



Cape Peninsula
University of Technology

**EFFECTIVENESS OF A LEARNING MANAGEMENT SYSTEM IN DEVELOPING
GRADE 10 LEARNERS' CONCEPTUAL UNDERSTANDING OF FUNCTIONS IN
MATHEMATICS**

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DECLARATION

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ABSTRACT

Learning Management Systems (LMS) have come into common use recently and most educational institutions from basic to higher education are increasingly adopting them, mainstreaming them into their daily teaching and learning of functions. The Western Cape Education Department piloted the Moodle (Modular Object Oriented Dynamic Learning Environment), a Learning Management System (LMS) aimed at improving teaching and learning. The aim of this research was to ascertain the effectiveness of this LMS in developing Grade 10 learners' conceptual understanding of Functions in Mathematics with minimum educator assistance. The research investigated two classes; one class used the traditional chalk and talk teaching (control) while the other class was exposed to the Moodle LMS. The thesis unpacked the functionalities in Moodle that makes learning of Functions in Mathematics easier. Learners constructed their knowledge by using resources embedded in Moodle using "ScenTRLE" learning model that follows Vygotsky's Theory of Social Constructivism. The hybrid e-learning framework was used, where learners were expected to gain pedagogically by interacting with computers. Their interaction was monitored and results are recorded using online surveys and tests. A quasi-experimental design was used to compare the groups, then statistically analysed in comparison with the traditional way of learning.

Results showed that the functionalities embedded within the Moodle LMS were instrumental in improving the learning and understanding of Functions in Mathematics.

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To God Be the Glory

DEDICATION

This thesis is dedicated to my wife Loreen, son Mzwandile, daughter Nomthandazo Nicola and the future generation of my clan.

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CHAPTER ONE: INTRODUCTION TO THE RESEARCH

1.1 Introduction

In 2001, the South African Department of Education established the DINALEDI school project as part of the National Strategy for Mathematics, Science and Technology Education. The main aim of this project was to improve the quality of Mathematics and Science passes at schools, particularly the schools in previously disadvantaged communities (DoE, 2009). The Chief Director of Further Education and Training (FET) schools, Mosuwe, stated: "Dinaledi schools are intended to raise the participation and performance by historically disadvantaged learners in National Senior Certificate Mathematics and Physical Science." (DoE, 2009:6). The Dinaledi project started with a modest number of 102 schools between 2002 and 2004, and by 2008 approximately 500 schools had been incorporated into to the programme nationally (DoE, 2009).

Following a painstaking effort to determine the resource requirements of the targeted schools, the Department of Education embarked on a massive programme of refurbishing and building computer and science laboratories. Their role was also to distribute English, Mathematics, Physical Science and Life Orientation textbooks. They distributed 500 000 copies of Mathematics textbooks, workbooks called '911' for grade 11 and grade 12, a total of 235 000 scientific calculators for grade 11 and grade 12 learners and 20 000 Mathematics and physical science exemplar papers (DoE, 2009). They distributed ICT equipment and assisted in setting up internet connectivity at schools. In the context of the country's recent past, this was one of the biggest undertakings to improve educational outcomes, especially in the area of Mathematics, Science and Technology.

Although these resources were not solely meant for Mathematics alone, Mathematics was, without doubt, the main subject targeted for a massive boost given its centrality in contemporary science education. Comparative country indicators, like the Science and Mathematics results had shown that South Africa was performing poorly (DoE, 2009), hence a concerted effort to significantly alter and improve the situation. The Department of Education commissioned the Dinaledi schools so that at least they will have a group of schools performing above the 50% mark, of which from this target, 20% of schools to be from Dinaledi project. The results of this project and its massive boost in technology and

other learning resources offer some revealing insights about the potential impact of technology on general learning outcomes. In 2008, 298 831 learners wrote Mathematics and 63,035 of these were Dinaledi school learners. The Dinaledi passes as percentage of total passing was 24% - a figure that exceeded the target of 20% (DoE, 2009:7).

Although the statistics above appeared to indicate a positive impact of the project, subject statistics show that the Mathematics enrollments have been declining over the past few years, from 270,958 in 2010 to 231,180 in 2014 (DoE, 2014). Campbell and Prew (2014:2) noted, “The Basic Education Department's reports indicate a 17% decline in the number of candidates who wrote Mathematics between 2009 and 2013 (from about 290,400 to 241,400)”. They further noted that, as the number selecting to do Mathematics is dropping, the overall number of learners who are achieving an NSC pass with more than 40% in Mathematics has been falling over the same period to 17% in the class of 2013. Meanwhile, the number of learners enrolling for the much easier Mathematical Literacy – which is not a gateway subject – increased significantly.

Even in cases where multi-media or ICT-based methods had been used, it is clear, based on the previous studies, that the potential of technology has not been fully harnessed. In particular, the great variety of educational software and teaching and learning programs have not been fully integrated in classrooms (Chigona, 2015) .

Technology by its nature simplifies and enhances the performance of tasks. The possibility exists that older forms of technology were not flexible enough to enable easier customization in the teaching of concepts that might require semi-autonomous learning by learners. According to Howie and Blignaut (2009), newer and improved forms of educational ICTs offer a great deal of potential, and some educational policy makers and implementers have started warming up to the idea. Particular models of ICT-based teaching and learning have been adopted and tried in different contexts.

The Western Cape Education Department (WCED) e-Learning Unit initiated the use of the Moodle (Modular Object Oriented Dynamic Learning Environment), an online Learning Management System (LMS), in 2009. The WCED hosts the Moodle platform for any school to use at no cost. However, the system has not yet been fully utilised by all schools. Furthermore, the potential of the tools of the Moodle system have not been fully exploited

by teachers. In 2013, a changed strategy by the WCED saw the Moodle LMS rolled out in selected schools in the Western Cape Province as a Moodle focused pilot school project. Training and advocacy of the system was done with these schools, and some began using this platform in May 2014.

In 2007, the then Minister of Education, Pandor set an education policy goal:

“Every South African in General and Further Education and Training bands will be ICT capable (that is use ICT confidently and creatively to help develop skills and knowledge they need to achieve personal goals and to be full participants in the global community)” (DoE, 2004).

Even though aimed at improving education via accessibility, quality and efficiency, this ambitious goal has not been fully realized, as most schools are yet to utilize the optimum resources given to them through different initiatives. In addition, schools are still deprived of the benefit of using latest software. Most schools that are still developing their IT environments are dependent on the use of ICT multimedia such as CD ROMS, internet or preloaded software like Encarta or Microsoft Office packages.

A Report to the Department of Education showed that, of schools that have ICT resources, 44% were using computers for administration purposes and only 24% were using computers for teaching and learning (Western Cape Education Department, 2012). This is a very low percentage as an outcome. It should be noted that despite other factors causing them not to use ICT, the number shows that most stakeholders in education are yet to believe in using computers for teaching and learning.

The ICT infrastructure for Inclusive Education report for schools done by Mwelil (2013) for the Department of Education indicated that various companies fund many projects at schools to support learning. From the report, he noted that *Dion-wired* has 16 projects; *Vodacom Foundation* has 9 resource centres for learners countrywide, while the Department of Education had about 50 projects running throughout the country, (Mwelil, 2013).

The main project related to this research is the Dinaledi Mathematics and Science project that is run in about 492 schools countrywide, with more than 60% of the schools having

access to the internet and software support from the Department. Access to the internet is vital as the World Wide Web provides a lot of learning material that should be beneficial in teaching and learning. The school under study was also a Dinaledi school and a LMS focus pilot school.

This chapter will explore the research questions that will guide this study in the quest to solve the underlying problem. The rationale of the study will also be outlined and then a brief outline of the theoretical framework underpinning the study will be given. This chapter closes with an overview of chapters 2, 3 and 4 in this research.

1.2 Statement of the Research Problem

South Africa and most countries are struggling with the problem of producing Mathematics learners who can conceptualise, apply and analyse real life problems. This was reported in 2015, in the Trends in International Mathematics and Science Studies (TIMSS) report, (Maoupe, 2016), which ranked South Africa at the bottom with countries such as Botswana, Jordan, Morocco and Saudi Arabia. The Department of Education is supportive of national and provincial interventions that will take the TIMSS scoring points to 400 by the year 2019, (Reddy *et al.*, 2015).

Many studies have been done to harness learners' interest in Mathematics. However, it is evident that most studies concentrate on evaluating the ability of learners so that they are stimulated by ICT to become attracted to the subject. The ICT resources are used to unwind their negative attitude towards the subject as it is known that most of the digital natives are highly interested in technology, (Leendertz, Blignaut & Niewoudt, 2013).

A notable study using a blended learning approach at a school that employed the use of DVDs was undertaken by Padayachee in 2010, (Padayachee *et al.*, 2011). In the study, learners were given DVDs, with content from these discs aligned to the curriculum to watch for some time. The study revealed that using the DVD approach within a blended learning environment lead to an improvement in learners' perceptions about Mathematics and an improvement in the manner in which they understood Mathematics concepts. The researcher concluded that blended learning extended their Mathematics knowledge and provided learners with a supportive environment in which to learn Mathematics.

Draper (2010) did a study on how teachers used ICT, in teaching Science and to investigate whether ICT was used when teachers' teaching aids were minimal. In her study, she discovered that most of the educators under investigation, prior to the research, were using ICTs only for the internet searches and typing materials for teaching. However, a shortcoming of the research was that it did not show how the use of the ICT benefits the learners in the classroom.

This research aims to extend the understanding of previous studies related to the use of ICTs for teaching and learning. According to Kotzer and Elran (2012), new e-Learning environments may contribute immensely to teaching and learning if properly integrated with tried and tested pedagogical frameworks.

Presently, educators find it difficult to complete the Curriculum and Assessment Policy Statement (CAPS) syllabus on time within the given 40 minute period offered by schools. There is a need to improve the way subjects like Mathematics are taught especially to learners who struggle to understand concepts within the teaching period. A second identified problem is that classes have become so large, that it has become difficult for learners to benefit from individual attention in class. There is a need to make sure that learners are able to access educator assistance, without the limitation of time.

In this research, the Moodle Learning Management System (LMS) platform was explored to investigate to what extent; it can be used for assisting learners in understanding Mathematics. The Moodle LMS enables educators to develop interactive tools such as quizzes, and links to the internet and videos, (Kotze & Elran, 2012). Moodle is adaptable to social constructivist teaching and learning approaches. The research was done by testing the effectiveness of Moodle in addressing the issues of time of learning, breaking down of learning components and collaboration between learners and educators in the teaching of Mathematics.

1.3 Research Aim

The research aim was to investigate the effectiveness of the Moodle Learning Management System in developing the conceptual understanding of a topic in Grade 10 Mathematics called 'Functions'. The focus was to establish whether Moodle could assist learners construct knowledge with minimum educator involvement. The tools within Moodle that promote constructivist teaching and learning were used. The aim of this research was also to understand how these learners use these skills to master concepts in Mathematics. This was done using a design that assessed learners' work and the results were analysed statistically.

1.4 Significance of the Research

The highest number of failures in Mathematics at the sample school is at Grade 10 level. This study introduces construction of knowledge without the full involvement of the educator at an early stage, to cultivate the culture of independency in studying Mathematics. These learners, are expected to benefit from this type of teaching and learning to enhance their learning of Mathematical concepts up to Grade 12. Padayachee, van der Merwe and Kotze (2015) have shown that communication between lecturer and student had improved when a LMS was used and the researchers saw an improvement of learning and management techniques in some courses that learners usually struggled with. The research seeks to contribute to knowledge on how the Moodle LMS can be adapted for school level learning of Mathematics, by giving learners an early opportunity to experience learning through knowledge construction, knowledge transfer and acquisition systems.

1.5 Research Questions

The study is about the use of learning management systems in teaching Mathematics. The research explored using different tools and techniques in the system to teach Mathematics. The research question is:

What is the effect of introducing Moodle using a constructivist pedagogical approach in learning of Functions in Mathematics?

The sub-questions are:

1. In what ways, can Moodle be used to enhance the learning of Functions in Mathematics?
2. How can the tools of Moodle be used to make learning of Functions easier?

1.6 Purpose of the Study

The efforts of the massive, albeit selectively applied, Dinaledi project has not reversed the general trend of decline in Mathematics performance standards. The purpose of this study was a small effort towards exploring alternative practices in the teaching of Mathematical concepts. The assumption of the researcher was that the low marks in Mathematics could be improved by the use of the Moodle LMS with additional teaching software in a blended learning environment.

1.7 Rationale of the Study

Moodle, a software with great potential, is piloted in different schools (including the school where this research was conducted) in the Western Cape as a resource for subject teachers to use. However, there is little documented research about its use and effectiveness in teaching and learning of Mathematics. While thousands of researches have been focusing on the general usage of ICT usage in classroom, the aim of this research is to contribute to empirical knowledge, which could be vital in understanding the extent to which Moodle, as a tool, can enhance Mathematical learning in classrooms.

According to Lopes, Babo and Azevedo (2008), Moodle was designed with a variety of features that can easily enable constructivist ways of learning and solving of problems. It is my view, according to previous studies that have been done, that it is possible that Moodle will be able to help education specialists. The specialists could use this study to gauge the learners' rate of learning from the time the topic is introduced; to the time, the learner is able to solve complex questions at the end of each topic. The assumptions made with the constructivist type of learning is that by using Moodle, educators will be

able to assist learners even outside school boundaries. Moodle will assist educators to easily identify learners' areas of weakness and undertake remedial interventions in time.

1.8 Introduction to the Theoretical Framework

Rapidly developing technology has resulted in a paradigm shift in educational approaches and teaching. Technology has been used to aid traditional approaches of teaching, which are being challenged in a digital age. Traditional approaches have become inadequate and cannot be solely depended upon as the only means of delivering learning (Uredi, 2013:53). The combination of the traditional approach and the new technology-based approaches create a hybrid approach with great potential for creating or tapping into the appropriate constructivist models and theories of learning.

Advances in technology in education continue to rise, even though some are yet to be investigated as to whether they improve the quality of e-Learning in education (Hirumi, 2013). Protheroe in Tsai (2011:145) stated that "in settings of knowledge based learning; learning theories used in the context of e-Learning are usually dealing with collaborative, scaffolding and community adaptive theories". This is commonly called, hybrid e-Learning theories, where more than one theory is used to explain how learning takes place in Information Technology platforms.

In this research, the hybrid e-Learning framework 'Student Centered Technology Rich Learning Environment (SCenTRLE) Framework,' developed by Hirumi in 2002, was adopted. Hirumi sets out three levels of planned e-Learning interactions, namely:

1. The lower level, which involves learner instruction from the instructor;
2. Middle level, where a learner interacts with computers and its surroundings (Hirumi 2013) and,
3. The upper level, where the learner absorbs what they could have learnt and then use it to develop others and solve related problems.

1.9 Chapter Overview

This study consists of five chapters, namely

1.9.1 Chapter One

Chapter 1 provides an overview of the thesis by highlighting the research questions that model the research. Furthermore, the rationale of the study, significance of the study and a brief outline to the theoretical framework is provided. The last part of chapter one provides a summary of subsequent chapters.

1.9.2 Chapter Two

Literature, which underpins and supports the theoretical framework used in this research, is outlined in chapter two. The chapter begins by unpacking the learning theories of Behaviorism and Constructivism. These theories are fused together, and then used with Vygotsky's social constructivist theory. The Vygotsky theory focuses on the premise that conceptual learning depends on social relations that surrounds learners, with interaction between the learner, the educator and their peers. Hirumi who designed a model, which incorporated technology rich environments for learners to learn, adopts the theories.

Literature on the use of technology is explored, particularly the Learning Management System's use globally and in South African Institutions. This chapter also explores the tools in the chosen Moodle LMS.

1.9.3 Chapter Three

This chapter outlines the research methodology, and describes in detail the research design and research approach used in this study. Data collection and data management strategies that were used are described. Finally, the ethical consideration issues are explained.

1.9.4 Chapter Four

Chapter Four deals with data collection and analysis. Data from the pre/post tests and the tests and quiz results obtained from Moodle are presented. This is followed by the analysis of data, according to the categories presented by the researcher.

1.9.5 Chapter Five

This chapter discusses the findings of the study. The results of learner achievement from the control and experimental groups are discussed. The researcher focusses on the results obtained during the use of the Moodle LMS. The chapter concludes with the researcher summarising main ideas of the research and provides concluding remarks based on the data analysis and findings.

1.10 Summary

This chapter discussed the research background that prompted the researcher to conduct this study. The research question and sub-questions were revisited and a brief theoretical framework was provided. Lastly, a summary of chapters contained in this research was outlined. The next chapter will discuss the theoretical framework, and the literature review.

CHAPTER TWO: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

In the previous chapter, the background of the research, the research questions to be used and the overview of the chapters of this research were discussed. The focus of this chapter was the theoretical framework and the underpinning theories of learning that framed this study.

In the literature review, the usage of LMSs globally and in South Africa and the most common LMSs were compared. The tools of the Moodle LMS were compared.

This chapter is organised into subsections as follows:

2.2 Introduction of the technology and the learners in the digital age.

2.3 Outlining of learning theories underpinning the study

2.4 Explanation of the scaffolding when using e-Learning.

2.5 Outlining the theoretical framework adopted from Hirumi that was used in the study.

2.6 Exploration of previous studies on this subject, and literature that guided this study.

2.7 Description of what LMSs are and how they are used in education and learning.

2.8 Outlining the effect that LMSs have on global education.

2.9 Zeroing down to the South African curriculum and how ICT has been used to address challenges in learning.

2.2 Technology and Learners in the Digital Age

Technological advancements have greatly affected the way teaching and learning is conducted in various learning institutions. The advent of portable computers and smartphones has influenced learners who are regarded net citizens or digital natives to spend a great deal of time browsing or using these gadgets for a variety of entertainment and social networking purposes. Frankl and Bitter (2012:80) note that: “today’s learners are more (inter-)active and engaged in the virtual world”. Although the spread of digital

resources has been uneven across countries and within communities, the use of e-mails, chat rooms, blogs and a variety of social networking software has increasingly become a main feature of youth culture (Frankl & Bitter, 2012).

Learning institutions across the globe have been grappling with ways of taking advantage of the growing interest in digital media and leveraging resources and opportunities. The challenges are developing strategies of converting the prior knowledge and time spent on social networking into gainful learning opportunities. The practice of adapting and incorporating digital media in learning environments in order to augment and improve traditional teaching methods has come to be popularly known as e-Learning (Frankl & Bitter, 2012).

In order to achieve the best results in the integration process, education specialists have been exploring the pedagogical advantages and disadvantages of e-Learning practices that are dependent on the constantly evolving digital media technologies (Mödrischer, 2006). E-Learning, which is a derivative of electronic learning, can be defined as the delivery of learning or educational materials and concepts by electronic means, which mainly involves the optimum use of computers or mobile devices such as smartphones and tablets (Vintere, Arevee & Rimkuviene, 2012). Several theories have been advanced to explore these developments and shed light on the issues underlying e-Learning practices.

2.3 Learning Theories of e-Learning

Although there are no specific models of e-Learning *per se*, Myers and de Freitas in Maddux (2011) reiterated that there are existing educational theories, namely the “Big Three” theories: Behaviorism, Cognitivism and Constructivism, that have been used to understand e-Learning. These three theories drive the culture of learning in classrooms to enable easy understanding when educators incorporate ICT in their teaching.

2.3.1. Behaviorism and Cognitivism

Behaviorism suggest that learning behaviour is caused by external stimuli, an approach based on Pavlov's (1927) theory of Classical Conditioning (Mergel, 1998). In behaviorism, learners in class are stimulated through some concepts which are intended to guide them to understand more each time they learn. Learning materials are arranged sequentially by the instructor for easy assimilation (Mödrischer, 2006). The weakness of this theory is that if the stimulus does not occur or if it becomes very weak, optimum learning will not take place.

On the contrary, Cognitivism views learning as a process within the mind, involving memory, thinking, motivation and meta-Cognitivism. The major developer of the Cognitivist theory was Jean Piaget in the 1920s. According to Good and Brophy in Mergel, (1998) cognitive theorists view learning as having taken place when cognitive structures called *schema* have been processed and stored in memory banks as information by humans. Information is processed when it is needed. The content learned is usually given to the learner in bits and pieces at a given time in hierarchical order to avoid overloading. Like behaviorism, researchers state that it is not clear how this theory can be adapted to e-Learning practices. It encourages rote learning whereby learners memorise to master techniques, which might be a disadvantage if the learning environments change. Learners may not be able to apply the same concept as the one stored in their memory banks.

2.3.2. Constructivism

Constructivists assert that learners construct their knowledge based on their interpretation of events and using previous experiences. A constructivist approach, according to Sultan, Woods and Koo (2011), considers the context in which learning occurs as paramount. Schunk, in Casimiro, Macdonalds, Thompson & Stoddel (2009), proposed that constructivism can be *exogenous*, where learning is entirely extracted from surroundings or *endogenous* where the mental structures use the previous knowledge to develop learning. The foundations of this approach can be traced back to the work of Vygotsky and Piaget. Piaget developed the theory of cognitive constructivism after observing: "Children are active thinkers constantly trying to construct more advanced understandings

of the world” (Siegler & Ellis 1996: 211). According to this view, children are seen as having the capacity to build conceptual structures in memory, assimilate knowledge and store it as information, based on prior experiences and existing cognitive structures. This theory has not only been influential in general child developmental psychology, but also in teaching, learning and educational reform.

Vygotsky’s theory of constructivism hinges on the premise that conceptual learning is primarily dependent on the social relations surrounding the learners, and also the initial interaction between the learner, the educator and their peers (Bunce, 2003). Learners are active agents who are expected to learn more from, and through, purposeful engagement with their surroundings, either by interaction with peers or working as groups, with the teacher’s guidance. Vygotsky’s theory, also known as social constructivism, largely underscores the concept of collaborative learning and social interaction as key to cognitive and conceptual development. This collaboration is regarded and encouraged, as it allows learners to improve their metacognitive skills through interactive learning activities.

This theory was an elaboration by Vygotsky of the ideas of child development that he first articulated through his theory of the Zone of Proximal Development (ZPD). As illustrated in Figure 2.1, the main premise of this theory is that there is a particular zone that controls, shapes and enhances a child’s learning opportunities and capabilities, initially through adult guidance, and eventually independent of such guidance. For Vygotsky, the ZPD encompasses "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (Cozy, Roque, Culatta & Johnson, 2011). According Kalina & Powell (2009:244), Vygotsky suggested that learners learn easier in such zones, especially when other enabling factors are present around them. Once the student achieves this initial goal of learning, then the zone grows and enables them to do more, including learning new concepts on their own.

Therefore, a classroom organised on the principles of social constructivism, helps the student to learn much better from the environment around them. In such a classroom,

learners learn with minimal guidance, since constructivist teaching practices have an important role to play in the developing of the both cognitive and social skills of a learner (Kalina & Powell, 2009). A diagrammatic view of Vygotsky's zone of proximal development is shown below in Figure 2.1.

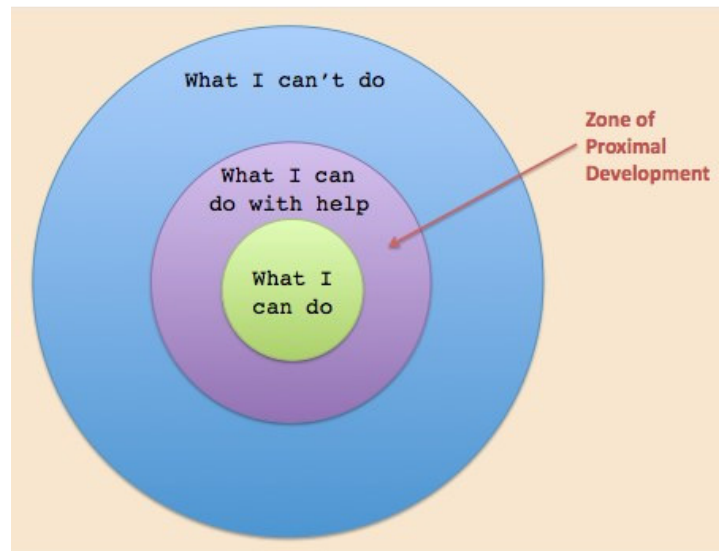


Figure 2.1: A diagrammatic view of Vygotsky's Zone of Proximal Development. Source: www.innovativeLearning.com/educational_psychology/development/zone-of-proximal-development.html

Learning strategies and tools used in e-Learning have mostly been found to be suitable for the creation of Constructivist Learning Environments (CLEs). This is because these tools stimulate interaction between the learner and the surrounding virtual environments (Casimiro *et al.*, 2009; Sultan *et al.*, 2011). These virtual environments host different players and end-users who are part of the collaborative teaching and learning community. In e-Learning classes, educators mainly act as facilitators, and use computer programs and other related media tools to scaffold the learning process. This is done in order to enable learners to engage with learning tasks, even during periods when instructors are physically out of reach.

A great deal of research on how to strategically use e-Learning technologies to create constructivist and collaborative classrooms across all educational levels, has started to emerge globally (Sultan *et al.*, 2011; Florian & Zimmerman, 2015; Frankl & Bitter, 2012).

Many education role players have adopted these technologies, as they stimulate good learning environments.

2.3.3. Social Constructivism and Instructional Design

The creation of “task-driven computing activities supported by social constructivist theory” (Reynolds, 2016:737) has become an issue of interest among scholars and instructional design coaches. Through constant observation, it was observed that instructors in e-Learning should strive to develop strategies and learning set-ups that create a constructivist environment for learners in the classroom. Bednar in Mergel (1998) emphasized that the goals of instructional design during learning should be to enable communication or transfer of knowledge to learners in the most effective manner available. The advent of technology-rich classrooms and social environments has compelled educators and educational administrators to explore some ways of operationalizing these ideals. Some of the latest ideas have come from researchers such as Rutgers scholar, Reynolds (2016:735), who has proposed a framework for defining, designing for, and measuring *social constructivist* digital literacy development in learners. De-emphasizing the pursuit of technology-deterministic approach, where the tail ends up wagging the dog in favour of a social constructivist digital literacy approach, Reynolds has argued that:

“Such effort requires clear articulation and development of prioritized learning objectives, appropriate technology curriculum scope and sequences, technology affordances in schools, and new modes of assessment and evaluation, supported by rigorous research designs on effectiveness, moving more quickly forward towards comparative research that offers insight on improved practices” (Reynolds, 2016:736).

The idea of appropriate technology curriculum scope and sequences in the above quote references another aspect of technology-based curriculum design, which is scaffolding.

2.4 Scaffolding and e-Learning

As a teaching and learning technique, scaffolding originated in the 1950s, while technical scaffolding is an adaptation of the older concept in line with e-Learning opportunities, has recent origins, (Yelland & Masters, 2007). Scaffolding entails the provision of tools (digital and conceptual) that learners can use to solve certain tasks or understand topics studied. Technical scaffolding might entail the provision of online-based resources, such as websites, online tutorials or videos, which learners can resort to when they need assistance with a particular topic, reading, concept or any given task. At its most basic form, scaffolding might include a set of systematic instructions to guide the learners, or breaking the tasks into smaller chunks that allow for easier understanding.

While constructivist based approaches, encourage educators to design lessons that allow learners to discover knowledge semi-autonomously or even autonomously, scaffold-based lesson design helps boost the confidence and learning capabilities of learners, and sets them up for good assessment outcomes. The design of learning environments suitable for this type of learning creates the kind of freedom that allows learners to apply their minds and possibly create unique concepts (Kalina & Powell, 2009). However, scaffolding is just one of the many ways of harnessing the resources created by the availability of student technology rich learning environments.

In this study, it was therefore deemed that the constructivist approach would be the most appropriate for an e-Learning delivery model.

2.5 The Student Centered Technology Rich Learning Environment (SCenTRLE) Framework.

In traditional teacher-centred teaching, the teachers are sources of knowledge, directing the process of learning to learners. Learners become the 'receivers' of knowledge. The advent of technology that could be manipulated for e-Learning has been embraced as an advantageous development in classroom. Student-centred technology helps in the realisation of the goal of student-centred approaches to teaching and learning, as

opposed to traditional methods that forced learning to be an educator-oriented practice. According to Meyers and Jones in Hirumi (2002), previous theorists that have investigated learning processes, found that learners are active agents; they can engage, listen, write, read and solve problems. In modern ways of student-centred teaching, learners are capable of constructing their own knowledge; they can work individually and are capable of setting up groups, which can enable them to solve problems that are more complex.

During the early 2000s, an American-based scholar, Hirumi (2002), formulated a model for designing student-centered, technology-rich learning environments (SCenTRLE). Quoting a number of scholars, Hirumi (2002:497) emphasized that: “Student-centred approaches to teaching and learning stress the importance of learners’ past experiences, exploring individual needs and interests, promoting active participation, stimulating higher-order thinking, and encouraging life-long learning”.

The two contrasting learning techniques – newer student-centred and older teacher-centred approaches - are compared diagrammatically below in figure 2.2.

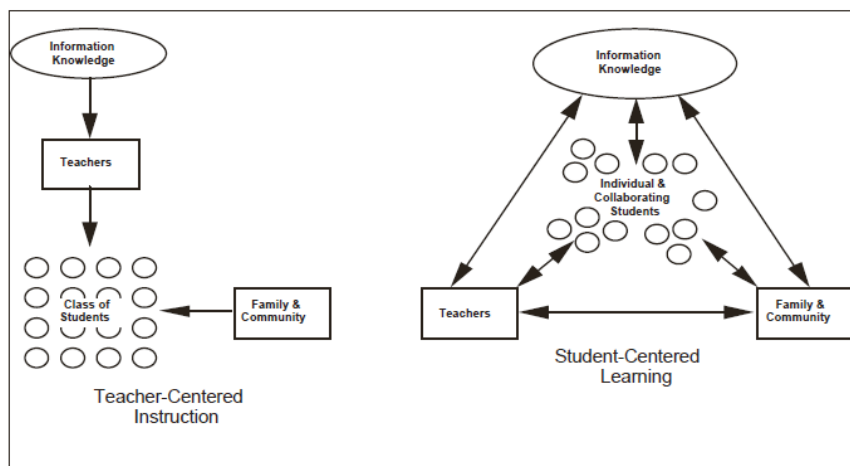


Figure 2.2: Teacher-centred instruction versus student-centred learning. Source: Hirumi (2002:505)

Hirumi’s model (2002:497) “helps educators use constructivist and student-centered approaches to teaching and learning by delimiting eight instructional events for facilitating knowledge construction and the development of life-long learners.”

In his schema, Hirumi (2002) presents the eight processes (see figure 2.3) and features that should define a student-centred, technology-based module that can help learners construct their knowledge based on their own interests and knowledge from previous educational levels. The eight steps are:

1. Set learning challenge
2. Negotiate goals and objectives
3. Negotiate learning strategy
4. Construct knowledge
5. Negotiate performance criteria
6. Assess learning
7. Provide feedback of steps 1-6
8. Communicate results

Hirumi (2002) has diagrammatically illustrated these events as follows:

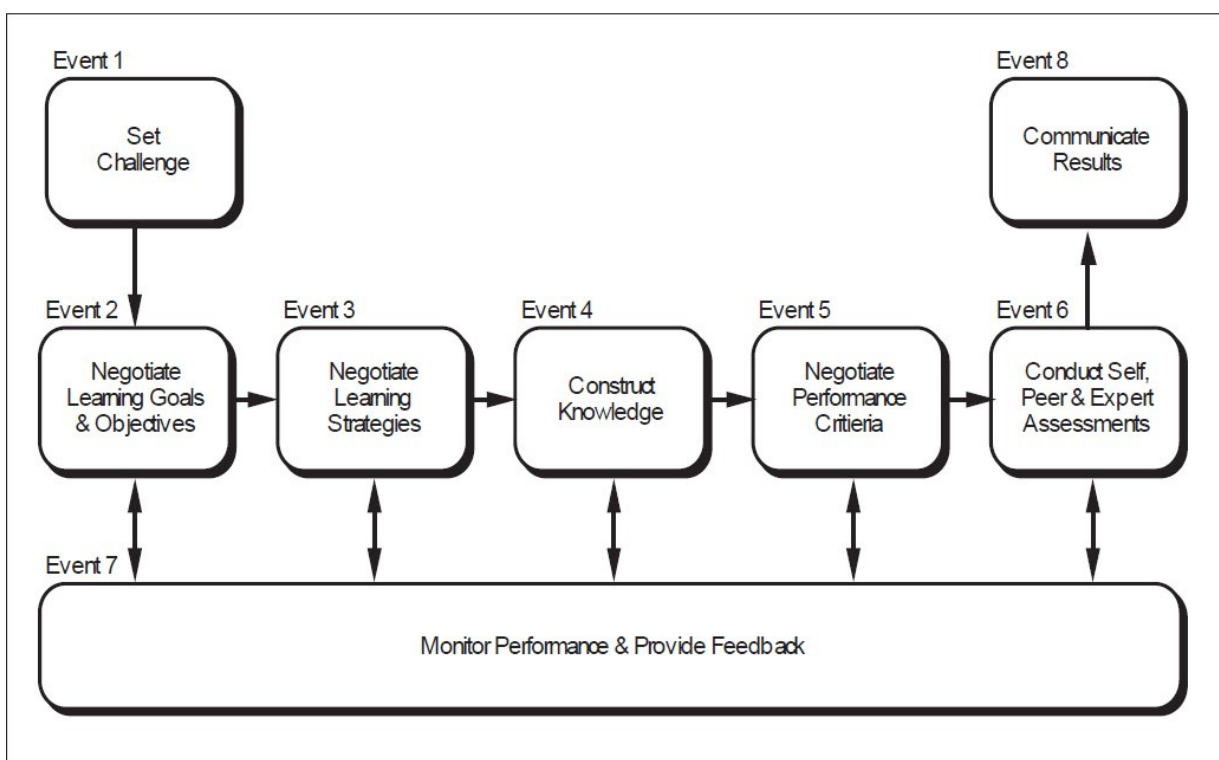


Figure 2.3: Processes set to assist learners to construct knowledge based on their previous knowledge. Source: Hirumi (2002:510)

This study is largely informed by Hirumi's (2002) hybrid e-Learning framework. In adopting Hirumi's e-Learning framework, the three levels and their constitutive elements were found suitable for this type of school setup. The eight processes are incorporated into the Hirumi's three levels of interactions, where learners use these processes to interact with humans and non-humans surrounding the learner. The levels of interactions are outlined below:

2.5.1 LOWER LEVEL: Learner instruction

Learner Instruction. This level deals with instructions that guide learners with regard to what is expected from them. Instructors are expected to use their expertise to answer questions of concern from learners, explain clearly, what they expect learners to do, facilitate some activities and, if possible, organise balanced groups. Instructions should not only rely on traditional ways of explaining strategies of learning as e-Learning requires more complex instructions like training and technical support. Most of the instructions in e-Learning are communicated and mediated by the technology in use (Hirumi, 2002; Zimmerman, 2012; Su *et al.*, 2005).

2.5.2 MIDDLE LEVEL: Learner-Human and Learner-Non Human Interactions:

- i. **Learner-Instructor Interactions.** The instructor or educator gives instructions and explains what needs to be done. Learners can ask for clarification if the instructions were misunderstood. The educator constantly gives feedback to learners to make sure that accuracy is maintained (Hirumi, 2002); Zimmerman 2012; Su *et al.*, 2005).
- ii. **Learner-learner interactions.** This interaction occurs when learners share information and their opinions about the content of the course. They can work together to interpret data or solve problems even though the presentation of results may differ. The interactions are similar to the traditional classroom environment whereby learners can be asked to work together in groups to solve particular problems. Learners are monitored to make sure that learning is not compromised.

It is at this very moment when social constructivism is at its peak (Hirumi, 2002); Zimmerman, 2012; Su *et al.* 2005).

- iii. **Learner-content interactions.** Learners use multimedia components like video, audio and graphics to assist in their learning. There is a strong belief that what learners listen to in class is easily forgotten compared to what is seen or engaged upon practically (Hirumi, 2002). Visual perception skills have a significant impact during learning as seeing real objects or simulations creates a lasting picture in the mind of the learner. Learners can download, rewind or pause audio and video materials, to be used at a convenient time for them. The use of media programs like *VLC*, *Geogebra* and other specialized multimedia programs can play a major role in stimulating learners' interest and learning capabilities. Current cohorts of learners belong to the new visual generation.

- iv. **Learner-tool interactions.** Learners can use chat rooms, SMS systems and other tools to complete tasks with the learning management system and outside the computer environment. Tools in the Microsoft Suite such as Word, Excel and PowerPoint can be used to facilitate learner-tool interaction by drawing graphs or presenting work that needs to be assessed (Hirumi, 2002); Zimmerman, 2012; Su *et al.*, 2005).

2.5.3 UPPER LEVEL: Learner self-interactions:

Learner self-interactions entail learners working on their own or in pairs or groups. Learners are expected at this level to confirm their readiness to tackle the subject or module as required by the instructors. This enables them to gauge the amount of content they can handle at a given time. Constructed knowledge can be shared in groups, a situation regarded by social constructivists as socially mediated learning. This learning process is motivational and is effective as it is influenced by social factors (Hirumi, 2002); Zimmerman, 2012; Su *et al.* 2005).

The theoretical framework of this study is represented diagrammatically in Figure 2.4 below.

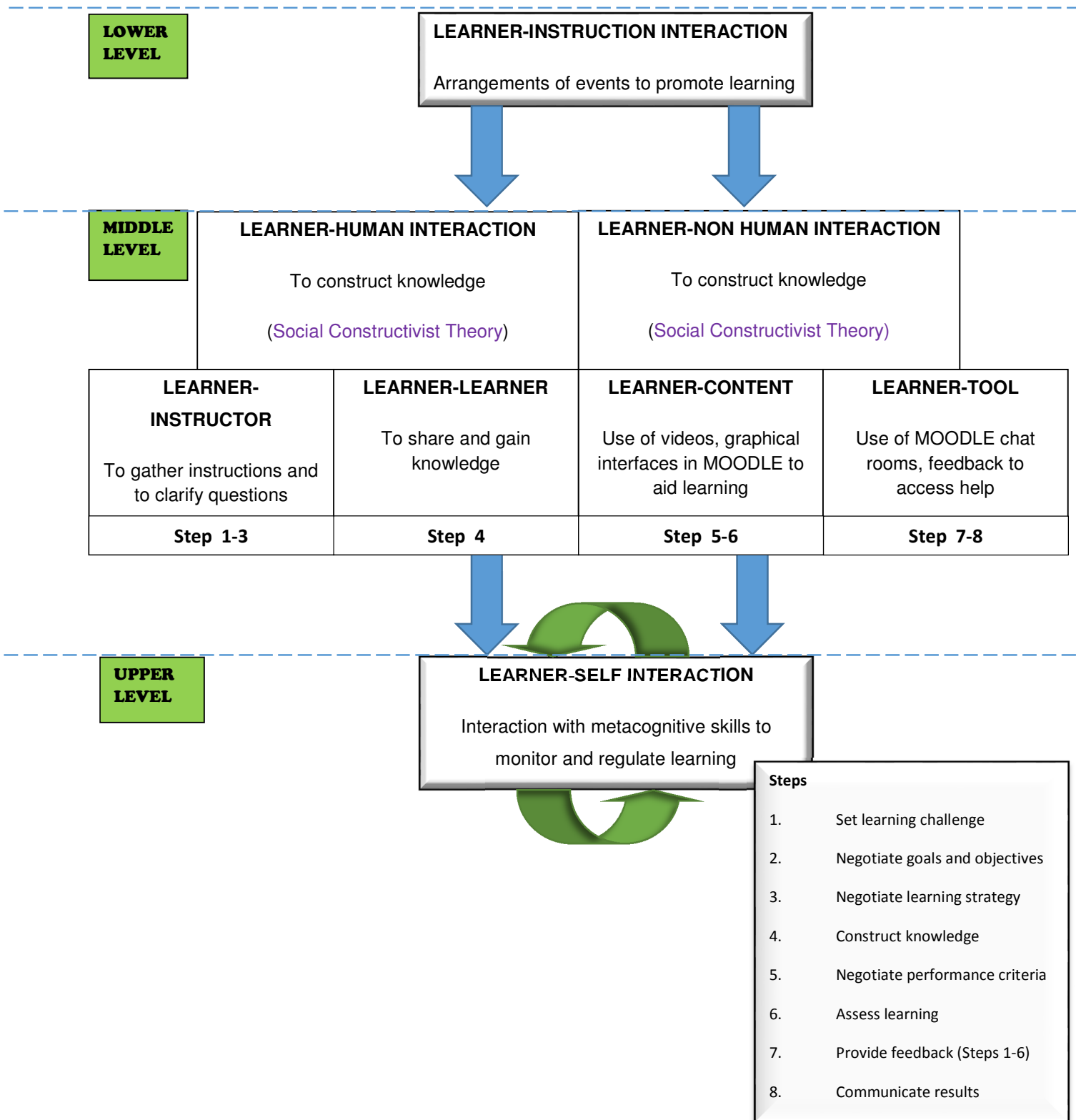


Figure 2.4. The summary of the theoretical framework with learner interacting with content, LMS and instructors. Adapted from Hirumi (2013:3).

2.6 Technology in Education

According to Mouton (2001:87), a literature review enables the researcher to investigate what has been done in the field that is being investigated. The researcher analyses existing scholarship, comparing available body of knowledge to learn more about their findings.

2.6.1 ICT usage in Mathematics in Africa

In Africa, developing countries have been gearing up to use technology in learning so that their graduates are able to compete with the changing digital world globally. The e-Learning Africa report of 2014 showed that e-Learning was growing rapidly in 16 leading countries with technology in Africa. Countries like Nigeria and South Africa are trending globally as they compete with developed countries in empowering most of its learners with technology (Elletson & MacKinnon, 2014). According to the 2012 survey by GSMA Sub-Saharan Mobile Observatory, 27.8% of school learners in Senegal reported that they have acquired better knowledge from using ICT in class (GSMA & Deloitte, 2012:40). The use of ICT in classroom, will therefore enable educators to trace the performance of the learners and at the same time, learners will be able to work at their pace.

2.6.2 Technology and Mathematics

The technology that has been developed recently allows embedding media tools that provide audio, visual and interaction to improve the quality of learning (Deliyiannis , Floros, Vlamos & Tania, 2007). Karami and Attarn in Joshi (2017) found that if ICT is integrated in Mathematics teaching, it becomes very effective and helpful in delivering content. The use of Internet tools and audiovisual instruments that are embedded within the ICT programs motivates learners towards learning, helping learners to become independent.

Applications that are designed to work with other ICT tools, like Geogebra, help learners to observe, represent and interact with Mathematical concepts (Joshi, 2017). Chrysanthou (2008) ascertained that Geogebra in Mathematics makes graphs and other shapes look 'pleasant' and practical. In their book, Hegedus *et al.*(2016) described

Geogebra learners who were drawing Euclidean and Cartesian diagrams as “Mathematical cyborgs who like to express themselves through tools.”

Teaching and learning using technology is very beneficial in saving time. Currently lessons in Mathematics are averaging 40 minutes, making it difficult for an educator to attend to all learners in a particular lesson. Pachler (2001) stated that computers allow very quick storing, displaying, analyzing and synthesizing, allowing learners to have more time to think about what they have learnt.

There are sections of the Mathematics curriculum that do not lend themselves to the current teaching style of using the chalkboard and textbook. The section on ‘Functions’ in Mathematics is one such example, as learners need to be able to visualize the vertical and horizontal shifts as prescribed by the curriculum. Topics like Euclidean geometry and measurement are also a challenge.

Carrol (2006) noted that he faced difficulties drawing good figures and graphs, working with graphs and showing the shifts and transformations during lesson time. Some educators occasionally use an overhead projector to illustrate diagrams for learners to draw. These diagrams are also supposed to be copied by learners for them to understand easily.

Methods that relied on memorizing the times table or logarithmic table worked well in the past and are difficult strategies to replace. However, some methods used in the teaching and learning of Mathematics can be enhanced by integrating them with technology so that the classroom becomes a better learning environment. Taylor (2008) reiterated that, educators need to set goals for learners that will support them in understanding the use of computers in classroom.

Despite the use of technology by educators, a survey showed that 75% of teachers used technology for administrative tasks, such as the mark sheet and class register, while the remainder only use it for support in classroom (Williamson & Redish, 2009). Recent research in India on about 300 schoolteachers indicated that, apart from using computers for delivering entire lessons, teachers used computers for other reasons. Teachers used computers for preparing question banks, downloading additional class material and most of the times used as hardware for learners doing presentations in class (Bhalla, 2013). It

is with the understanding of the literature above that it is envisaged that the introduction of a learning management system in teaching will improve the use of ICT in classrooms.

The approaches and systems discussed above can, however, only be implemented through a learning management system chosen by a school, depending on its needs and structure.

2.7 Learning Management Systems

Learning Management Systems (LMS) are web based learning platforms that deliver learning content and provide functions for communication and collaboration. Some examples are assignments and recorded lessons, and managing access and tracking progress of the user with the view of supervising the process of learning (Watson & Watson, 2012). According to Frankl and Bitter (2012:80), the purpose of a LMS is to “provide electronic support or function as a centralized tool to provide materials for learners”. The LMS can be incorporated in a single lesson, topic or the whole curriculum, depending on the need. It can be used to collect student results, and as a storage and analytical tool for those same results, making it easier for the instructors to track and manage the progress of learning. LMS are central in blended learning approaches where learners use both e-Learning and traditional ways learning, (Cohen, Manion & Morrison, 2007).

Coates, James and Baldwin (2005) predicted that the LMSs would increase in usage in education as it simplifies instruction and teaching. It tends to maximize the contact time with the learners, as learners do not need to depend on classroom time only to gain knowledge. The LMSs also allow the teachers to send announcements and schedule tasks for learners and in turn can allow learners to have discussions and share information outside the prescribed school times. The LMS can be used for fully online distance education courses, as is the practice among higher education institutions or, it may be used for blended learning by schools in general.

A number of software and service companies are emerging and developing fast as competition for this fast-growing market of LMSs gains momentum. Learning Management systems like Blackboard, WebCT, ANGEL and Canvas, are sold by

companies, while Moodle and Sakai are freely available as open source management systems.

The following reasons were gathered by Coates *et al.* (2005:23-24) to explain the expected exponential growth in the use of LMS:

- i. The LMS help facilitate a flexible course delivery: - learners use uploaded resources by the teacher. There is no need to gather around the teacher to learn.
- ii. It supports constructivism in learning: - Learners develop learning on their own, supported by surroundings as supported by the Constructivists Theories. The tasks are repeated at the frequency of the student until they become the master of the concept.
- iii. Academic institutions have seen that learners are digital natives who spend a great deal of their time using technology and therefore that time is harnessed and used for learning. Most learners easily lose focus when taught using the traditional chalk and talk way of teaching.
- iv. The LMSs are aimed at regulating and controlling the process of learning and teaching. This helps to track whether learning takes places, as resources are sequenced in an easy way to follow.

The LMSs vary according to their specifications but generally have the same setup, with the following common features:

- Announcement area, email, chat and instant messaging and discussion forums;
- Learning resources, learning object content and links to important sites like YouTube on the internet;
- Submission of assessments, multiple choice testing, collaborative work and feedback;
- Facilities for registering, enrolling learners and managing their activities.

Universities, as many studies have shown, are clearly attracted to LMS as evident in the annual uptake of this software (Padayachee *et al.*, 2011). It is envisaged that the trend of using LMSs for teaching and learning will become part of school education. It is therefore useful for studies to be undertaken that shed light on how certain learning processes, concepts and topics can be adapted to these e-Learning technologies.

2.8 The LMSs and Global Education

The popularity of LMSs has been noticeable in higher learning institutions like universities and colleges globally. However, this practice has started cascading into schools as well. Countries like New Zealand and United States of America adopted this system into their classrooms very fast. In New Zealand, according to a survey conducted by that country's Ministry of Education in 2012, there were about 28% of schools using learning managements systems, and the ministry was in the process of marketing them widely after seeing the benefits (Talk, 2015). The usage of LMSs in Australia and Canada showed that most schools are increasingly integrating learning and its enabling technologies by using virtual classrooms to harness the learners' interest in technology.

According to the 2015 Springs Report, there are only about 5.3% of U.S.A. institutions with more than 700 student enrolments that are not yet using the LMSs, which is a significant improvement from 2014 when 7.4% did not use the LMS (Edutechnica, 2015). As discussed earlier in the chapter, these statistics indicate that there are immense benefits in using LMS, which could be the main reason why 95.7% of the U.S.A. institutions are attracted to the LMSs. U.S.A. is one of the few countries that have documented the LMS usage in schools for academic purposes.

In Africa, many countries have embarked on educational transformation to follow global trends. In East Africa, countries formulated policies to guide them in the implementation of ICT in education. (Hennessy *et al.*, 2010).

Technology nowadays is important in creating virtual environments that are interactive and user friendly. This is a goal that many developing countries are keen to achieve in order to reduce the gap between them and other countries (Nwabude, 2012). This was supported by the *e-Learning Africa Report 2012*, on use of different technologies available, and found that the Moodle LMS was mostly used in Africa. The report further alludes to the fact that 74% of these respondents used ICT in classrooms for teaching and learning (Isaacs & Hollow, 2012). More than half (52%) of these respondents also used the internet to access teacher resources. Unwin *et al.* (2010) also interviewed representatives from about 25 African countries in 2009. Their research showed that,

despite the challenges in resourcing, there was a general increase in the use of LMS in schools, with the greatest increase observed in Kenya and South Africa.

South African major universities are leading in the usage of LMS, and have been documented as institutions benefiting from the use of LMS to enhance teaching. These LMS have helped students at university with learning, ensuring that content is transferred to them without problems. Table 2.1 below shows a summary of Universities and the type of LMSs (Bagarukayo, 2015).

Table 2.1: A List of Universities in South Africa with LMS

UNIVERSITY	TYPE OF LMS used
University of Pretoria (UP)	WebCT
University of South Africa (UNISA)	Sakai (myunisa)
University of Cape Town (UCT)	Vula (Sakai) Moodle
University of Stellenbosch (US)	SUNLearn (Moodle)
Cape Peninsula University of Technology (CPUT)	Blackboard
University Of Western Cape (UWC)	Sakai
Nelson Mandela Metropolitan University (NMMU)	SharePoint 10
University of Johannesburg (UJ)	Blackboard
Tshwane University of Technology (TUT)	Blackboard
University of the Witwatersrand (Wits)	Sakai
North-West University (NWU)	Sakai

2.9 ICT in the South African Mathematics curriculum

In 2004, the White Paper on e-Education, by the Department of Basic Education, outlined the role of ICT in education in general, and specifically the use of ICT in education and how it intended to fully integrate fully ICT in education. This White Paper made the emphatic declaration that:

“Every South African manager, teacher and learner in the general and further education and training bands will be ICT capable (that is, use ICTs confidently and creatively to help develop the skills and knowledge they

need as lifelong learners to achieve personal goals and to be full participants in the global community) by 2013” (DoE, 2004:17)

The statement was crafted by policy stakeholders with a vision that by the year 2013, ICT will be the major tool for development and educational delivery. Although there have been immense challenges with regard to implementation, the statement is evidence of the fact that the education experts acknowledge that ICT has the potential to enhance the way teaching and learning can be done, either as a support tool, for blended teaching or as an alternative to the traditional approach of lesson delivery.

In Mathematics, the country’s latest CAPS emphasizes that:

“In the FET Phase, learners should be exposed to mathematical experiences that give them many opportunities to develop their mathematical reasoning and creative skills in preparation for more abstract Mathematics in Higher/Tertiary Education institutions” (DoE, 2011).

The creativity and reasoning mentioned in this statement can be supported by the use of the LMS, which follow a constructivist approach of learning. This encourages independence of learners in addition, who could develop because of learning from their surroundings, based on their abilities.

The Trend in International Mathematics and Science Study (TIMSS, 2011) is a survey that conducted a research on schools of 63 countries using 14 benchmarking entities. It found that the achievement of Mathematics had a positive correlation with the number of computers available at schools, (Mullis *et al.*, 2012). The results showed that learners in schools with no computers available for instruction had a lower average than the learners who were in schools with access to computers.

Given the positive findings of the correlation between the use of ICT and results, this research sought to check the effectiveness of using a LMS in teaching and learning of functions in Mathematics. Mathematics is, inherently, a problem-solving

subject, which requires a great deal of methodical scaffolding and sequencing. Since constructivist learning environments “are characterized by active engagement, inquiry, problem solving, and collaboration with others” (Abdal-Haqq, 1998:1), it is argued in this study that the collaborative learning environment offered by Moodle, possesses the potential for the teaching and learning of Mathematics.

2.11 Summary

In this chapter, the e-Learning theoretical framework that informs the study is addressed. First, the meaning of e-Learning was addressed, thereby exploring the different approaches to harnessing e-Learning and delivering e-Learning environments that are embedded in the widely accepted constructivist teaching and learning approaches. The chapter concluded by zooming into the Moodle LMS used as a heuristic device in the study. The main argument in the chapter is that there seems to be a great deal of mutual reinforcement between the established constructivist learning theories and the newly emerging e-Learning technologies. Although the constructivist approaches to e-Learning are mere enhancements of established learning theoretical frameworks, the operationalization of these theories is much easier and enhanced in e-Learning.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In the previous chapter, the literature review and the theoretical framework used in this study were discussed. The purpose of this chapter is to discuss the research design, sampling, data collection and analysis of results. The chapter further explains the validity of this study. This chapter is organised into subsections as follows:

3.2 Presentation of the research design

3.3 Outline of the research methodology followed in this study

3.4 Presentation of the extraneous factors identified during this research

3.5-3.11 Presentation of data collection and analysis.

3.12 Description of how Moodle was implemented and deployed

3.13 Description of the classroom before Moodle was implemented

3.14 Explanation of how learners were taught the basics of computers

3.15 Description of the tools in Moodle that are used for teaching and learning

3.16 Description of how Moodle was assessed online

3.17 Presentation of the learning process in Moodle

3.18 Outline of the limitations of using Moodle LMS

3.19 Description of how the traditional classroom was taught during the research

3.20 Summary of the chapter

3.2 Research Design

Corbin and Strauss (1990:3) conceptualize a research design as the “procedures and canons” used in the accomplishment of the research. This is underscored by Louis and Mouton (2013:126) who define a research design as “a logical plan involving strategic decisions with the aim of maximizing the validity of findings”. A research design is a plan structure that is designed to show how the study is to be carried out, in order to obtain the answers to the problem being investigated (Kumar, 2011). A research design should be able to show the different tools and methodologies that will be used in the study. Among

other things, it encompasses identifying and fully describing the population sample or participants who will be the subjects of the research or those who will contribute to the study in different ways. Such samples must be fully justified. Research designs also detail how the required data will be collected and why the particular data targeted for the study will be selected.

According to Kumar (2011) there are many variables in research that affect the design of the study. Such variables are determined by the nature of the phenomena being studied. Researchers make choices from a variety of possibilities, but there is no consensus among methodology scholars about the criteria used for distinguishing research designs. However, what is clear is those aspects of design that have a *control* component normally lead to a decision having to be taken between experimental versus non-experimental design. These designs that have a *time* component, have an option between longitudinal vs cross-sectional designs; and lastly, a methodologically inclined focus calls for a choice between qualitative versus quantitative versus mixed method approach (Louis & Mouton, 2013: 127). The design followed in this study was a quasi-experimental design that employed a quantitative research method.

3.2.1 The quasi-experimental design

According to Jackson (2014: 146), *quasi* means “having same but not all features”, and *experiments* means it resembles even though it is not following the proper experimental procedures. The underlying feature here is that the protocol borrows from and approximates an experimental design. A quasi-experimental design also necessarily involves the application of an intervention in the experimental group and the following of events in the control sample. An intervention involves any set of protocols or programs closely, observed for their effects. It is closely related to what Van der Akker (cited in Cronje, 2013), calls “empirical testing”. Empirical testing determines the practicality and effectiveness of the intervention (Ibid). This research will follow a quasi-experimental design, because it fits the purpose of the study, which is to assess the effect of using Moodle on learning practices and outcomes.

In this case, the researcher selected learners who populate the experimental and the control groups as units, and the groups were not split randomly as is normally done in the

typical experimental design. This is because it was impossible to split a standard set of learners in a classroom into randomly assigned groups. Two groups of learners in two classrooms were therefore selected. In designing the research in this way, it was assumed, for instance, that the differences in the extent of learning that would result in each of study population groups would depend on the effectiveness of the two teaching methods, namely the traditional method of “chalk and talk” versus the one where the Moodle LMS is used for learning.

Although the researcher took cognizance of the fact that variables such as, learner motivation or teacher competence could affect the results of the study, these were not incorporated into the design to be part of the investigation because they each require separate thorough studies. However, it is imperative to take into consideration and keep them in mind in order to be aware of the cases where they could have an unequivocal effect on the nature of the results. In this research, it was assumed, since the sampling was non-random, issues of motivation or lack of it were naturally part of the intrinsic variables of each group.

3.2.2 Limitations of quasi-experiments

The participants in the quasi-experimental group are not randomised; that is the participants were selected as a group just because of the nature of their existence (Bradley, 2009). For example, learners at schools are allocated to a fixed class such as 10A or 10B, and it was impractical to separate learners from a set group for the research. However, this was applicable to both the control and experimental groups. This assisted in offering a comparison between the groups to establish the effectiveness of the treatment.

3.3 Research methodology

Research methodology is a chronological way of solving a problem. It illustrates why the chosen problem is suitable for research (Rajasekar & Philominathan, 2006:5). A research methodology sets out the steps, which a researcher follows when studying the problem.

In this research, the methodology was to use a quasi-experimental design of non-equivalent pre-test/post-test design. Data was collected from assessments given to the control and experimental group and the results were analysed statistically.

The two sampled classes in this research had an equal chance of being selected for traditional teaching model and the experimental teaching model (Moodle). As school authorities equally distributed the classes at the beginning of the year, one class was chosen to be the experimental class and the other a control class, without using any characteristics. These two classes were then colour coded, with one class named 10 *BLUE* (control) and the other one named 10 *GREEN* (Moodle). The research sample is shown diagrammatically below:

The flowchart showing how the classes will be exposed to the two methods

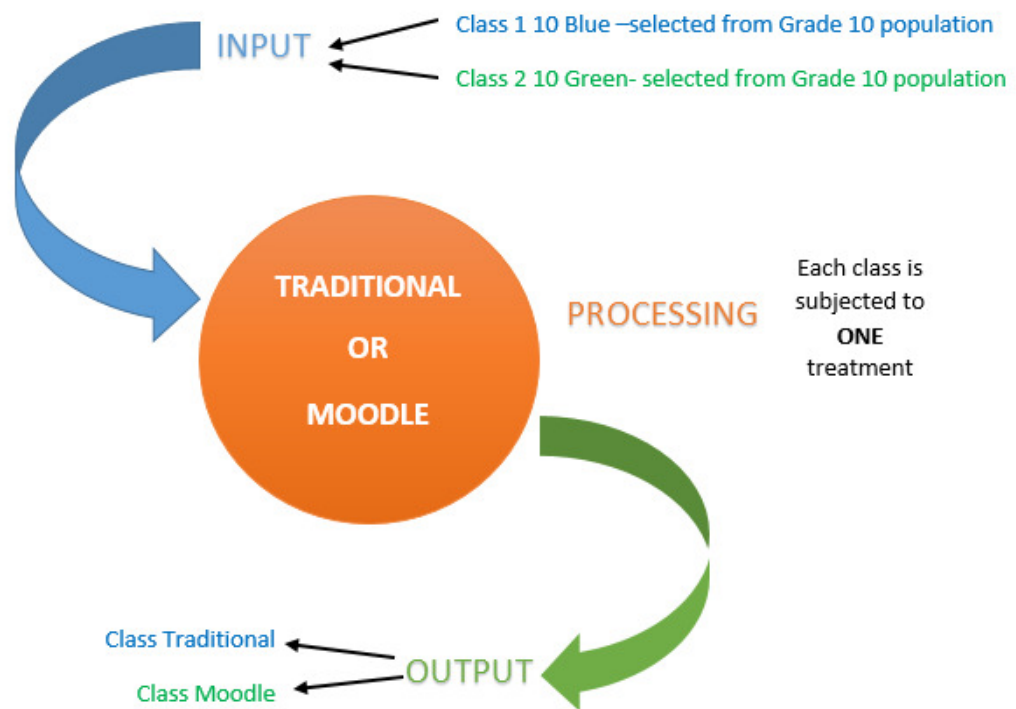


Figure 3.1. Two classes and their treatments in the research

The diagram in Figure 3.1 shows the two INPUTS and the two identical but differently coded classes that were chosen to conduct the experiment. These classes were then PROCESSED using two methods: one class by Moodle and the other by using the traditional methods of teaching. The OUTPUT was two distinct classes taught using two different methods (treatments). The results from these two classes were subjected to analysis to compare whether there was a significant difference, if any, in results given the two teaching methods.

3.4 Extraneous factors

In most cases, learning in classrooms is affected by a range of factors. Within the Moodle Learning Management System and the traditional method of using chalk and talk, there can be extraneous factors, which could influence the results of this research. The researcher was aware that, even though utmost care was taken during the conducting of the research, there were some factors that could not be controlled in the study. Table 3.1 below shows the factors that are common to the school set up as described by Jackson (2014). The factors expected are:

Table 3.1. Extraneous factors from the two teaching methods

MOODLE EXTRENOUS FACTORS	TRADITIONAL EXTRENOUS FACTORS
<ul style="list-style-type: none"> • Motivation to learn • Eagerness to learn • Interest in Mathematics • Willingness to work as a group • Competency of the teacher • Internet connection 	<ul style="list-style-type: none"> • Motivation to learn • Eagerness to learn • Inability to work as groups • Interest in Mathematics • Willingness to work as a group

- a) **Motivation to learn:** Mathematics is a subject that most learners fear. They have the feeling of not doing enough to pass the subject. This demotivates them. Learners are misled on how difficult the subject is. This factor could cause the performance in class to be affected, because they do not get the support they need from the people around them.
- b) **Failure to work as groups:** In both methods of teaching, learners were expected to work as groups and discuss instructions and ideas on how to solve problems. However, there are learners who cannot interact properly in groups. If learners cannot work as a group, it will affect the result of the research.
- c) **Eagerness to learn:** Learners might *hate* learning in general. This cannot be easily controlled. This factor might affect the results of the research, as the performance of these learners will be minimal.
- d) **Lack of interest in Mathematics:** There could be learners who do not have any interest in pursuing Mathematics as a future subject. Some opt for Mathematical Literacy. Therefore, this lack of interest could affect their performance in this research.

- e) **Competency of the educator:** Some learners fail to do well, not because they do not understand the subject, but because of the way the lesson is delivered to them. This could affect the learners' performance and the research results might be jeopardized.

The extraneous variables found in this research will be monitored using a control group in the study. The inclusion of a control group in the study, gives the researcher assurances whether the results are not due to the extraneous variables (Jackson, 2014). The impact of the experimental programme (in this case Moodle) plus the extraneous variables associated with it, is expected to be counteracted by the control group (in this case the traditional method) and, the extraneous effect associated with control. This is the reason why these extraneous variables, if they are not wholly suppressed before the research, are ignored in both groups as they are assumed to cancel each other. In other words, if both Moodle experiment and traditional experiment both have extraneous factors, it means excluding the effects of both extraneous factors will not affect the results of the research study.

This is illustrated by a simple equation below:

$$(Moodle + Extraneous factors) - (Traditional method + extraneous factors) = Effect of the intervention$$

Therefore, the difference in results between the experimental group and the control group was attributed to the effects of the intervention.

3.5 Sampling

According to Jackson (2014), the population involves all the participants that the research needs to generalize. A sample becomes a representative of the population under investigation. A sample is used when it is practically impossible to survey the whole population due to cost, time and labour involved during the research. Sampling, as authors say, has benefits of saving time and resources. This however, might compromise the level of accuracy of the findings.

Non-probability sampling was conducted to select the participants. This is when learners from a population under investigation do not have an equal chance of being selected, (Jackson, 2014). A non-probability cluster sampling was suitable for this research. This

cluster sampling was selected as participants are already part of a *cluster* as they were already in classes. Using the academic capabilities of the Grade 9 results, which was known to be significantly uniform, six, Grade 10 classes were formed at the school. The composition of the two Grade 10 classes selected for the research are shown in Figure 3.2 below:

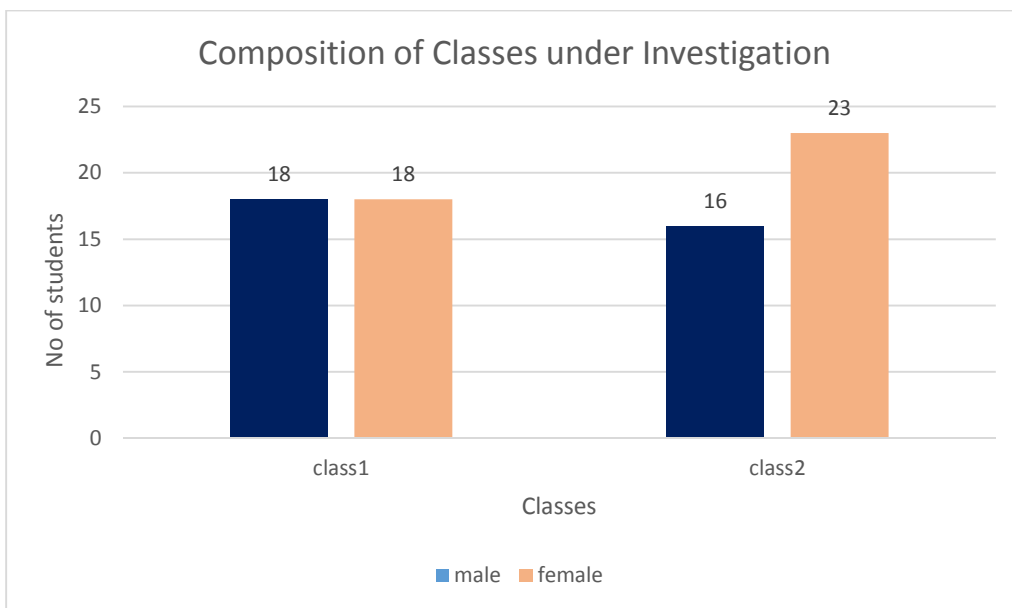


Figure 3.2. A bar graph comparing the composition of the two classes

The number of females to males of the Grade 10 population was compared to the sample numbers of females to males. The difference was less than 5%. This was a significant difference in the study as the sample chosen was almost identical to the composition of the Grade 10 population. The composition is summarised in the table (Table 3.2) below.

Table 3.2 Sample vs Population

	POPULATION	%	SAMPLE	%	DIFFERENCE IN %
FEMALES	124	56	41	54.6	2.4
MALES	97	44	34	45.4	1.4

3.6 Characteristics of participants

The participants of this research were selected from a school located in Athlone on the Cape Flats, formerly under the Department of Indian Affairs. This Department was then incorporated into the Western Cape Education Department following the 1994 democratic change of government in South Africa. This school was selected, as it was one of the Dinaledi schools the WCED included as its Moodle focus pilot schools. Most educators at this school were also trained by the Department in the Moodle entry-level courses to make the pilot a success. The composition of this school is about 98% Indians/Colored and 2% Africans. The Grade 10 stream has an enrollment of 221 learners separated into six classes. The gender composition of the whole grade as documented is shown in Table 3.3 below.

Table 3.3 Gender composition of Grade 10 learners at School under study

NUMBER OF LEARNERS ENROLLED		PERCENTAGE
FEMALES	124	56%
MALES	97	44%
TOTAL	221	100

Table 3.4 Class composition of Grade 10 learners by gender of all six classes

GENDER	CLASS1	CLASS2	CLASS3	CLASS4	CLASS5	CLASS6	TOTAL
FEMALE	18	23	10	22	28	23	124
MALE	18	16	26	15	9	13	97
TOTALPER CLASS	36	39	36	37	37	36	221

The school follows the new CAPS. Educators per subject and per grade discuss the content to be taught and a work schedule with dates are drawn up and used. However, teachers plan their lessons independently and use their own teaching aids. The researcher was the teacher of both classes, the experimental group and the control group. Issues of bias and the influence of the researcher will be discussed in the section on validity in section 3.10 and 3.11.

3.7 Data collection methods

3.7.1 Quantitative and qualitative study

Creswell (in Leedy & Ormrod, 2001) defines a quantitative study as an investigation into population by testing a variable measured with numbers and analysed using statistical procedures. Quantitative research becomes an advantage especially when the researcher is part of the investigation as the researcher's beliefs and values will not influence or contaminate the results produced (Girden *et al.*, 2011). A quantitative study was used because learners wrote tests and their marks were analysed. The main data collection method was extracted from quantitative methods from pre-tests and post-tests and other data sets were extracted from within the LMS tools. Data was obtained from the participants' tests, communication with the facilitator (researcher), and the surveys that the learners completed online.

A qualitative study is a study of understanding a variable, measured by words and views of participants (Creswell in Leedy & Ormrod, 2001). The learners completed online surveys to express their opinions on the teaching and learning method used.

3.7.2 Assessments

In section 3.2, the research design was explained as the non-equivalent group pre-test/-post-test design. In this research, all the participants were given assessments on Functions in Mathematics before the intervention (pre-test). After the intervention, all the participants were assessed. These assessments were different from the pre-test, but were set on the same topic of Functions. The differences in assessment performance between the two groups was noted. The effectiveness of the research was judged by monitoring the results during the pre-test results and post-test results.

3.7.3 Surveys

Research has proven that what is in the minds of the participants is also important. An online survey was designed to collect information on learners' understanding of the section of Functions in Mathematics. Technology has made it easier for researchers to make surveys available online to get the view of the people who are participating in the study. The main advantages of using online surveys is the time factor and convenience, (Evans, Evans & Mathur, 2005). Responses can be sent from anywhere at any time as

long as there is internet access. As soon as the respondents finish the survey, the results are available immediately for analysis. However, some researchers have argued that it lacks the *personal touch*, as some respondents need a skilled interviewer to get clarity of the questions, otherwise they do not participate in good faith (Evans *et al.*, 2005). The participants using Moodle already had a survey section and were able to complete the survey online. The survey questions are available in Appendix L.

3.7.4 Observations

McBurney and White (2007) defines observational research as a method of study where a researcher observes and records participants' ongoing behavior without changing what is being observing. According to Mcleod (2015), there are different types of observations: controlled observations, natural observations and participatory observations.

Controlled observations are structured and involves planning and is procedural. The researcher classifies the behaviour of participants systematically. The advantage of controlled observations is that they are reliable and the observation schedule can be used over again. The major drawback is that they can lack validity as they are easily affected by the Hawthorne¹ effect, as participants will know someone is watching their activities and may act differently.

Natural observations are unstructured observations that study unplanned behaviour of participants without being disturbed in their natural surroundings. The researcher notes whatever is happening in the scenario being observed.

Participant observations is where the researcher becomes indirectly involved with participants, to gather more information about the participants. This type of observation becomes a disadvantage as it may lead to bias.

In this research, the researcher used natural observations as he observed learners use computers without any influence, checking that the learners were fulfilling the objectives of the lesson. Learners in the Mathematics lessons were expected to develop understanding of concepts constructively, thus interacting with the LMS and their peers. The researcher also observed the group discussions that were done by the class that was using the traditional teaching method, checking the level of participation of members in

¹ Alteration of behaviour by subjects of a study due to their awareness of being observed

groups that were formed. In the Moodle group, however, there were less verbal discussions as most communication with peer, (if there was a need), was done through chat forums and messaging.

3.8 Data analysis and reporting

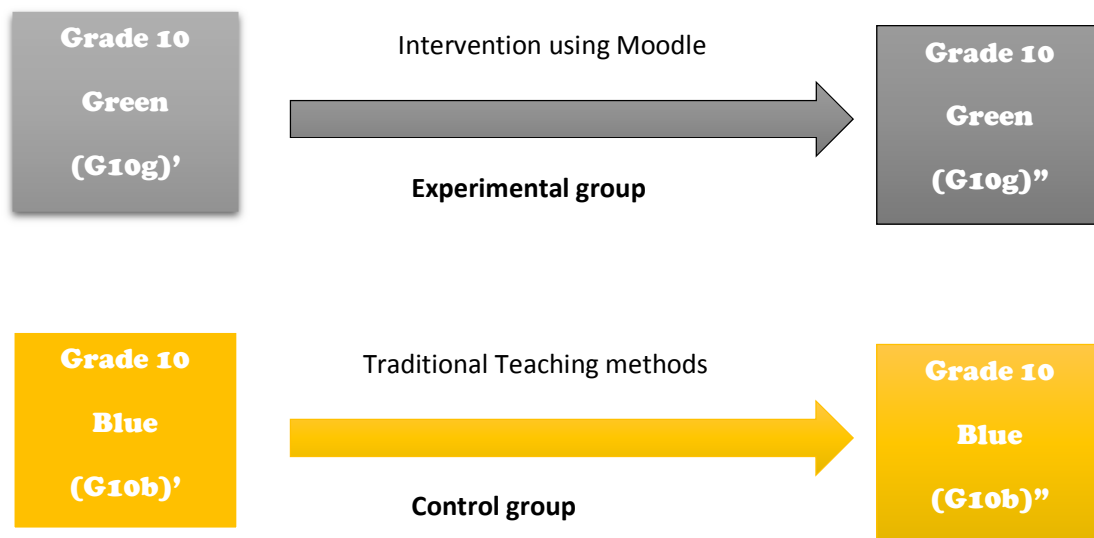
The data was collected using the following design:

3.8.1 The Non-equivalent Pre-Test/ Post-Test control design

This is a design that can be used to measure a change in the state of something mainly because of the impact or effectiveness of a programme (Kumar, 2011). This design evaluates the qualitative changes in the study population's level of understanding between two points, in order to understand fully the impact of the variable or intervention applied or investigated at the *before* and *after* points of observations. This design includes a control group that has identical features as the experimental group.

In this experimental design, just as in other quasi-experiments, groups were considered non-equivalent as groups were randomised (Cohen, Manion & Morrison, 2007). Non-equivalent groups mean that the learning in class may not be balanced equally among the control and experiment group. In addition, non-equivalent groups mean that participants' experiences during the study may differ. Some will fit in the experiment, while others will think otherwise.

The identical features include all learners being exposed to the CAPS curriculum and being exposed to the same assessment criteria. The other advantage is that the target population was also of the same socio-economic background. The only notable difference was subject combinations, which grouped them to a cluster of Sciences, Commercials and Arts subjects, with Mathematics being taken by the whole population. The two groups were given identical assessments and marks were equally evaluated and deviations and differences were analysed and compared before (Pre-test) and after the intervention, the same process of analysis was repeated (Post-test). The process is illustrated in Figure 3.3 below.



Where $G10g = G10g'' - G10g'$
Grade 10green = After – Before (of experiment)

$G10b = G10b'' - G10b'$
Grade 10blue = After – Before (of control)

Figure 3.3. Implementation of processes with the experimental and control groups

The difference between the *mean of the experiment* and the *mean control groups* was given by

$$Grade\ 10green - Grade\ 10blue$$

The mean differences were analysed using statistical analysis of the t-distribution and the analysis of variance, in order to establish the impact of the programme. The t-distribution was analysed with the software *QuickCalcs* (GraphPad n.d.). This was used to analyse the two classes that wrote the pre- test. The pre-test/ post-test allows researchers to analyse the differences that can exist between the two groups. Additional data was extracted from the Moodle surveys, class participation and the login patterns in Moodle. All these data sources were used to reach conclusion in this research.

3.8.2 The Analysis of Variance (ANOVA)

The two Grade 10 classes (samples) were drawn from the Grade 10 (population). These became independent as one sample did not influence the selection of individuals of the other sample (Peck, Olsen & Devore, 2012: 639). If the average mean of assessments are compared, a hypothesis can be developed that states:

H₀: $\mu_1 = \mu_2$ (Null Hypothesis that the two means are equal)

H₁: $\mu_1 \neq \mu_2$ (Alternative Hypothesis that the two means are different)

The decision between H₀ and H₁ was based on examining the two mean values to see whether the discrepancies were caused by the effect of the experiment or were they simply different because of sample variability (Peck, Olsen & Devore, 2012: 836).

If a sample variance is used to estimate the population standard variance, it then follows F-distribution, which is identified by degrees of freedom. The degrees of freedom are determined by subtracting the number of restrictions placed on the data from the number of scores (William, 2005:385). Variance measures how far a set of numbers is spread out. A variance of zero indicates that all the values are identical. Analysis of Variance (ANOVA), tests the null hypothesis that two or more population means being investigated are equal. If the ratios are calculated, it uses the F-distribution and two degrees of freedom.

To determine the F-ratio for one way ANOVA the numerator degrees of freedom is given by ***k-1*** where

k= number of sample means

The denominator is given by ***N-k*** and

N=number of scores in the analysis.

In this research, the number of learners in the classes were not equal because of the given sets of 75 learners were used, 36 from one class and 39 from the other learners in each classroom. No learner was to be moved to other classes because of the research. In this case, the degree of freedom of numerator will be one, one less than the number of

sample means therefore the denominator *degrees of freedom* will be will be 73, which is the number of learners minus the number of samples used.

If the F value is more than the critical value at 73 degrees of freedom, then it will be statistically significant to reject the null hypothesis and conclude that the mean values are different. If the F value is less than the critical value, then there would be no significant difference between using Moodle and the traditional method of teaching (Wiersma et al. 2005:387).

3.9 Triangulation

Triangulation was used to measure the validity of data in this research. This process is defined as the use of more than one method of data collection methods to prevent the vulnerability of using a single method approach. (Cohen, Manion & Morrison, 2007). This prevents a single view analysis of the human behaviour and eliminates the bias of a single method when conducting the research. Two types of triangulation were used in this research: methodological triangulation and data triangulation. Methodological triangulation was used where quantitative methods and researcher observation of learner activities or participation yielded data, and data triangulation was used where test scores, paper, and online surveys yielded data. This technique was employed to ensure the validity and credibility of the data captured.

3.10 Validity and reliability

The validity of the study is the confidence placed on the research that the results are purely attributable to the variable being measured. It is necessary to make sure that other confounding factors are minimized or eliminated in research so that they do not affect the results that could have been intended for the variable being investigated (Girden & Kabacoff, 2011). In quantitative research, the validity of the experiment is usually made from inferences made from test scores. Test scores might vary due to hidden factors, thereby compromising the validity of the experiment. (Creswell & Dana, 2000).

Critical friends and colleagues were asked to help the researcher explore their preferences for certain kinds of evidence, interpretations and explanations, consider alternatives and locate blind spots (Norris, 1997). Data in this study was monitored, and

evaluating instruments checked consistently for errors at certain intervals by third parties and supervisors who verified the authenticity of data collected.

Previous studies claimed that certain factors influence variables under investigation. In this research, the researcher made the following adjustments in an effort to minimize the influences:

History. Most pre-test and post-test research are affected by history that could have affected the participants before the research. However, in this research, all the learners were in different Grade 9 classes and exposed to the same assessments. Moreover, the topic of Functions used in the investigation was new and done only in Grade 10.

Selection strategy. According to (Kumar, 2011) selection strategy is the way in which the learners are selected from the population. The selection of the two groups was fair from the Grade 10 population, as it comprised participants of the same age group. It was virtually impossible to use the entire Grade 10 population. The two classes were of mixed gender and assessed using the same materials.

3.11 Ethical considerations

In any research activity, both the participant and the researcher must be protected from unethical issues. It is the researcher's responsibility to consider the rights of the participants who are taking part in this research. This is cemented by Pillay (2014) who reiterates that the right of the children being subjected to a research must be protected throughout the research process. The learners who participated in this research were protected against the following ethical issues based on data collection, consent, maintaining confidentiality, bias and deprivation of treatment.

3.11.1 Data collection issues

According to Kumar (2011), participants should know the reason why they are giving information or the reason why they are completing a survey. The researcher must explain the relevance of the information being collected and the usefulness of the research.

Learners were told about the objectives of the research and the importance of data that was collected. This discussion was expected to give the participants who were to take part a positive attitude towards the research. The overview of the project and how data

was to be collected was explained to the learners. They were encouraged to complete all necessary information anonymously, as the results were to be used at the end of the research as feedback. The learners were also notified that their marks and views were to be collected and used on research, without using their real names.

3.11.2 Consent

Information collected without the knowledge of the participant is regarded as unethical. The researcher sought consent from the parents as the participants were under the age of 18. The learners were informed of how the research was to be conducted and how it would directly or indirectly affect them. The consent letter (Appendix H) was given to the learners for parental consent. The WCED also gave the researcher consent (Appendix G) to conduct the study at school. The Department emphasized that research was not to be conducted during the 4th term as the schools were preparing for examinations.

To use the laboratories and other school equipment, permission was granted from the principal of the school. Timelines of the projects were submitted to the Mathematics Head of Department. This was to assure the management of the school of content coverage, notwithstanding that the research was to be covered as per the school term planning.

3.11.3 Maintaining confidentiality

The participants were not identifiable in the reporting of this research as coding was used for both classes. For the purpose of analysis, the learners were labelled according to the classes they were in (for example, class 10BLUE). The information provided by them was to be attached to individual participants and the performance of the participant was used only to analyse group performance. The protection of data that was collected is very important. It is the responsibility of the researcher to assure participants that the information will in no way be used to embarrass, harm feelings of the participants after the data has been collected.

3.11.4 Bias

Bias is when a researcher attempts to deliberately hide the results of the study or highlight something not true based on the research (Kumar, 2011). Researchers should be able to

control bias in such a way that participants' real results are the ones that are analysed. The possible bias that could have emerged in this study was that content coverage may have been compromised. To counter this possible bias, the researcher ensured that, even though different teaching methods were used, the content coverage of Functions was done equally with both classes. Although the researcher was also the teacher delivering the lesson in both classes, there was no willful bias given to one as opposed to the other. The only difference was the intervention with Moodle used in the experimental group and traditional teaching used with the control group.

3.11.5 Provision or deprivation of treatment

In this research, there were two groups, one experimental group, that received treatment and the other was a control. Provision or deprivation occurs when one group gains favour or become disadvantaged by the investigation involved. When a research is in progress, syllabus coverage continues, and there is fear that it might affect the participants.

However as a researcher, these ethical issues are known and previous authors have argued that deprivation of a trial treatment group is not unethical as the effectiveness was not yet known (Kumar, 2011). To counter any issues such as any unbalanced learning between the two groups, or evidence of deprivation, then the researcher will do remedial lessons to the affected class. The researcher had measures in place that were to be used as remedial tools to cater for participants who may feel they were disadvantaged by the project.

3.12 Moodle LMS

The Learning Management System used in this research is Moodle. The LMS was chosen because it is free for schools and administered by the WCED. The maintenance was not a burden to the schools that used it. The main role of the LMS is to safely keep and track records of learners that are registered. The second role is to make continuous communication between the learner and the instructor easier. Most importantly, it has online forums that are imbedded within the LMS to facilitate collaboration between learners, enabling them to work together, thereby acquiring and sharing knowledge independently from the educator (Psycharis & Kalogiannakis, 2013). Teachers of all pilot

schools were trained and became competent Moodle 1² users and were able to use the tools of the LMS.

3.12.1 Implementing Moodle

The researcher, with the assistance of the school ICT department administrator, prepared the laboratories and computers to be used for this research.



Figure 3.4. The view of the laboratory used for Moodle lessons

The laboratory shown above in Figure 3.4 comprised 40 internet connected computers, which were accessed during working hours from 8am to 5pm Monday to Saturday. The laboratory was prepared in such a way that the learners would use the laboratory whenever they are free. For research purposes, the learners who were using Moodle were given passwords to access the program as most learners used the laboratory for other purposes. The passwords also made sure there was no contamination of data by unauthorized users.

3.12.2 Deploying the Moodle system

The school that was being studied was registered by the WCED, and learning content was designed according to the specification of the system. The researcher was registered

² Moodle 1 is basic navigation of the LMS and the uploading of content

as Moodle administrator and facilitator with the help of the WCED to be able to enroll learners and administer the space, which the school was allocated to use and conduct the research.

The researcher also tested and uploaded some electronic files, online videos and files called Sharable Content Object Reference Models (SCORM) packages and had to test tools such as messaging, chats and forums, so that learners would not have problems when using them.

3.12.3 Piloting the Moodle platform

Learners' profiles were created and tested to establish problems or any other underlying issues when using the LMS. The researcher and WCED administrators enrolled as *learners* to test the system for about two weeks to make sure it ran smoothly. A summary of issues below was discussed before the actual research was implemented:

- Clear instructions on what to do with the videos.
- A learner manual that learners were expected to use, to familiarise themselves or serve as a quick guide for them whenever using the system.
- Unlimited internet usage and unlimited access to computer labs was granted.
- The fonts and display size of some materials had to be improved.

The issues that were expected to give problems to the learners were then rectified during this pilot phase and the system was considered ready for implementation.

3.12.4 Information sessions

The two classes were briefed separately on the intentions of this research. The class using traditional methods was told about the importance of submitting the assessments. The class exposed to the experiment was given instructions on the overview of Moodle and how it was to be implemented. To avoid contamination, the learners were not told that their results will be compared to other classes. Care was taken to treat both classes as normal as possible. The information sessions were well received by learners as most of the question they had, were answered by the researcher.

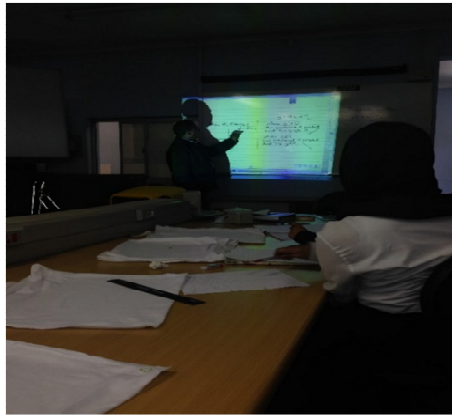


Figure 3.5. Information session in progress. The educator giving instructions

The figure 3.5 above shows the educator giving instructions on how the project was to be conducted. Issues of ethical consideration were discussed.

3.12.5 ICT skills of educators at focus

The Western Cape Education department and other stakeholders rolled out several workshops to its educators so that they become empowered to use ICT. School records and certificates indicate that educators did a course to upskill their ICT usage. The common course for all educators in recent years was the Microsoft Partnership in Learning (MsPil) ICT skills for educators. The aim was empowering all educators in the region with basic skills to use ICT in classes (WCED – MsPil n.d.). The system uses Moodle as a platform for learning, which is the same as the LMS under investigation in this study.

The educators of the school recently developed an interest in technology as they have been attending various ICT workshops on how to blend their teaching with the use of computers.

3.13 An overview of the current classroom

Observations in current classes show the forty learners sitting, textbook in front of them and listen to the teacher explain concepts. Some learners do not have the textbook given to them and are sharing with friends. This is because the book is voluminous so they have excuses for not carrying it. Others keep the books at school for convenience. Occasionally some learners lose focus and can become disruptive by speaking among themselves while the teacher attempts to draw imperfect diagrams on the board. The

researcher noted that only some learners were seen asking questions while others continued with their conversations.

3.14 Computer basics lesson

The initial stage was to ascertain if learners had basic computer skills before the implementation of Moodle. Learners were given a 2 period Windows 7 and Moodle basics lesson for them to be able to use the computer and Moodle program. The researcher used the checklist in Appendix E.

3.15 Tools for teaching and learning in Moodle

Moodle is a platform that enables educators to upload content, which they use to teach. This content is dependent on the grade, ability of learners and the work schedule that educators would have discussed during the beginning of the year. The content, however needs to be created or sourced before it is uploaded into the LMS. The following computer software were used to develop teaching material for both educators and learners. The software used was freeware, namely *Hot Potatoes*, *Geogebra*, *Screen-casting* and *Multiple Choice Quiz Maker*. These applications enabled the educator to build in content that was used by learners to learn independently using Moodle.

3.15.1 Use of Hot Potatoes

The Hot Potatoes software (n.d.) has six applications, enabling one to create multiple choice, short answer, jumbled sentence, crossword and gap filling exercises using the internet. These questions are then exported as a SCORM object from Java Hot Potatoes to Moodle.

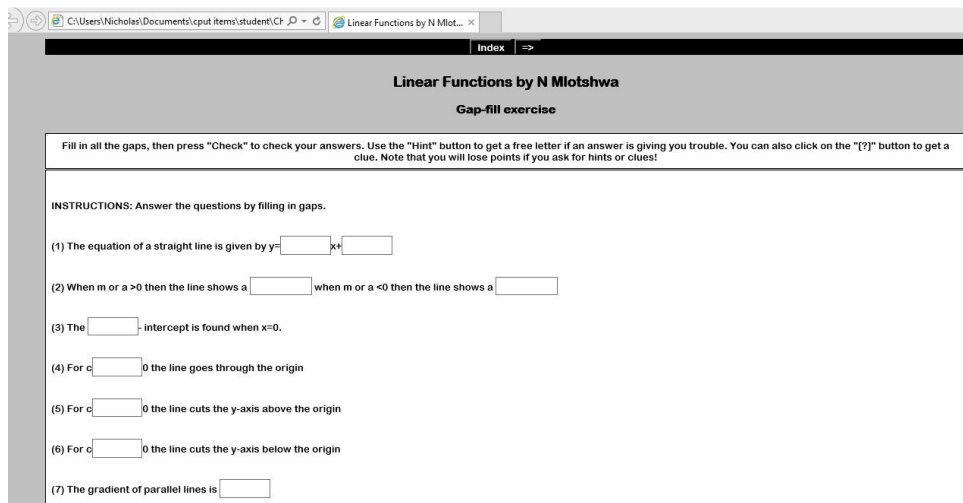


Figure 3.6. An example of an exercise created by using JCloze, Hot Potatoes

Figure 3.6 above shows an exercise with blank spaces. A learner was expected to fill in the blank spaces and the results are immediately available to the learner. Hot Potatoes enabled the researcher to design exercises that were used by the learners to practice concepts that were taught in class. The results ranked learners according to performance, motivating themselves to do better. The exercises were informal for practice, containing hints if the user is stuck.

3.15.2 Use of Screen-casting

Screen-casting is a teaching tool, which allows one to record as well as share as a video, the computer screen accompanied by the person's voice over in the background. The person is seen clicking and explaining on the screen (Screencast-o-Matic n.d.). The researcher created video content using the CAPS document to allow learners to understand concepts. PowerPoint slides were used and converted to videos with the researcher's voice-over. These videos were uploaded in series in the Moodle platform to allow the learners to view, pause, and rewind the videos during and after the lessons. The videos assisted learners to recap lessons and concepts at their own pace.

3.15.3 Use of Geogebra

Geogebra (n.d.) is an interactive geometry software, which allows the user to enter equations directly and draw accurate graphs and diagrams (Hohenwarter & Fuchs 2005).

The researcher created a link to Geogebra directly from the Moodle space, which enabled learners to draw Functions and practice for examination purposes. Both the educator and learners could use Geogebra during the lesson, drawing accurate graphs at ease.

3.15.4 Use of Multiple Choice Quiz Maker (MCQM)

Another tool used to create multiple-choice questions was the MCQM program. This program created multiple questions used by learners for practicing. This was another alternative colorful multiple-choice maker. Learners used the multiple choice questions created for informal practice, preparing for the tests that were to be written on this topic. The researcher used the multiple-choice marks (as shown in Figure 3.7) to identify problematic sections on the Functions topic.

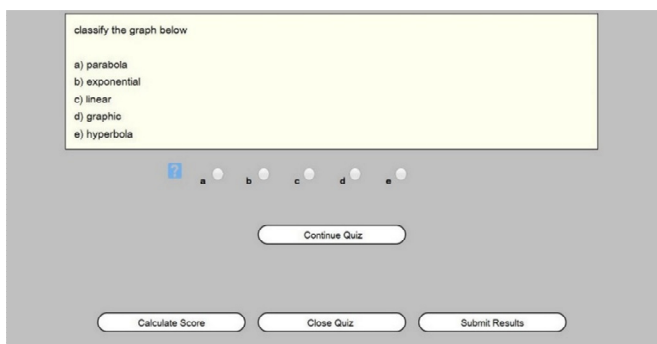


Figure 3.7. Creation of multiple choice questions using MCQM

3.16 Accessing the Moodle platform

The administrators from Western Cape Department and the researcher created learner profiles and generated passwords for learners to keep track of who accesses the system. To assist learners with a simple way to remember their passwords, the following format was used:

rhs_dateofbirth_studentinitials

Example

NAME	SURNAME	DATE OF BIRTH	PASSWORD
John	Smith	10 February 1967	rhs100267js

3.16.1 The front page

The initial page is accessed as shown in Figure 3.8 using the website link provided by the WCED <http://testing.wcape.school.za/elearn/>

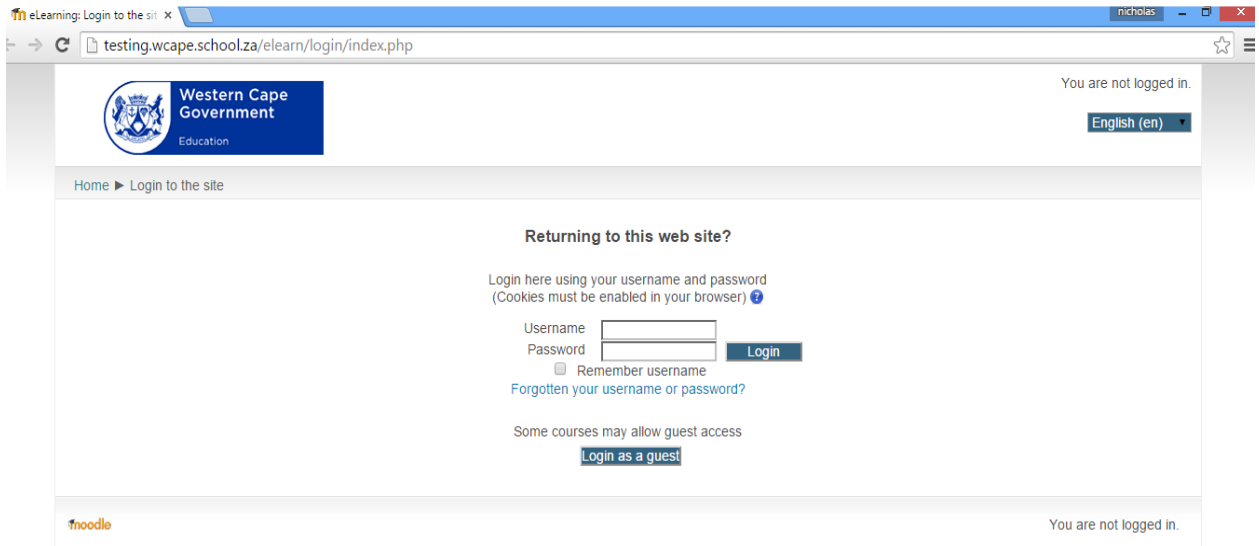


Figure 3.8. The home page for Western Cape Moodle

This section allows you to log on to Moodle to access the courses. Figure 3.9 shows the initial page after log in. When logged in, then the courses registered by the user are listed on the left.

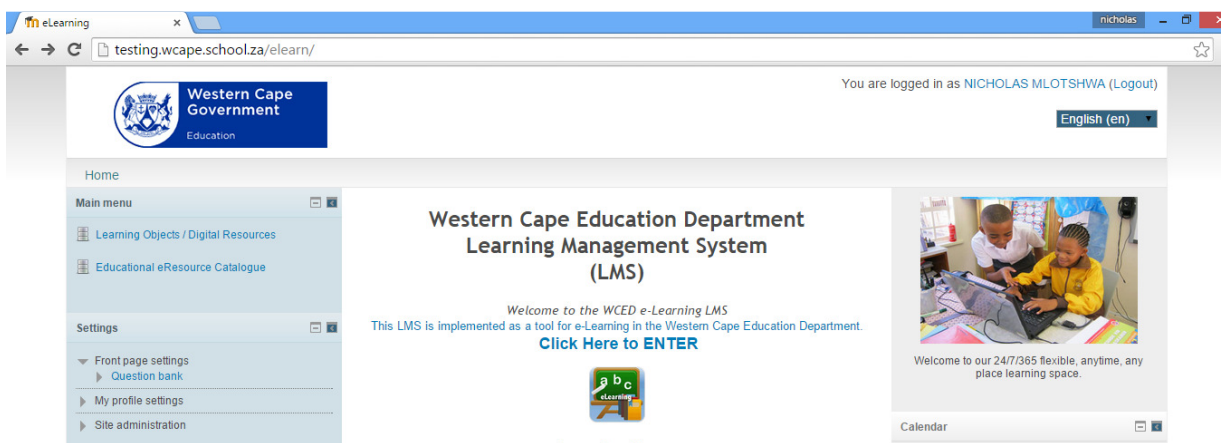


Figure 3.9. After login to Moodle Western Cape

Each teacher develops courses, (subjects that are offered at school). Then teachers add content as per their preferences guided by the CAPS requirement.

The standard Moodle LMS has activities, which facilitates interaction between the teacher, learner and its peers. Table 3.5 below summarises some of the useful tools available to be used for teaching and learning processes.

Table 3.5. Tools for teaching and learning found in Moodle

Tool	Role in teaching and learning
Assignments	Teachers and facilitators upload assignments questions, learners upload them back, and then teachers grade them and give comments to the learners.
Chats	Learners have real time conversations among themselves, discussing issues or raising queries.
Database	Stores records of what has been done in the course.
Feedback	This tool is used to create and conduct surveys and collect feedback on a particular section of the topic.
Forum	This platform allows participants to have discussions asynchronously – whenever they are able to
Lesson	This is where the lessons are, according to the CAPS document. The lessons are sorted according to the instructor's references.
Quiz	The educator designs and sets quiz tests, which are automatically marked, and feedback and answers shown to participants.
SCORM	SCORM (Sharable Content Object Reference Model) package is online materials that can be shared across all LMS systems. This makes it easier to upload lessons that can also be used anywhere online
Survey	This platform is for gathering data from learners so that instructors can learn about the quality of their teaching.
Wiki	This is a webpage that allows participants to add or edit information in a single document

After accessing the Western Cape Moodle LMS, learners logged onto the LMS, using the flow-chart shown on Figure 3.10 below to view the content of Functions.

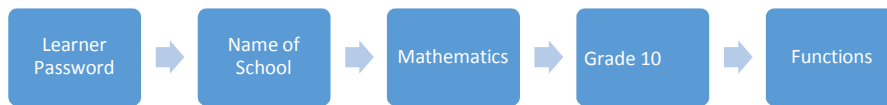


Figure 3.10. Flow Chart showing the path a learner follows when accessing Moodle lessons

Figure 3.11 below shows the area where learners were asked to view.

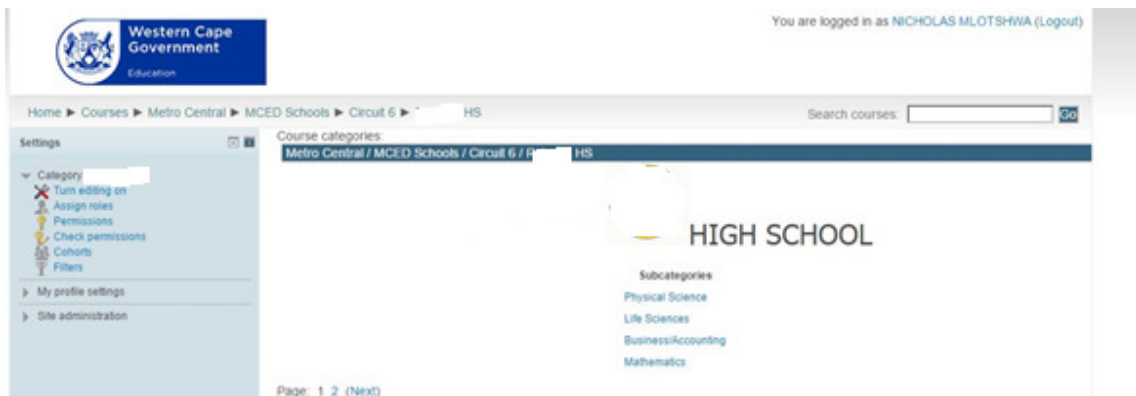


Figure 3.11. The front of Moodle space allocated to the school by WCED

Figure 3.11 shows the space allocated to the focus school by WCED. When they clicked *Mathematics*, they were taken to the following page:

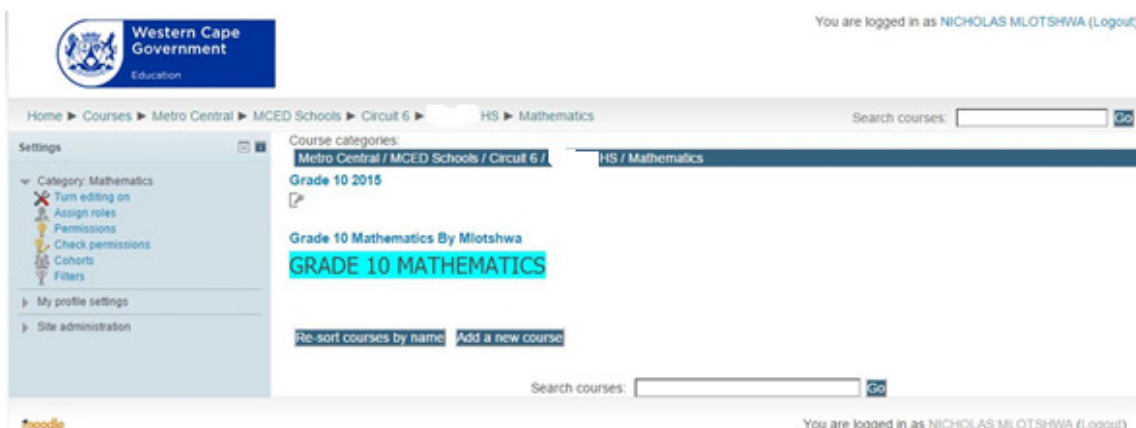


Figure 3.12. The view of subject Mathematics space when school space is clicked.

From the above page, learners chose the “Grade 10” section.

3.16.2 Educator Space

The educators then create a space, which is viewed by the registered learners in the class. This space has a sequence of content that the learners view in chunks (depending on the time the educator makes it available). All the course instructions and educator updates are available in this space. This is where the educator put lesson plans for learners using this LMS. Once logged on, the learner finds instructions of the content they were expected to complete for that section. This was equivalent to lesson plans that were in paper form in the traditional learning group. Figure 3.13 below shows a small section of the Grade 10 space that was created by the researcher for the participants.

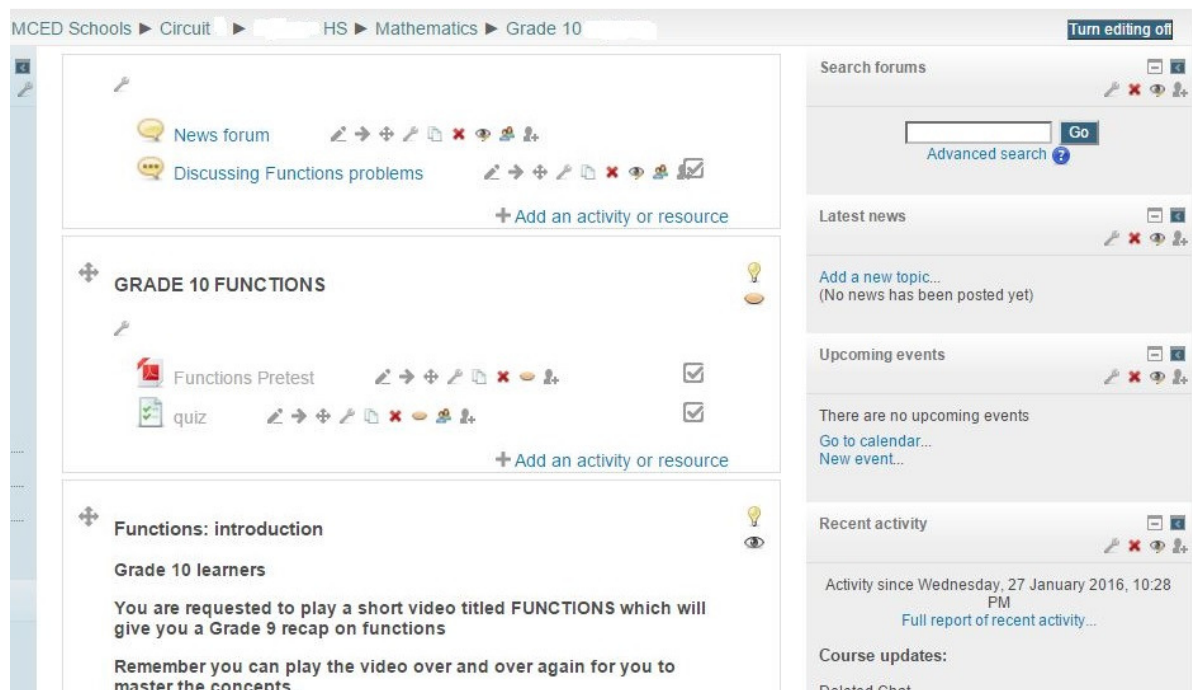


Figure 3.13. The view of Grade 10 space when the subject space is clicked

3.17 The learning process stage

Learners were given the CAPS outline and the topics needed to be covered at Grade 10. They are as follows:

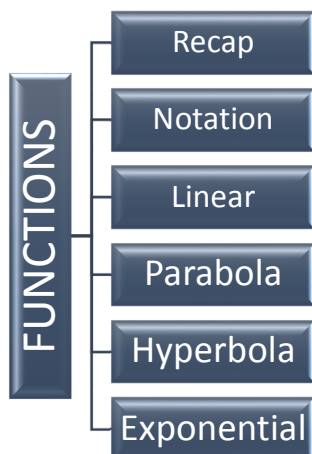


Figure 3.14. The subtopics of Functions in Grade 10 as stipulated by CAPS

Figure 3.14 above shows that learners were expected to identify, draw and interpret graphs of Functions namely the linear, parabola, hyperbola and the exponential graphs.

Learners used common tools such as messaging and chat rooms, to gather more information from peers and the educator. The teacher monitored how frequently learners used the learning platform, during and after the allocated lesson time.

3.18 Limitations of LMS usage

It must be highlighted that the use of LMS is dependent on the ability of users to navigate through it. The instructor must have basic computer knowledge that will enable him to use applications to upload resources and transfer instructions to the computers for learners. LMSs are also dependent on the connectivity of the internet as this is an online platform (Coates, James & Baldwin, 2005).

In the Western Cape, South Africa, some communities have been allocated uncapped internet and Wi-Fi routers for easy access to the internet at schools. Slow internet might frustrate both learners and the instructor, compromising the main goal of e-Learning.

This study was based in an environment that attended to the following assumptions and conditions:

- That computers are in good working condition and use the latest software (Windows 7 or better) (Dvorak, 2011);
- There is good, high-speed internet connection, which is not subject to interruptions;
- The instructor has proper computer training – a primary condition that allows for the development of properly designed LMS based lessons/modules.
- Learners have basic computer knowledge – which ensures that end-user activity optimizes the available technology by creating properly functional constructivist and collaborative learning environments.

3.19 Teaching the Traditional classroom

The lessons of the control classroom were done using the standard lesson plan illustrated in Table 3.6 below:

Table 3.6 Grade 10 Lesson plan template for traditional classroom

Topic	Functions
Teacher/Learner Activities	
Teaching Methods	Telling , Explaining ; Question and Answer , Illustrations
Lesson Development: Introduction (10 minutes)	<ul style="list-style-type: none"> • Check homework • Mark homework, giving corrections • Oral questions to unpack the knowledge
Main Body: Lesson Presentation (25 minutes)	<ul style="list-style-type: none"> • Breaking down concepts into small parts • Draw graphs on board • Learners draw some graphs in their exercise books • Learners ask questions • If time allows learners discuss in pairs or group
Conclusion (10 minutes)	<ul style="list-style-type: none"> • Revise key elements of the lesson • Give homework

The lesson plan above was followed constantly, slightly adjusted when there was a quiz or small test. The specific objectives of the topic of Functions, as outlined by the CAPS document, are listed as follows:

- Work with relationships between variables in terms of numerical, graphical, verbal and symbolic representation of functions.
- Generate as many graphs as necessary, usually by point-by-point plotting supported by available technology.
- Generalize the effect of the parameter, which results in a vertical shift or reflection about the x-axis.
- Problem solving involving the prescribed functions.

(An extract from Grade 10 CAPS Document Grade 10 Functions- Education, 2004).

The duration of the teaching and learning of Functions was done in two weeks, and the learners were assessed when both groups had completed the section.

3.20 Summary

In this chapter, the research design was outlined and discussed, and data collection methods to be used in the study were presented. Non-equivalent pre-test /post-test design used for this research was explained. Issues of confidentiality were explained and the relevant participants properly informed. The aims of this research was to investigate the effect of LMSs on Mathematics learners' understanding of Functions in Mathematics as compared to the traditional ways of teaching. In the next chapter, the analyses and interpretation of the data collected is discussed.

CHAPTER FOUR: FINDINGS AND DISCUSSION

4.1 Introduction

In chapter three, the research design of this study was discussed. The research methodology, sampling and data collection and analysis were explained. The research question of this study was to investigate the effectiveness of a Moodle LMS in improving learner performance on the topic of Functions in Mathematics.

The focus of the study was to specifically monitor the performance of a learner's independently building knowledge using the tools of LMS. The educator becomes the facilitator and the learners are guided by the contents available in the Moodle LMS. They are then evaluated to gauge their understanding.

In the study, the experimental group engaged with content through the Moodle LMS and the control group through traditional means. The results of tests were monitored in both groups and compared.

The research question that guided this research was:

What is the effect of introducing Moodle in a constructivist pedagogical approach in learning Mathematics?

The sub-questions of the research were:

- i. In what ways can Moodle be used to enhance the learning of functions in Mathematics?
- ii. How can the tools of Moodle be used to make learning of functions easier?

This chapter is organised into subsections as follows:

4.2 Presentation of the results from the pre-tests

4.3 Discussion of the Pre-test results

4.4 Discusses how the control class was taught using the traditional way

4.5 Presentation of results collected from Moodle tools.

4.6 Discussion of the communication tools used

4.7 Analyses the results from the online survey

4.8 -4.10 Presentation of results collected from both the Moodle class and the traditional class.

4.11 Summary of the chapter is presented

In this chapter, the findings of the two teaching strategies used in this research are presented. To contextualize the Moodle findings, a brief overview of a traditional lesson and classroom is presented below:

Grade 10 educators, with a vast experience of an average of 20 years, were following the traditional teaching methods. Educators delivered the lessons to the learners according to the requirements of the curriculum. The learners became the receiver of knowledge and teachers wrote Mathematics questions on the chalkboard or whiteboards, with all the calculations presented in front of the learners. Learners in turn copied examples from the board, took notes and attempted questions in their workbooks. The educator then marks approximately 35 learners' work during the period to check if they are solving the problems correctly.

Learners bring their Mathematics textbooks every day and have to take the books home for their homework. Sometimes the teacher re-explains a concept if learners are struggling. Those who understand the concept have to be patient as the teacher is the only source of information. Teachers expressed a concern of how to help some learners who lag behind or learners who were absent as they miss most of the content taught. This is because during a 40-minute lesson, the time is short and it becomes difficult for teachers to repeat the concept that is being taught repeatedly. Teachers have to organise afternoon classes to help those who require extra attention and more understanding.

4.2 Results of pre-test

A pre-test was administered to the control and experimental groups to assess their level of understanding of Functions in Mathematics. Both groups were given the same typed

paper and were all instructed to use the spaces provided to write down the answers. Previous knowledge was expected to assist learners, as they were not taught the Grade 10 concepts yet.

The screen capture below shows a sample of the script of a learner who sat for the pre-test. The sample test paper is in Appendix A.

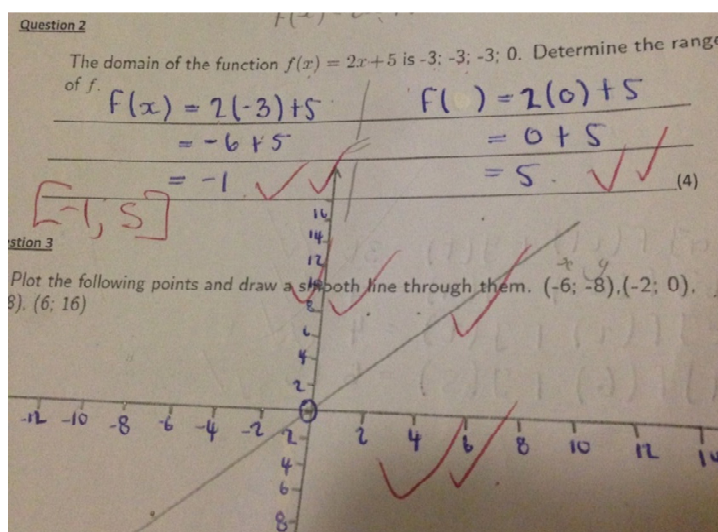


Figure 4.1. Screen capture of the pre-test marked script (from both groups)

The pre-test was marked out of 30 with the pass mark being 50%. 15 out of 36 learners in class Blue passed the test, while 17 out of 39 learners in class Green passed the test. The results of the two groups were analysed using the T-distribution to compare group average to determine whether there was any significant difference between these two classes.

The groups' marks are shown below:

Table 4.1 showing the statistics from results of the pre-test between two classes, The Traditional Class was the Control class

CLASS BLUE (Control)

CLASS GREEN (Moodle)

	MEAN		13,94444
	PASS		15
	FAIL		21
	Pass Rate		41,66667
	VARIANCE		26,99691
	STANDARD DEV		5,195855

	MEAN		14,71795
	PASS		17
	FAIL		22
	Pass Rate		43,58974
	VARIANCE		27,89481
	STANDARD DEV		5,281553

4.3 Discussion of pre-test results

Although all educators in the grade used the pre-test, the analysis of variance was conducted in only the control and experimental groups. The main hypothesis was:

H₀: $\mu_1 = \mu_2$ (Null hypothesis that the two class means are equal)

H₁: $\mu_1 \neq \mu_2$ (Alternative hypothesis that the two class means are different)

The results are shown in the Figure 4.2 below. Group one below is the data analysis from traditional type of teaching of the control group and Group two is data from the Moodle type of teaching.

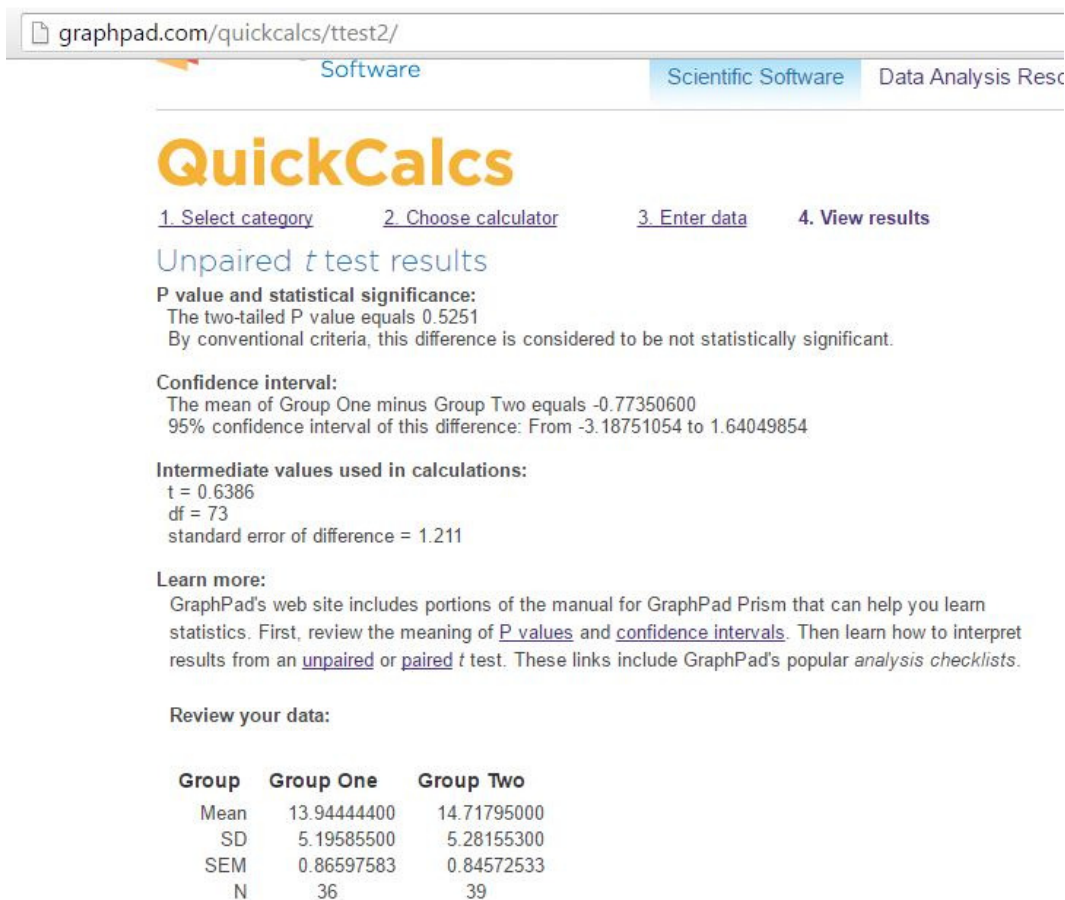


Figure 4.2. Statistical analysis comparing the two means of the two classes during the pre-test

The researcher used an online program, QuickCalcs (n.d.) to analyse the two classes that wrote the pre-test. From the information, group One ([Mean 13.944444 Class Blue](#)) and Group Two ([Mean 14.71795 Class Green](#)), the probability value (*P-value*) is greater than the significance level of 0.01 or 0.05, and we can safely state that the difference between the two means is not statistically significant to conclude that the means are different. Statistically we therefore fail to reject the hypothesis (Triola, 2001:389). This is possibly because the two classes were coming from a population in Grade 9. Their content knowledge of Functions at the beginning of this study was at the same level. Generally, one can see that the learners performed relatively low in both classes, their knowledge of the content was evidently weak.

4.4 Teaching the control (traditional) group

The researcher taught the learners as before the commencement of the research with the standard lesson plan and the following issues were noted:

Lesson time. Lessons were 40 minutes long with one double period (80 minutes) per cycle. Learners were able to do group discussions. However, as time is so limited that they seldom finished the task given, group discussion and interaction with the educator were minimal.

Groupwork. Learners were allocated groups to make sure that some of the questions are answered with peers; some groups worked very well, especially the ones with learners who were used to each other. Learners with different learning abilities, who made it difficult to interact, affected the other groups. Most groups were disturbed, and there was hardly any learning-taking place.

Learning Materials. During the period of research, the school was using *Classroom Mathematics Grade 10 Learner's Book* as the primary reference book. The educator was the source of knowledge, as there were no other references to access during the lesson. The educator sometimes made copies of some sections from other sources to assist struggling learners or for enrichment.

4.5 Data collected from Moodle tools

The data was gathered from various tools of Moodle and assessments that were created from applications embedded within Moodle.

4.5.1 The effect of using Hot Potatoes

The learners, after studying the content, were able to do the exercise by completing blank spaces. The advantage of this Hot Potatoes tool was that, after completing the exercise, the results were immediately available to the learner. This meant that time was saved, as the learner who previously had to wait for their work to be manually marked by the educator, could see the results immediately, as shown in the Figure 4.3 below.

INSTRUCTIONS: Answer the questions by filling in gaps.

(1) The equation of a straight line is given by $y=mx+c$.

(2) When m or $c > 0$ then the line shows a when m or $c < 0$ then the line shows a

(3) The -intercept is found when $x=0$.

(4) For c 0 the line goes through the origin

Your score is 20%.
Some of your answers are incorrect. Incorrect answers have been left in place for you to change.

OK

Figure 4.3. Learners type in the answers in blank spaces shown above

Figure 4.4 below shows the hint for a function that added one letter at a time until the learners completes the answer on their own. These guidelines are impossible to provide during the traditional method, as learners have to await their turn to get hints from the educator. Another tool that was used in Hot Potatoes was Match. This application allowed questions or objects to be correctly matched. On the example below, learners were asked to match the graphs with the correct name.

INSTRUCTIONS: Answer the questions by filling in gaps.

(1) The equation of a straight line is given by $y=mx+c$.

(2) When m or $c > 0$ then the line shows a when m or $c < 0$ then the line shows a

(3) The -intercept is found when $x=0$.

(4) For c 0 the line goes through the origin

(5) For c 0 the line cuts the y -axis above the origin

(6) For c 0 the line cuts the y -axis below the origin

(7) The gradient of parallel lines is

(8) The product of gradient of perpendicular lines is equal to

By N Mlotshwa

The next correct letter has been added to the answer.

OK

Figure 414.4. A learner, struggling along the exercise, is given a hint when they click the hint button

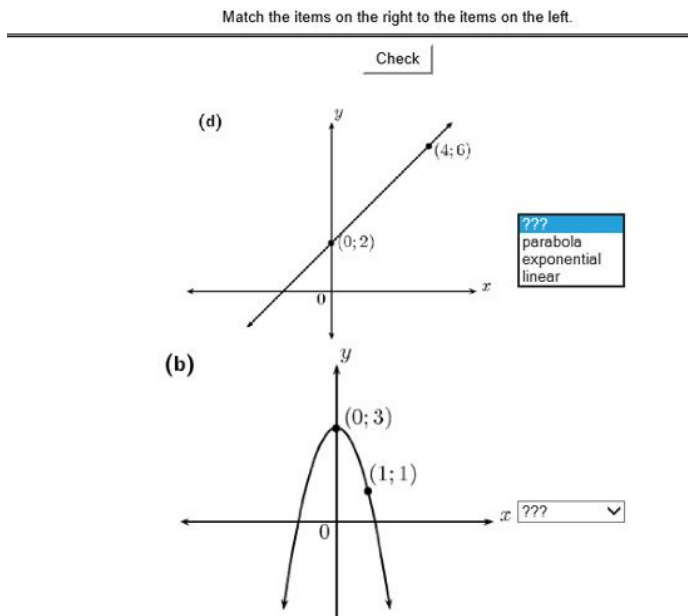


Figure 4.5. An exercise showing matching exercise with drop down selections for learners

The correct answers were selected from a drop down menu and the results are instantly published as below. If a wrong choice was made, an indication of the correct answer became available.

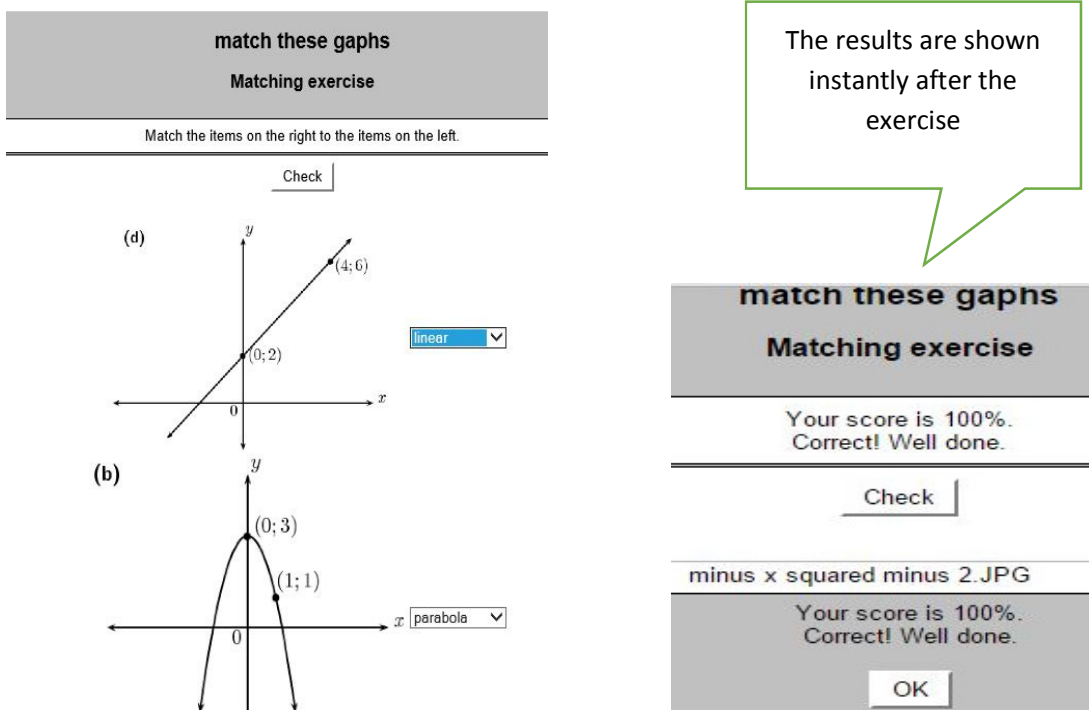


Figure 4.6. Results are shown as soon as the learner finishes the exercise

The data collected in this section is shown on the first column (*Quiz: Sketching Methods Linear functions*) in Figure 4.7 below.

The screenshot shows a Moodle LMS interface for exporting quiz results to an Excel spreadsheet. The breadcrumb trail is: Home > My courses > Metro Central > MCED Schools > Circuit 6 > Rylands HS > Mathematics > Grade 10 Rylands > Grade administration > Export > Excel spreadsheet. The left sidebar contains a 'Settings' menu with options like 'Grade administration', 'Import', 'Export', and 'Add a block'. The main content area is titled 'Export to Excel spreadsheet' and features a 'Download' button. Below this is a 'Preview rows' section with a table of quiz results. A large text overlay reads 'names were removed for research purposes'. The table has the following columns: First name, Surname, ID number, Institution, Department, Email address, Quiz: quiz, Quiz: quiz, Quiz: Sketching Methods : Linear functions, Quiz: Equations of Graphs Test, Quiz: Equation of a line given 2 points, Quiz: Linear functions, Quiz: Linear functions, and Quiz: Sketching Methods : Linear functions. The 'Email address' column contains the text 'names were removed for research purposes'. The 'Quiz: Sketching Methods : Linear functions' column contains numerical scores. A 'Customize...' button is highlighted in the bottom right corner.

First name	Surname	ID number	Institution	Department	Email address	Quiz: quiz	Quiz: quiz	Quiz: Sketching Methods : Linear functions	Quiz: Equations of Graphs Test	Quiz: Equation of a line given 2 points	Quiz: Linear functions	Quiz: Linear functions	Quiz: Sketching Methods : Linear functions
					names were removed for research purposes	-	-	83.33	92.31	80.00	88.89	-	-
					names were removed for research purposes	-	-	83.33	92.31	-	77.78	-	-
					names were removed for research purposes	-	-	83.33	-	-	88.89	-	-
					names were removed for research purposes	-	-	83.33	69.23	-	88.89	-	-
					names were removed for research purposes	-	-	100.00	100.00	-	100.00	-	-
					names were removed for research purposes	-	-	83.33	92.31	-	100.00	-	-
					names were removed for research purposes	-	-	83.33	76.92	-	77.78	-	-
					names were removed for research purposes	-	-	66.67	84.62	-	100.00	-	-
					names were removed for research purposes	-	-	83.33	84.62	-	100.00	-	-
					names were removed for research purposes	-	-	66.67	-	-	88.89	-	-

Figure 4.7. Showing Quiz results (First column)

Figure 4.7 shows marks that were produced immediately as the learners completed the quiz.

4.5.2 The effect of screen-casting

Traditionally, lesson times are fixed, usually 40 minutes long. However, in a class with different learning abilities, the restless ones tend to miss most concepts during class time. Screen-casting videos were broken down into small sections “chunks” so that the learners would assimilate the content slowly. These videos were watched to understand concepts any time that they find suitable. The lesson was able to continue even during the absence of the educator, as learners were observed playing the videos even after the lessons for understanding. The classes with no videos relied on the presence of the teacher, making it difficult for the “quiet or reserved” learners to ask for clarification. The screen capture below shows the view when a learner clicks on the videos on Moodle.

testing.wcape.school.za/elearn/pluginfile.php/29546/mod_resource/content/2/M101

DEFINITION OF A FUNCTION

- A relationship between two variables where every input has one output variable
- **GRADE 9 RECAP**
Find the output given the following values

$y = 2x + 3$ $y = x^2$

input	Output
-3	
-2	
0	
2	

Introduction
Feedback in good faith
m 17 August 2014 to 29 August 2014.'

Introduction
Feedback in good faith
m 17 August 2014 to 29 August 2014.'

Introduction
Feedback in good faith
m 17 August 2014 to 29 August 2014.'

Feedback to Functions introduction
Please complete the Feedback in good faith
Restricted: 'Available from 17 August 2014 to 29 August 2014.'

Intro to Functions

Figure 4.8. When the link of the video is clicked, a video screen pops out as shown for learners to view, pause, fast-forward and rewind

A Video pops up on the top left of the screen and plays immediately. This video can be repeated as many times as the learner seeks to understand the concept.

4.5.3 Effect of using Geogebra program

The researcher created a link of Geogebra, which enabled learners to draw functions and practice for examination purposes. The learners were able to replicate diagrams accurately, made it easier to understand. The graph below was drawn using Geogebra compared to one that was drawn using free hand. The one drawn by Geogebra clearly shows the intercept of the graphs, whereas the free hand drawn graph is not very accurate. The time taken by learners to complete the task was quicker as compared to the free hand drawn graph. More time is now focused on other complex concepts of the topic than drawing.

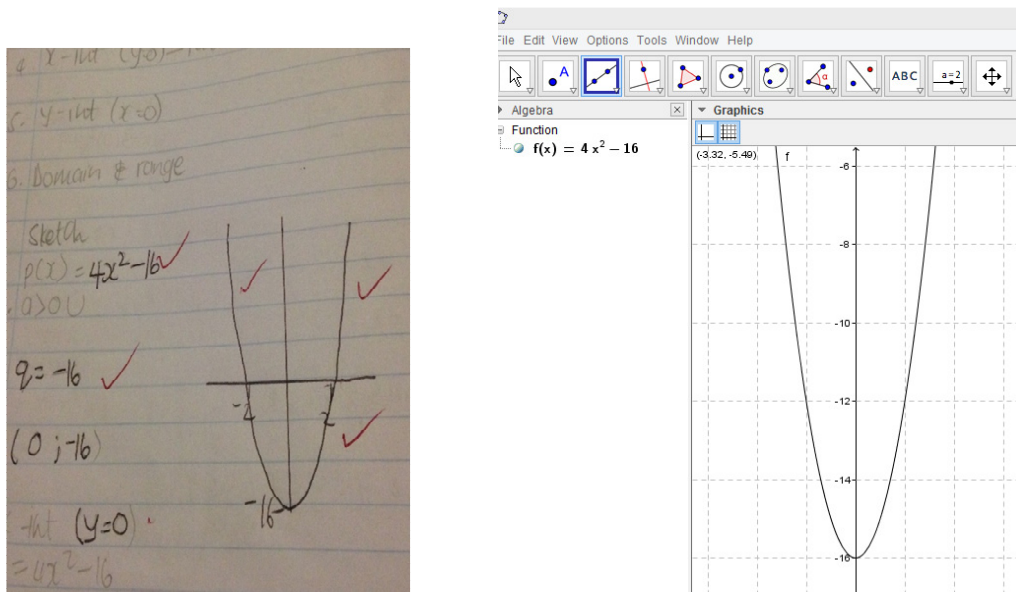


Figure 4.9. Free hand (left) VS Geogebra (right)

4.5.4 Effect of using Multiple Choice Quiz Maker (MCQM)

Various quiz questions were created by the researcher and a question bank of multiple-choice questions was uploaded using the MCQM. The quiz maker then randomised the questions in such a way that each learner had a different set of questions. The picture below shows the messages when learners do not do well on these questions

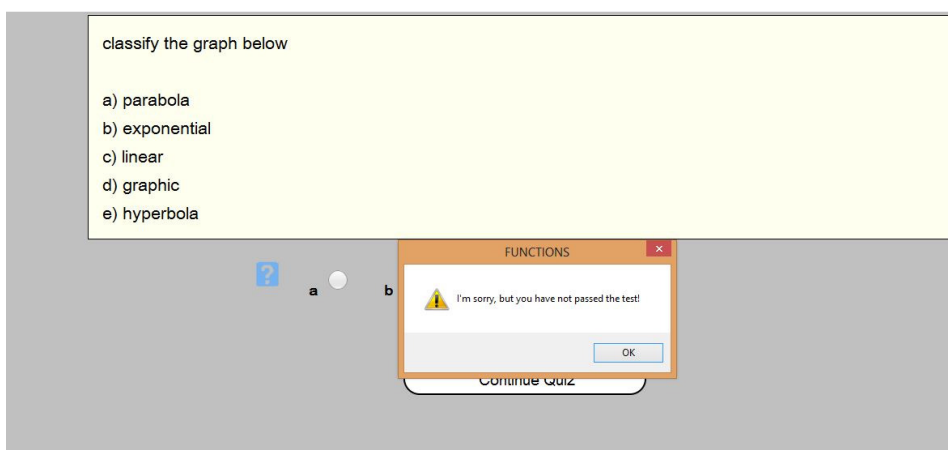


Figure 4.10. MCQM screenshot

The advantage of this program is that learners can calculate their scores while conducting the quiz (as shown below). When the quiz has been completed, the totals are shown and the learner can gauge their performance without waiting for the teacher to mark. Randomizing questions was not possible in a traditional classroom as the educator usually

gives all the learners the same questions so that marking of scripts becomes a manageable task.

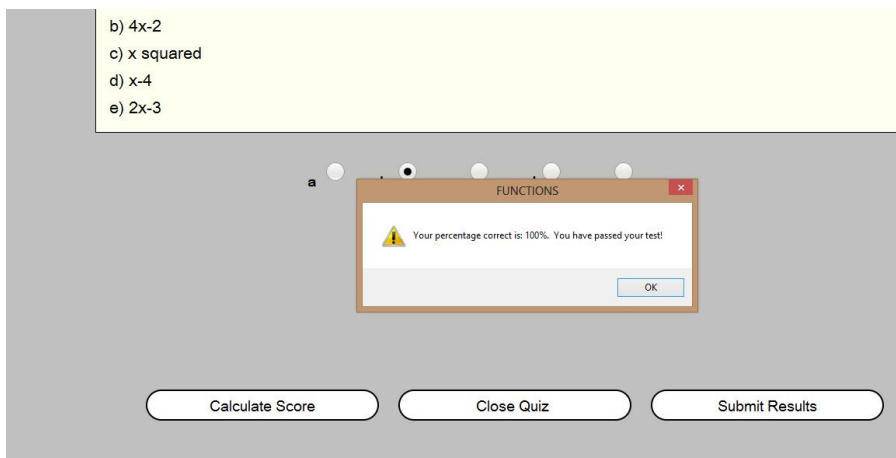


Figure 4.11. A learner can use the MCQM to calculate the marks before the quiz is even completed

The above tool is also an advantage to the educators , who in some cases will be teaching at least 50 learners at one time and cannot easily mark all materials on time, (Lopes *et al.*, 2008).The data collected from this quiz is shown in the previous figure 4.7 as column two. (*Equation of graphs test*).

4.6 The use of communication tools

Communication between peer (learner) to peer and between peer to instructor (educator) was important throughout the research period. As Hirumi's framework (2002) outlines it, the three levels of integration play a pivotal role in teaching and learning. This begins with the desire by the learner to learn and preparation of learning material by the educator (Lower Level). Learners use instructions from the computer and the instructor to understand (communication) the objectives of the topic, thereby choosing to learn by picking up chunks of learning content according to their activities (Middle Level). Then the learner uses the non – human source (Moodle), the instructor and peers to construct knowledge at the rate at which they prefer. The learners were able to communicate with the educator when seeking clarification on concepts, and communicated with their peers, sharing information.

4.6.1 Feedback

The assessments conducted in Moodle were automatically marked and then the results were made available soon after the learner completed the assessment.

The average marks from work received and marked by Moodle tools ranged from 53.85% to 100%. The results were analysed by Moodle and then summaries were generated in the form of graphs so that the educator could track the performance of the learners, and was available to learners or their parents. This made it easier to locate the areas that needed improvement.

Moodle showed the grades of content that was covered and assessed and ranked learners according to performance in each given assessment. This became a motivational tool as learners would work extra hard to be placed in a better position. The Figure 4.12 below show a section on of the grader report (with participants' initials).

Grader report

Grader report

Separate groups Maths 10A

Surname		First name	Email address	quiz	Sketching Methods : Linear ...	Equations of Graphs Test	Equation of :
F	Al		rhs@webot.com	83.33	83.33	92.31	
Ni	A:		rhs@webot.com	83.33	83.33	92.31	
Mi	T.		rhs@webot.com	83.33	83.33		
A	B		rhs@webot.com	83.33	83.33	69.23	
S	C		rhs@webot.com	100.00	100.00	100.00	
Mc	Di		rhs@webot.com	83.33	83.33	92.31	
F	Ei		rhs@webot.com	83.33	83.33	76.92	

Figure 4.12. Grade report showing the rankings of learners ranked according to performance

4.6.2 Chats

Communication was important in the research and most learners learnt how to communicate effectively using the chat facility. They used this to communicate with their

peers and with their educators, wherever they needed assistance or when they shared information. The learners were able to use this tool mostly on content related issues, even though occasionally they used it for social communication. This tool was very useful for learners with barriers of communication in normal lesson. They presented their problems via the chats, ensuring that the learning process is not broken down. This tool was important, as there was no need to wait for the next lesson to understand a concept or to give other learners *hints*. Figure 4.13 below shows an extract of the chat section between the learner and the educator.

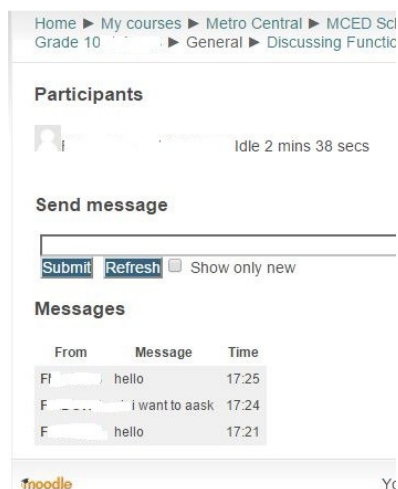


Figure 4.13. Chat section between the learner and educator

4.7 Online survey

The online survey was completed by Moodle learners, who were asked questions on the following aspects

- i. Relevance- Did the LMS play a pivotal role in teaching and learning?
- ii. Reflective thinking- Did it allow learners to think critically? Were they independent thinkers?
- iii. Interactivity- Did the LMS give them the freedom to interact between their peers and educator?
- iv. Tutor activity- Was the tutor helpful?
- v. Peer support- Were they able to get or offer support from their classmates? Were they able to evaluate each other?

- vi. Interpretation- Did the instructions of what to do, make sense to them? Were they able to interpret messages they received from their peers or educator?

The complete details of the survey are attached as Appendix L - Learners were able to log in at any free time they had to answer the questions. Figure 4.14 shows the view of the question they answered after using Moodle.

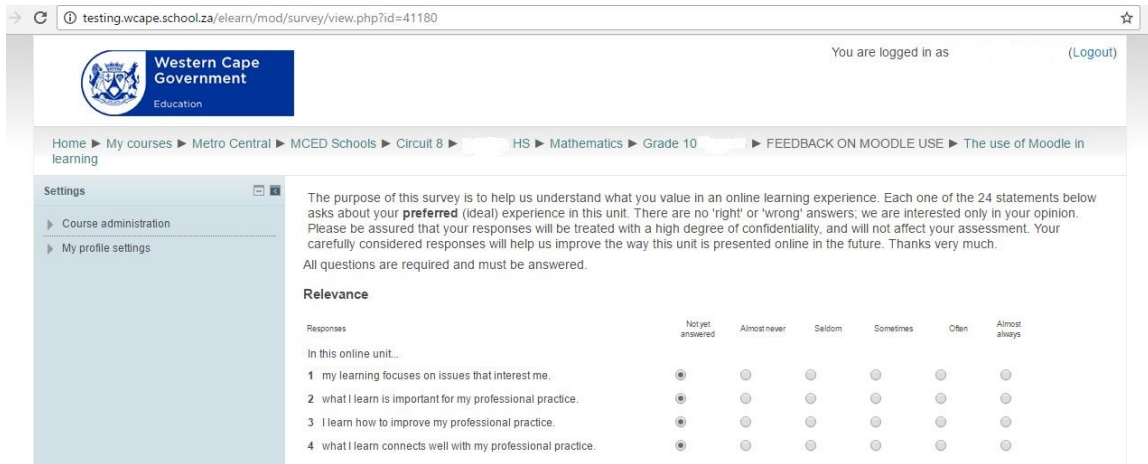


Figure 4.14. A Likert scale type of survey allowing participants to evaluate their use for Moodle

Learners chose the five options that suited their experiences on Moodle. After the completion, as in Figure 4.15, Moodle analysed the scores of all the learners who participated in the survey.

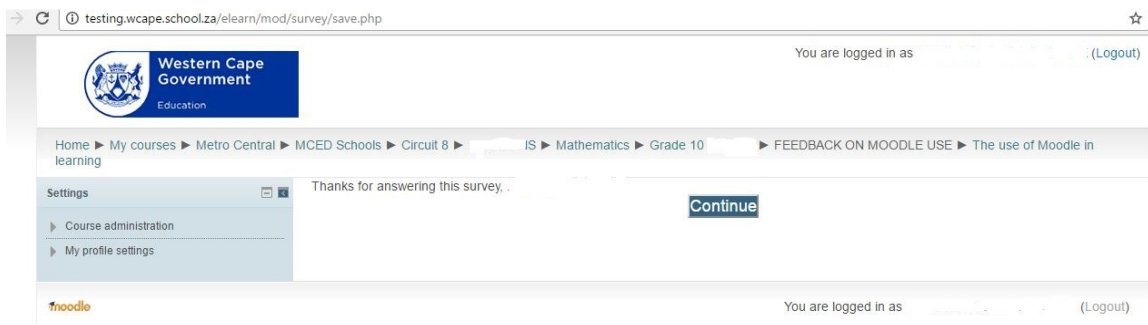


Figure 4.15. The picture showing a learner who has completed the survey

The researcher was able to identify the participants who completed the survey. The qualitative survey becomes authentic when there is evidence of the source. Hard copy surveys tend to be contaminated as one would not have used their log in details to access, it (Cohen *et al.*, 2007).

4.7.1 Results of the online survey

As soon as the participants were finished with the online survey, Moodle published the results that are shown in Figure 4.16 below:

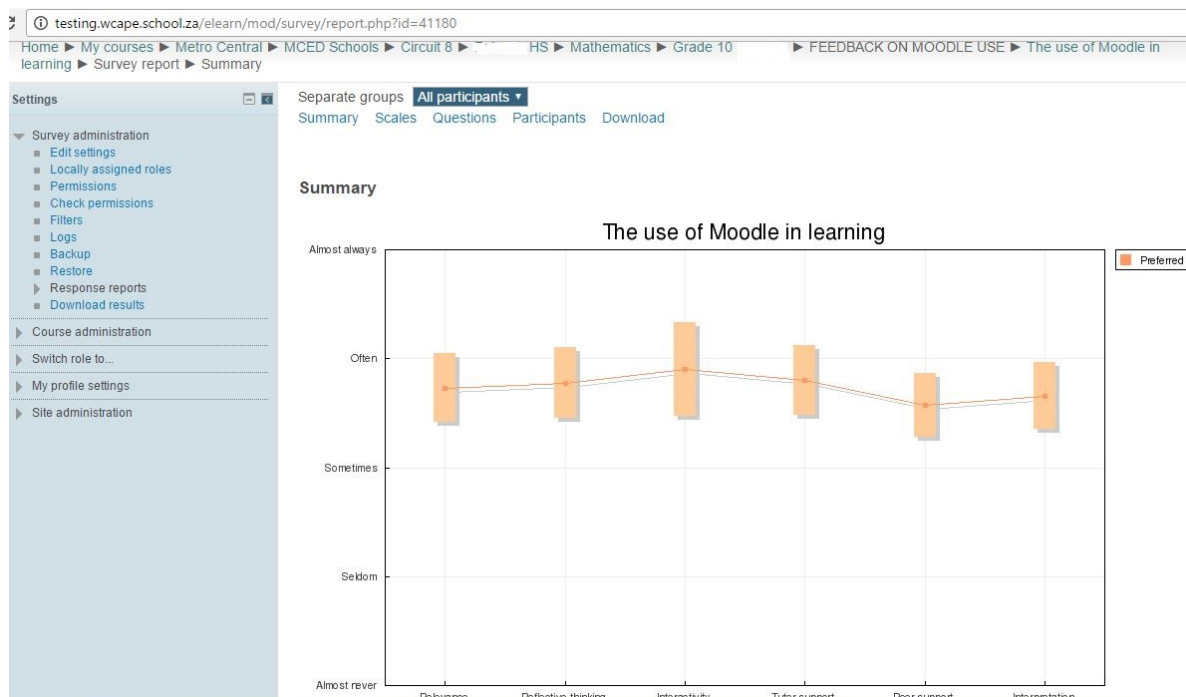


Figure 4.16. Participants views on use of Moodle

The learners' responses showed:

Relevance: Learners chose above 'sometimes' level to just above 'often' level. This means that the learners viewed the use of Moodle as playing a major role in their studying of Mathematics. It appears to indicate that learners felt Moodle gave them the ability to be interested in the topic of functions.

Reflective thinking: The choice was between 'sometimes' level and slightly above the 'often' level. It shows Moodle assisted learners in thinking critically, thereby building the knowledge that enabled them to solve complex tasks. This was evident on the quizzes they attempted.

Interactivity: The choice was above the 'often' level, indicating that learners were able to interact between each other; it was evident during the Moodle session where learners were seen moving around assisting each other. This evidence of social constructivism

from findings presented by Kotzer & Elran (2012) is reiterating that Moodle is a suitable tool of teaching and learning.

Tutor/Facilitator Support: As it is shown by the graph, the tutor support was scored slightly above the 'often' level. Learners were satisfied with the motivation they got from their tutor. The tutor monitored the learners, offering support to learners who had problems with the system, and most importantly, explained complex activities to them as individuals, and responded to their messages promptly.

Peer Support: The peer support scored below but above "sometimes" level. Learners did not have time to evaluate each other as they spent more time on their own work. They did however; get praise from the facilitator as he checked on the work they completed.

Interpretation: The participants scored the interpretation above the 'sometimes' level and slightly below the 'often' level. Learners were able to interpret messages they sent each other via the chat platform. Messages were simple and mostly directed to friends or the educator. These messages were content based and were most frequent when they were preparing for a quiz or a test.

Overall results of the online survey showed the enthusiasm in using Moodle and learners were able to score the LMS above the 'sometimes' to 'often' levels. The choices by learners who took part in the online survey seem to suggest that was indeed evidence of learning within this group of learners.

4.8. Activity log

The activity log for Moodle recorded the number of minutes the learners spent on the system. The educator could also see who was online and the number of hours spent using Moodle was calculated in correlation with the number of activities completed during that particular session.

Moodle allows users to be traced when they are online, and this assists the researcher to check which learners are using the LMS and their frequency. The researcher counted the number of times Moodle was accessed per day by learners. Some learners accessed the LMS more than once a day. The results in Table 4.2 below shows the frequency of use

by learners. Most learners who frequently used the LMS performed better in quizzes and other assessments that they did during the period of the research.

Table 4.2 Frequency of LMS use

Accessing times by day of the week					
	Week 1	Week 2	Week 3	Week 4	TOTALS
Monday	55	42	42	30	169
Tuesday	40	35	32	34	141
Wednesday	41	34	23	34	132
Thursday	33	25	22	41	121
Friday	62	29	32	38	161
Saturday	40	31	25	34	130
Sunday	16	15	18	21	70
	287	211	194	232	924

The Pie chart in Figure 4.17 below shows the percentage number of logins recorded per day for the duration of the research.

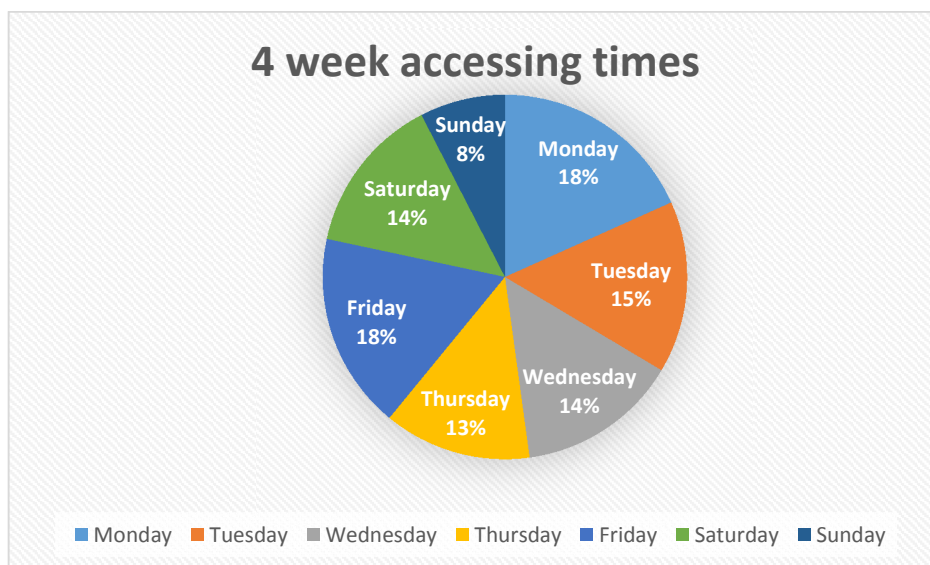
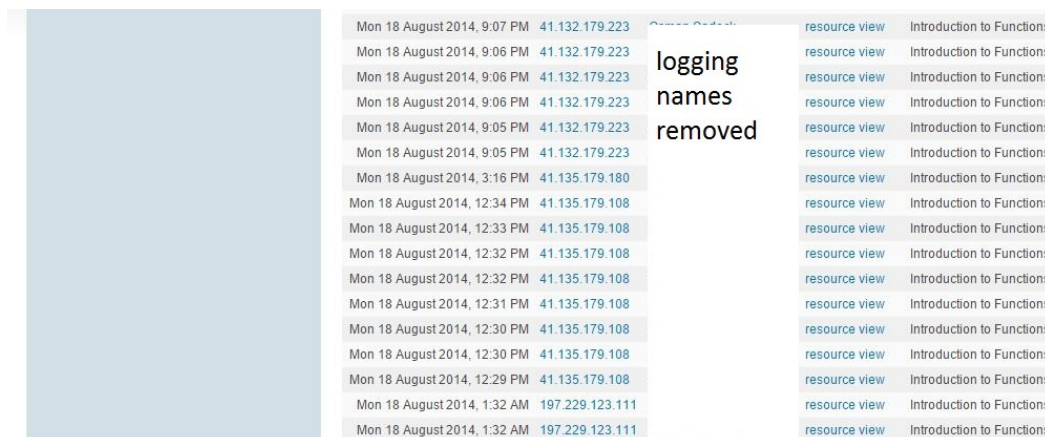


Figure 4.17. Pie Chart showing percentage accessing times per week

The chart above shows that most of the log in to Moodle occurred during the week. This is because those who were active during the week were using the school laptops or personal computers. The number decreases during the weekends (Saturdays 14% & Sundays 8%) , when learners go home as the majority of them don't have computers or internet that they could use to log on to the system. Most learners who were recorded as

more active users of Moodle had higher marks in most of the quizzes conducted during the research period.



The image shows a screenshot of a Moodle activity log. On the left side, there is a large blue rectangular redaction box. The log itself is a table with columns for time, IP address, activity name, and resource name. A text overlay in the center reads "logging names removed".

Mon 18 August 2014, 9:07 PM	41.132.179.223	resource view	Introduction to Functions
Mon 18 August 2014, 9:06 PM	41.132.179.223	resource view	Introduction to Functions
Mon 18 August 2014, 9:06 PM	41.132.179.223	resource view	Introduction to Functions
Mon 18 August 2014, 9:06 PM	41.132.179.223	resource view	Introduction to Functions
Mon 18 August 2014, 9:05 PM	41.132.179.223	resource view	Introduction to Functions
Mon 18 August 2014, 9:05 PM	41.132.179.223	resource view	Introduction to Functions
Mon 18 August 2014, 3:16 PM	41.135.179.180	resource view	Introduction to Functions
Mon 18 August 2014, 12:34 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:33 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:32 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:32 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:31 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:30 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:30 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 12:29 PM	41.135.179.108	resource view	Introduction to Functions
Mon 18 August 2014, 1:32 AM	197.229.123.111	resource view	Introduction to Functions
Mon 18 August 2014, 1:32 AM	197.229.123.111	resource view	Introduction to Functions

Figure 4.18. The activity log showing the times, learners accessed Moodle

The Figure 4.18 above showed that on that particular day, learners logged on during the specified times above. Most learners showed interest in practicing Mathematics and engaging their peers in solving problems that they could not do during the day. The log above was also used by the educator for correlations between frequency of use and marks obtained during the post-test of the research. The statistics above show that, there was a positive correlation between the frequencies of Moodle access with the marks learners obtained at the end of the study.

The Figure in 4.19 below shows the time taken to complete a quiz on a particular day.

E	F	G		H		I	J
email addr	State	Started on		Completed		Time taken	Grade/100.00 Q.
rhs@webc	Finished	10 September 2014	3:28 PM	10 September 2014	3:30 PM	1 min 21 secs	100
rhs@webc	Finished	10 September 2014	2:40 PM	10 September 2014	2:42 PM	1 min 44 secs	100
rhs@webc	Finished	10 September 2014	3:15 PM	10 September 2014	3:17 PM	1 min 46 secs	88,89
rhs@webc	Finished	10 September 2014	2:41 PM	10 September 2014	2:55 PM	13 mins 58 secs	100
rhs@webc	Finished	10 September 2014	3:17 PM	10 September 2014	3:20 PM	2 mins 19 secs	100
rhs@webc	Finished	10 September 2014	3:18 PM	10 September 2014	3:21 PM	2 mins 26 secs	100
rhs@webc	Finished	10 September 2014	3:22 PM	10 September 2014	3:24 PM	2 mins 9 secs	77,78
rhs@webc	Finished	10 September 2014	3:46 PM	10 September 2014	3:49 PM	3 mins 15 secs	100
rhs@webc	Finished	10 September 2014	3:59 PM	10 September 2014	4:02 PM	3 mins 2 secs	88,89
rhs@webc	Finished	10 September 2014	4:14 PM	10 September 2014	4:18 PM	3 mins 25 secs	88,89
rhs@webc	Finished	10 September 2014	4:24 PM	10 September 2014	4:27 PM	3 mins 3 secs	100
rhs@webc	Finished	10 September 2014	4:14 PM	10 September 2014	4:18 PM	3 mins 34 secs	77,78
rhs@webc	Finished	10 September 2014	2:33 PM	10 September 2014	2:37 PM	3 mins 55 secs	100
rhs@webc	Finished	10 September 2014	3:23 PM	10 September 2014	3:28 PM	5 mins 11 secs	100
rhs@webc	Finished	10 September 2014	4:00 PM	10 September 2014	4:06 PM	5 mins 45 secs	77,78
rhs@webc	Finished	10 September 2014	4:12 PM	10 September 2014	4:18 PM	5 mins 48 secs	88,89
rhs@webc	Finished	10 September 2014	4:20 PM	10 September 2014	4:26 PM	5 mins 52 secs	88,89
rhs@webc	Finished	10 September 2014	2:57 PM	10 September 2014	3:03 PM	6 mins 3 secs	100
rhs@webc	Finished	10 September 2014	4:21 PM	10 September 2014	4:27 PM	6 mins 3 secs	88,89
rhs@webc	Finished	10 September 2014	4:01 PM	10 September 2014	4:08 PM	7 mins 17 secs	88,89
rhs@webc	Finished	10 September 2014	3:52 PM	10 September 2014	3:59 PM	7 mins 24 secs	88,89
						Overall average	92,59
						Quiz	Q

Figure 4.19. The log showing the duration it took to complete a task on particular day

It can be noted that, for a quiz given to learners at any point, Moodle is able to record the time taken to complete the quiz and the results of the quiz are published. The frequency in Table 4.3 below shows the breakdown of the times used to complete the quiz on that particular day.

Table 4.3 Frequency time intervals of completing the quiz

Time intervals	Frequency
0-3 minutes	6
4-6 minutes	6
7-10 minutes	8
10-12 minutes	9
13+	7
TOTAL	36

The educator was able to relate the time taken and the amount of marks that the learner obtained. There was not a limited time for learners to do the quizzes. However, the time of completion varied. Both learners who scored low (70s) and those who scored high (80s and 90s) took varying times, some less time and others more time. Learners took more time on questions of higher order reasoning. Those who excelled (100%) spent less time in completing the quiz. This was in line with the research that was conducted by Dimasaury

and Pabro who were investigating the use of Moodle (Dimasuay & Pabro, 2009:22.1). This could be attributed to the fact that most of these good learners were very prepared as seen by the time they took to complete the task.

The Moodle LMS also records the average performance per question automatically so that the educator is able to identify the questions that were not well answered. This is evident in Table 4.4 below.

Table 4.4 The average scores per question of a particular task

' mins 17 secs	88,89	22,22	0	11,11	11,11	11,11	11,11	11,11	11,11
' mins 24 secs	88,89	22,22	11,11	11,11	11,11	11,11	11,11	11,11	-
Overall average	92,59	21,69	9,52	11,11	10,05	10,05	10,05	11,11	8,99
	Quiz	Que1	Que2	Que3	Que4	Que5	Que6	Que7	Que8

The quiz above shows that Question 2 (Que2) and Question 8 (Que8) had the lowest score points. This helps the educator, when doing remedial action, to highlight the problems learners faced when they were doing the quiz.

4.9 Comparing the Tests Results

The tests that were administered to the learners in both classes were analysed in two ways using the Analysis of Variance (ANOVA). The first comparison was comparing the test BEFORE the research and AFTER the research, whether there was any difference in marks between the two tests. The second comparison was comparing the performance of the two classes against each other, thus the two pre-tests BETWEEN each groups and the two post-tests BETWEEN the two groups.

4.9.1 Analysis of all tests written by the classes during the period of research

The tests were compared to the class that used the traditional method. The Analysis of Variance of the two tests written by the two groups are shown in Table 4.5 on following page.

Table 4.5: ANOVA of two tests written by two groups

Anova: Single
Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Before Moodle	36	502	13,94444	27,76825
After Moodle	36	719	19,97222	30,02778
Before Traditional	39	574	14,71795	28,62888
After Traditional	39	600	15,38462	28,40081

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1077,443	5	215,4885	7,620955	0,0000012711	2,255283
Within Groups	6192,397	219	28,27579			
Total	7269,84	224				

The ANOVA tables above compared the two tests that were written by the two groups, namely pre-tests (*before Moodle and before Traditional*) and the post-tests (*after Moodle and after Traditional*). The conclusion from the analysis based on the F-statistic of all the two tests after combining their variances, showed that the means of the tests were indeed different. The distribution of passing level grades (1-7) are compared using a bar graph in Figure 4.20 below.

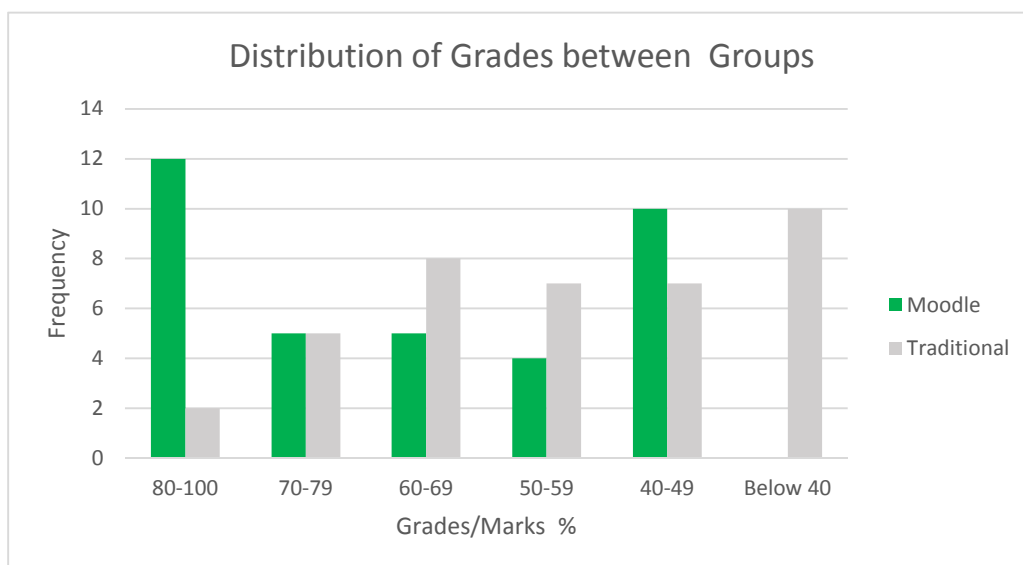


Figure 4.20. Bar graph showing the grades of marks between the two groups

The Department of Education uses a scale showing performance during assessments according to codes 1-7, with 7 being the highest code (80%-100%) and 1 the lowest code (0%-29%). Similarly, the results of the two groups were also compared according to the codes. Figure 4.20 shows that the Moodle learners had 12 learners who scored between 80-100% compared to the traditional method, which had two learners. Most importantly, the graph shows that no one scored below 40% from the Moodle class compared to 10 learners from the traditional classroom.

4.9.2 Results of the post-tests

The results of the tests were analysed using ANOVA table 4.6 below. The raw scores are attached in Appendix C and D. The Analysis of Variance comparing the control post-test and the Moodle post-test are shown on next page:

Table 4.6: ANOVA comparing the two post-tests

Anova: Single
Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
After Moodle	36	719	19,97222	30,02778
After Traditional	39	600	15,38462	28,40081

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>Df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	393,9837	1	393,9837	13,50144	0,000452	3,972038
Within Groups	2130,203	73	29,18086			
Total	2524,187	74				

According to Triola (2001:618), conclusion of the analysis of variance is based on the following:

If P-value ≤ 0, 05 then reject the null hypothesis of equal means.

If P- value > 0, 05 then fail to reject the null hypothesis of equal means.

OR

If the F statistic is excessively larger than the F_{crit} , then we reject the claim of equal means and conclude that the means are unequal.

If the F statistic is smaller than the F_{crit} we fail to reject the null hypothesis of equal means.

The results between the two groups' assessment after the research shows that the P-value (0, 00452) is less than 0, 05 and F statistic (13.50144) is excessively larger than F_{crit} (3.9720). The analysis suggest that the null hypothesis is rejected. The researcher

concludes that, as the two means were different, the use of Moodle to teach functions was shown to be effective.

4.9.3 Discussion of the post-test results

The pre-test and post-test results shows a marked difference. This appears to indicate that learning has taken place. There was also a difference compared to the group that used the traditional ways of teaching. The tools of Moodle played a major role on these results as the learners who were frequently using the LMS were seen to have better results. The findings in the study singled out a variety tools that were pivotal in the research, which made it possible for learners to get better scores than the traditional method. The tools of Moodle that made the post-test to improve are tabulated in Table 4.7 below:

Table 4.7: Tools of Moodle that improved the post-test results

Goals of Teaching or learning	Moodle tool satisfying the role	Notes
Facilitator instructions, Notifications	Forum, Notes	The LMS allowed facilitator to post instructions to learners , these instructions were a click away and were always available to them for quick reference
Communication between facilitator and peer	Chats , Forums	The educator would broadcast a single message to all the participants at ease. Learners with problems communicated with the educator directly and got a personal response
Lesson reinforcement	Teacher Videos, YouTube, Handouts, Website Links , Teacher Notes	Videos enabled learners to watch the learning content at their own pace, rewinding and pausing for clear understanding. The YouTube videos were available for further enrichment about the topic
Social Constructivism and collaboration	Forum discussions, Chats	With the group discussions on forums, course outline , examples , practice questions and quizzes, the learner manage to develop understanding of the topic on their own , taking charge of their learning
Learner assessment	Quizzes from Hot Potatoes , Questions from MCQM	Feedback was instant , learners didn't wait to view their mistake, and were able to establish where their

		point of weaknesses were in the topic
Evaluation	Online survey and Questionnaire	Learners were able to share their experiences about the LMS, this information was important to improve the quality of future lessons
Graphic accuracy	Geogebra	Graphs of functions were accurately drawn and learners could easily navigate the behaviour of the types of graphs they were supposed to cover in Grade 10

The above tools reinforced the topic of functions, which appear to have increased the scores of the Moodle class above those of the experimental group. The results are similar to the research done by Arman (2013), who used the pre-test and post-test method on learners who were being evaluated for using Moodle on 8th grade learners in Palestine.

4.10 Discussion of the overall results

The results show that the use of Moodle on learners was effective compared to the classes that used conventional methods of learning. Learners were able to interact independently with the LMS and the majority of them were able to use the tool easily. Learners were observed communicating with the peers and with their educators. Learners spent different times understanding a concept as they understood differently and there was no pressure on learners to move on to the next concept as they had full control of how much they could study.

Learner's assignments or homework were uploaded directly into Moodle for marking. This improved the rate of submission of assignments on time, as the LMS will *lock* as soon as due date passes. Moodle has these pedagogical contents that makes it easier to construct knowledge in a social environment, with learners learning through these interactive functions, (Kotzer & Elran, 2012).

The survey showed that learners were motivated by the immediate feedback as their results were immediately available to them and they could easily go over the concepts they did not understand. The educator was able to receive messages even during after-hours. This became an advantage, as there was no need to wait for next day for the

problem to be solved. The graph on figure 21 below shows the messages received by the educator during the course of the research.

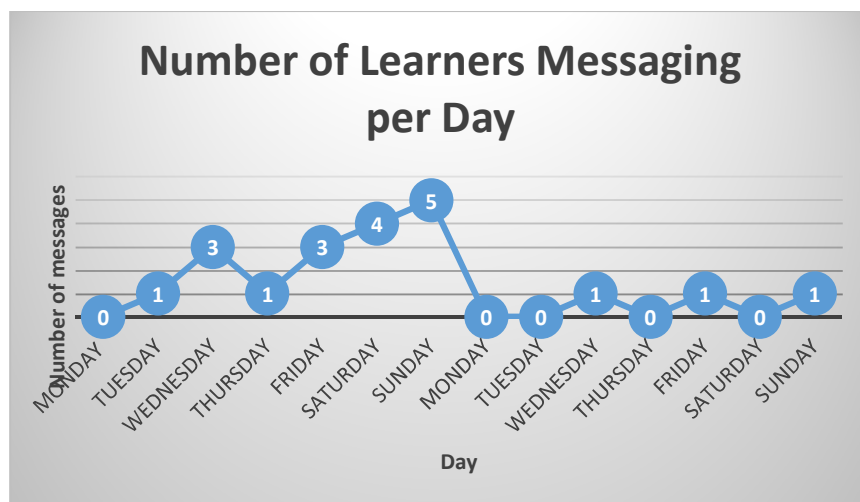


Figure 4.21: A line graph showing number of learners messaging per day for the 2-week duration

The interesting part from the statistics from the graph is that some learners were able to communicate with the educator during weekends, showing that learners were able to use their home devices to access the LMS. However there was a decrease in the number of messages as the research progressed, the most probable explanation to this is that the learners had gained much confidence to operate as individuals. The availability of the LMS at any time of day made learners solve questions continuously as shown by the times these learners accessed the program. This advantage of continuous availability of LMS was also found by Lazakidou & Retalis (2010), who were investigating primary school learners in Piraeus, Greece.

The Moodle LMS was also used to identify where learners experienced problems. The educator was able to track the sections where learners struggled by using the low marks that learners got on certain sections. This information was used to prepare remedial work, adding emphasis on unclear concepts. The traditional classroom had a drawback in keeping track of their performance in homework, as this was supposedly done at home but there was not track to show whether learners were actually doing the work themselves or improving. The educator, because of limited class time, usually did a selection of questions given for homework.

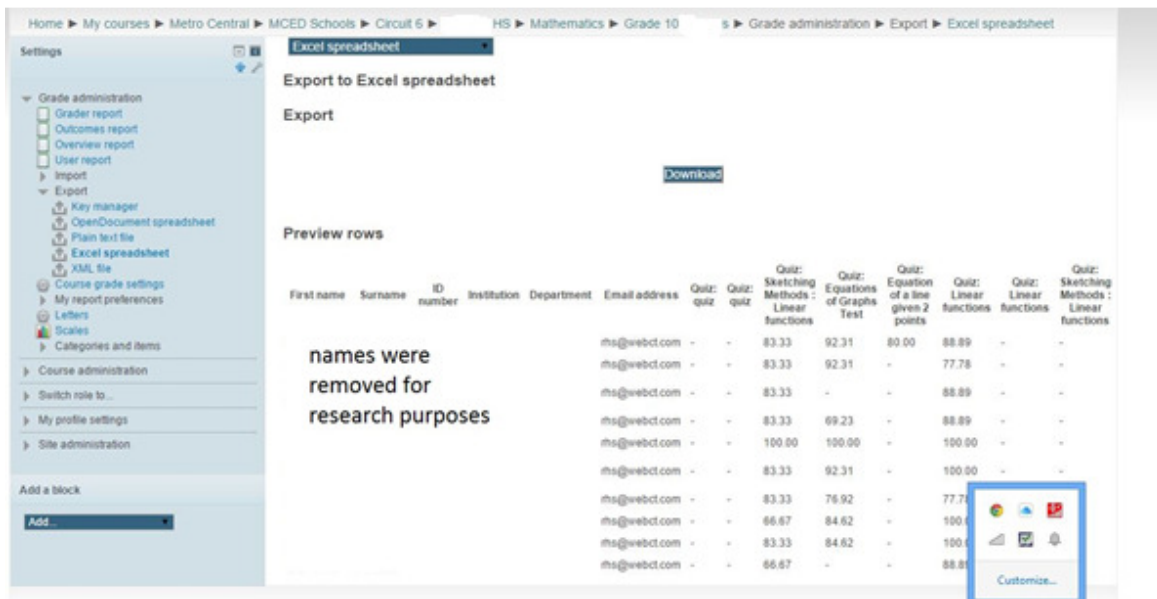


Figure 4.22: The educator can view all completed tasks and some yet to be completed

Figure 4.22 above shows that some learners were able to complete most of the quizzes while some were still in the process of completion (those with dashes).

4.11 Summary

The chapter has presented and analysed the data that was used in this research. The analysis of variance was generated using the data extracted from the pre and post-tests of the two groups as outlined in previous chapters. The results were then compared according to the principles of statistical analysis. The chapter also presented results from the tools of Moodle. The results from the communication tools of Moodle were also equated to the Framework underpinning this study. The next chapter discusses findings based on the way the analysis was done, and then recommendations are outlined where possible.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The previous chapter, chapter 4 contained the findings of the study. These findings were thoroughly discussed, linking them to the literature that was previously reviewed. The findings of this study showed that learners were able to benefit from using Moodle Learners Management System. Learners' marks improved from the initial test given to them, they were able to interact amongst their peers and educator and were able to use the tools of Moodle to learn about functions in Mathematics.

This chapter will discuss the following:

5.2 The summary of previous studies of this research.

5.3 Discusses the effect of introducing Moodle in a constructivist pedagogic approach as per the results of this research.

5.4 Outlines how the use of Moodle has enhanced the learning of Functions in Mathematics as per the findings of this research.

5.5 Summarises the tools of Moodle and how they were pivotal in teaching and learning.

5.6 Describes the overall performance of learners who participated in this study

5.7 Outlines the limitations of this study.

5.8 Proposes recommendations to educators and learners who will be using Moodle in future.

5.9 Suggestions to those who will be conducting future research on this subject

5.10 Summarises this chapter.

5.2 Summary of previous chapters

The aim of this study was to investigate the effectiveness of a learning management system (Moodle) on Grade 10's learning of Functions in Mathematics. The topic of

Functions has been found to be challenging to teach, as this is a practical topic with a lot of graph sketching. Mathematics marks were seen to be low and there was a need to discover other new ways to remedy the situation.

Educators were struggling to reach all learners in class. Learners were also struggling to grasp concepts without emphasis (re-explanation).Learners were facing problems drawing shapes of graphs that made it easier for them to analyse the graphs.

Literature of ICT use in classroom was discussed, both locally and globally. Relevant Theories related to e-Learning were also discussed, and Hirumi's model was adopted for this study.

As the learners were not to be separated from each other, a quasi-experimental design was adopted as it suited the classroom environment. Data was collected from pre-tests from both groups and then post- tests. Additional data was collected amongst the tools of Moodle to ascertain whether learners were using tools to construct knowledge.

The tests data were analysed by Analysis of Variance. The results showed that the marks from the learners before the treatment was significantly different from the marks they got from tests after Moodle treatment. Moreover, the mean of tests between the two methods of teaching was compared and the Analysis of Variance concluded that there was a difference between the methods of teaching.

The research question was:

What is the effect of introducing Moodle in a constructivist pedagogical approach in learning Mathematics?

To answer the main question the sub-questions of the research were:

1. In what ways can Moodle be used to enhance the learning of functions in Mathematics?
2. How can the tools of Moodle be used to make learning of functions easier?

As the findings of the study were summarised in Chapter 4, this chapter will synthesise these findings to answer the three questions that guided this research.

5.3 Introducing Moodle in a constructivist pedagogical approach in learning Mathematics

Learners were found to be able to use the Moodle LMS to construct knowledge independently with minimum supervision. The use of computers enabled learners to *discover* concepts, which assisted them to solve problems related to the topic.

With the contact time of 40 minutes during normal lesson and 80 minutes during a double lesson, it became impossible for the educator to reinforce remedial lesson in a Mathematics classroom for these learners. The implementation of Moodle in classroom saw learners have a one-on-one with their problems via the management system. During lessons, learners were able to use the videos and other resources independently, they used chat forums to consult their peers whom they felt comfortable with, then engaged with the facilitator wherever possible via the chat messages outside lesson time.

During the Mathematics period, learners were able to cover different aspects of functions based on their rate of understanding. This method of teaching was advantageous, as the number of learners in class did not affect it, as this would be the case in the traditional method.

Learners independently construct knowledge, becoming the *controllers* of their own learning. The learners gained equal exposure to the content, at different times and levels, and the facilitator was able to randomly support those who were struggling without a waste of more time.

5.4 The use of Moodle in enhancing the learning of functions in Mathematics

In the context of this study, the facilitator who was previously using chalk and talk, the traditional method, introduced instructions and learning content using typed notes. In the past educators used to avoid using computers due to problems that were associated with it, (Chigona & Chigona, 2010). Amongst other fears were inadequate skills that they had, or lack of resources in their schools to implement the change. However new developments have emerged that have enabled educator confidence in teaching or blending their traditional ways with the use of ICT. The Western Cape Education Department currently has ICT courses running through the term and holidays in the quest to empower their

educators, (WCED, 2012) The classes in most Western Cape schools have an average of forty learners who have different learning abilities. With this composition, it makes the understanding of Mathematics difficult as some learners need repetitions or remedial always to ensure understanding. Moodle provides the tools that free up time and allows for individual attention.

Previously when the educator introduced the topic, handouts would be given to learners with an overview of what will be covered. With the use of LMS, the overview was read online and it was in chunks, broken down per topic. This student centered learning , was evident in this study as learners were absorbing content based on their abilities, not at the pace of the educator , who sometimes lost the understanding from learners as they will be in a multicultural classroom.

The videos of lessons that were created by the educator were widely viewed by learners, who wanted to understand functions. This was evident during lesson observation, where the majority of learners were rewinding and pausing, taking down notes, were possible, at their own pace. The activity log on figure 4.18 is evidence to the claim.

There was also a strong correlation between the performance and the time spent watching videos that were explaining different concepts of functions. YouTube links were also used that were provided extra resources in Moodle. Learners were able to check on different explanations of different concepts on functions from other sources using the website links. This was evident when learners performed well in the quizzes after watching the videos.

Printing costs were also reduced as most of the materials for studying became paperless. Moodle contained resources like chats, exercises, lecture notes, video or Microsoft Office tools to manage and promote learning and allows teachers to organise, manage and deliver course materials (Kotzer & Elran, 2012:123). These tools were very user friendly and they made lesson planning to be convenient. Figure 5.1 on next page shows the tools as they appear in the Moodle platform.

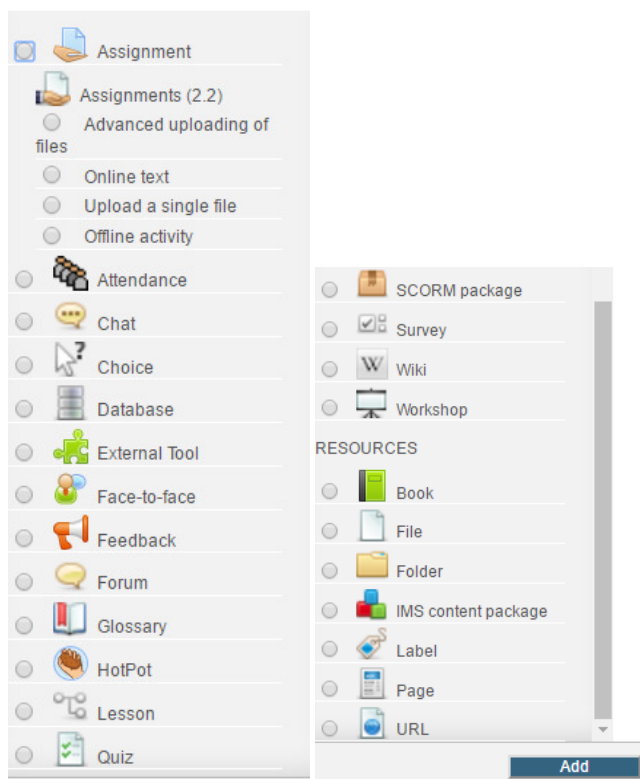


Figure 5.1: The tools of Moodle as viewed in the LMS

5.5 Using Moodle tools to make learning of functions easier

The tools that made learning of functions easier were identified and grouped into three categories, tools of teaching and learning, tools of communication and tools of assessment.

5.5.1 Teaching and Learning

- a. **Online assignment-** Learners were encouraged to upload the homework they were doing at home as soon as they completed so that the facilitator would download the assignment to mark. This ensured that learners would be able to work independently. The uploading of assignments also ensured that learners could stick to the due date, as the setting within Moodle had to manage due dates of all assignments.
- b. **Lesson-** the educator uploaded all lessons as per CAPS overview and made them available at a specific time, so that learners are not overloaded. The

lesson was broken down into chunks that enabled them to understand properly concepts depending on their level of understanding. The lesson comprised of notes, instructions, videos, quizzes and short practice questions that learners could answer so that it kept them focused. The traditional lesson was however, a chalk and textbook lesson as discussed earlier.

- c. **Quiz-** The Educator's pre-designed quiz questions were frequently used by learners constantly, who used it to gauge their knowledge periodically. The quiz was used often for drill and practice before the tests. The advantage of the quizzes was that it gave instant marks and a statistical analysis of what learners did. This made learners see the topic they will be struggling with and will be able to communicate with the educator for more assistance.
- d. **Hot Potatoes-** Hot potatoes as a question creation and question marking software, the most commonly used. The educator used JCloze, to created questions where learners fill in blanks and answers. The educator also jumbled graphs of functions and used a program called JMatch to allow learners to match the graphs with proper equations. This program made it easier for learners to identify different type of functions as per CAPS requirements.
- e. **URL-** the Universal Resource Locator made it easier for the educator to add links of online resources that was mainly used by "fast" learners who needed extra work. These links contained YouTube video links and other useful resources related to the content of the topic.
- f. **Videos-** learners spent most of the lessons watching lesson videos recorded by the educator. The educator created videos using Screen-casting and PowerPoint slides. This was an advantage as they could watch, listen, and rewind the lesson for easy understanding. The learners who previously could not keep up with the pace in class were actively participating in discussion sessions.
- g. **Geogebra-** Previously the educator used to struggle to draw smooth and accurate graphs that were visible to the learners. With Geogebra smooth parabolas and hyperbolas, we drawn for the learners and the learners were able to plot easily using the application without any problem. Geogebra served

most of the teaching time and learners. The Geogebra application, with the accurate generation of graphs was beneficial to both educators and learners.

The above teaching and learning tools were very significant for both learners with barriers and fast learners, as they did not entirely rely on the educator for lesson delivery. The use of LMS improved classroom efficiency, in terms of time management, content coverage and reinforcement of concepts to help in understanding, as learning was self-paced.

5.5.2 Moodle tools for Communication

As the Moodle class was designed to be of constructivist nature, learners were expected to discover their learning by means of discovery from the environment surrounding the learner. Learning incorporated a large amount of discussions between peer to peer or between the learner to facilitator. Moodle had tools that supported this type, such as:

- a. **Chat**-When the learners were not close to the facilitator, they used the chat tool to communicate. Learners would leave questions or comments in the facilitator's inbox or vice versa. That became an advantage than the use of verbal questioning, as some learners did not have time to raise questions during lesson time. Chat extended communication to outside classroom time.
- b. **Forum**- Learners used the forum when they were discussing a topic as a group. The forum had an advantage, as all learners would view all the questions being raised and discussed. Those who could not raise questions benefited from the questions that were recorded in the forum.
- c. **Feedback**- The facilitator gave feedback to the class using this tool, highlighting their performance per section. This was an advantage as he would highlight areas of concern as earlier as possible, allowing the learners to rectify or gauge their understanding in some concepts. The feedback was used for keeping records and to compare the performance with other classes.

The tools above were not available during the traditional way of teaching. The control class used more handouts, culminating to too many photocopying costs incurred by the school. Using the LMS became an advantage, as the resources were on-line, and were available as PDF files eliminating the need for printing. The use of paperless teaching

ensured that learners were able to use these tools wherever there was internet. For learning purposes, Moodle allowed learners to be active authors within the environment by providing a platform from which to share ideas via individual and collaborative efforts (Ke & Hoadley, 2009) in (Aranda, 2012:26).

5.5.3 Moodle tools for assessing learners

Learners were tested regularly (using informal quizzes) to establish whether learning was taking place, especially those who work independently. This has been alluded to by Ally (2008) , who said that learners achievement of online learners must be checked periodically.

The facilitator made sure that learners are not saturated with content and lessons were divided into small chunks per day as per the lesson plan. This made it easier for learners especially the fast learners, who were observed to be covering more content because of this arrangement. Learners had some more time for remediation and could watch videos as many times as they could. This was also reiterated by Ally (2008:27), when learners using ICT were observed to have more time for research on other aspects of the lesson.

Even though it involved moving from classroom to the computer lab every time, there were a lot of resources exposed to the learners who used Moodle LMS than before. The interactive lessons made learners enjoy learning Mathematics as the generation of the digital natives, who continue to change all their surroundings into a technology environment. The use of the textbooks and photocopies in this class was greatly minimized.

5.6 Overall performance of learners

Learners who participated in the research were evaluated on how they performed in various learning components namely,

- Completion of tasks
- Interaction with peers
- The testing of content they have learnt

Completion of tasks -Moodle LMS measured learning in various ways. The facilitator was able to trace how the learners completed exercises and quizzes, which areas in these tasks they struggled with. The rate at which learners completed tasks improved as learners knew that the results were available instantly.

Interaction with peers- the use of communication forums made it easier for learners to consult each other without any barriers before engaging with the facilitator. Learners who understood concepts were seen sharing information during lesson time and discussion forums.

Testing of content- As the researcher noted on the results of quizzes, scores were showing improvements as the lesson progressed (figure 4.7 & table 4.4). The results of post-tests also showed a greatly improvement in the understanding of the functions as compared to learners who only used the traditional method. This was possible because the learners were using the LMS to re-teach themselves using videos and other tools that have been discussed previously, as it was easily available whenever they needed to learn.

5.7 Limitations of the Study

The use of technology in schools cannot be flawless, free of challenges, as one would expect. Some of these challenges are rarely identified in theory, but are identified when one begins to use the computers and cellphones. It is however expected that the challenges identified, after the learners get used to the new environment, will be minimized. Similarly, using Moodle as a tool in teaching and learning faced some obstacles during the implementation phase. The researcher identified the limitations as faced by the facilitator and the learners.

Reluctance of Educators :-As Prensky (2010) in (Frankl & Bitter, 2012) put it, learners are “digital natives” educators are “digital immigrants” , they are often reluctant to adapt to changes on technology especially the one to be used in classrooms. The Western Cape Education Department is continuously encouraging teachers to enroll on Moodle 1 and other ICT courses that are freely available.

Time taken to prepare material:-Educators might complain about the time it would take them to prepare electronic worksheets, materials and applications before the lessons,

which can be a drawback for other facilitators. However, these are done once and kept safe for future use.

Movement of Learners to laboratories:-If educators were dealing with disorderly learners, the time taken to settle down from classroom to the laboratory would also be a concern. However, this was compensated when learners used Moodle outside teaching time.

Setting of Moodle to be a teaching tool:-Customizing Moodle to make a nice feel on the home page was also a challenge. This is so because it is an open source program, different from other LMS programs, where you could easily customize and put more of your school information. Most of the set up though, was done with the assistance from WCED who were administering the LMS on behalf of schools.

It must be noted that the above limitations however do not outweigh the advantages of using LMS in classes and the benefits were highlighted and were shown by the results of this research.

5.8 Recommendations

5.8.1 Factors that will assist the school and the educators.

There are changes that can be implemented to ensure optimum usage of ICT learning in school.

Teachers who are using Moodle and other ICT must create forums where they engage in discussions on how to improve the usage of the LMS and share resources, especially in the grades they are currently teaching. This will create diverse resources for learners who log on, as they will have access to a variety of options gathered from other schools to make them understand the Mathematics concepts. The Education authorities must increase campaigns to encourage ICT integration at schools by educators so that become aware of the advantages in classroom

5.8.2 Factors that will assist learners

The schools should model the computer literacy lessons in such a way that they are related to the subjects that are offered at the school. Subjects can use various tools on ICT differently, if this is identified as early as Grade 8 or lower grades. This will assist

teachers to minimise their time in guiding learners who struggle with computers. The WCED also should assist educators to design online lessons, to create a lesson bank of various levels that can be CAPS compliant to standardise them in a way that they are not too easy or too difficult for learners.

5.8.3 External Factors

Parents should also be encouraged to support their children and help them identify the benefits of using ICT in Mathematics. Learners can, at an early age empower learners with ICT skills. Moodle has an option of parents to register so that they can be able to monitor learner progress or communicate with the facilitator if need arises.

5.8.4 Using Moodle for other subjects

Using the methodology in this research, educators who teach other subjects can use Moodle as a tool for learning. This will also cement some of the recommendations outlined above.

5.9 Recommendation for future research

Further studies can be conducted to ascertain which one of the quiz authoring tools used in this research, Hot Potatoes or the Multiple Choice Quiz Maker is best suited for compiling good questions for teaching and learning. A second recommendation will be to conduct further research on self-paced video-based learning in other subjects.

5.10 Summary

The researcher used learners' interests in ICT to improve their Mathematics learning experiences. Lesson delivery became easy from an instructor's point of view as Moodle supported the Social constructivist theories. The many activities embedded in the LMS to promote instructor –to student, student-to-student and student-to learning environment interaction, was a distinct advantage to the learning.

The project of using Moodle LMS improved learners marks tremendously compared to the other group. The cost of using Moodle LMS was minimal (mainly computer consumables) for the school as it is administered by WCED. Most of the programs used or embedded in the LMS are either freeware or licensed for school use, for example Microsoft Office.

However, it must be noted that the use of Moodle solely does not guarantee higher-order thinking. The teacher must facilitate active learner engagement; this can be achieved in Moodle by the use of discussion forums and chats. Learners must be able to be guided, argue and collaborate within the Moodle environment to construct knowledge and enhance their understanding of the subject being studied.

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APPENDICES

APPENDIX A: Pre Test Question Paper

_____ HIGH SCHOOL

Grade 10 Functions Pre-test 1 Mr N Mlotshwa

40 marks

Question 1 NAME _____ GRADE _____

Complete the following table for the given functions:

x	$y = x$	$y = 2x$	$y = x + 2$
1			
2			
3			
50			
100			

(15)

Question 2

The domain of the function $f(x) = 2x + 5$ is $-3; -3; -3; 0$. Determine the range of f .

(4)

Question 3

Plot the following points and draw a smooth line through them. $(-6; -8), (-2; 0), (2; 8), (6; 16)$

(5)

Question 4

If $f(x) = x + x^2$, write out:

- (a) $f(t)$
- (b) $f(a)$
- (c) $f(1)$
- (d) $f(3)$

(8)

Question 5

If $g(x) = x$ and $f(x) = 2x$, write out:

- (a) $f(t) + g(t)$
- (b) $f(a) - g(a)$
- (c) $f(1) + g(2)$
- (d) $f(3) + g(s)$

(8)

	CLASS 10 green			Before G	During G	After G
	NAME	SURNAME	PSEUDO	30	30	30
1	Name1	Surname1	GStudent 1	11	9	20
2	Name2	Surname2	Gstudent 2	18	17	26
3	Name3	Surname3	GStudent 3	27	22	25
4	Name4	Surname4	GStudent 4	16	22	28
5	Name5	Surname5	GStudent 5	10	13	24
6	Name6	Surname6	GStudent 6	7	15	17
7	Name7	Surname7	GStudent 7	7	25	23
8	Name8	Surname8	GStudent 8	16	11	14
9	Name9	Surname9	GStudent 9	7	22	25
10	Name10	Surname10	GStudent 10	9	17	21
11	Name11	Surname11	GStudent 11	8	9	13
12	Name12	Surname12	GStudent 12	12	14	19
13	Name13	Surname13	GStudent 13	16	15	18
14	Name14	Surname14	GStudent 14	6	13	13
15	Name15	Surname15	GStudent 15	10	12	15
16	Name16	Surname16	GStudent 16	20	21	23
17	Name17	Surname17	GStudent 17	12	25	29
18	Name18	Surname18	GStudent 18	19	17	19
19	Name19	Surname19	GStudent 19	11	20	15
20	Name20	Surname20	GStudent 20	9	26	13
21	Name21	Surname21	GStudent 21	11	24	23
22	Name22	Surname22	GStudent 22	14	13	14
23	Name23	Surname23	GStudent 23	15	11	13
24	Name24	Surname24	GStudent 24	26	21	21
25	Name25	Surname25	GStudent 25	17	20	25
26	Name26	Surname26	GStudent 26	19	14	28
27	Name27	Surname27	GStudent 27	16	8	15
28	Name28	Surname28	GStudent 28	14	13	14
29	Name29	Surname29	GStudent 29	12	14	14
30	Name30	Surname30	GStudent 30	10	8	13
31	Name31	Surname31	GStudent 31	13	14	14
32	Name32	Surname32	GStudent 32	21	28	27
33	Name33	Surname33	GStudent 33	18	18	26
34	Name34	Surname34	GStudent 34	13	15	19
35	Name35	Surname35	GStudent 35	10	20	27
36	Name36	Surname36	GStudent 36	22	27	26
		MEAN		13,94444	17,02778	19,97222
		PASS		15	21	26
		FAIL		21	15	10
		Pass Rate		41,66667	58,33333	72,22222
		VARIANCE		27,76825	30,9159	29,19367
		STANDARD DEV		5,195855	5,560206	5,403117

APPENDIX C

The tests administered to the Class Green (Moodle Class)

	CLASS 10 blue			Before B	During B	After B
	NAME	SURNAME	PSEUDO	30	30	30
1	Name1	Surname1	BStudent 1	10	6	13
2	Name2	Surname2	BStudent 2	10	18	11
3	Name3	Surname3	BStudent 3	12	4	13
4	Name4	Surname4	BStudent 4	11	6	15
5	Name5	Surname5	BStudent 5	10	8	6
6	Name6	Surname6	BStudent 6	14	8	10
7	Name7	Surname7	BStudent 7	11	8	19
8	Name8	Surname8	BStudent 8	10	22	7
9	Name9	Surname9	BStudent 9	20	8	22
10	Name10	Surname10	BStudent 10	13	18	20
11	Name11	Surname11	BStudent 11	17	13	16
12	Name12	Surname12	BStudent 12	17	18	18
13	Name13	Surname13	BStudent 13	22	15	19
14	Name14	Surname14	BStudent 14	11	18	21
15	Name15	Surname15	BStudent 15	8	10	15
16	Name16	Surname16	BStudent 16	23	19	20
17	Name17	Surname17	BStudent 17	14	13	14
18	Name18	Surname18	BStudent 18	14	13	9
19	Name19	Surname19	BStudent 19	9	14	20
20	Name20	Surname20	BStudent 20	24	22	21
21	Name21	Surname21	BStudent 21	16	13	14
22	Name22	Surname22	BStudent 22	10	6	7
23	Name23	Surname23	BStudent 23	7	12	16
24	Name24	Surname24	BStudent 24	9	10	13
25	Name25	Surname25	BStudent 25	11	12	17
26	Name26	Surname26	BStudent 26	18	11	14
27	Name27	Surname27	BStudent 27	11	20	20
28	Name28	Surname28	BStudent 28	26	18	23
29	Name29	Surname29	BStudent 29	15	19	16
30	Name30	Surname30	BStudent 30	12	14	14
31	Name31	Surname31	BStudent 31	9	13	10
32	Name32	Surname32	BStudent 32	18	10	19
33	Name33	Surname33	BStudent 33	22	16	25
34	Name34	Surname34	BStudent 34	19	18	8
35	Name35	Surname35	BStudent 35	21	18	24
36	Name36	Surname36	BStudent 36	9	14	8
37	Name37	Surname37	BStudent 37	21	7	15
38	Name38	Surname38	BStudent 38	25	13	22
39	Name39	Surname39	BStudent 39	15	18	6
		MEAN		14,71795	13,41026	15,38462
		PASS		17	15	22
		FAIL		22	24	17
		Pass Rate		43,58974	38,46154	56,41026
		VARIANCE		27,89481	22,80605	27,67258
		STANDARD DEV		5,281553	4,775568	5,260474

APPENDIX D

The 3 tests administered to the Class Blue (Control Class)

APPENDIX E: Computer Competency Check List

Computer checklists for Participants

(Teacher to tick all boxes where the learner managed to fully operate)

NAME OF LEARNER _____ Teacher: Mr N Mlotshwa

Student demonstrates the following skills:

- Start up a computer and related equipment (printer, scanner, etc.)
- Shut down and Restart the computer;
- Use a mouse: point, click, double-click, drag and drop; right-and left-click; scroll
- Insert and eject CD-ROMs, flash drives from ports or drives
- Initialize disks, drives and other media; name/re-name
- Know/Determine storage capacity of flash drives
- Identify and use icons and menus: click and double-click on icons; use pull-down menus; use pop-up menus; move an icon
- Identify and use windows: select, open, and move a window; resize a window; scroll in a window; activate and de-activate a window
- Create and name files/documents and folders
- Start an application and create a new document
- Open and move among more than one application at a time
- Surf the internet
- Upload files
- Use chatting platform
- Use Geogebra program

Modified from the document from www.oregon.gov/ccwd/abe/pdf/computerskillschecklistfinal.pdf

APPENDIX F: Confirmation Letter from Supervisor & University



Faculty of Education & Social Sciences
Room 0.37 Main Building
Mowbray Campus
Highbury Road
Mowbray, 7705
Ph: +27 21 680 1586
E-mail: chigonaa@cput.ac.za

29th July, 2014

Research Department
WCED
Cape Town

To whom it may concern.

This is to confirm that Mr Nicholas Mlotshwa (Student No. 209102977) is currently registered for Masters in Education (MEd) at Cape Peninsula University of Technology. Osman Sadeck and I are supervising him on his MEd studies. Mr Mlotshwa is at the stage of applying for ethics clearance for his studies. As the supervisor, I support his application for the ethics clearance.

Yours faithfully,



Agnes Chigona (DE.d)
Department of Research and Postgrad

APPENDIX G: Letter of Consent to Use Western Cape School



**Western Cape
Government**

Education

Directorate: Research

Audrey.wyngaard@westerncape.gov.za

Tel: +27 021 467 9272

Fax: 0865902282

Private Bag x9114, Cape Town, 8000

wced.wcape.gov.za

REFERENCE: 20140730-33873

ENQUIRIES: Dr A T Wyngaard

Mr Nicholas Mlotshwa

Dear Mr Nicholas Mlotshwa

RESEARCH PROPOSAL: THE EFFECTIVENESS OF A LEARNING MANAGEMENT SYSTEM IN DEVELOPING GRADE 10 LEARNERS' CONCEPTUAL UNDERSTANDING OF FUNCTIONS IN MATHEMATICS

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01 August 2014 till 30 June 2015**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

**The Director: Research Services
Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000**

We wish you success in your research.

Kind regards.

Signed: Dr Audrey T Wyngaard

Directorate: Research

DATE: 31 July 2014

APPENDIX H: Parents/Guardian Consent Letter

From Nicholas Mlotshwa

_____ High School

Mathematics Department

13 August 2014

Title of Research Project: **THE EFFECTIVENESS OF A LEARNING MANAGEMENT SYSTEM IN DEVELOPING GRADE 10 LEARNERS' CONCEPTUAL UNDERSTANDING OF FUNCTIONS IN MATHEMATICS**

Dear Parents/Guardian

I am a student at Cape Peninsula University of Technology, doing Masters in Education (Specialisation: Mathematics). I am investigating on how learners exposed to a computer program, called Moodle, perform in a particular section of Mathematics. This program is administered by the Western Cape Education Department and our school is part of the pilot project. The school has kindly agreed that I conduct research at school during lesson times. I am therefore seeking permission for your child to participate in this project.

Learners will be taught a topic fully using a computer and will be expected to continuously learn with the assistance of a computer for the duration of this study. The learners who do not participated will not be disadvantaged, as they will continue their usual way of learning.

I confirm that all information and data collected in this study will be **confidential**; names of the children will not be used

To give permission for your child to participate, you are kindly requested to sign and return the attached form and should be sent back to school.

Please do not hesitate to contact me if you need more clarification.

Yours sincerely

Nicholas Mlotshwa

APPENDIX I: Parent Consent/Withdrawal Letter

Parent Consent Form

I _____ parent of _____ 10____ hereby **AGREE** that he/she takes part in the above research. I have read the letter attached to this form.

I understand that all information provided will be treated as confidential and anonymous.

Signed_____

Name_____

Date_____

Parent Withdrawal Form

I _____ parent of _____ 10____ would like to **WITHDRAW** my son/daughter from the above research.

Signed_____

Name_____

Date_____

APPENDIX J: Post Test 1 Sketching Methods: Linear Functions

Sketching Methods : Linear functions

Gap-fill exercise

Fill in all the gaps, then press "Check" to check your answers. Use the "Hint" button to get a free letter if an answer is giving you trouble. You can also click on the "[?]" button to get a clue. Note that you will lose points if you ask for hints or clues!

THE DUAL-INTERCEPT METHOD

This method is for finding intercepts.

y-intercept is found by putting $x=0$ and x-intercept by putting $y=0$

(1) Find the intercepts in the following equations

Given

$y=3x-6$ then

y-intercept = and x-intercept =

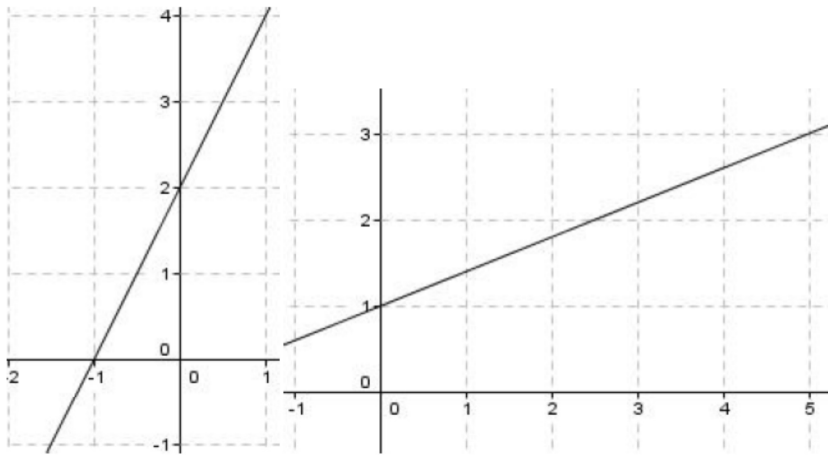
$2x+3y=6$

y-intercept = and x-intercept =

THE GRADIENT INTERCEPT METHOD

This method uses the gradient and the intercept to sketch the graphs.

(2) Find the gradient and intercepts used to sketch the graphs below



Graph A is Graph B is

by N Mlotshwa

[Check](#) [Hint](#)

[Index](#) [=>](#)

APPENDIX K: Post Test 2 Finding the Equation of a Line Given 2 Points

Index =>

Linear Function

Gap-fill exercise

Fill in all the gaps, then press "Check" to check your answers. Use the "Hint" button to get a free letter if an answer is giving you trouble. You can also click on the "[?]" button to get a clue. Note that you will lose points if you ask for hints or clues!

INSTRUCTIONS: Answer the questions by filling in gaps.

(1) The equation of a straight line is given by $y = \square x + \square$

(2) When m or $a > 0$ then the line shows a when m or $a < 0$ then the line shows a

(3) The -intercept is found when $x=0$.

(4) For $c \square 0$ the line goes through the origin

(5) For $c \square 0$ the line cuts the y -axis above the origin

(6) For $c \square 0$ the line cuts the y -axis below the origin

(7) The gradient of parallel lines is

(8) The product of gradient of perpendicular lines is equal to

(2) Find the gradient and intercepts used to sketch the graphs below

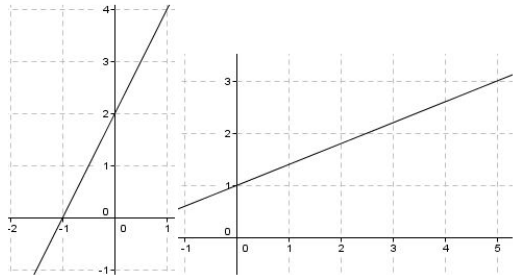
Given

$y=3x-6$ then

y -intercept = and x -intercept =

$2x+3y=6$

y -intercept = and x -intercept =

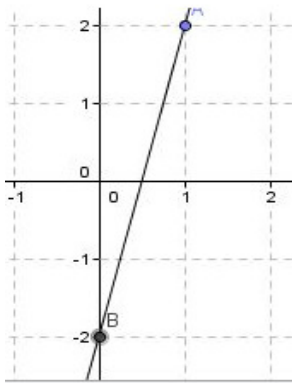


THE GRADIENT INTERCEPT METHOD

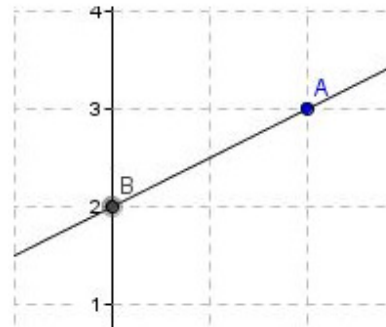
This method uses the gradient and the intercept to sketch the graphs.

Graph A is Graph B is

2) Find the equations of the following graphs



Equation is



APPENDIX L: Feedback on Moodle Use the Survey

Settings
[View 10 survey responses](#)

Survey administration

- [Edit settings](#)
- [Locally assigned roles](#)
- [Permissions](#)
- [Check permissions](#)
- [Filters](#)
- [Logs](#)
- [Backup](#)
- [Restore](#)

Response reports

- [Download results](#)

Course administration

Switch role to...

My profile settings

Site administration

The purpose of this survey is to help us understand what you value in an online learning experience. Each one of the 24 statements below asks about your **preferred** (ideal) experience in this unit. There are no 'right' or 'wrong' answers; we are interested only in your opinion. Please be assured that your responses will be treated with a high degree of confidentiality, and will not affect your assessment. Your carefully considered responses will help us improve the way this unit is presented online in the future. Thanks very much.

All questions are required and must be answered.

Relevance

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
1 my learning focuses on issues that interest me.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2 what I learn is important for my professional practice.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3 I learn how to improve my professional practice.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4 what I learn connects well with my professional practice.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Reflective thinking

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
5 I think critically about how I learn.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6 I think critically about my own ideas.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7 I think critically about other students' ideas.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8 I think critically about ideas in the readings.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Interactivity

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
9 I explain my ideas to other students.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10 I ask other students to explain their ideas.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11 other students ask me to explain my ideas.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12 other students respond to my ideas.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Tutor support

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
13 the tutor stimulates my thinking.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14 the tutor encourages me to participate.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15 the tutor models good discourse.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16 the tutor models critical self-reflection.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Peer support

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
17 other students encourage my participation.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18 other students praise my contribution.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19 other students value my contribution.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20 other students empathise with my struggle to learn.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Interpretation

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
21 I make good sense of other students' messages.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22 other students make good sense of my messages.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23 I make good sense of the tutor's messages.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24 the tutor makes good sense of my messages.	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

25 How long did this survey take you to complete?

Choose...

26 Do you have any other comments?

[Click here to continue](#)

You are logged in as NICHOLAS MLOTSHWA (Logout)

APPENDIX M: Letter from the Editor

Dr Viki Janse van Rensburg Professional Academic Editing

24 May 2017

TO WHOM IT MAY CONCERN

I hereby certify that I have edited the language of the dissertation of Nicholas Mlotshwa, submitted in fulfilment of the requirements for the degree Masters in Education in the Faculty of Education at the Cape Peninsula University of Technology, entitled

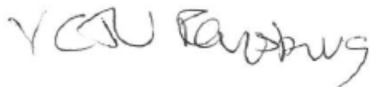
**THE EFFECTIVENESS OF A LEARNING MANAGEMENT SYSTEM IN
DEVELOPING GRADE 10 LEARNERS' CONCEPTUAL UNDERSTANDING
OF FUNCTIONS IN MATHEMATICS**

My qualifications are

PhD. Educational Psychology

M.Phil. Educational Psychology

B. Occupational Therapy



Dr. V.C. Janse van Rensburg

33 Rouwkoop Road, Rondebosch, Cape Town 7700

vikiceleste@gmail.com