how the problems can be solved algebraically. In the investigation part of the lesson, learners work as partners to solve more age and money problems. The practice provides problem situations in which learners write expressions and write and solve multi-step equations.</p>
Reflection	<p>Learner reflections:</p> <p>learners should write in journals about one or both of these topics: the peculiarities of writing expressions and equations for such problems; a comparison of how they first approached the problems and how they are solved algebraically.</p> <p>Teacher reflections: Learners may come to this lesson at different entry levels and can be supported at these levels. Some may be able to solve the equation only if they are helped in writing them, whereas others may be able to write and solve the equations if they are helped with writing the expressions.</p>

Materials:	<ul style="list-style-type: none"> ❖ Teacher's notes ❖ Practice problems ❖ Quiz ❖ Individual practice ❖ Journals ❖ Internet
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Teacher Notes

Money Problem

In my change purse I have a lot of coins. I have some quarters and some nickels. I actually have twice as many nickels as quarters. I also have some pennies and dimes. There are two less pennies than nickels and five more dimes than quarters. I know that I have \$5.65. How many of each coin do I have?

A learner with some algebra experience might write the following expressions:

$$\text{Quarters} = q$$

$$\text{Nickels} = 2q$$

$$\text{Pennies} = 2q - 2$$

$$\text{Dimes} = q + 5$$

He might write $q + 2q + 2q - 2 + q + 5 = 5.65$

$$6q + 3 = 5.65$$

$$6q = 2.65$$

...and eventually realise that something is wrong.

An observant learner might notice that one cannot combine the -2 and 5 because one of them is pennies and the other is dimes, so one must combine -2 and 50 to get 48¢ .

Other learners might approach the problem in a guess and check method:

q		n		p		d		Total
8	\$2.00	16	\$0.80	14	\$0.14	13	\$1.30	\$4.24
10	\$2.50	20	\$1.00	18	\$0.18	15	\$1.50	\$5.18
12	\$3.00	24	\$1.20	22	\$0.22	17	\$1.70	\$6.12
11	\$2.75	22	\$1.10	20	\$0.20	16	\$1.60	\$5.65

By comparing the two methods, learners can see that the difference is that in the correct solution, the learner determined the money value of the coin by multiplying each quarter by 25, each nickel by 5, etc., thus leading to a better algebraic solution:

Money Value (in cents)

Quarters = q	25q
Nickels = 2q	5 · 2q or 10q
Pennies = 2q - 2	2q - 2
Dimes = q + 5	10(q + 5) or 10q + 50
Total = \$5.65	565

$$25q + 10q + 2q - 2 + 10q + 50 = 565$$

$$47q + 48 = 565$$

$$47q = 517$$

$$q = 11$$

$$n = 22$$

$$p = 20$$

$$d = 16$$

Age problem

I know you are always wondering how old I am, so I decided that today I'd just tell you. First I'll have to tell you a little bit of my family history. My sister has a son, my nephew, Eddie. I was 15 when he was born. 31 years ago, I was 4 times his age. So, by the way, how old am I?

Learners will probably be most successful at first by solving this in an intuitive way.

Many might make a table of ages:

Mr. R.	Nephew
15	Birth
16	1
17	2
18	3
19	4
20	5

By doing this they'll find that at age 20, I was four times his age. Since that was 31 years ago, I must be 51 and my nephew is 36.

The chart can be used to focus on an important aspect of this problem: although our ages always remain 15 years apart, the ratio of my age to his changes. At age 16, I was 16 times older than my nephew; at age 18, 6 times older; at age 20, 4 times older; and if the chart is continued: at age 25, 2 ½ times older; and at age 30, twice as old.

This makes for an interesting situation when solving the problem algebraically.

Now

Then

Nephew's age = x

$x - 31$

My age = $x + 15$

$x + 15 - 31$ or $x - 16$

Let's pretend it is **then**, so I could say,

“My age is 4 times his age.”

From this we can write the equation:

$$x - 16 = 4(x - 31)$$

$$x - 16 = 4x - 124$$

$$108 = 3x$$

$$36 = x$$

$$51 = x + 15$$

Partner Practice

Name: _____

Date: _____

Learners are arranged in pairs with each pair having a copy of “Age and Money Partner Practice”, and a shared piece of paper and pencil.

As each learner is working, the partner observes, coaches, and encourages.

After each step, the shared paper is passed from one partner to the other.

After each problem, partners exchange roles.

Money problems

Learner A	Learner B
Identifies the unknowns, writes them on the paper.	Assigns the variable and writes expressions for each unknown.
Writes the expressions for the money (cent) values.	Writes an equation using the expressions.
Solves the equation.	Uses the solution to assign values to each unknown.
Substitutes values into original problem and checks that solutions are correct.	

Age problems

Learner A	Learner B
Identifies the unknowns, writes them on the paper	Assigns the variable and writes expressions for each unknown.
Writes the expressions for “then”.	Rewrites the question into a “then” statement.
Writes a “then” equation.	Solves the equation.
Uses the solution to assign values to each unknown.	Substitutes values into original problem and checks that solutions are correct.

Age and Money Partner Practice

Name: _____

Date: _____

1. Jon is 8 years old. Mr. Dawson is 5 times older than Jon. In how many years will Mr. Dawson be 3 times as old as Jon?
2. Janet is 3 times as old as Thomas. In 7 years she will be twice as old as he will be then. How old are Janet and Thomas now?
3. Aaron is twice as old as Robert. Seven years ago the sum of their ages was 16. How old are Aaron and Robert now?
4. Jessica is 14 and her grandfather is 54. How many years ago was her grandfather 6 times as old as Jessica?
5. Pamela is 4 years older than Joseph. Nine years ago, Pamela was 5 times as old as Joseph was then. How old is each one now?
6. A certain number of nickels, dimes, and quarters equal \$22.95. There are 54 quarters and 3 less nickels than dimes. How many of each coin is there?
7. \$40.00 is made up of twice as many dimes as nickels and three times as many quarters as nickels. How many of each coin is there?
8. Sally bought some ordinary pencils and 4 times as many special pencils. Each ordinary pencil cost \$0.20 and each special pencil cost \$0.35. She spent \$14.40. How many of each pencil did she buy?
9. I have 16 coins in my pocket, some nickels and some quarters. If I have a total of \$2.20, how many of each coin do I have?
10. For the school fundraiser, packs of gum are 50¢ and candy bars are 75¢. Matthew spent \$12.00 and bought twice as many candy bars as he did packs of gum. How many of each did he buy?

Lesson 4: Quadratic equations

First name and Surname	Robert L Mukelabai
Date	
Subject	Mathematics
Grade	11
Syllabus theme(s)/ topic (s)	Lesson 4: Quadratic Equations
Driving Questions	How can the transformations of parabolas be used to model/explain real-world situations?
Learning objectives	<ul style="list-style-type: none"> • solve quadratic equations by factorisation, by completing the square and by use of the formula • solve simultaneous equations, one linear and one quadratic • solve simple linear inequalities
Introduction (5 minutes)	<p>Have learners graph the following equations $y = 2x$, $y = 2^x$, and $y = x^2$. After learners have finished the graphs, discuss how the graphs are alike and how they are different. Discuss the U-shape of the graph of $y = x^2$ and that this U-shape is called a parabola. Ask learners to write another equation whose graph is a parabola. Let them graph the equations and discuss the results. Lead learners to see that any equation that can be written in the form $y = ax^2 + bx + c$ will have a graph that is a parabola. This type of function is called a quadratic function. Let the learner discuss the fact that $y = x^2$ is considered the parent function.</p>
Prior Knowledge	Learners learned in previous lessons how to find coordinates for linear graphs and exponential graphs.
Investigate/Explore	Transformations of $y = x^2$

	<p>Materials needed: graph paper or a graphing calculator</p> <p>See attachment "Transformations of $y = x^2$</p> <p>A 2nd exploration has been provided for completion after the 1st investigation. (See exploration of quadratics attachment.) This exploration will be done in class the next day.</p> <p>After this 2nd exploration, the teacher will introduce vertex form of a quadratic equation: $= a(x - h)^2 + k$.</p> <p>The "a" in the equation represents the horizontal or vertical stretch, the "h" represents the horizontal transformation and the x-value in the vertex, and the k represents the vertical transformation and the y-value in the vertex.</p> <p>Give the learners practice sheets that have been provided .</p>
Reflection	<p>Exit Slip or Journal writing:</p> <p>What are the differences between linear, exponential, and quadratic graphs?</p> <p>What are the characteristics common to all quadratic graphs?</p>
Materials:	<ul style="list-style-type: none"> ❖ Graph paper or graphing calculator ❖ Lab for Transformations of $y = x^2$

	<ul style="list-style-type: none">❖ Exploration of Quadratic Equations❖ Graphing Parabolas Practice❖ Graphing Parabolas Practice Key❖ Applications of Quadratic Equations❖ Applications of Quadratic Equations Key❖ Teacher Notes for Transformations $y = x^2$❖ Journals
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Investigate/Explore: Transformations of $y = x^2$

Materials needed: graph paper

Step: 1. Graph each of the functions below:

$$y = x^2$$

$$y = x^2 + 1$$

$$y = x^2 - 1$$

Step: 2.

- What effect does the addition or subtraction in Step 1 have on the graph of the parent function?
- What do you think would happen if you add 2?
- What do you think would happen if you subtract 2?
- Graph the equations to see if your prediction is correct.

Applications of Quadratic Equations

Name:

Date:

1. Find two consecutive odd integers whose product is 143.
2. Find two consecutive integers such that the sum of the number and its reciprocal is $2\frac{1}{6}$.
3. A rectangle has a perimeter of 23 cm and an area of 33 cm^2 . Find the dimensions.
4. Derek runs a race at an average speed of x m/s.

His time is $(3x - 9)$ seconds and race distance is $(2x^2 - 8)$ metres.

- (a) Write down an equation in x and show that it simplifies to

$$x^2 - 9x + 8 = 0$$

- (b) Solve $x^2 - 9x + 8 = 0$

- (c) Write down Derek's time and the distance of the race.

5. On the 1st March 2003. Adam was x years old.

Ben was 5 years older than Adam and Cindy was twice as old as Adam.

- (a) Write down in terms of x , the ages of Ben and Cindy on 1st March 2003.

- (b) Write in terms of x , the ages of Adam, Ben and Cindy on 1st March 2005.

- (c) The product of Cindy's age and Adam's age on 1st March 2005 is the same as the square of Ben's age on 1st March 2003.

Write down an equation in x and show that it simplify to $x^2 - 4x - 21 = 0$.

- (d) Solve the equation $x^2 - 4x - 21 = 0$.

- (e) How old was Cindy on 1st March 2005?

- (f) Cindy's height, h , metres, is one of the solutions of $h^2 + 8h - 17 = 0$.

- (i) Solve the equation $h^2 + 8h - 17 = 0$.

Show all your working and give your answer correct 2 decimal places.

- (ii) Write down Cindy's height, to nearest centimetre.