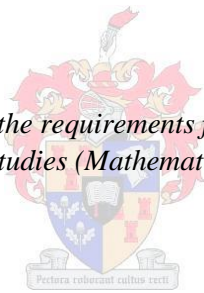


**On the feasibility of Moodle use to assist Deaf and Hard of Hearing Grade 9 learners with
mathematics problem-solving**

by

Nolan Brandon Damon

*Thesis presented in partial fulfilment of the requirements for the degree of Masters of Education in
Curriculum Studies (Mathematics Education)*



at

Stellenbosch University

Supervisor: Dr Faaiz Gierdien
Co-supervisor: Ms Lynette Collair

March 2015

Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own original work, that I am the authorship owner and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Nolan Brandon Damon

March 2015

Abstract

This thesis sets out to examine Moodle use to assist Deaf and Hard of Hearing Grade 9 learners with understanding mathematics problem-solving. The methodology used in this research project is that of formative evaluation. In this qualitative data analysis I worked as a participant-observer with three Deaf and H/H Grade 9 learners from a local school for the Deaf and H/H. These learners engaged in a course constructed in Moodle based on ratio and rate. The course was designed along the lines of a constructivist pedagogical model, different levels of learning as well as including multi representational features. Through the qualitative analysis of the interviews conducted with learners who participated in the research project and observation done by the teacher researcher, three categories emerged i.e. Weaknesses, Potential strengths and Learner suggestions. Although the findings indicate that different factors negatively impact Deaf and H/H learners' ability to solve mathematics problems, it also highlights the representational features of mathematics content via Moodle, and how it can assist Deaf and H/H learners with the struggle with mathematics problem-solving.

Opsomming

Die doel van hierdie navorsingsprojek is om te evalueer of Moodle gebruik deur Dowe en Hardhorende graad 9 leerders hulle kan help met moeilikhede wat hulle ondervind met wiskunde probleem oplossing. Die navorsing is 'n formatiewe evaluering. Binne hierdie kwalitatiewe data ontleding werk ek as 'n deelnemer-navorsers met 3 Dowe en Hardhorende graad 9 leerders by 'n plaaslike skool vir Doof en Hardhorende leerders. Hierdie leerders het deelgeneem in leeraktiwiteite wat ontwerp is in Moodle en wat gebaseer is op verhouding en koers. Die leeraktiwiteite is ontwerp inlyn met 'n konstruktivistiese pedagogiese model, verskillende vlakke van leer en multi voorstellings formate. Drie kategorieë o.a Tekortkominge, Moontlike Sterkpunte en Leerder voorstelle, het ontstaan tydens die kwalitatiewe data ontleding waar onderhoude met die deelnemers gevoer asook observasie wat gedoen is deur die deelnemer-navorsers. Alhoewel die bevindinge daarop dui dat verskillende faktore negatief inwerk op Dowe en Hardhorende leerders se vermoë om wiskunde probleem op te los, wys dit ook uit die vermoë van Moodle om wiskunde probleme voor te stel en hoe hierdie voorstellings Dowe en Hardhorende leerders kan help met wiskunde probleem oplossing.

Acknowledgements

All the praise and all the glory goes to God Almighty, for without Him, this thesis would not have been possible. He gave me strength when I was weak, He showed me the way when I was lost and He gave me insight when I prayed for wisdom.

All my thanks to Dr Faaiz Gierdien for his continuous support and motivation and always giving me positive feedback and input. I am especially grateful for his insightful comments and for keeping me focused and on track.

All my thanks to Ms Collair for advising me on Deaf and H/H learners and for giving me support based on your expertise in Deaf education.

My sincere appreciation goes to my wife, Selesty-Kay and my sons Keanu and Nevan, for all your support, prayers and motivation. Thank you for giving me the time and space to complete this thesis.

Nolan Brandon Damon

STELLENBOSCH

March 2015

Dedication

I dedicate this Master's Thesis to my wife Selesty-Kay and my two sons Keanu and Nevan. Thank you for all your sacrifices during the anti-social life I have been leading these past two years; I really appreciate it.

Table of Contents

Declaration.....	ii
Abstract.....	iii
Opsomming.....	iv
Acknowledgements.....	v
Dedication.....	vi
List of Figures.....	xii
List of Tables.....	xv
List of Abbreviations.....	xvi
Chapter 1: Introduction.....	1
1.1 Background.....	1
Aim of the study.....	4
1.2 Statement of the problem.....	4
1.3 Research Question.....	4
1.4 Research Methodology.....	4
1.5 Key concepts.....	5
1.5.1 Mathematics problem-solving.....	6
1.5.2 Deaf and Hard of Hearing.....	7
1.5.2.1 Deafness.....	7
1.5.2.2 Hard of Hearing.....	7
1.5.2.3 Models of Deafness.....	7
1.5.3 Moodle.....	8
1.6 Provisional chaptering.....	8
Chapter 2: Literature Review.....	10
2.1 Introduction.....	10
2.1.1 Background.....	10
2.2 Learning theories.....	12
2.2.1 Constructivism.....	12
2.2.2 Social Constructivism.....	13
2.2.3 Effects of Deaf and H/H learners' disability on their learning.....	15

2.2.4 Effects of Deaf and H/H learners’ disability on mathematics learning.....	16
2.2.4.1 Informal learning	16
2.2.4.2 Communication.....	16
2.2.4.3 Type of instruction.....	17
2.3 Moodle	18
2.4 Current Grade 9 mathematics content according to curriculum policy	19
2.5 Problem-solving with reference to school mathematics	20
2.6 Polya’s 4-stage model	22
2.6.1 Understanding the problem.....	22
2.6.2 Devising a plan	22
2.6.3 Carrying out the plan.....	23
2.6.4 Looking back	23
2.7 The nature of mathematics problem-solving in the case of Deaf learners	24
2.8 Strategies to assist Deaf learners with mathematics problem-solving	26
2.9 Representation.....	31
2.10 Grade 9 mathematics content represented via Moodle	33
2.10.1 Forums	34
2.10.2 WIKI	35
2.10.3 The Glossary Tool.....	37
2.10.4 Quizzes.....	38
2.10.5 Lessons.....	40
2.10.6 Assignments	42
2.11 Online course design.....	43
2.11.1 Murphy’s constructivist based pedagogical model.....	43
2.11.2 Gagne’s nine events of instruction.....	44
2.11.3 Ainsworth’s multi-representational model.....	45
2.12 Conceptual framework of this research report	46
Chapter 3: Methodology	49
3.1 Introduction.....	49
3.2 Research paradigm.....	49
3.2.1 Qualitative research.....	50
3.2.2 Quantitative research.....	50

3.3 Sampling method	51
3.3.1 Sample.....	51
3.4 Research methodology	51
3.4.1 Evaluation research.....	51
3.4.2 Types of evaluation strategies.....	53
3.4.3 Formative evaluation.....	54
3.5 Research cycle	55
3.5.1 First phase – needs assessment phase	55
3.5.1.1 Data collection	56
3.5.2 Second phase.....	57
3.5.2.1 Data collection	57
3.5.2.1.1 Instructional goals.....	57
3.5.2.1.2 Instructional content.....	58
3.5.2.1.3 Technology	58
3.5.2.1.4 Message Design	58
3.5.3 Third phase – production formative evaluation	59
3.5.3.1 Data collection	59
3.5.4 The Fourth phase.....	60
3.5.4.1 Data collection	60
3.6 Data analysis	61
3.6.1 Stages of data analysis	62
3.7 Limitations of this study	63
3.8 Validity	63
3.9 Summary.....	64
Chapter 4: The Moodle-based tasks used: data collection and data analysis.....	65
4.1 Introduction.....	65
4.1.1 Formative evaluation of the tools in Moodle	65
4.1.1.1 Number of representations	65
4.1.1.2 The way in which the information is distributed	66
4.1.1.3 Form of representational system	66
4.1.1.4 Sequence of representations.....	67
4.1.1.5 Support for translation between representations	67
4.1.1.6 Summary	67

4.2 Formative evaluation of the design of the learning program	68
4.2.1 The Constructivist-based Pedagogical Model.....	68
4.2.1.1 Multiple perspectives and representations of concepts and content are presented and encouraged.	68
4.2.1.2 Goals and objectives are derived by the student or in negotiation with the teacher or system.	68
4.2.1.3 Teachers serve in the role of guides, monitors, coaches, tutors and facilitators.	69
4.2.1.4 Activities, opportunities, tools and environments are provided to encourage metacognition, self-analysis, -regulation, -reflection and -awareness.	69
4.2.1.5 The student plays a central role in mediating and controlling learning.	69
4.2.1.6 Learning situations, environments, skills, content and tasks are relevant, realistic, and authentic and represent the natural complexities of the 'real world'.	70
4.2.1.7 Primary sources of data are used in order to ensure authenticity and real-world complexity.....	70
4.2.1.8 Knowledge construction and not reproduction is emphasized.....	70
4.2.1.9 This construction takes place in individual contexts and through social negotiation, collaboration and experience.	71
4.2.1.10 The learner's previous knowledge constructions, beliefs and attitudes are considered in the knowledge construction process.	71
4.2.1.11 Problem-solving, higher-order thinking skills and deep understanding are emphasised.....	71
4.2.1.12 Errors provide the opportunity for insight into students' previous knowledge constructions.	71
4.2.1.13 Exploration is a favoured approach in order to encourage students to seek knowledge independently and to manage the pursuit of their goals.....	72
4.2.1.14 Learners are provided with the opportunity for apprenticeship learning in which there is an increasing complexity of tasks, skills and knowledge acquisition.	72
4.2.1.15 Knowledge complexity is reflected in an emphasis on conceptual interrelatedness and interdisciplinary learning.	72
4.2.1.16 Collaborative and cooperative learning are favoured in order to expose the learner to alternative viewpoints.	73
4.2.1.17 Scaffolding is facilitated to help students perform just beyond the limits of their ability.	73
4.2.1.18 Assessment is authentic and interwoven with teaching.	73
4.2.1.19 Summary	73
4.3 The structure of the Moodle-based course	74
4.3.1 Gain attention.....	75
4.3.2 Inform learners of objectives	75
4.3.3 Stimulate recall of prior learning	76

4.3.4 Presenting the stimulus	78
4.3.5 Providing learning guidance	79
4.3.6 Eliciting performance.....	83
4.3.7 Providing feedback	84
4.3.8 Assessing performance	85
4.3.9 Enhancing retention and transfer	86
4.3.10 Summary	88
4.4 Interview and observation of learners’ interaction with the Moodle-based learning materials ..	88
4.4.1 Introduction.....	88
4.4.2 Findings.....	89
4.4.2.1 Category 1: Weaknesses	91
4.4.2.2 Category 2: Potential strengths	94
4.4.2.3 Category 3: Learner suggestions.....	95
4.4.3 Discussion.....	95
Chapter 5: Conclusion and Recommendations	98
5.1 Conclusion	98
5.2 Recommendations.....	102
Addendum A (Skedule vir Onderhoud).....	104
Addendum B (Observasie Skedule).....	115
Addendum C (Research Approval Letter from the WCED).....	123
Addendum D (Stellenbosch University Consent to participate in research).....	124
Addendum E (Participation information leaflet and assent form)	129
References.....	132

List of Figures

Figure 2.1 Dynamic, cyclic model of genuine problem-solving (Wilson et al, 1993:5).....	21
Figure 2.2: Multiple representation of Grade 9 mathematics content in the Forum module including discussions based on the representation.....	35
Figure 2.3: A multiple representation of Grade 9 mathematics content in the WIKI module.....	36
Figure 2.4: Two interactive Geogebra representations that can be used to represent Grade 9 mathematics content in the Quizzes module.....	40
Figure 2.5: A single interactive representation that can be used to represent Grade 9 mathematics content in the Lessons module.....	41
Figure 2.6: Three different representations can be used to represent Grade 9 mathematics content in the Lessons module.....	41
Figure 2.7: The Conceptual framework for the current research study.....	48
Figure 3.1: The different phases of the life cycle as it was implemented within the current research report.....	61
Figure 3.2: Data Analysis Process that was followed throughout this research project.....	62
Figure 4.1 Who wants to be a millionaire.....	75
Figure 4.2 Blokkiesraaisel.....	75
Figure 4.3: Polya’s (1945) principles and techniques of problem-solving represented visually within a slideshow with examples and interactive activities.....	77
Figure 4.4: Examples and practice exercises learners need to do while using the principles and techniques of Polya (1945).....	78
Figure 4.5: visual representation of ratio and rate.....	79
Figure 4.6: visual/textual representation of ratio and rate.....	79
Figure 4.7: algebraic/video representation of quiz questions based on ratio and rate	79

Figure 4.8: Step by step guide to solving ratio and rate problems where learners can interact with features of the representation like changing the ratio or finding similar problems.....80

Figure 4.9: Interactivity in the Lessons module where learners can increase either the speed, time or distance and experience how distance speed and rate is calculated.....80

Figure 4.10: Scaffolding feature in the quiz module where learners have immediate access to a CAS to assist them with representing ratio and rate.....81

Figure 4.11: video and textual representation of ratio and rate problems.....81

Figure 4.12 represents a graph model of rate problems where learners can interact with the graph by moving the car back and forth and simultaneously increasing or decreasing the time or the distance.....82

Figure 4.13 represents the verbal/sign language representation of ratio and rate problems.....82

Figure 4.14: Quizzes module in Moodle is used to assess learner’s performance and provide learners with immediate feedback.....83

Figure 4.15: The Assignments module used to assess learner’s performance in ratio and rate.....84

Figure 4.16: Feedback feature of the Quizzes module where learners are provided with instant feedback based on their answers.....85

Figure 4.17: different question types and the question pool within Moodle where question types can be selected and question can be imported from the question pool.....86

Figure 4.18: matching exercise in the Assignment module that is used to assess learner’s performance on ratio and rate.....87

Figure 4.19: multi-representation of ratio problems that is used to represent ratio problems in different formats.....87

Figure 4.20: Interactive template within the Assignment module where learners can construct their own representations of the ratio and rate problems.....87

Figure 4.21: representation of ratio in the Wiki module.....87

Figure 4.22: representation of rate in the Wiki module.....87

Figure 4.23 Representation of problem-solving steps in the Wiki module.....87

Figure 4.24 Coding process of the data within MAXQDA after categories and subcategories were identified.....	90
Figure 4.25 Figure 4.25: Frequency of Codes and the identification of themes in MAXQDA.....	91

List of Tables

Table 2.1 A multiple representation of Grade 9 mathematics content in the Glossary module.....	37
Table 3.1: Personal information relating to each participant’s disability	51
Table 3.2: Formative Evaluation program development within the current research project (adapted from Flagg, 1990:35).....	55
Table 3.3: The analysis of the needs identified in the current research project (Adapted from Davidson-Shivers and Rasmussen, 2006:81).....	56
Table 3.4: The stages used to analyse the data within the current research project.....	62
Table 4.1: The number of different representations that can be used within the modules of Moodle.....	65
Table 4.2: Includes a checklist of the characteristics of a constructivist online learning environment and which characteristics are present within the current research project (adapted from Murphy, 1997:13).....	74
Table 4.3: Grade 9 mathematics content and what learners should know as prescribed by CAPS (2011:14).....	76
Table 4.4: Categories and Subcategories that surfaced from the interview and observation analysis using MAXQDA together with the corresponding text units.....	90
Table 5.1 illustrates the strengths and weaknesses of using Moodle for mathematics problem-solving.....	95

List of Abbreviations

ASHA	American Speech-Language-Hearing Association
CAPS	Curriculum and Assessment Policy Statement
CMS	Content Management System
DEAFSA	Deaf Federation of South Africa
DoE	Department of Education
FAL	First Additional language
GSP	Geometer Sketchpad
H/H	Hard of Hearing
HOTPOT	Hot Potatoes quizzes
ICT	Information and Communication Technology
LAs	Learning Areas
LMS	Learning Management System
MAXQDA	MAX Qualitative Data Analysis
MOODLE	Modular Object-Orientated Learning Environment
NAPMERD	National Action Plan for Mathematics Education Reform for Deaf
NCTM	National Council of Teachers of Mathematics
SCORM	Shareable Content Object Reference Model
TU	Text Unit
VLEs	Virtual Learning Environments
WCED	Western Cape Education Department
ZPD	Zone of Proximal Development

Chapter 1: Introduction

1.1 Background

There exists very little research on mathematics teaching and learning specific to Deaf and Hard of Hearing learners in the South African context (Scott-Wilson, 2010). In particular, no research can be found on Virtual Learning Environments (VLEs) and their use in mathematics classrooms within schools for the Deaf in South Africa. I am of the view that such research can contribute to the poor performances of Deaf learners in high school mathematics. Improvements in the performances of Deaf learners in school mathematics might grant them easier access to higher education and possible career advancements.

Poor performance in the case of Deaf and H/H learners is due to a combination of timing, the type of instruction and the lack of learning opportunities they are provided. Deaf learners tend to fall behind their hearing peers when it comes to mathematical performances (Traxler, 2000). Nunes and Moreno (1998) emphasise that hearing loss is not a direct cause of the poor results that Deaf and H/H learners obtain in mathematics. Kelly, Lang and Pagliaro (2003:27) concluded in their study that the reason teachers do not create opportunities for Deaf and H/H learners to engage in stimulating mathematical opportunities to solve real world problems is due to: (1) teachers not preparing efficiently for mathematics education, (2) teachers that have preconceived ideas of the abilities of Deaf learners; and (3) that teachers see the language of instruction as the major obstacle and give more attention to language issues than to the actual skills needed to solve mathematics word problems.

According to Pagliaro (2006) the poor performance of Deaf learners in mathematics is the result of limited informal learning experience, language barriers and mathematics instruction. The researcher will argue that these three factors play a crucial role in the “development of schemata” (2006:34). Pagliaro argues that for Deaf learners to excel in mathematics, teachers should give attention to these three factors. This means that Deaf learners need to be given opportunities to explore mathematics, drawing links between what they do and do not know. It also means that opportunities should be created for Deaf learners to communicate their understanding of mathematics problem-solving and be motivated to continually reflect on what they are doing. Accordingly this can lead to their own, personal construction of mathematical concepts.

Deaf learners’ attitudes towards solving mathematics word problems is that of “impulsivity” according to Mousley and Kelly (1998:325). They note that Deaf learners tend to tackle mathematical word problems too quickly without any logical thinking. They also state that the Deaf and Hard of Hearing learners are unable to structure and perceive relevant knowledge about

the problem. This impulsivity causes learners to make mistakes more easily resulting in unsuccessfully solving mathematical problems and hence leaving gaps or unanswered questions in formal assessments. Furthermore, Pagliaro and Ansell (2002, 2012) highlights that the low performances of Deaf and H/H learners in mathematics can be due to exclusive focus on computation and basic mathematics skills in the curriculum. This focus hinders Deaf learners from engaging in word problems.

Another major obstacle that Deaf learners struggle with is the written mathematical word problems. Kelly, Lang and Pagliaro (2003), Frostad (1999) and Nunes and Moreno (1998) point out that this difficulty can be attributed to “linguistic factors”. Essentially, they are saying that the linguistic content of the written and verbal instructions of mathematics word problems can be regarded as the primary obstacle as to why Deaf and Hard of Hearing learners struggle with school mathematics and specifically mathematics word problems.

Ansell and Pagliaro (2006:154) argue that sign language can be a means of visually representing the word problem, but they also highlight the importance of the written presentation of mathematical problems. In essence this means that it is very important to include both written and visual representations of mathematics problems in Deaf learners’ teaching and learning. I draw on Kelly, Lang, Mousley, and Davis (2003:131) who concluded in their study on Deaf learners and mathematics that instruction and practice of mathematics problem-solving should include multi-step problems with a range of comparative language structures in the case of Deaf learners.

Nunes and Moreno (2002), Kelly, Lang and Pagliaro (2003), Ansell and Pagliaro (2006) and Blatto-Vallee, Kelly, Gaustad, Porter and Fonzi (2007) are of the view that visual representation of mathematics information can assist Deaf learners in mathematics problem-solving. According to them Deaf and H/H learners tend to be more dependent on their visual sense for perception, than any other remaining sense. Thus the teaching of mathematics problem-solving for Deaf learners should focus on the development of their visual thinking abilities or “concrete visualisation”. Thus, to assist Deaf learners in mathematics problem-solving, information should be directed towards their visual senses.

The use of VLEs in the case of Deaf learners makes it possible to represent mathematics problems and language in multiple formats and multiple representations. For instance Straetz; Kaibel; Raithel; Specht; Grote and Kramer (2004) show that it is possible for Deaf adults to interact and understand what is being taught. Examples of VLEs that are currently used in educational institutions include: Blackboard, Sakai and Moodle. My research report will focus on Moodle.

Moodle (Modular Object-Oriented Dynamic Learning Environment) is an example of a VLE and is a web-based Content Management System (CMS) or Learning Management System (LMS). Moodle is based on the pedagogical principles of Social Constructivism (Kaminski, 2005). This means that the use of Moodle is largely concerned with the manner in which the course content is delivered to the learners and how the learners are actively and interactively involved in constructing their own knowledge (Nedeva, 2005:15). Furthermore it means that the aim of Moodle should be to “provide a set of tools that support an inquiry- and discovery-based approach to online learning” (Kotzer & Elran, 2012:122).

Studies conducted by Giménez and Rosich (2005) on improving Deaf learners’ mathematical skills rendered positive results. These researchers agree that the use of VLEs made it possible for Deaf learners to gain access to abstract mathematical objects/theories through interacting in the VLE as well as learning from their classmates.

Another study (“Project Solve”) conducted by Kelly (2003) proved to be promising especially for Deaf learners. Not only does Project Solve assist Deaf learners in understanding mathematics but it also gives them a chance to practise their mathematics problem-solving skills independently at their own pace.

From the above, the following conclusions can be drawn:

- Deaf and H/H learners struggle with mathematics problem-solving more than their hearing counterparts.
- The linguistic structures of mathematics word problems result in Deaf and H/H learners struggling to solve mathematics problems.
- The potential of VLEs to represent mathematics problems in different formats, i.e. numerically, graphically, algebraically as well as textually at Grade 9 level.
- The value of multiple representations, especially presenting mathematics word problems in the case of Deaf and H/H learners.

Despite the fact that the Department of Education (DoE, 2004; 2007) provides a framework for Information and Communication Technologies (ICT) use especially in the case of Deaf and H/H learners, and although ICTs pose promising results for Deaf and H/H learners specific to mathematics education (DoE, 2004; NCTM, 2000), ICTs are not currently being used in South African schools for the Deaf.

Aim of the study

The principle aim of this research report is to contribute towards the development of Moodle-based mathematics learning materials to assist Deaf and H/H learners with their understanding mathematics.

1.2 Statement of the problem

In general Deaf and H/H learners tend to fall behind their hearing peers in mathematics problem-solving. This disparity in mathematics problem-solving between Deaf and hearing learners is not necessarily due to hearing loss but rather to a combination of timing, the type of instruction, the learning opportunities provided to Deaf and H/H learners as well as language (Traxler, 2000, Nunes and Moreno, 1998 & Kelly, 2003). A quick ‘fix’ to this phenomenon and a general practice in most schools for the Deaf and H/H is the use of drill and practice exercises which focus mainly on the memorisation of mathematics ideas and concepts. Although ICTs have been proven to assist Deaf and H/H learners with mathematics in general, they are seldom used in schools for the Deaf and H/H in South Africa. My view is that the presence of such an eLearning environment, which categorizes the numerous educational functions of the use of Moodle, would have huge educational value and facilitate mathematics teaching and learning for grade 9 learners that are Deaf and H/H in South Africa. This study is intended to assist Deaf and H/H Grade 9 learners (through Moodle-based mathematics problem-solving materials) in their struggle with mathematics problem-solving.

1.3 Research Question

What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?

Questions that relate to the main research question are:

- i. What strengths and weaknesses within Moodle were identified by the Deaf and H/H Grade 9 learners?
- ii. What strengths and weaknesses within Moodle were identified by the teacher researcher?

1.4 Research Methodology

This study is an evaluation or formative research which falls under the heading of development or design research (Van den Akker, 1999; Bakker, 2004), since it regards design as the focal point of research. Proponents of evaluation research argue that it is a way to improve the design of a specific programme or intervention. This means that it provides all the information needed to optimise further designs (Scriven, 1967 in Maslowski & Visscher, 1999). Also, the use of evaluation research might prevent “undesired effects and unnecessary costs as well as an increase

of design effectiveness” (Maslowski & Visscher, 1999:244). For this reason formative evaluation plays a central role within evaluation research. Van den Akker (1999) argues that the reason for this is that “formative evaluation provides the information that feeds the cyclic learning process of developers during the subsequent loops of a design and development trajectory. It is most useful when fully integrated in a cycle of analysis, design, evaluation, revision, etcetera, and when contributing to improvement of the intervention” (p.10). The aim is thus to use a formative evaluation approach to create learning material within Moodle specific to Deaf and H/H Grade 9 learners based on mathematics problem-solving. Details are given below.

A formative evaluation research conducted by Van Rooyen (2011) rendered positive results. The researcher designed an online learning programme in order to provide Grade 12 First Additional Language (FAL) learners with assistance in literature studies and included learning materials with the aim of preparing Grade 12 FAL for their final literature examinations. Van Rooyen (2011:85) concluded that: "it is possible to provide Grade 12 learners with online learning material that can result in effective learning. Moodle has several activity modules that can keep the learning experience interesting and positive and it can provide quality feedback”.

Since learning in Moodle takes place within a social context, Social Constructivism will form the underlying learning theory of this study. In addition a literature review based on mathematics problem-solving specific to Deaf and H/H Grade 9 learners will be included. Moreover it is also deemed necessary to research the design of VLEs as this will guide the study in the design of such an environment.

Although Moodle can be used for all learning areas (LAs), this research report only focusses on the use of Moodle specific to mathematics education for Deaf and H/H Grade 9 learners. The learning material created in Moodle is evaluated according to how Deaf learners assimilate mathematics problem-solving. These learning materials will be available at:

<http://www.nuwehoop.wcape.school.za>. Since language, multiple representations and problem-solving are barriers that Deaf learners have to overcome in mathematics, the activities will be evaluated and adjusted accordingly. In order to accomplish this goal I: 1) outline the learning activities in Moodle, based on problem-solving in mathematics and its formative evaluation; 2) present the findings of the formative evaluation; and 3) use the information of the formative evaluation to revise the design of the learning activities within Moodle.

1.5 Key concepts

In the paragraphs that follow I will be explaining the various definitions relating to my research question. These definitions will illustrate the context in which Moodle must be viewed and in which way it influences school mathematics teaching and learning.

1.5.1 Mathematics problem-solving

Problem-solving is defined as an exercise for which the “solution method” is not known (Moore & Martin, 2006:32). In the case of school mathematics this essentially means that the problem solver’s (or learner’s) endeavour is to comprehend the problem situation by utilising his/her mathematical knowledge and to try to find new knowledge about the problem situation to the point where he/she can “resolve the tension of ambiguity” (Nunokawa, 2005 cited in Hanna, Jahnke & Pulte, 2010:220) created by it. Problem-solving is thus “not only a goal of learning mathematics, but also a major means of doing so” (NCTM, 2000:52).

Problem-solving was endorsed by the National Council of Teachers of Mathematics (NCTM, 2000) as part of the mathematics school curriculum based on the claim that mathematics cannot exist as a discipline without problem-solving as an essential feature. Their claims are underpinned by the following reasons:

- “problem-solving is a major part of mathematics
- mathematics has many applications and often those applications represent important mathematical problems
- the intrinsic motivation embedded in solving mathematics problems needs to be taken into account
- problem-solving can be fun and used as a recreational activity
- it can develop problem-solving as an art in learners” (Wilson et al, 1993:9).

I agree with the view of the NCTM (2000) that problem-solving should be the focal point of school mathematics. A point that needs emphasising is that every one of us is bombarded with problems to solve from the moment we get out of bed in the morning, for example, what time to get up to be in time for school or work, how much to spend on an item, time management on chores and homework, etc. If learners can master the skills to solve basic problems, it will help them in their everyday life.

One of the proponents of problem-solving, Polya (1945), proposed certain steps and strategies to employ when engaging in problem-solving. These steps and strategies will be discussed in detail in chapter 2.

Specific aspects of mathematics problem-solving are highlighted within this research report. Firstly, special attention is given to the multi-representation of mathematics problems which means that these problems are being presented textually, algebraically, graphically, numerically, through tables and visually (videos, pictures). Secondly, mathematics problems are a representation of real life scenarios which means that they can be applied to everyday situations.

This notion of authentic, real life mathematics problems is proposed by Pagliaro (2006) who explicitly argues that Deaf and Hard of Hearing learners should be given the opportunity to engage in cognitively challenging mathematics problems based on real life scenarios.

1.5.2 Deaf and Hard of Hearing

1.5.2.1 Deafness

Moore (2001:6) defines deafness as: “a person whose hearing is disabled to an extent (usually 70 dB ISO or greater) that precludes the understanding of speech through the ear alone, with or without the use of a hearing aid”. In addition Berg and Fletcher (1970) argue that a Deaf child is “a hearing impaired person who can identify through hearing only a few of the prosodic and phonetic features of speech and then not enough to permit auditory recognition of sound or word combinations”. Both these views imply that Deaf individuals are completely dependent on speech reading, but also that they are unable to perceive any linguistic data through their hearing.

1.5.2.2 Hard of Hearing

Moore (2001:6) argues that a Hard of Hearing (H/H) person is one whose hearing is disabled to an extent (usually 35 to 69 dB ISO) that makes it difficult, but does not preclude the understanding of speech through the ear alone, with or without a hearing aid”. On the other hand, Berg and Fletcher (1970) define H/H as “a hearing impaired individual who can identify through hearing and without visual receptive communication, enough of the distinguishing features of speech to permit at least partial recognition of the spoken language”. This means that a H/H learner can perceive language by making use or not making use of assistive devices, i.e. cochlear implants, bone relays and hearing aids.

1.5.2.3 Models of Deafness

Scott-Wilson (2010) highlights two models in which deafness is defined: firstly according to the medical model, and secondly according to the socio-cultural model.

The medical model of deafness is defined by Wikipedia (Models of deafness, 2013) as a person who is unable to comprehend speech even in the presence of a hearing aid or a cochlear implant. Society also sees persons fitting this model as having a disease or a defect and who is unable to progress in life. Scott-Wilson (2010) argues that the medical model takes on the audio logical perspective which sees hearing as normal and deaf as abnormal; hence deafness is seen as a personal defect which needs professional medical attention.

The South African Educational Policy (Republic of South Africa, 2001) adopts the medical model with respect to deafness. This view manifests itself in White Paper 6, sections 1.2.3 and concludes that:” the South African Educational policy “will retain the international acceptable terms of

disability and impairments when referring specifically to those learners whose barriers to learning and development are rooted in organic/medical causes”.

The socio-cultural model with regards to deafness denies “seeing disability as a characteristic within the person” (Scott-Wilson, 2010:8). In other words the author believes that this model highlights the circumstantial barriers as well as discrimination against the human rights of the Deaf and hearing impaired individuals. Hence Deaf learners should not be seen as different but rather in the same sense as differences in gender or race are viewed. I agree with Scott-Wilson’s view and believe that a Deaf person needs particular requirements to communicate effectively in their respective communities. Moreover, I believe that opportunities should be created for Deaf individuals to communicate effectively and make the social context in which they interact more accessible to them.

The Deaf Federation of South Africa (DEAFSA, 2005b) emphasises the distinction between the term Deaf (capital letter “D”) and deaf (small letter “d”). DEAFSA suggests that the term “deaf” “is specific to the medical model whereas “Deaf” refers to those individuals belonging to a community that adheres to a specific culture and language (sign language), hence a Deaf community. This study sees Deaf and Hard of Hearing in line with the DEAFSA’s view of people with disabilities that deserve a fair chance in life.

1.5.3 Moodle

Moodle (Modular Object-Oriented Dynamic Learning Environment) is a web-based Content Management System (CMS) or Learning Management System (LMS) (Dougiamas, 2001). A CMS/LMS is a piece of software that “automates the administration of training events” (Itmazi & Megias, 2008:235). In essence this means that a CMS manages courses, tracks all the learners’ activities and results, provides detailed reports to management and keeps track of registered users. Furthermore it means that a CMS/LMS consists of ready-made tools that can be utilised to create dynamic content. Moodle is the leading open source CMS used by universities, colleges and schools over the world. In South Africa it is a relatively new concept in secondary schools considering that there are already 86,317 registered sites over 237 countries (Moodle statistics, 2013).

1.6 Provisional chaptering

This research report consists of five chapters. The chapters are arranged in the following format:

Chapter 1 (Introduction) provides an overview of the entire research report. Within chapter one I raise the statement of the problem as well as the research question. Furthermore a preliminary literature review is also presented in this chapter as well as an outline of the remaining chapters.

Chapter 2 provides an in depth review of literature strands on mathematics problem-solving specific to Deaf and H/H learners as well as an in depth review of literature on Moodle as an example of ICT. Furthermore I explore Moodle use in the case of Deaf & H/H learners in the middle grades (Grade 9) with special reference to South Africa.

Chapter 3 outlines the specific research methodology I used, i.e. formative evaluation research and why I chose to use this type of research as well as the criteria for the design of online learning programs.

Chapter 4 presents a detailed discussion on the literature findings as well as on the formative evaluation of the Moodle-based learning material and the Moodle tools and how it supports multi-representations of mathematics content in general and mathematics problem-solving in particular.

Chapter 5 concludes with possible answers to the research question and recommendations which the research report exposes. It also gives recommendations for further studies.

Chapter 2: Literature Review

2.1 Introduction

The main question that drives this research is:

What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?

This chapter describes literature related to mathematics problem-solving specific to Deaf learners. Firstly, it includes a brief background of the problems Deaf learners face when confronted with mathematics problem-solving. Secondly, a rationale for the learning theory, social constructivism, which underpins the design of the learning program, will be discussed. This is followed by a description of the current Grade 9 mathematics content as it is set out in the Curriculum Assessment Policy Statement, (2011) CAPS. Thereafter, a review of problem-solving in relation to school mathematics with reference to Deaf learners follows. Afterwards there is a brief description of multiple representations specific to mathematics as well as the use of ICTs in accommodating multiple representations. The chapter ends with an outline of an analytic framework that will illuminate data collection and data analysis methods.

2.1.1 Background

The problems Deaf learners experience when studying mathematics in general and mathematics problem-solving in particular is well captured in different research studies (Traxler, 2000; Pagliaro & Ansell, 2002; Kelly, Lang, Mousley & Davis, 2003). Although some researchers (Ansell & Pagliaro, 2006; Kelly & Gaustad, 2007) claim that causal factors include: a) cognitive abilities of Deaf learners, others (Lang & Pagliaro, 2007; Marschark & Everhart, 1999) contend that it is due to their b) metacognitive and c) non cognitive abilities. While some researchers (Blatto-Vallee, Kelly, Gaustad, Porter & Fonzi, 2007) assert that Deaf learners' struggle with mathematics can be resolved with proper instructional strategies, i.e. multiple representations techniques of mathematics content, others (Pagliaro, 1998 ; Kelly, 2003) argue that ICTs, especially Virtual Learning Environments (VLE), can assist Deaf learners in this matter. Proponents (Khairiree, 2010) of the use of VLEs in mathematics education believe that appropriate applications of ICTs can foster understanding in learners since it can assist learners in developing mathematical procedures, concepts and methods by way of linking learners' current knowledge with the new acquired knowledge. My own view, based on my experience with Deaf and H/H Grade 9 learners, is that VLEs, Moodle in particular, have the potential to assist them in their struggle with mathematics in general and mathematics problem-solving in particular. Firstly, Moodle can represent mathematics in an interactive manner, which is impossible through the use

of paper and pencil representations. Secondly, Moodle has a build-in vocabulary system which can be linked site wide which means that Deaf learners having trouble understanding difficult words can click on the link and it can either provide them with an explanation of the word or the sign of the word. Although I concede that causal factors like language, interpretation and reading abilities do influence Deaf and H/H learners' ability to understand mathematics, I maintain that if these causal factors are addressed within the VLEs, this could be of great assistance in their overall understanding of mathematics.

According to Van de Walle, Karp and Bay-Williams, understanding mathematics is "a measure of the quality and quantity of connections that an idea has with existing ideas" (2013:23). As an illustration, most Deaf Grade 9 learners (from my own experience) have some knowledge of fractions. They know that in the fraction $\frac{6}{8}$, the 6 and the 8 are either the numerator or the denominator. They may also know that $\frac{6}{8}$ is equivalent to $\frac{3}{4}$. However, these learners will have different understandings of the concept of equivalence. Some may have the knowledge of how to simplify fractions, $\frac{6}{8}$ and $\frac{3}{4}$ but they may not understand that $\frac{6}{8}$ and $\frac{3}{4}$ is the representation of the same quantity and it is not a reduction in size. Others may even know how to represent different fractions either through pictures, illustrations or signs. While this is indeed the case, learners have a limited set of ideas which they can use to link their individual understanding of mathematical concepts in order to make meaning.

Thus, understanding means that learners must be able to do an array of things with a particular topic in school mathematics. For instance, they need to be able to discuss what equivalence is, explain to their peers what they understand equivalence means; they also need to be able to represent fractions in different modes, generalise and apply concepts, amongst other things. (Perkins, 1993). Therefore, to assist learners in learning and doing mathematics with understanding, teachers should accommodate the construction of mathematical ideas, concepts and processes by means of carefully selecting mathematics learning resources (Khairiree, 2010). It follows then, that if learners are provided with tools to assist them in representing mathematics ideas, concepts and processes, they can link their current knowledge with new found knowledge, which in turn would lead to new knowledge construction and better understanding of mathematics content. This research report agrees with this view of providing Deaf and H/H Grade 9 learners with a set of tools to assist them in representing mathematics content and using the tools to construct new mathematics knowledge. However these tools should be accessible to Deaf and H/H learners and should create opportunities for them to experience and explore mathematics content previously inaccessible because of their hearing loss.

Before we look into learners' construction of ideas, concepts and processes in mathematics education and the Moodle tools to represent this mathematics content, we first need to look at the relation between doing mathematics and how learners learn. For this reason the two learning theories, i.e. constructivism and social constructivism, and in what way they relate to this study, will now be discussed

2.2 Learning theories

Learning theories underpin the process of how learning occurs, whether internal or external. Wikipedia defines learning theories as “conceptual frameworks that describe how information is absorbed, processed and retained during learning” (Learning theory, 2013). In other words learning theories are instruments that are used to understand how people learn. According to Van de Walle et al. (2013), the most widely used learning theories within mathematics education are constructivism and social constructivism. They claim that both these learning theories can be used jointly to explore how learners learn mathematics. For example, on the one hand constructivism can be used as an instrument to examine learners' subjective interpretation of an idea and, on the other hand, social constructivism can be used to evaluate the sociocultural effects of the learning environment on the individual's learning. The essence of this argument is that mathematics learning depends on how learners perceive mathematics content, as well as depending on the environment to which learners are exposed to and what role these factors play in influencing mathematics understanding. This research report emphasises the extent to which the learning environment can influence Deaf and H/H Grade 9 learners' mathematics understanding, hence the focus on social constructivism. These learning theories, constructivism and social constructivism, will now be looked at individually in the next section.

2.2.1 Constructivism

Constructivism is viewed by many scholars as the doctrine of knowledge. On the one hand Von Glasersfeld (in Husen & Postlethwaite, 1989) coined the word constructivism as developing a theory of knowledge and on the other hand Jaworski (2002) posits it as the philosophy of knowledge. Von Glasersfeld further argues that constructivism in education consists of two basic principles, i.e. (1) knowledge is not passively received but actively built up by the cognising subject and (2) the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality (Glasersfeld in Husen & Postlethwaite, 1989:114). In other words, learners do not come to class as if they have no knowledge or ideas of the topic at hand. They do already have their own existing ideas or knowledge of the topic, and these ideas or knowledge they use as the basis for interpreting new ideas. For this reason I believe that learners' cognitive structures or their current knowledge or ideas must be taken into consideration within the educational process, especially in the case of Deaf and H/H learners.

Equally important, Jaworski (2002) argues that each individual's cognitive structures enable them to make connections about what they already know and what they do not know, as well as allowing them to draw patterns, make generalisations and construct rules from past experiences. He called this "operative knowledge" which implies that with change and transformation of cognitive structures, knowledge is generated (Blake & Pope, 2008:59). In other words learners must reorganise their current knowledge structures, built up out of previous learning experiences, for learning to take place. My own experience yields a point that differs from Jaworski's (2002) argument. What I propose is that Deaf and H/H learners have very little experience of most mathematics concepts, and they also experience problems retrieving past learning experiences. For example, while hearing learners are constantly learning through interaction with others, or just watching television, Deaf and H/H learners must wait for formal learning situations that are accessible to them for learning to take place. As a result they (Deaf and H/H learners) miss out. So, useful learning experiences must be created for them, and this is where this research fits in.

Piaget (1999:8), on the other hand argues that any changes or transformations of cognitive structures occur when "equilibrium between the action of the organism on the environment and vice versa" takes place. He further argues that when a balance is obtained between the learners' mental schemas and the environment, they are in a well-situated state of equilibrium. Moreover he argues that these changes in cognitive structures happen through the process of assimilation and accommodation. Whereas assimilation is the process of how the individual translates what happens with respect to their current cognitive structures, accommodation refers to learners abstracting meaning from the environment by means of adapting their cognitive structures. In other words, this means that through the process of assimilation, individuals adapt knowledge from their environments to make it correlate with their existing knowledge, whilst with accommodation, individuals adapt their own way of thinking as a result of their experience with the environment. More importantly, this means that every individual is able to construct his/her own knowledge on the basis of what they think or perceive. For example, as you read this text, your brain is using your existing knowledge to make sense of what you read; if you adopt these new ideas, construction of new knowledge take place, hence learning occurs which results in better understanding.

The next section focusses on Social Constructivism as a learning theory.

2.2.2 Social Constructivism

Social constructivism encompasses beliefs that children learn and develop optimally as a result of the influence imposed by their social and cultural context (Derry, 1999 in Kaino, 2008). This view is closely related to Vygotsky's belief that the culture and social context in which the learner finds

himself/herself provides the cognitive instruments for their development (Davidson-Shivers & Rasmussen, 2006). What this means is that the cognitive development of learners is dependent on their interaction with knowledgeable others, e.g. parents, teachers and other learners. In other words while constructivism focusses on cognition as an activity dependant on the individual, social constructivism emphasises the role society or culture plays in the collective construction of knowledge. Accordingly, this also means that knowledge is mediated by society.

Vygotsky argues that mediation is the key mechanism for development and learning. This argument is well captured in what Vygotsky coins “semiotic mediation” (van de Walle et al., 2013:20). Semiotic refers to the cultural tools used to convey ideas, and mediation refers to the interchange of these cultural tools amongst individuals. For example, all mental processes are controlled by mental instruments, i.e. language, signs and symbols. Adults use these mental instruments to teach learners through social interaction. When children become aware of the existence of these mental instruments, they on their part become mediators of more elevated mental processes. More specifically, in mathematics education, ‘semiotics’ refers to mathematical symbols, i.e. equals sign, square root, etc., but it is only through classroom interaction and learning activities that knowledge about this is developed (van de Walle et al., 2013). However the meaning of such symbols can only be constructed or developed if it is within the zone of proximal development.

The zone of proximal development (ZPD) refers to the acquisition of knowledge by an individual with the assistance of his/her peers or a knowledgeable other (Vygotsky, 1978). Vygotsky claims that the zone of proximal development constitutes the amount of learning experience one learner can obtain when provided with the desired learning environment. This means that in the ZPD, the teacher and the learner collaboratively work together on a problem, because the learner finds it difficult to do on his/her own. It also means that learning activities should be broken down into small chunks; however these chunks should increase in difficulty.

Powell and Kalina posit that social constructivism is a “highly effective method of teaching that all students can benefit from since collaboration and social interaction are included” (Powell & Kalina, 2009:243). These researchers agree that when learning takes place in a social context, learners not only learn from their peers, parents or teachers, but they are actively involved in the learning process through critical reflection. Moreover, I would argue that teaching and learning mathematics specifically to Deaf and H/H learners should focus on social interaction which must include clear direction from the teacher, collaboration with other learners and sound communication via sign language.

A recent study conducted by Stears (2009) serves as proof that knowledge can be collectively constructed through collaboration and social interaction. The aim of the study was to expose forty-five isiXhosa speaking Grade 6 learners in a school in the Western Cape, to a social and critical constructivist's approach to science teaching and learning. Not only did learners' participation through these activities improve but it also increased learners' interest, because the activities focussed on their cultural and social settings. Moreover, these findings are in line with Vygotsky's view of "a culturally diverse learning environment" (1962:133). This view highlights the importance of the learners' social and cultural environments in giving meaning to their learning process, and further points out that cultural learning is what happens first in the child's life, it is only afterwards that individual learning takes place.

This section of the research report focusses on the effects that Deaf and H/H learners' disability has on the process of learning.

2.2.3 Effects of Deaf and H/H learners' disability on their learning

According to the American Speech-Language-Hearing Association (ASHA, 2014), hearing underpins speech and language development, communication and learning. Essentially this view highlights that any hearing loss results in a delay in the ability to communicate effectively. Furthermore it means that Deaf and H/H learners cannot express themselves correctly, due to this language deficit. The essence of this argument is that hearing loss affects the development of vocabulary. For example, Deaf and H/H learners learn concrete vocabulary like *dog, cow, boat, table*, faster than abstract words like *a, an, the*. At the same time they find it difficult to understand words with the same meaning (synonyms). Because of this vocabulary deficit they use simpler sentences and find it difficult to understand and write complex sentences, because of the linguistic structure of the sentences. Moreover, since they cannot hear words or sentences, they cannot make meaning by connecting what they already know about the word or sentence. Since language is crucial in every area of their lives and since they have gaps in their language structure due to their hearing loss, it influences the process of learning.

The order in which sentences are structured in Afrikaans is also a major problem for Deaf and H/H learners. Take, for example, a sentence like: *Ons kry wiskunde die periode na eerste pouse* (*we have mathematics just after the first break*). In Sign Language this sentence will be signed and understood as: *een pouse kla wiskunde*. For this reason, teaching of any language should be in line with the manner in which Deaf and H/H learners translate the sentence in Sign Language.

In the next section I look at how Deaf and H/H learners' disability affects their learning of mathematics.

2.2.4 Effects of Deaf and H/H learners' disability on mathematics learning

Researchers have long assumed that Deaf and H/H learners' poor performance in mathematics is due to their hearing loss. However evidence presented by Nunes and Moreno (1998) claims that hearing loss is not a direct cause of poor performances in mathematics. This is not to say that their hearing loss has no influence at all, but rather that other factors like informal learning, communication and the type of instruction play a major role in Deaf and H/H learners learning of mathematics (Pagliaro, 2006). Although some may object, I tend to agree with this view. I will now look at these factors individually and highlight how they influence Deaf and H/H learners' learning of mathematics.

2.2.4.1 Informal learning

Firstly, because Deaf learners cannot perceive any sound whatsoever, it makes it extremely difficult for them to gain access to informal learning (Pagliaro, 2006). This means; that while hearing learners are exposed to all types of sounds and communication through friends, television, shops, sports, etc., and can acquire basic mathematical knowledge and vocabulary, for example, a fuel price drop announced on the radio, advertisements about sales over loudspeakers or just the counting of stones out loud, it is not accessible for Deaf learners. Accordingly, Deaf and H/H learners enter the mathematics classroom with either a limited basic knowledge of mathematics vocabulary or a distorted view of mathematical topics due to their limited experience of informal mathematics learning. I have personally encountered this problem. For example, concepts like 'in front', or 'behind', or even 'the next two numbers', are concepts that need to be taught to Deaf and H/H learners.

2.2.4.2 Communication

Language encompasses the ability to understand those around one as well as the need to be understood by others. Proponents of mathematics education for Deaf and H/H learners all agree that language difficulties underpin poor performance in mathematics, especially mathematics problem-solving (Barham & Bishop, 1991; Kelly & Mousely, 1999; Kidd & Lamb, 1993; Kidd, Madsen, & Lamb, 1993). These researchers' theories are extremely useful since they shed light on the difficult problem of reading and comprehension. Although it is documented that reading and interpretation problems persist with mathematics problems in English, it is the same for Afrikaans mathematics problems as well. The reason may be that Afrikaans is not the Deaf and H/H learners' home language. Their home language is Sign Language. Secondly, sentence construction within a mathematics problem in Sign Language and sentence construction in mathematics (Afrikaans) problems differ. Thirdly, Sign Language is not an official language and therefore very few mathematics signs exist. While teaching mathematics to Deaf and H/H

learners, I have to search in advance for signs that represent mathematics topics and then translate the Afrikaans mathematics concepts into sound Sign Language signs. Because the structure of Afrikaans as a language and Sign Language differs, and since mathematics is also a language on its own, it poses further interpretation problems. Furthermore, signs are borrowed from either American Sign Language or British Sign Language. This further causes confusion amongst Deaf and H/H learners because every teacher creates a different set of signs and there are no set standards.

2.2.4.3 Type of instruction

Teaching and learning of mathematics in classrooms for the Deaf and H/H learners is still dominated by teacher - directed instruction (Pagliaro, 2006). Although a reformed mathematics curriculum in the case of Deaf and H/H learners was proposed by NAPMERD, the reality is that classrooms are still underpinned by the memorisation of concepts and formulas through drill and practice exercises. So, instead of challenging Deaf and H/H learners' higher order thinking skills with real life mathematics problems, teachers tend to expose learners to simple calculations with less demand on their cognitive abilities. Furthermore, I would point out from my own experience teachers in the lower grades tend to skip mathematics word problems altogether, due to their language and interpretation problems. Instead of addressing these issues through intervention strategies, teachers focus on teaching step by step strategies or previously worked out examples. Accordingly, learners have very little experience of true mathematics problem-solving when they enter higher grades. Previous work on education for Deaf and H/H learners, by Pagliaro (1998); Kelly (2003); Stinson, Elliot, Kelly, Liu (2006) and Marschark, Sapere, Convertino and Pelz (2008) supports the view that adopting alternative instructional strategies can make content more accessible to Deaf and H/H learners.

To summarise, awareness of the extent to which hearing loss influences Deaf and H/H learners' learning ability, could and should result in intervention strategies being put in place to assist them in their difficulties with learning in general and the learning of mathematics in particular. Since my belief is that Deaf and H/H learners have the same intellectual potential as their hearing peers, I argue that making use of a LMS that accommodates the difficulties Deaf and H/H learners experience with learning, specifically in mathematics, I might add that representing mathematics information in a manner Deaf and H/H learners can comprehend, can assist them in understanding mathematics in general and mathematics problem-solving far better.

2.3 Moodle

This section of the research report will look at Moodle as a VLE and the characteristics of Moodle to represent mathematics content.

The design and development of Moodle is underpinned by the principles of social constructivism. Evidence of this claim is well established on Moodle's website (Philosophy of Moodle, 2012), where it is stated that: "Underpinning the dynamic view of learning is a new theory of knowing: social constructivism, which portrays the learner as an active conceptualiser within a socially interactive learning environment". Basically what this means is that learners can construct their own knowledge by interacting with other learners, and the teacher, in an online learning environment. So, while learners are engaging in activities, or watching other learners representing their knowledge, they measure it against their own knowledge and if they find this new knowledge feasible, they adopt it and new knowledge is constructed.

Further evidence of the claim that Moodle can assist learners in their knowledge construction is highlighted in a study conducted by Khairiree (2010) on the use of Moodle and the Geometer's Sketchpad (GSP) plug in. The aim of the study was to explore how Moodle use can assist learners in constructing their mathematical knowledge. He draws his conclusions from students who attended the business mathematics course of Suan Sunandha Rajabhat University in Bangkok, Thailand. The research findings indicated that the use of Moodle and Geometer's Sketchpad provided opportunities for learners to construct their own mathematical knowledge and broaden their understanding of mathematical concepts.

A distinctive feature of Moodle is that it can be used to represent mathematics content online through its tools and plugins (Cole & Foster, 2007). Plugins are tiny tools that provide functionality to Moodle courses. Different plugins can be freely downloaded and installed into one's Moodle site. Examples of such plugins include: Geogebra (maths plugin), WIRIS (maths plugin), STACK (maths plugin), Games, Skype and many other plugins (About Moodle, 2008). These plugins can be updated further at any time, as they become available. Not only do these plugins enhance the learning process, but Moodle provides space for learners to interact with content which cannot be achieved through pencil and paper exercises.

Martín-Blas and Serrano-Fernández (2009) conducted a study on Moodle use in the Physics class. These researchers found a constant improvement in the physics scores of learners who engaged in the Moodle-based physics learning material. They claim that through the use of Moodle, physics content could be represented in different formats with which learners could interact. Accordingly, the students in the study acknowledged that their interaction with the learning materials within Moodle "helped them reinforce their abilities and knowledge of physics content" (Martín-Blas

and Serrano-Fernández, 2009:44). This claim further supports the philosophy of Moodle; knowledge construction by means of social interaction and multiple representation of content by making use of the tools in Moodle. The question that should be raised is whether this can be done with mathematics content. In the next section I will first highlight the mathematics content according to CAPS (2011) which will be used in the current research report and then describe how the tools in Moodle will be used to represent this mathematics content.

The question that should be asked is: How does Moodle as an LMS relate to the learning theories as well as accommodate the effects of Deaf and H/H learners' disability on their learning?

Firstly, Moodle relates to constructivism and social constructivism through its interface design (Cole & Foster, 2007). This means, while other Learning Management Systems (LMS) present users with a list of tools as part of the interface, in Moodle, the tools are built into the Moodle interface, because the learning task is the essence and the focus. Accordingly, each user can organise his/her Moodle courses in a weekly, topical or social format. Additionally, Moodle is not like any other LMS, where course creators are encouraged to upload static content. Since Moodle is not a delivery portal, it makes use of its tools for discussions, creating and sharing ideas. So, the focus is not on dissemination of information but on sharing ideas and constructing new knowledge through social interaction between learners, their peers and teachers. The next section will shed more light on Moodle as a LMS and its potential use in representing mathematics content.

2.4 Current Grade 9 mathematics content according to curriculum policy

Mathematics as a school subject is a “language” that consists of “symbols” and “notations” to distinguish the relationship that exists between numbers, graphs and geometrical figures (Republic of South Africa, 2002; Curriculum and Assessment Policy Statement, 2011). Both the NCS and CAPS Grades R-12 emphasise the aim of equipping “learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfilment, and meaningful participation in society as citizens of a free country” (DoE, 2011:4). Moreover, the purpose of these statements is to develop all learners' critical and creative thinking skills in order for them to identify and solve problems as well as make their own decisions. Furthermore the aim of CAPS (2011) is to develop learners' understanding of the world as a set of interrelated systems and that problem-solving is not to be separated from any of these systems (p.5).

The Senior Phase Mathematics Curriculum and Policy Statement Grades R - 12 (CAPS, 2011) provides teachers in South Africa with the framework, for teaching and learning mathematics. According to this framework the teaching and learning of school mathematics aspires to develop

learners' knowledge and skills that are essential for the "application of mathematics to the physical, social and mathematical problems" (DoE, 2011:8). Therefore to demonstrate these skills, learners need to learn to pose and solve problems, as well as learn how to examine, represent and translate mathematics information.

Mathematics in the Senior Phase consists of five main content areas. These content areas are:

- Numbers, Operations and Relationships
- Patterns, Functions and Algebra
- Space and Shape
- Measurement
- Data handling

CAPS prescribes that problem-solving should feature in each of these content areas, hence it is described as "solving problems in context" (CAPS, 2011). For *Numbers, Operations and Relationships*, the solving of problems in context consists of: 1) ratio and rate and 2) direct and indirect proportion. Furthermore, it includes problems involving speed, distance and time as well as the ratio between two quantities. Since these types of problems are presented in sentence format, Deaf learners find them difficult to comprehend due to their limited vocabulary, language difficulties and sentence construction. They usually struggle to answer questions of this nature and leave them blank. Since I have experienced this problem with all the Deaf learners whom I have taught school mathematics over the years, I needed to find a way to assist them in their struggle with mathematics problem-solving at the Grade 9 level, in particular.

This research report is thus a means to assist Deaf and H/H learners in their struggle with these types of problems by making use of learning material created in Moodle-based on ratio and proportion problems. I will now look at problem-solving specific to mathematics education.

2.5 Problem-solving with reference to school mathematics

This section of the current research report describes mathematics problem-solving. Firstly, I will describe what mathematics problem-solving is and the models on which it is based. Secondly, I will highlight different strategies that are in place to assist learners in mathematics problem-solving. Finally, I will argue for the use of ICTs to assist Deaf learners in mathematics problem-solving.

Problem-solving is defined as an exercise for which the "solution method" is not known (Moore & Martin, 2006:32). In the case of school mathematics this essentially means that the problem solver's (or learner's) endeavour is to comprehend the problem situation by utilising his/her

mathematical knowledge and try to find new knowledge about the problem situation up to the point where he/she can “resolve the tension of ambiguity” (Nunokawa, 2005 cited in Hanna, Jahnke and Pulte, 2010:220) about it. Problem-solving is thus “not only a goal of learning mathematics, but also a major means of doing so” (NCTM, 2000:52).

Polya (1945) suggests four basic principles in mathematics problem-solving, i.e.:

- Understand the problem
- Devise a plan
- Carry out the plan
- Look back, review the problem and the possible solution

According to Polya the essence of mathematics education should be to teach learners how to think. This, however, should never be confused with teaching learners “what to think” or even “what to do” (Wilson, Fernandez & Hadaway, 1993:4). Moreover, most textbooks over-emphasise procedural knowledge in the case of problem-solving by posing linear approaches. These linear approaches in textbooks imply that mathematics problem-solving is:

- a step by step process and always in a certain sequence
- the steps and procedures can be memorised and practised
- a process of obtaining an answer(Wilson et al, 1993)

These researchers further argue for a framework to highlight the “dynamic and cyclic nature of genuine problem-solving” (Wilson et al, 1993:5). The following figure sheds light on Polya’s 4-step model which Wilson et al refers to as cyclic and dynamic in nature:

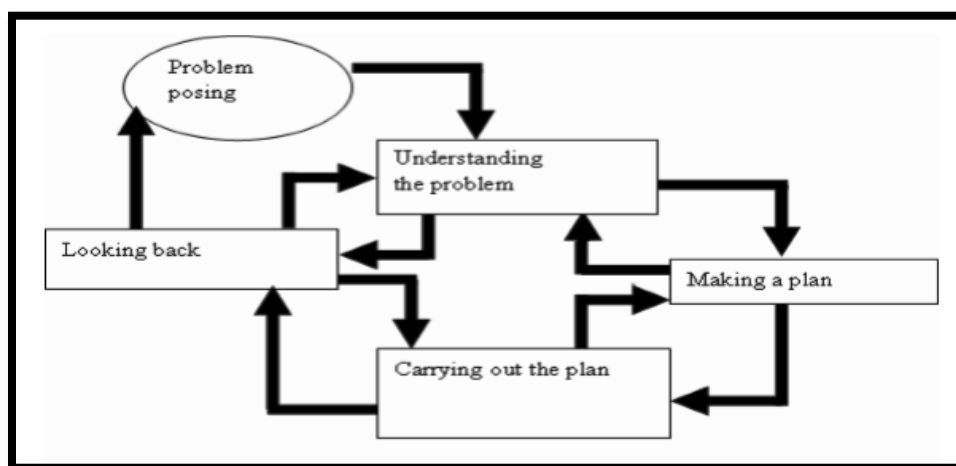


Figure 2.1: Dynamic, cyclic model of genuine problem-solving (Adapted from: Wilson et al, 1993:5).

The cyclic model in figure 1 illustrates that a learner can start by understanding the problem. However, while making a plan, the learner may realise that his/her understanding of the problem

is vague. In addition, the learner may have already implemented a plan and discovered that the plan does not work. Hence, the learner may develop a new plan or come to a better understanding of the problem. Figure 2.1 illustrates that problem-solving based on Polya's 4-step model, which is used in this study, is not a linear process. These steps are all interwoven with one another and learning material created in all the steps depends on each of the others in order to gain success in the whole process of mathematics problem-solving. I will now look at the different stages of Polya's model in particular.

2.6 Polya's 4-stage model

2.6.1 Understanding the problem

During this stage learners should focus on understanding the problem. They should distinguish between what is known and what they need to find out. Furthermore, learners need to extract the useful information and eliminate the less useful information. Polya (1945) argues that it is crucial that learners learn to restate the problem in their own words; it is only then that they can come to a sound understanding of the problem. Questioning is an essential tool that teachers can use to see whether learners truly understand the mathematics problem. Mochesela (2007:34) claims that questioning can highlight misunderstandings or gaps in learners' comprehension of the problem, "especially in the case where language maybe a barrier".

In my view this stage is crucial especially in the case of Deaf learners. Since Deaf learners struggle to grasp words and phrases in the mathematics problems with which they are unfamiliar, these words and phrases need to be clarified. Since misinterpreting these words can lead to learners not understanding the problem completely, and thus failing to solve the problem correctly it is important that teachers focus on questions such as: "What is the unknown? What is the data? What is the condition?" (Polya, 1945:26).

2.6.2 Devising a plan

When learners completely understand the problem, they need to devise a plan to go about solving this problem. Polya (1945) argues that it is relatively easy to select a plan or strategy to follow when you have enough experience in solving problems. However, Van de Walle (1998 in Mochesela, 2007) argues that learners should not only ask themselves what strategy or plan will best solve the problem, but teachers should also create opportunities for learners to devise their own plans, rather than give them a template with which to work. In other words, learners should be given ample opportunities to use strategies to try and represent the problem in a format that makes the problem clearer to them. Polya (1945) suggest that learners' attention should be focused on related problems. This means that they should look at the unknown and "try to think of a familiar problem having the same or a similar unknown" (Polya, 1945:28). Recalling similar

problems solved with the same ‘unknowns’ can assist learners in solving the current problem. The researcher further suggests that if learners are not able to solve the problem at hand they should be encouraged to solve similar problems.

Polya (1945) suggests the following strategies that learners can be taught in order to assist them in their quest to problem-solving. However, it should be noted that knowing these strategies does not guarantee success in problem-solving.

- Guess and check
- Look for a pattern
- Construct or draw a table
- Eliminate possibilities
- Make an orderly list
- Use symmetry
- Draw a picture
- Solve a simpler problem
- Act it out
- Make a model
- Work backwards
- Write an equation
- Use deductive/logical reasoning

2.6.3 Carrying out the plan

A well-developed plan gives a learner a clear indication of which route to take in solving the problem. Moreover, this means that the plan needs to be developed by the individual who is going to implement the plan. During this stage it is crucial that learners carry out their own constructed plan and not a template the teacher has developed since this can result in learners forgetting their plans, carrying out the plan inconsistently and not resolving the problem. A crucial point at this stage is that “the student should be honestly convinced of the correctness of each step” (Polya, 1954:30). As a result, teachers should focus learners’ attention on evaluating each step not just to see whether the step is correct but by proving why the step is correct.

2.6.4 Looking back

It has been remarked upon that when learners find the solution to the problem, they close their books or move on to another problem (Polya, 1945). Moreover, by neglecting to re-evaluate or re-examine the plan they used or the solution they obtained, they not only miss the most important phase of problem-solving but they do not “consolidate their knowledge and develop their ability

to solve problems” (Polya, 1945:30). Teachers should focus learners’ attention on reflecting on their solutions in order to come to a better understanding of the solution and to rule out the obvious: that a problem only has one answer and one plan of action. Furthermore, it is important for learners to remember the important aspects of their progress towards their solutions. In addition, learners should reflect on where in the cycle of progress they got stuck and what helped them in overcoming that obstacle as well as their “EUREKA” moments (Deepak, 2012:17).

Since mathematics problem-solving is based on Polya’s (1945) model of approaching and solving mathematics problems, many teachers apply it in a linear fashion and not as a set of interrelated phases, where one phase can be revisited more than once. This should be considered to be especially important in the case of Deaf learners, since Deaf learners experience mathematics problems in a manner different from their hearing peers. In the next section, I will look at the nature of mathematics problem-solving in the case of Deaf learners.

2.7 The nature of mathematics problem-solving in the case of Deaf learners

Frostad and Ahlberg (1999) posit that the semantic composition of the mathematics problems affected the level of difficulty deaf learners experience with mathematics problem-solving. These researchers studied Norwegian Deaf and H/H learners aged between six and ten years old and their quest to solve arithmetic problems in a non-reading format. Not only did they find that when Deaf learners struggled to understand the structure of the mathematics problem, they experienced difficulties in solving the problems, but they also interpreted the meaning of the mathematics problems in three different ways, i.e. a) as numbers and procedures, b) as take-away situations and c) as part of a whole relation (Frostad & Ahlberg, 1999:283). Though I concur with Frostad and Ahlberg’s view, I still insist that when mathematics problems are presented in a format that is accessible and in line with the sign language structure, the learners will have less difficulty understanding the problem. Researchers like Kidd (1991), Pagliaro and Ansell (2002) and Pau (1995) might not agree with me on this since they believe that representation of mathematics problems complicates Deaf and H/H learners’ linguistic and interpretation abilities due to the complexities of sign language. However, I still believe that adjusting the representation of mathematics content will assist Deaf learners in their struggle with mathematics problem-solving.

My view that mathematics problems should be presented in an accessible format was heavily influenced by Zarfaty, Nunes and Bryant (2004) who examined how well three- to four-year-old Deaf learners remember and reproduce numerical information. They also evaluated whether difficulties in remembering and reproducing numerical information are dependent on the mode of representation. Their results indicate that Deaf and Hard of Hearing learners performed equally well in comparison with their hearing peers when the numerical information was presented in a temporal mode. Moreover, when the numerical information was presented in spatial mode, the

Deaf learners outperformed their hearing peers. These findings together with my own experience emphasise the importance of representing mathematics information in a spatial mode, and that Deaf learners will benefit from instruction that focusses on multiple representation of mathematics problem-solving in particular.

Adding to Zarfaty, Nunes and Bryant's (2004) argument, I would point out that visual problem-solving strategies could make mathematics problems more accessible to Deaf and H/H learners. Not only did Mousley and Kelly (1998) find this to be true while conducting research on Deaf college students but they also added that when visualisation strategies were used the Deaf college students outperformed their hearing counterparts. Moreover, Mousley and Kelly found that Deaf college students' performances in mathematics problem-solving could be complemented by various modes of analytic strategies which included multiple representations of mathematics problems. This further strengthens my own argument that multiple representations of mathematics problems can assist Deaf and H/H learners in their struggle with mathematics problems.

Kelly and Mousley (2001) also share in this view and present their argument with ample support. They presented forty-four Deaf and hearing college students with thirty mathematics problems to solve. These thirty mathematics problems were presented in two groups. The first fifteen were presented as numeric/ graphics mathematics problems whilst the second fifteen were presented as mathematics word problems. Furthermore, the Deaf learners were divided into three groups according to their reading ability. The results of the research study showed that regardless of the Deaf learners' reading ability, when mathematics problems were presented in a numeric/graphics format they performed equally as well as their hearing counterparts. Moreover when mathematics problems were presented in a textual format with only one dimension in the problem-solving task they performed similar to their hearing peers.

In discussions by Ottem (1980, in Blatto-Vallee, Kelly, Gaustad, Porter, & Fonzi, 2007); Lang and Pagliaro (2007), Kelly, Lang, Mousley and Davis (2003) and Kelly and Mousley (2001) one controversial issue has been Deaf learners' struggle with mathematics problems when the complexity of the problems increase. In other words when the mathematics problem consisted of unfamiliar words, Deaf and H/H learners found it difficult to understand and solve. On the one hand Kelly, Lang, Mousley and Davis (2003) argue that it presents reading difficulties to Deaf students. On the other hand Kelly and Mousley (2001) contend that computational errors, skipping word problems as well as an approach of 'just getting it done', influences Deaf learners' ability to solve complex mathematics problems more than it influences their reading abilities. Others like Ansell and Pagliaro (2001) maintain that when translating mathematics word problems into sign language it changes the problem type but also changes the difficulty within the

problem type. The study further highlights the presentational characteristics of sign language and if used appropriately can create understanding amongst Deaf learners specific to mathematics problem-solving. My view is that when mathematics problems are presented in line with the sign language structure and in multiple formats, making use of different representational strategies, it can assist Deaf and H/H learners to solve mathematics problems.

As seen from the above arguments it becomes apparent that Deaf learners struggle with mathematics word problem-solving. Although many researchers claim that factors relating to Deaf learners' struggle with mathematics problem-solving occur on the cognitive level (language and sign language), meta-cognitive level (how learners manage their own thinking) and non-cognitive level (beliefs and affections), others (Bardelle & Ferrari, 2010) posit that eLearning platforms have the potential to assist all learners in mathematics education on all three levels, especially their beliefs towards mathematics. Essentially I am arguing that eLearning platforms, specifically Moodle, have potential strengths to assist Deaf and H/H Grade 9 learners in their struggle with mathematics problem-solving.

I will now look at different strategies used to assist Deaf learners in their struggle with mathematics problem-solving.

2.8 Strategies to assist Deaf learners with mathematics problem-solving

A number of researchers have developed strategies to assist Deaf and H/H learners with their struggle with mathematics problems solving. These strategies are in line with the NCTM (2000) principles for teaching and learning mathematics, which emphasise the importance of teaching learners to make connections between their prior knowledge of mathematics concepts and the newly acquired mathematics concepts while they are solving problems (Blatto-Vallee, Kelly, Gaustad, Porter, & Fonzi, 2007; Lang & Pagliaro, 2007). In the words of Lang and Pagliaro (2007) one of this view's main proponents, is that "mathematics should not be taught to deaf students as a discrete series of computational skills...rather an approach that emphasizes reasoning based on understanding of the content and follows a constructivist view of learning mathematics is likely to be more beneficial". According to this view, Deaf learners should be given ample opportunity to discuss, represent and interact with mathematics content, so that new knowledge can be constructed by the Deaf learners. To summarise, the issue whether representing mathematics content, interacting with mathematics content or discussing mathematics content can assist Deaf and H/H learners in their struggle with mathematics problem-solving.

Evidence of the above view is well captured in research findings of Lang and Pagliaro (2007) who claim that when mathematics geometry problems were depicted as mental representations, the recall rate of Deaf learners was higher. They investigated the factors predicting mathematics

recall of Deaf high school learners and found that an imaginative re-creation of mental representations of problems is an important skill especially in mathematics problem-solving. In other words, if learners can mentally construct representations of mathematics content, it can foster better problem-solving skills. My own view is that providing Deaf and H/H learners with opportunities to engage in mathematics discussions and exposing them to interaction with mathematics content through the use of VLEs as well as providing them with the tools to represent mathematics in multiple formats can help them not only with mentally creating representations but also the solving of mathematics problems.

The argument of imaginative re-creation of mental representations of problems is grounded in the argument of Douville, Pugalee, Wallace and Lock (2002:9) stating: “it follows that mental imagery strategies can also serve to help students concretize abstract mathematical concepts in ways that facilitate more effective problem-solving”. What this means is that the visual representation becomes the learner’s own “mental blackboard,” an “active and dynamic information-processing event that can aid the learner in problem-solving activities, especially those that are representative of unfamiliar or novel situations” (p.7). Although I concede Douville, Pugalee, Wallace and Locks’ (2002) view of mental imagery, I maintain that providing Deaf and H/H learners with tools to construct representations, can assist them in constructing their own mathematics knowledge and hence assist them with mathematics problem-solving. Essentially I am arguing not that we should focus solely on mental imagery per se, but on multi-representations of mathematics problems and to providing Deaf learners with the tools to represent problems in a format they find suitable to understand.

Kelly, Lang and Pagliaro (2003) on the other hand identified eight problem-solving strategies specific to Deaf Grade 6 -12 learners and their struggle with mathematics word problem-solving:

- identifying the target goal (what is to be solved)
- making a plan
- identifying the key information
- evaluating one’s plan and solution
- hypothesis generating and testing
- estimating
- testing trial and error approach
- dividing a problem into sub problems (two or more procedural operations)

Pagliaro and Ansell (2002:109) suggest a process for solving mathematics word problems in the case of Deaf learners. Firstly, they need to understand the problem situation, i.e. “identify a representational schema”. Secondly, they need to visualise the mathematical situation and

compute the answer, i.e. “activate an action schema”. Finally, they have to evaluate and check. These researchers further argue that the more frequently Deaf learners are presented with mathematics word problems, the more “it will help them develop robust and extensive schemata necessary for effective problem-solving” (Pagliaro & Ansell, 2002:1116). They further argue that a need exists to develop alternative instruction methods, one of which includes Deaf learners constructing their mathematical knowledge through problem-solving.

Although these strategies can be helpful, the strategies can also propose that problem-solving is a linear process which needs to be followed from a to z. From my own experience while working with Deaf and H/H learners, when presented with strategies to follow, they tend to memorise the steps and follow them just as they are presented to them. In my view following these strategies as a linear process might exclude the use of real life problems, and focus solely on textbook problems. In Lang and Pagliaro’s (2007) work they offered hard critiques of the use of textbook problems instead of true problem-solving activities. As the researchers themselves state, true problem-solving includes “time spent on high quality and meaningful teaching/learning activities that build knowledge through critical thinking, reasoning, and the synthesis of various information and skills” (Lang & Pagliaro, 2007:449). Although Lang and Pagliaro (2007) believe that Deaf and H/H learners should be presented with enough cognitively challenging mathematics problems, Kelly, Lang and Pagliaro insist that more focus should be placed on “the development of critical thinking, reasoning, synthesis of information, and other essential skills needed for effective problem-solving” (2003:116).

In recent discussions on strategies or ways of representing mathematics problems, a controversial issue has been what types of visual representation strategies should be used for presenting mathematics to Deaf learners. On the one hand, some (Blatto-Vallee, Kelly, Gaustad, Porter, & Fonzi, 2007) argue that when Deaf learners’ visual-spatial pictorial representation of mathematics problems increased, their test scores on the fifteen mathematics problems decreased. Furthermore, they noticed that when the visual-spatial schematic representations of the mathematics problems increased, the test scores increased. On the other hand, however, others (Presmeg, 2006) posit that the concrete imagery, which is one type of visual imagery strategy, is somewhat problematic, since it distracts learners’ attention away from the actual problem by bombarding them with irrelevant information. He further argues that pattern imagery, another form of visual imagery, is an essential skill in mathematics problem-solving and this involves relationships between mathematical objects depicted in a visual representation.

Although I agree with Blatto-Vallee, Kelly, Gaustad, Porter, and Fonzis’ (2007) view, I also support Presmeg’s (2006) notion of pattern imagery. I therefore believe that when Deaf/Hard of

Hearing learners apply visual spatial schematic representations to demonstrate the spatial relation comprised in mathematics problems, it will result in greater success in solving the mathematics problems. For this reason I not only included both these representations while constructing the Moodle-based learning materials but have also created space for learners to use the tools in Moodle to construct their own representations.

Although there is currently no separate mathematics curriculum for the Deaf and Hard of Hearing learners, a document titled *Moving towards the Standards: A National Action Plan for Mathematics Education Reform for the Deaf* (NAPMERD) (Dietz, 1995) was compiled by mathematics teachers for the Deaf and Hard of Hearing. The document highlights the need for a change in the mathematics education for Deaf learners but one that is parallel to the NCTM's standards. Furthermore NAPMERD also includes recommendations for pre- and in-service teacher training programmes, formal assessment and research as well as the specific issues Deaf learners encounter when doing mathematics (Pagliaro, 1998). Essentially NAPMERD encourages a reform based mathematics curriculum for Deaf learners (Pagliaro, 1998). Not only is a reform based curriculum learner centred, but the curriculum also focusses on the conceptual development of Deaf learners. Moreover, the main focus of a reform based mathematics curriculum is real world problem-solving which features throughout the whole curriculum. Additionally learners are presented with opportunities to construct their own knowledge through social interaction and reflection and by making use of manipulatives to assist them in their learning of mathematical concepts and mathematics problem-solving.

Moore and Martin (2006) propose a curriculum framework for the Deaf and H/H which should include the following:

1. "a strong curriculum which gives Deaf and H/H learners ample opportunities to exercise reason in depth
2. the curriculum should be based on a constantly changing body of knowledge...must be constantly adapted and that Deaf and H/H learners must assist in creating the curriculum
3. the curriculum must make learners aware of social injustices and be aimed at arming them to fight against social injustices
4. the curriculum must be creative and exciting and must be based on real life experiences;
5. it must prepare learners to encode and decode any type of information" (Moore & Martin, 2006:17)

Although I agree with all the proposed points within this framework it is especially points 1, 2, 4 and 5 that gain my attention. Although some might object to point 4, I believe that Deaf and H/H learners should be partakers in curriculum construction. For this reason this study makes use of

three Deaf and H/H learners to guide the construction of Moodle-based learning materials. I also believe that learners should be provided with tools to assist them in understanding (encode and decode) information, hence the use of Moodle tools to construct mathematics content which in turn might help them in understanding mathematics problems.

Additionally Moores and Martin (2006) suggest the following principles for teaching Deaf and H/H learners:

1. Teaching must be inquiry and problem-solving based. This means that learners should be actively engaged in their own knowledge construction and skilled in problem-solving
2. Instead of covering large amounts of curricula, the focus should be on depth of understanding. This means that teaching should focus on acquiring key skills and applying these skills in different situations instead of large amounts of knowledge and skills without any opportunities to apply these skills
3. Teaching should focus on the interrelatedness of all information. Deaf and H/H learners must be made aware of the relationship between information and making links between existing knowledge and new found knowledge

Easterbrooks and Stephenson (2006) did an extensive study in examining what accounts for best practices of education for the Deaf and Hard of Hearing. These researchers conducted a survey of literature strands on best practices for the Deaf and Hard of Hearing learners, websites of professional organisations as well as websites of educational departments, and constructed a document of twenty best practices in literacy, science and mathematics education for the Deaf and H/H. From the list of twenty best practices, ten best practices of educating the Deaf and H/H focussed on science and mathematics education. These include:

- “the teacher as a skilled communicator
- instruction through the primary language
- teacher as content specialist
- active learning
- visual organisers
- authentic, problem-based instruction
- use of technology
- specialised content vocabulary
- critical thinking
- mediating textbooks” (Eastbrooks & Stephenson, 2006:10)

Although this study agrees with both Moores and Martin (2006) and Eastbrooks and Stephenson's (2006) proposed best practices, it is the implementation thereof that I find problematic. Since all learners in South Africa follow the same curriculum prescribed by CAPS (2011) and implemented within the timeframe set out by CAPS (2011), best practices are left in the hands of teachers who are bound by legislation. What complicates the matter further is that sign language as an official language is not yet recognised in a South African context, which again places the notion of best practices in the hands of school administrators and teachers. My view is that if we have a standardised online platform where best practices can be administered nationally and internationally, Deaf and H/H learners all over the world can benefit from it. The question that should be asked is how all of the above relates to the current research study. To answer this question one has to consider the following:

- the above research studies indicates that Deaf learners do struggle with mathematics in general and mathematics problem-solving in particular
- the advantages of a reform based mathematics curriculum
- there exists best practices in mathematics teaching and learning for Deaf and Hard of Hearing learners
- the struggles Deaf and H/H learners experience with mathematics problem-solving can be addressed by applying certain instructional strategies
- the multi-representational features of ICTs and their role in mathematics education

One strategy that is under-researched especially in a South African context is the use of ICTs, especially LMSs as a tool to represent mathematics and assist Deaf and H/H learners in their struggle with mathematics problem-solving.

In summary, all of the above research studies were either conducted in primary school settings or higher educational settings, which leaves a gap at secondary school level. Furthermore all the research that was conducted made use of paper and pencil drills. Since very little research has been done on the use of learning management systems (LMSs) in mathematics education in a South African context and the possibilities they pose to assist Deaf learners in their struggle with mathematics problem-solving, it is the current research report's aim to investigate such avenues. We look at instances of representations next.

2.9 Representation

In this section I will argue for the importance of multiple representations when it comes to mathematics in general and mathematics problem-solving in particular and the influence it has on mathematics problem-solving specific to Deaf and H/H learners.

Representations of mathematics content are viewed as “useful tools both for communicating information and understanding” (NCTM, 2000:64). Furthermore, reforms in mathematics teaching and learning highlight the crucial role representations play in mathematics education. Moreover the NCTM (2000) recommends that all learners should make effective use of representations, hence teaching and learning should corroborate learners’ understanding of problem-solving by utilising a diversity of representations. In addition recommendations advise that learners should “create and use representations to organise, record and communicate mathematical ideas, select, apply and translate among mathematical representations to solve problems and use representations to model and interpret phenomena” (NCTM, 2000:64). Based on my experience with Deaf and H/H learners, I believe that multiple representations of mathematics content can help Deaf and H/H learners understand mathematics content and assist them in mathematics problem-solving.

Discussion based on mathematics representations have rendered different viewpoints. On the one hand Stylianou (2011) claims that symbolic expressions, drawings, written words, graphical displays, numerals, and diagrams are all external representations of mathematical concepts. From this perspective, these multiple representations cannot be understood apart from the context in which they are used, hence “the term representation refers both to process and product—to the act of capturing a mathematical concept or relationship in some form and to the form itself” (NCTM, 2000:67). On the other hand representation as a process is equated with terms like *translation* (Janvier, 1987) and *coordination of semiotic systems* (Duval, 1995). While both these terms refer to moving back and forth between different representations of the same mathematical concept, proponents advocate that it may improve problem-solving skills. Others believe that multiple representation skills are conducive to “articulate the same problem in different forms or views” (Hwang, Chen, Dung & Yang, 2007:191). I suggest that when learners can construct their own representations of mathematics problems they will find it easier to move or translate between representations.

Representations as a product highlight the difficulties learners experience, especially in utilising graphical representations (Leinhardt, Zaslavsky & Stein, 1990). These difficulties relate to misconceptions and misunderstandings specific to learners’ “responses to the visual qualities of graphs” (Stylianou, 2011:267). In contrast, I agree with Bardelle and Ferrari (2010:2) who argue that “the coordination of the verbal description of the function, its symbolic representation as an equation, its Cartesian graph and a table of values it assumes” can assist in dissolving these misconceptions and misunderstandings. In other words, when Deaf and H/H learners can represent mathematics problems in different formats they are more reluctant to move between these representations and hence understand mathematics problems.

Lesh, Post and Behr (1987 in Hwang, Chen, Dung & Yang, 2007) distinguish between five outer representations that are utilised in mathematics education. These include 1) real world object representation, 2) concrete representation, 3) arithmetic symbol representation, 4) language representation and 5) picture or graphic representation. This study focusses solely on language, arithmetic and picture or graphic representation. Firstly, language representation skill is the ability to linguistically restate the observed relationship within mathematics problems. Secondly, arithmetic symbol representation skill includes the ability to translate the mathematical problem into a formula. Finally, picture or graphical representation skill is the ability to depict a mathematics problem, either as an illustration or a graph.

Learners have their own set of preferences when it comes to representing mathematics content. Some learners favour concrete representations over symbolic representations and vice versa. From my experience as a mathematics teacher I have noticed that Deaf learners are more dependent on concrete representation than on translating mathematics problems linguistically. A study conducted by Hwang, Chen, Dung and Yang (2007) found a correlation between learners' problem-solving skills and the ability to translate or represent the mathematics problems. These researchers conducted a study with sixth graders on twenty one numerical and geometry problems and these learners' multiple representation skills. Not only did they find that learners' representational skills are in line with their problem-solving skills, but they also found that when learners could translate the problems into language representations their problem-solving skills increased. Essentially this study highlights the importance of utilising multiple representations in mathematics problem-solving. Improving their representational skills will lead to improvement in mathematics problem-solving skills. Another distinction in this research study was the crucial role ICTs played in assisting learners in executing multiple representations in mathematics problem-solving. Different researchers (Hwang, Chen, Dung & Yang, 2007; Bardelle & Ferrari, 2010; Psycharis, Chalatzoglidis & Kalogiannakis, 2013) advocate the potential of ICTs to be used to represent mathematics problems in different formats. The next section covers Grade 9 mathematics content represented in Moodle.

2.10 Grade 9 mathematics content represented via Moodle

In this section I will review what is involved in the representation of the selected Grade 9 mathematics content using Moodle. Firstly, I will describe the different tools in Moodle and how it can be used in general. Secondly, I will highlight how these tools can be used to represent mathematics content based on ratio and proportion problems. Moodle consists of an array of tools which gives the LMS its functionality. These tools include:

1. Administrative tools which assist users in self-registration and permission settings in courses i.e.

- Registration tools
 - Authorisation tools
2. Collaboration and communication tools which assist users in interacting and collaborating with each other inside and outside the classroom, i.e.
 - Forums
 - Wikis
 - Blogs
 - Lessons
 - Glossaries
 3. Assessment tools which assist users in taking assessments in the form of:
 - Quizzes
 - Assignments
 - Webpages

The tools used in this study as well as the significance of these tools, specific to mathematics, based on literature findings and my own experience, will be discussed below.

2.10.1 Forums

Rice and Nash (2010:19) argue that the Forum tool within Moodle allow users to create “dynamic and highly engaging collaborative learning activities”. In other words users can either take part in a discussion or start a new discussion based on mathematics concepts. Furthermore, learners can pose questions on content they do not understand and the teacher, as well as other learners can assist them, by participating in these discussions. What makes the Forum tool so flexible and easy to use is the fact that messages or discussions can include text, graphics, video and presentations (Rice & Nash, 2010). In addition the Forum tool can also be a means to motivate students and give comments on their work progression. Teachers can also use this tool to pose questions on learners’ experience with other tools.

The task of the teachers or administrators is to monitor the learners’ participation as they engage in the forums. Not only can teachers and administrators gain access to discussions but they can also track student participation by accessing the log files. The log files give a detailed analysis of who posted what, how many times learners accessed the forum discussions and how long they participated in these discussions. Furthermore teachers and administrators can access a detailed layout of the times, dates and types of forums in which the learners participated.

Through these discussions teachers can gain access to the learners’ understanding of mathematics concepts and approaches to problem-solving. Their discussions will be based on their

understanding of these concepts and problems which will highlight gaps in their understanding and in turn the teacher can address these gaps with intervention strategies.

Forums also have the potential to represent problems in multiple formats. Not only can teachers use multiple representations of mathematics problems in forums, but discussions can be based on these representations. This gives learners the opportunity to play in real time not only with changing the values of the mathematics problem, but also to see how the representation changes when adjusting the values. This of course cannot be accomplished by pencil and paper exercises. Figure 2.2 below demonstrates this multiple representation feature of forums in Moodle.



Figure 2.2: Multiple representation of Grade 9 mathematics content in the Forum module including discussions based on the representation.

2.10.2 WIKI

The Wiki forms part of the collaborative tools in Moodle. Rice and Nash (2010:117) argue that the Wiki tool “can be one of the most flexible collaborative tools one has in the eLearning toolkit”. Although Wikis are seen as a space where users can add or modify information, they have enhanced capabilities within Moodle. Wikis within Moodle can be used for group projects,

presentations, and tailor-made, personalised learning activities. Hence individual and group Wikis can be created. In a group Wiki, all the learners can participate to add or alter content. This is a very useful feature since learners can learn from each other. The individual Wiki is a private Wiki, where only the registered user for that Wiki has access to it. Accordingly, the individual Wiki can offer effective differential learning since it offers “one-on-one instruction and guided note taking” (Rice & Nash, 2010:121).

There are several advantages for using the Wiki tool. These include:

- It is a useful place for a learner to capture his/her thoughts independently
- Users can create Wiki pages for each topic and at the end they will have one document based on the whole subject.
- Learners can see the progression of their understanding of the topic and they can go back and forth to alter content as their understanding of the topic increases.
- The history tab within the Wiki lets one see learners’ previous entries

The illustration below depicts the use of multiple representations of mathematics content by making use of the WIKI module. Furthermore, it illustrates that learners can use algebraic, graphic or spreadsheet representation of a mathematics topic within the Wiki module.

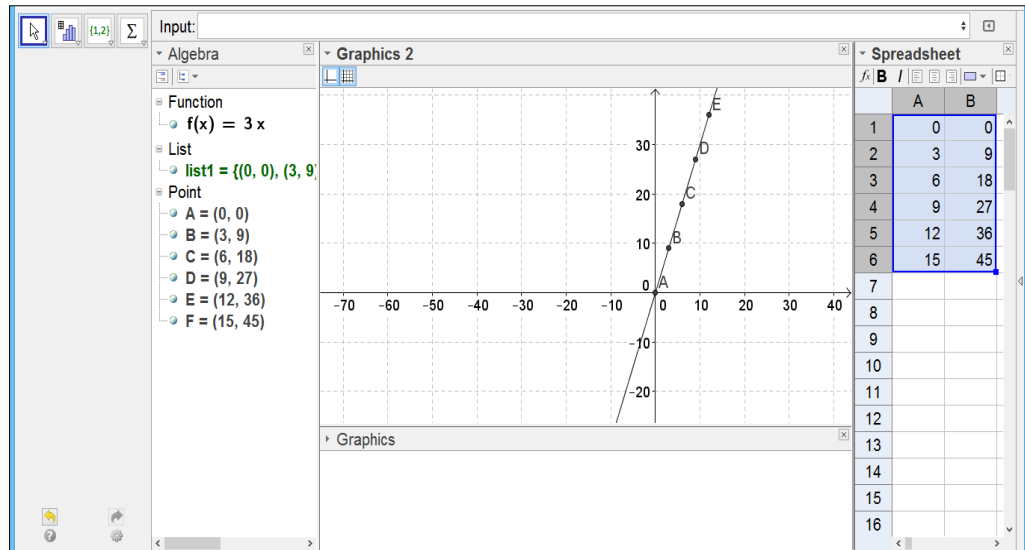


Figure 2.3: A multiple representation of Grade 9 mathematics content in the WIKI module

As seen from figure 2.3 above, a Wiki can be used to guide learners to participate as well as to draw learners’ attention to the connections between the learning content, the learning goals and the assessment. Moreover, while learners are constructing all these representations it will not only

enhance their representation skills but it will further assist them in their problem-solving skills (Hwang, Chen, Dung & Yang, 2007).

2.10.3 The Glossary Tool

For most people glossaries are nothing more than online dictionaries. However the Glossary tool within Moodle has much more functionality than your ordinary online dictionary. Not only can it be used to create dynamic learning activities that can assist learners in achieving the course outcomes, but it can also represent mathematics content in different formats. Essentially it can assist learners in “developing categories of knowledge, make connections to their experience and to elaborate the concepts” (Rice & Nash, 2010:135).

These categories of knowledge are referred to as schemata. In other words glossaries assist learners in creating systems of knowledge which are organised in a certain manner. Furthermore, schemata enable learners to organise or categorise their knowledge which can lead to learners making connections between newly acquired knowledge and existing knowledge.

Auto linking is an essential feature of the Glossary tool within Moodle. Not only can entries be linked within a particular course, but the entries can also be linked throughout the Moodle site. This means when one creates an entry, e.g. ratio, the entry can be linked within the course and as a result the word “ratio” when used in other activities within the whole course, can be accessed by learners by just clicking on the word and the description or definition will show (Cole & Foster, 2007). This can also be done with entries through the whole site.

Another distinct characteristic of glossaries is their collaborative feature. Instead of the teacher creating all the entries, i.e. definitions and description of concepts, learners create entries on difficult concepts they do not understand. Accordingly, learners can be allowed to comment on other learners’ entries which further enhances collaboration. When learners are allowed to create definitions of words or concepts they are more likely to remember these words as well as their definitions (Cole & Foster, 2007). In essence learners are engaging in the process of learning and constructing their own knowledge, hence new terms and concepts can emerge from this collaboration.

The Glossary tool makes it easy to import multimedia content and link this to existing content. For example, a teacher can present learners with a problem such as: 3 hens cost R9. How many hens can you buy for R12? The teacher then asks the learner to represent this problem through using 1) pictures, 2) a table, 3) a graph and 4) an equation. Table 2.1 will highlight this feature of the Glossary tool.

Verbal representation	3 hens cost R9. How many hens can you buy for R12?								
Bar graph representation									
Picture representation									
Algebraic representations	$3x \text{ hens} = R9 \dots R12 = x \text{ hens}$ $y = 3x$								
Line graph representation									
Tabular representation	<table border="1"> <tr> <td>3 hens</td> <td>?</td> <td>5 hens</td> <td>n</td> </tr> <tr> <td>R9</td> <td>R12</td> <td>?</td> <td></td> </tr> </table>	3 hens	?	5 hens	n	R9	R12	?	
3 hens	?	5 hens	n						
R9	R12	?							

Table 2.1: Different representations that can be used to represent Grade 9 mathematics content within the Glossary module.

2.10.4 Quizzes

The Quizzes tool in Moodle allows users to take assessments based on the course goals and objectives. The Quizzes tool is ideal for creating practice assessments where learners can be asked to share their thoughts on the best way to approach these questions. Cole and Foster argue that a quiz tool is an effective assessment tool when learning outcomes that involve “identification, definition and explanations of concepts and key terms” (2007:72) are assessed. Moreover, these quizzes are directly linked to a gradebook which captures learners’ performances. Furthermore this means that learners can retake quizzes for practice and comprehensive learning.

The Quizzes tool in Moodle consists of different question types which can be used in different subjects or learning areas. These include: multiple-choice, essay, matching, short answer, numerical, calculated, true/false, cloze, random, drag and drop and ordering question types (O’Rourke, 2010). Assessments can be created using a mixture of these question types and including video, text, images or interactive content in these questions.

Feedback is an essential feature of the Quizzes tool in Moodle. The Quizzes tool consists of different types of feedback.

- Overall feedback includes feedback on the entire quiz which is based on the grade boundary.
- General feedback involves feedback on the learners' performance irrespective of how they perform in the quiz.
- Adaptive feedback which gives learners immediate feedback on answers.

This research report is concerned with the adaptive mode of feedback. When quizzes are set in adaptive mode, it implies that when learners give answers to questions, immediate feedback is given to them. When the answer is wrong feedback is given to enrich their understanding on the concepts. When answers are right additional feedback is given to strengthen learners' understanding. In other words Moodle forces learners to engage with the feedback which results in enhancing learners' understanding of the content. Ekins (2007) on the other hand argues that the feedback must be instantaneous, specific as well as detailed, in order for it to stimulate learning.

A study conducted by O'Rourke (2010) on the possibility to replace written exams with Moodle-based e-exams rendered useful results. The researcher conducted an empirical study with sixty two learners on the use of e-assessment to see whether there was improvement in the learners overall performance. He concludes his study by arguing that e-assessment within Moodle poses many advantages to teachers and learners. Not only does e-assessment in Moodle reduce the time spent on marking assessments but feedback is given immediately which further enhances learning.

Lopes, Babo, and Azevedo (2008) developed a project called MatActiva, made up of Moodle-based activities to supplement their theoretical and practical classes. These researchers found that the availability of online mathematics material via Moodle provided learners with opportunities for self-study and self-assessment. Not only did learners have access to this mathematics content but they could also engage in mathematics assessments which prepared them for end of the year assessments. Additionally the researchers found that the project had a positive influence on the learners, since they continually asked for more learning material.

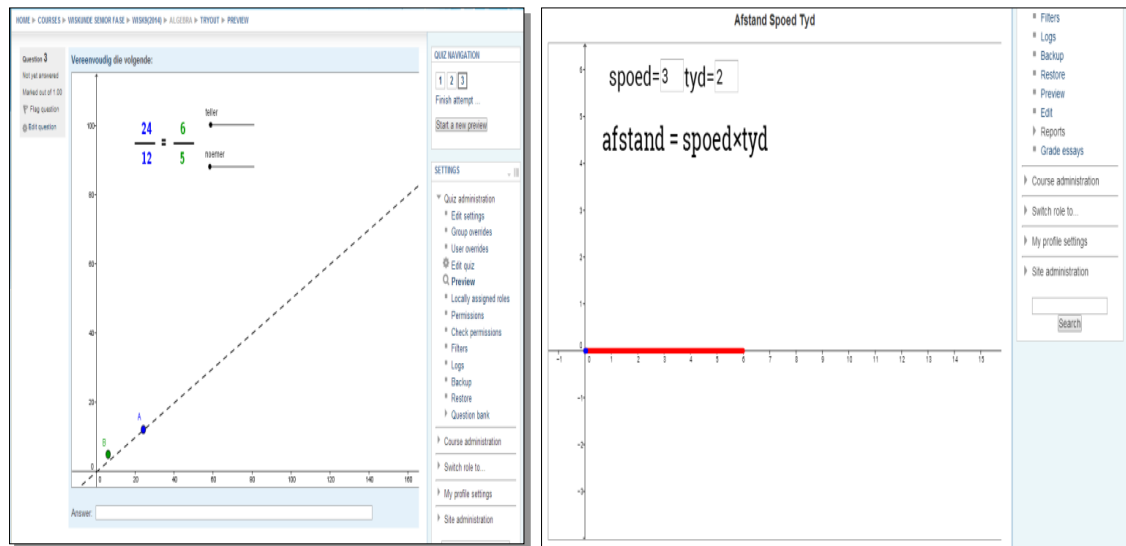


Figure 2.4: Two interactive Geogebra representations that can be used to represent Grade 9 mathematics content in the Quizzes module

2.10.5 Lessons

The Lessons tool in Moodle can be used to teach and learn new content about a specific topic. The lessons differ from the traditional lessons in classrooms since they consist of a range of interactive pages. These pages can either be in a linear format, i.e. slideshow format or set in a branch-like manner. The branch-like manner is very useful since learners can only progress to a new branch when the outcome of the current branch is achieved. This further means that the learner is directed based on the choices they make and will be presented with either new content or sent back to review the current content.

The Lessons tool is an essential vehicle to employ scaffolding. Scaffolding, coined by Bruner (1975) as the process to assist students by providing them with a model from which to work, to do an activity. The teacher assists the learner up to a point where the learner can do the activity on his/her own. In essence this means that the teacher's support is taken away bit by bit. Hammond and Gibbons (2005:9) argue that scaffolding refers to: "support that is designed to provide the assistance necessary to enable learners to accomplish tasks and develop understandings that they would not be able to manage on their own". Essentially this means that teachers use a set of activities and support to push the boundaries of learners' understanding and abilities to an extent where they themselves can master other similar activities on their own. The focus is thus to not only support learners but to provide continual assistance leading to a state where learners can apply newly acquired skills and knowledge to a new context.

The Lessons tool has distinct multiple representation features. The illustration below demonstrates how multiple representations in the Lessons tool can assist learners in constructing their own knowledge. Learners can use the purple handles to either increase or decrease the speed or time

over a fixed distance. Not only can learners extract useful information regarding distance, speed and time but they can also be lead to deduce the formula for rate.

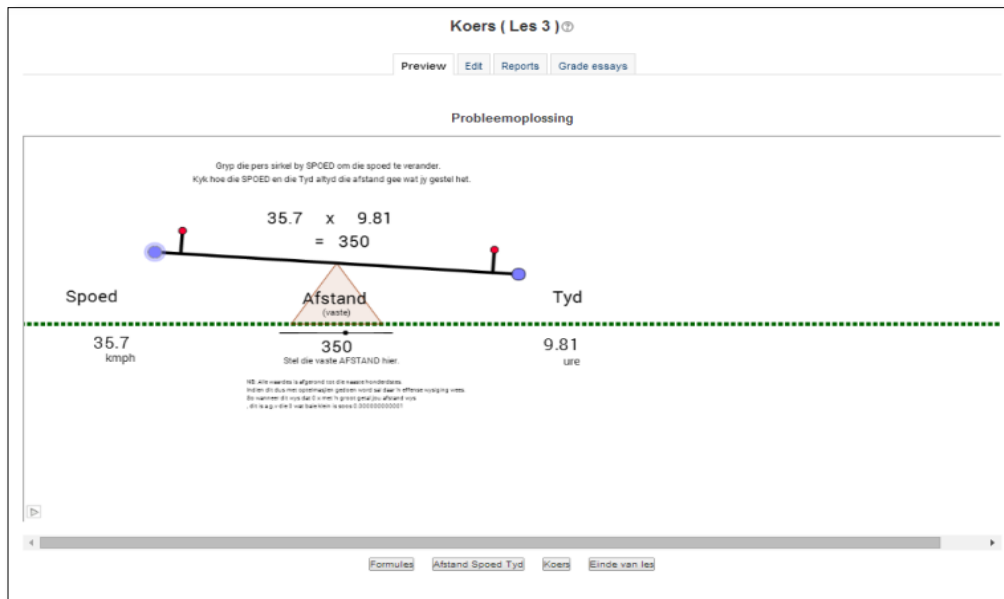


Figure 2.5: A single interactive representation that can be used to represent Grade 9 mathematics content in the Lessons module.

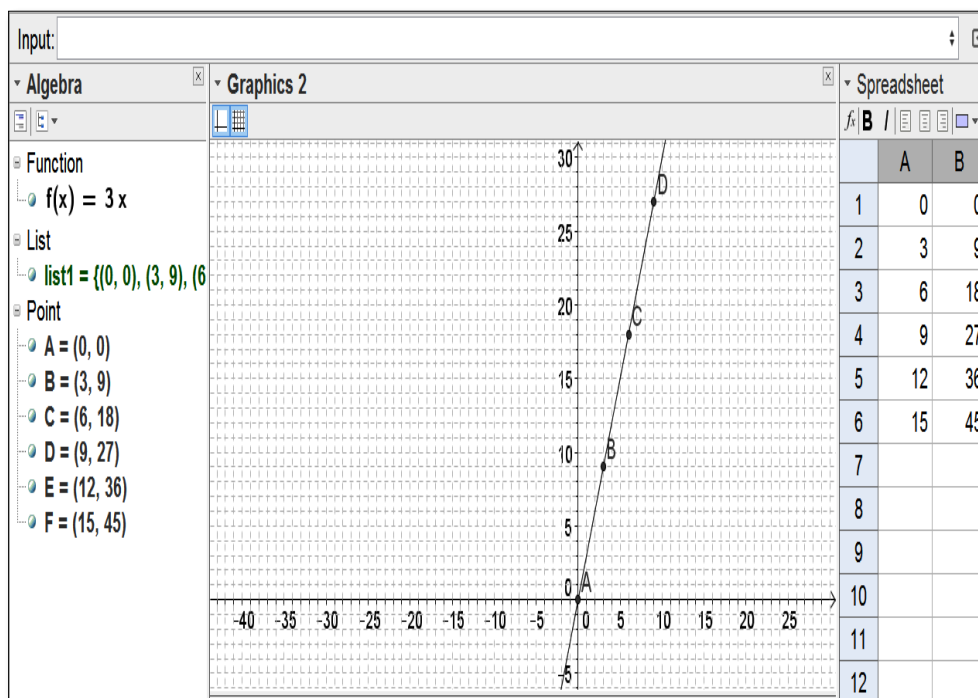


Figure 2.6: Three different representations can be used to represent Grade 9 mathematics content in the Lessons module.

2.10.6 Assignments

Assignments is one of the simpler tools in Moodle and is used to collect learners' work. Not only does it create space for learners to upload their digital content, but this content can also be graded. Learners can be asked to upload videos, images, Microsoft Office documents and webpages. Assignments can also take the form of offline activities which learners can do without logging in to Moodle. These types of assignments are then manually graded and the marks the learners obtained can be captured in Moodle.

Moodle consists of four assignment types:

- Upload a single file
- Offline activity
- Online text
- Advanced uploading of files

Petrus and Sankey (2007) did a comparative study on the use of Writely and Moodle online assignment submissions in the mathematics and computing department at USQ. The study was conducted with thirteen students on their individual experience with these two types of online assignment systems. An online questionnaire was administered after the completion of the assignments. These researchers found that “9 out of the 13 students found the Moodle systems to be more intuitive to use” and “10 out of the 13 students preferring Moodle system” (Petrus & Sankey, 2007:8). Not only did the questionnaires point out that students found Moodle more flexible and easy to use, in the case of online assignments, but Moodle accepted a variety of formats to submit assignments which made it easy to upload assignments in different formats.

As discussed and illustrated above, a potential strength of Moodle is the ability to multi represent mathematics content in general and mathematics problems in particular. Although the possibility exists that Moodle can represent mathematics content, it cannot just be uploaded onto Moodle and present itself; the content should adhere to certain criteria. It is thus imperative to look at the characteristics of online course designs and what they should look like in order to adhere to a constructivist online learning environment and promote multi-representational skills amongst Deaf learners.

To evaluate whether the Moodle-based online course, which includes the goals, the instructional methods, the Moodle-based materials and the Moodle-based assessments, adheres to a constructivist model and multi-representational features, it is imperative to evaluate the course design against a set of criteria. The next section focusses on the characteristics of online course design and sets out the criteria for courses designed online.

2.11 Online course design

This section of the research report describes the criteria to which online courses need to adhere. Firstly it describes Murphy's (1997) framework for a constructivist based pedagogical model and how it relates to the current study. Secondly, it describes Gagne's (1985) nine instructional events and how they relate to this study and finally it describes Ainsworth's (2006) multi-representational model and its importance to the current study.

This research report sets out to create a Moodle-based learning course to assist Deaf learners in their struggle with mathematics problem-solving. The aim is thus to create an online support system that will assist Deaf learners to overcome the barriers that mathematics problems present. It is thus imperative that these Moodle-based learning materials in the course should adhere to certain constructivist based pedagogical models.

2.11.1 Murphy's constructivist based pedagogical model

Murphy (1997) provides a framework for a constructivist based pedagogical model. She synthesises the characteristics of a constructivist learning environment by adapting the work of Jonasson (1991) on design principles of a constructivist learning environment; the manner in which knowledge construction can be facilitated (Jonasson, 1994) ; the constructivist design, teaching and learning (Wilson & Cole, 1991) ; Ernest's (1995) school of thought on constructivism (radical and social); Honebein's (1996) seven goals for the design of a constructivist learning environment and Vygotsky's (1978) view on learners' problem-solving skills. The framework developed by Murphy will be useful for developing the Moodle-based learning materials since it is underpinned by the pedagogical principles of social constructivism. I believe that constructing the Moodle-based mathematics learning materials in line with Murphy's (1997) framework will not only ensure that learners are provided ample opportunities to construct their own mathematics knowledge but it will also create space for them acquire the skills needed for mathematics problem-solving. For this reason I have chosen Murphy's (1997) constructivist based pedagogical model. The characteristics of this model include:

1. "Multiple perspectives and representations of concepts and content are presented and encouraged.
2. Goals and objectives are derived by the student or in negotiation with the teacher or system.
3. Teachers serve in the role of guides, monitors, coaches, tutors and facilitators.
4. Activities, opportunities, tools and environments are provided to encourage metacognition, self-analysis -regulation, -reflection & -awareness.
5. The student plays a central role in mediating and controlling learning.

6. Learning situations, environments, skills, content and tasks are relevant, realistic, and authentic and represent the natural complexities of the 'real world'.
7. Primary sources of data are used in order to ensure authenticity and real-world complexity.
8. Knowledge construction and not reproduction is emphasized.
9. This construction takes place in individual contexts and through social negotiation, collaboration and experience.
10. The learner's previous knowledge constructions, beliefs and attitudes are considered in the knowledge construction process.
11. Problem-solving, higher-order thinking skills and deep understanding are emphasized.
12. Errors provide the opportunity for insight into students' previous knowledge constructions.
13. Exploration is a favoured approach in order to encourage students to seek knowledge independently and to manage the pursuit of their goals.
14. Learners are provided with the opportunity for apprenticeship learning in which there is an increasing complexity of tasks, skills and knowledge acquisition.
15. Knowledge complexity is reflected in an emphasis on conceptual interrelatedness and interdisciplinary learning.
16. Collaborative and cooperative learning are favoured in order to expose the learner to alternative viewpoints.
17. Scaffolding is facilitated to help students perform just beyond the limits of their ability.
18. Assessment is authentic and interwoven with teaching" (Murphy, 1997:12).

Although Murphy (1997) provides a framework for a constructivist based pedagogical model for online learning, it does not propose a structure for the Moodle-based learning materials. I believe that in order to answer the research question set out in this research report which is: *what are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?* I have to look at how these Moodle-based learning materials should be structured to provide meaningful learning experiences for Deaf and H/H Grade 9 learners. For this reason I have chosen Gagne's (1985) nine events of instruction. These nine events will now be discussed.

2.11 2 Gagne's nine events of instruction

Gagne (1985) argues that there are different types or levels of learning. He further posits that for every individual level of learning there should be a different type of instruction attached. His argument is along the same line as Howard Gardener's (1993) multiple intelligence, where the author claims that each individual has a set of eight multiple intelligences and that teaching and learning should focus on the individuals' dominant intelligence. Consequently, Gagne (1985) distinguishes between five categories of learning: a) verbal information, b) intellectual skills, c)

cognitive strategies, d) motor skills and e) attitudes. Additionally, Gagne proposes that teaching and learning that focusses on intellectual skills development should be engineered in a hierarchical sequence with relation to its complexity:” stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem-solving” (Gagne, 1985:1). Not only does the hierarchy expose learners’ ‘prior knowledge but it also provides for the basis of how the instruction should be arranged. Accordingly Gagne (1985) proposed nine instructional events to ensure that structured learning takes place:

1. “Gaining attention (reception)
2. Informing learners of the objective (expectancy)
3. Stimulating recall of prior learning (retrieval)
4. Presenting the stimulus (selective perception)
5. Providing learning guidance (semantic encoding)
6. Eliciting performance (responding)
7. Providing feedback (reinforcement)
8. Assessing performance (retrieval)
9. Enhancing retention and transfer (generalisation)” (Gagne, 1985:1).

Gagne’s (1985) theory on instructional events is extremely useful since it sheds lights on how to structure the Moodle-based learning materials. My own view is that learning materials should be presented in a structured sequence for them to expose learners’ prior knowledge, build on learners’ prior knowledge and create space for new knowledge construction. From this perspective the nine events of Gagne will thus be used to organise the Moodle-based course to guarantee that the learning takes place according to Gagne’s hierarchical sequence of complexity. The next section focusses on the multi-representational model of Ainsworth.

2.11.3 Ainsworth’s multi-representational model

Because Deaf and H/H learners are dependent on their visual sense of perception it is thus crucial that online learning content should consist of different visual representations. For this reason Ainsworth’s (2006) multi-representational model was used in order to formatively evaluate the tools in Moodle on the basis of how effectively it can represent mathematics problems and assist Deaf and H/H Grade 9 learners in mathematics problem-solving. Ainsworth (2006) posits that the following criteria are crucial when multi-representational designs are considered for use:

- 1) The number of representations employed, which refers to the ability of multi-representational systems to employ more than one representation at a time or simultaneously.

- 2) The way that the information is distributed over the representations, which refers to how flexible the representational system is to distribute information across the different representations.
- 3) The form of the representational system which refers to the format in which the content is represented.
- 4) The sequence of representations which refers to when different representations should be used.
- 5) The support for translation between representations which refers to the extent that the representation system allows for moving between translations. (Ainsworth, 2006).

I believe that by representing the mathematics content within Moodle-based on Ainsworth's (2006) model of multi-representation, might create opportunities for Deaf and H/H Grade 9 learners to gain access to mathematics vocabulary, concepts and ideas which might bring about better understanding of mathematics problem-solving.

In summary, a Moodle-based mathematics course will be constructed based on and formatively evaluated according to Murphy's constructivist based pedagogical model. Furthermore, the content will be structured according to Gagne's nine events of instruction. The tools in Moodle will also be formatively evaluated according to Ainsworth's (2006) model on multi-representation. The next section will shed light on the conceptual framework for this research report.

2.12 Conceptual framework of this research report

This research report sets out to investigate the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle? Moodle as a LMS will be used to represent mathematics content. Accordingly, Moodle-based learning material will be constructed by making use of the tools in Moodle, i.e. Glossary, Lessons, Forum, Wiki, Quizzes and Assignments tools. These Moodle-based learning materials consist of mathematics problems based on ratio and proportion, which cover the prescribed mathematics curriculum set out in CAPS (2011). Since learners will be interacting with online learning activities, it follows then that learning occurs in a social context. Therefore, social constructivism will be the underlying learning theory of these Moodle-designed learning materials. Moreover, Moodle as a learning management system will be evaluated to the extent to which it accommodates social constructivism as a learning theory by measuring it against the criteria set out in this chapter. Additionally, a thorough review of the concept of multiple representations will be carried out by evaluating the tools in Moodle and examining to what extent it provides space for multiple

representations as well as the advantages it encompasses to assist Deaf learners in mathematics problem-solving.

The integration of the different strands of literature will now be done by means of relational statements. The reason for this is to shed some light on the conceptual framework that underpins this research report. Although teaching and learning school mathematics in traditional classrooms is quite different from online teaching and learning of school mathematics, the two instructional approaches share a mutual goal and that is to make school mathematics understandable for all learners irrespective of their disabilities. Furthermore, online learning is an extension of classroom mathematics since it can make mathematics teaching and learning more dynamic, by representing mathematics in different formats and in a way that learners can interact with mathematics content and thus strengthen classroom teaching. Therefore, online learning, specifically representing Grade 9 mathematics content through making use of Moodle, is communicated through the different strands of literature as well as the interaction of Deaf Grade 9 learners, with the mathematics content. Figure 2.7 is a representation of the conceptual framework related to the research question.

The first two arrows pointing down from mathematics content represented via Moodle refer to the *what* (Grade 9 mathematics content, i.e. mathematics problem-solving) and the *how* (represented via Moodle). This is linked to the two rectangles which cover 1) the tools that will be used in Moodle to represent the Grade 9 mathematics content (on the left) and 2) the design of the online course, which includes the Moodle-based learning material based on mathematics problem-solving (on the right). These two rectangles, which symbolise the tools of Moodle (left) and the online course design (right) connect to formative evaluation, since different criteria, based on different literature strands, will be used to formatively evaluate them. Both rectangles will be evaluated against social constructivist pedagogy and for that reason both connect to social constructivism which is the underlying learning theory of this research report.

A Conceptual framework for the current research report

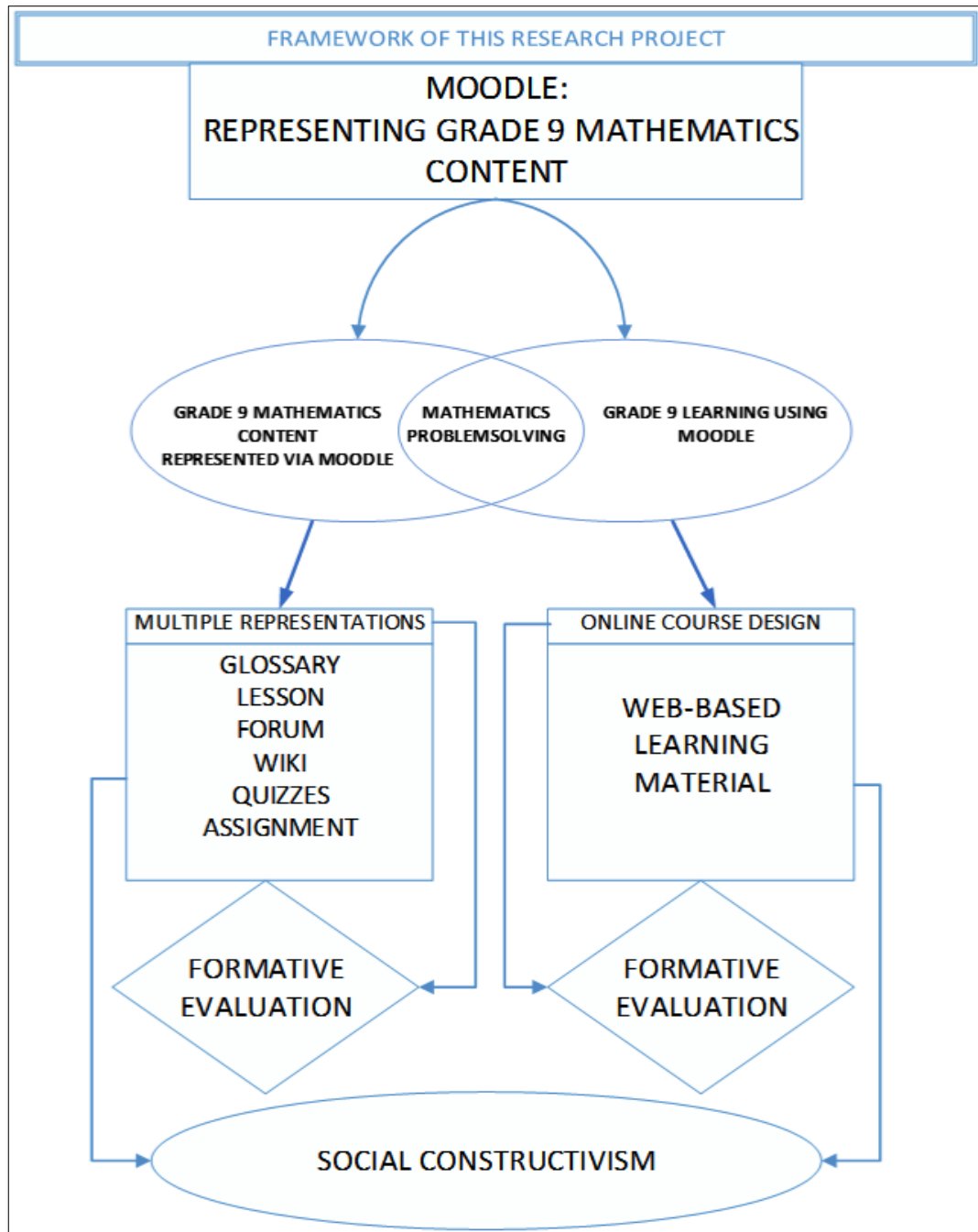


Figure 2.7: The Conceptual framework for the current research study.

Chapter 3: Methodology

3.1 Introduction

This chapter starts with the research design which is followed by the research method. Secondly, the chapter includes the sampling method followed in this research report as well as the methods of data collection. The chapter concludes with a summary of how the data was analysed in order to assist the researcher in answering the research question which is: *What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?*

This study is coined an evaluation research or formative research which falls under the heading of development or design research (Van den Akker, 1999; Bakker, 2004), since it regards design as the focal point of research. The aim of this research report is to inform the design or development of mathematics online learning programs for Deaf and H/H learners. Proponents of evaluation research argue that this type of research is within the domain of social science research and for this reason it should be used to evaluate intervention programs in social settings (Babbie & Mouton, 2001). Since this Moodle-based mathematics learning material is regarded as an intervention program, because it will be developed to assist Deaf and H/H learners with mathematics problem-solving, it needs to be evaluated before it can be implemented. The next section will focus on the research design.

3.2 Research paradigm

Every research study is underpinned by a unique research philosophy (Ritchie, Lewis, Nicholls & Ormston, 2013). This specific philosophy prescribes how the research should be conducted and what type of knowledge is extracted. There exist two main paradigms in which social research is conducted, i.e. *qualitative* and *quantitative* paradigms. The current study is conducted within a qualitative paradigm by examining a social phenomenon in its natural setting and providing an account of this phenomenon. For example: the idea of the current research report is not to present a generalisable result but to give a detailed account of the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners at *school zee* (pseudonym used) through the use of Moodle. The next section will describe qualitative and quantitative research in detail and how qualitative research was integrated in the current research report.

3.2.1 Qualitative research

Denzin and Lincoln define qualitative research as: “a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. These practices ... turn the world into a series of representations including field notes, interviews, conversations, photographs, recordings and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them” (2000: 3).

From the above definition by Denzin and Lincoln it becomes apparent that in qualitative research the researcher uses an inductive approach to uncover and discover themes, patterns and categories within the data that could be used to describe the phenomenon in its natural context. Furthermore it means that the possibility exists for different themes, patterns or categories that can be uncovered or discovered from the same naturalistic context which in turn provides the researcher with different perspectives of the same phenomenon. Additionally qualitative research is more subjective in nature since it relies on the researcher’s interpretation of the phenomenon. Furthermore Neuman (2000) argues that the data generated through qualitative research is less likely to be generalised since it is based on the context and dependant on individual meaning making. Moreover the researcher is responsible for gathering the data, and the research design becomes clearer as the research study unfolds (Neuman, 2000).

3.2.2 Quantitative research

According to Neuman (2000), quantitative research sets out to develop generalised findings which will enable the researcher to control, predict, comprehend and explain a phenomenon in its natural environment. Neuman’s (2000) view also emphasises the objectivity of the researcher which means that the researcher remains independent of the phenomenon being researched. This also means that the researcher is only interested in the results from the current study that can be replicated to other studies.

With the aim of answering the main research question which is: *what are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle*, this research study aligns itself to a qualitative paradigm. Therefore, the aim of this research report is to provide a detailed account of the way in which the Moodle-based learning materials should be constructed to assist Deaf and H/H Grade 9 learners with mathematics problem-solving. The detailed account includes the strengths i.e. a rich description of the use of the tools in Moodle and the multi-representation of mathematics problems within

Moodle. Furthermore it also includes the weaknesses i.e. the barriers Deaf and H/H learners' experience when doing mathematics problems solving through the use of Moodle.

Another aim of this research report is to highlight repetitive themes and patterns as well as capture Deaf and Hard of Hearing Grade 9 learners' knowledge construction within an online learning environment. Not only will the learners' interaction provide the teacher and the reader with useful knowledge on how the use of Moodle affects the learners' knowledge construction but it can also assist the teacher researcher in further developments of the Moodle-based learning materials. The next section focusses the sampling methods used in this research report.

3.3 Sampling method

3.3.1 Sample

This research report made use of purposeful sampling (Marshall, 1996). The participants were selected from *school zee* (pseudonym used), a school for the Deaf and H/H, on the grounds of their hearing loss. They consisted of three Grade 9 learners who are either Deaf or H/H (illustrated by Table 3.1).

Participants		Disability	Causes of disability	Hearing aids
1.	User01	Deaf	Born Deaf	2
2.	User02	H/H	Meningitis at grade 2 level	1
3.	User03	H/H	Alcohol misuse of mother while still unborn.	1
N = 3 D / H/H		D = 1 H/H= 2	Born Deaf = 1 Other causes = 2	Hearing Aids = 4

Table 3.1: Personal information relating to each participant's disability

3.4 Research methodology

3.4.1 Evaluation research

Mouton (2012) defines evaluation research as a qualitative (naturalistic) and empowerment evaluation. This means that qualitative or naturalistic evaluation research describes and evaluates how well the Moodle-based course is performing in its natural settings and is only concerned with the process of implementation rather than the outcomes. Furthermore naturalistic means that the Moodle-based learning materials are examined with certain criteria in mind, i.e. 1) the learners are Deaf and more dependent on their visual sense of perception, 2) the verbal and linguistic barriers the Deaf learners face, and 3) the problems Deaf learners experience when doing mathematics in general and mathematics problem-solving in particular.

Teaching and learning mathematics in schools for Deaf learners is still underpinned by pencil and paper exercises. For example, the teacher explains the mathematics concepts, does a few examples on the blackboard and afterwards gives learners a few textbook examples to practise either in class or at home. They bring their homework to class and the teacher checks their work and continues with the next section. Mathematics discussions are rare and only stretch as far as the learners ask questions, since there is not any time for classroom discussions or assisting learners individually with difficulties. The pencil and paper drills differ from using an online learning environment such as Moodle to teach and learn mathematics. Because learning takes place online, with the help of the teachers and fellow learners, mathematical knowledge construction occurs in a social context. This means that through the use of Moodle, space is created for mathematics discussion relating to content and learners can receive immediate access to feedback on problems, they can watch and do simulations of mathematics problems and they can assist other learners in solving mathematics problems. Essentially it adds time to the mathematics timetable.

This study follows Mouton's (2012) definition of evaluation research since it will be conducted in the classroom settings of the Grade 9 Deaf learners at "*school zee*". Mouton (2012) further argues that empowerment evaluation entails the use of "evaluation concepts, techniques and findings to foster improvement and self-determination" (Mouton, 2012:161). On the other hand, Paulsen and Dailey (2002) argue that evaluation research serves the purpose of monitoring the implementation of the intervention or the program. These researchers (Paulsen and Dailey) developed a comprehensive guide that can assist schools, districts as well as state personnel in evaluating a new intervention or program. The aim of this step-by-step guide is "it provides steps to help you get started in the planning process, identify areas where you may need assistance, and help in finding assistance to conduct an effective evaluation tailored to your program or intervention" (Paulsen & Dailey, 2002:1). Accordingly, the aim of this research report is firstly, to establish an intervention program in the form of a Moodle-based course and secondly to evaluate these course materials in order to improve it. Both Paulsen and Daily (2002) claim that the evaluation of implementations is very important since it highlights obstacles in the implementation stage of the program or intervention and therefore adaptations to the program can still take place. Furthermore, it means that evaluating the Moodle-based learning materials can help to determine whether or not the intervention, in this case, online learning of school mathematics, improved Deaf learners' understanding of mathematics problems by taking into account the barriers Deaf Grade 9 learners have to face when doing mathematics in general and mathematics problem-solving in particular. However, since different types of evaluation strategies exist, a clear distinction should be established between these strategies and which of these strategies are appropriate for the current

research report. The next section describes the different evaluation strategies as well as the strategy used in this research report and why it was used.

3.4.2 Types of evaluation strategies

This section describes the different evaluation strategies and why the specific strategy was chosen for the current research report.

Scriven (1967) distinguishes between two different types of evaluation research strategies, i.e. Formative and Summative Evaluation. Firstly, Summative Evaluation is designed to provide information regarding the impact of the program or intervention. These types of evaluation are usually done by state agencies in the form of standardised tests. Information accumulated through these tests is presented in the form of written reports (Paulsen & Dailey, 2002). Summative evaluation is exclusively done to report to stakeholders on the impact of an intervention. Thus, if the intervention is well implemented and successful in increasing learners' test scores, it will give the stakeholders the satisfaction of continuing with the program or intervention, hence investing further resources into the program development. Since the current research report is only a prototype, and thus only a sub section of the Grade 9 mathematics syllabus based on *Numbers, Operations and Relationships* (Department of Education, CAPS, 2011) covered in the Moodle-based learning materials, summative evaluation will not be used for this study.

Secondly, Formative Evaluation focusses on evaluating the quality, implementation and impact of an intervention. In other words the aim of formative evaluation is to provide feedback for adapting the intervention or program, for improvement purposes (Nieveen, 2007). For instance, the aim of the present research report is to use Moodle as an intervention strategy in the mathematics classroom for Grade 9 Deaf learners and the use of multiple representations with respect to the particular mathematics content. By identifying the obstacles and successes relating to Deaf learners' experiences with the Moodle-based intervention, the teacher/researcher can make improvements to the Moodle-based program and hence develop it to a state where it can assist Deaf Grade 9 learners' understanding of mathematics problem-solving. Furthermore, the information with regard to the successes and obstacles based on the Deaf learners' experiences with mathematics problem-solving in an online learning environment can potentially inform further developments of the Moodle-based program and it can also inform the teachers/ researcher on the individual needs of the Deaf Grade 9 learners. As a result of this feedback on learners' experiences with the Moodle-based mathematics problem-solving materials, improvements can be made to the overall Moodle-based program while it is still in its developmental stage. Since this study makes exclusive use of formative evaluation research, it will be discussed in detail below.

3.4.3 Formative evaluation

Tessmer defines formative evaluation as the “judgement of the strengths and weaknesses of instruction in its developing stages, for the purpose of revising the instruction to improve its effectiveness and appeal” (Tessmer, 1993:11). In other words, data specific to the type of instruction is gathered from one or a variety of sources by making use of different methods or instruments. Furthermore, it means that formative evaluation is not a plugin or add-on to examine the effectiveness of one’s type of instruction, but it plays a crucial role in the design and product development, since it highlights shortcomings or obstacles in the original design and development (Tessmer, 1993).

Beyer (1995:1) defines formative evaluation research as: “assessing educational programs or other kinds of educational products while they are being developed, to help shape them into their final forms... This applies to all sorts of curriculum development - whether an elementary or secondary school course or curriculum, a university degree program, a textbook, computer software, site-based management, or other kinds of instructional or learning material... “. On the other hand, Brown and Kiernan (2001) argue that formative evaluation is the process of strengthening the initial program or product by drawing on the findings of the formative evaluation research and adjusting the final product in line with the feedback. Basically what these researchers are saying is that formative evaluation research encompasses the evaluation of educational programs or products to: 1) evaluate whether the program serves its intended purpose, and 2) evaluate whether it meets the needs of the users. It is thus a process of continual reflection and adjustment of a program/intervention so that the final product will adhere to certain criteria that the developer has set.

Formative evaluation is one of the “least-well done parts” in the process of program development (Beyer, 1995:2). Although formative evaluation is an essential step towards effective program development, since it will guarantee the final product will work as intended, it is the most neglected step in the development cycle. Moreover, an effective intervention program or an effective program development refers to the effectiveness of the goals set out by the developers, the content, technology used and the design of the intervention or program (Davidson-Shivers & Rasmussen, 2006). Each of these concepts will be discussed below with the goal of illustrating how it was used in the current research study and how it assisted the researcher in answering the research question, i.e. what are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?

Beyer (1995) acknowledges that negligence of evaluating program development is due to poor funding, not enough time at hand, a shortage of staff, as well as stakeholders not understanding

the process of formative evaluation, hence not showing enough interest in the process. Furthermore he argues that formative evaluation is usually planned at the end of the program development cycle, and when funds are withdrawn from the project, formative evaluation gets eliminated. Since Moodle-based learning material specific to mathematics education for the Deaf is a new endeavour in a South African context, it is crucial to evaluate such an online learning program and make adjustments where needed. Moreover, it is crucial to evaluate such an online learning program while it is still in its implementation stage. I will argue that Moodle-based mathematics learning material has the potential to facilitate meaningful learning opportunities for Deaf Grade 9 learners. For this reason the nature of formative evaluation is discussed in the next section.

3.5 Research cycle

Flagg (1990), on the other hand, describes the stages of formative evaluation specific to the development of a program or intervention as well as the evaluation steps. Since Moodle-based learning materials will be used in this research study, Flagg's model is relevant to this study. The table below describes formative evaluation specific for the Moodle-based learning materials.

	Program Development	Evaluation
1.	Planning	Needs assessment
2.	Design	Pre-production Formative Evaluation
3.	Production	Production Formative Evaluation
4.	Implementation	Implementation Formative Evaluation

Table 3.2: Formative Evaluation program development within the current research project (adapted from Flagg, 1990:35).

The following phases were implemented within the research report.

3.5.1 First phase – needs assessment phase

Flagg (1990) highlights the first evaluation phase as the needs assessment phase. This phase includes the rationale for the intervention or program, the content and the implementation of the system. Davidson-Shivers and Rasmussen (2006) argue that needs analysis or problem analysis involves identifying the problem at hand as well as possible solutions for the problem. They further posit that there are two main steps that need to be followed, i.e.: 1) find out the nature of the problem/needs, and 2) find out possible solutions to the problem /needs.

3.5.1.1 Data collection

The needs assessment of this research report was done by gathering data from an extensive literature review of Deaf learners and their struggle with mathematics problem-solving. Data was also retrieved from my own experience as a teacher of the Deaf. The teacher researcher made use of field notes and memos which were later transcribed and imported into MAXQDA, a qualitative data analysis software. On the basis of this data I have constructed a table to highlight what Davidson-Shivers and Rasmussen (2006:73) coined “actuals” (the current condition within the school for the Deaf) and the “optimal” (identifying the sought after condition at the school for the Deaf) specific to mathematics problem-solving.

ACTUALS	PROBLEM/NEED	OPTIMALS
Deaf Grade 9 learners struggle with mathematics problem-solving.	Lack of skills between translating mathematics problems into multiple representations.	Skilled in using multiple representations within Moodle to translate mathematics problems.
Leave questions blank and lose marks. Failing maths and repeating grade.	Give learners opportunities to use ICTs to move between multiple representations of mathematics problems and construct their own representations.	Describe and translate mathematics problems, increase exam and test scores and increase chances for enrolling in higher education.

Table 3.3: The analysis of the needs identified in the current research project (Adapted from Davidson-Shivers and Rasmussen, 2006:81).

The needs identified in this research report are as follows:

- Deaf learners need assistance in translating the mathematics problems into formats they will comprehend
- Deaf learners need mathematics learning material that that will assist them in reading and language difficulties they experience.

This study proposes the following goals to accommodate the needs that were identified:

1. The Moodle-based learning material should include activities that foster multi-representations of the mathematics problems

2. The Moodle-based learning material should cover the content on mathematics problem-solving and should provide for a significant learning experience, which means that the online learning materials must be adapted to the Deaf Grade 9 learners' needs

The tools in Moodle will thus be evaluated according to Ainsworth's (2006) multi-representation model discussed in chapter 2 which includes: a) the number of representations it can employ, b) the way in which the tools can distribute information over the representations, c) the form of the representational system, d) the sequencing of the representations and e) the support the tools give for translation between representations.

3.5.2 Second phase

According to Flagg (1990) this phase is called the pre-production formative evaluation phase. During this phase a prototype is designed according to the literature review and the characteristics of the users.

3.5.2.1 Data collection

The expert review will inform the content and the design of the program or intervention (Tessmer, 1993), which in the case of this study is the teacher researcher. From the literature, the teacher researcher collected data relating to the characteristics of how the online design should look by focusing on ideas such as arrangement of the learning materials, clarity of objectives, multimedia content, Moodle interface as well as the particular mathematics content. The teacher researcher made use of field notes to capture important information regarding online learning construction as well as how Deaf and H/H learners learn. The teacher researcher also makes use of memos within MAXQDA, a qualitative data analysis software to capture these field notes.

In addition the literature review and the characteristics of the learners also informed decisions about the instructional goals, the instructional content, the technology that was used and the message, in this case is the format of the Moodle-based course. Each of these are discussed in detail below.

3.5.2.1.1 Instructional goals

According to Davidson-Shivers and Rasmussen (2006) the instructional goals should be reviewed for their "accuracy, clarity, completeness as well as its congruency to other parts of the web-based instruction" (p.136). The instructional goals intended for this research report are 1) multi-representing mathematics content in general and mathematics problem-solving in particular through the use of Moodle, thus learning mathematics through multiple representations and 2) integrating learning of mathematics in a realistic and relevant context, thus providing a significant

learning experience for Deaf learners. Since two instructional goals were identified it will be evaluated accordingly.

3.5.2.1.2 Instructional content

The Instructional Content is evaluated according to its accuracy and whether the sequencing is appropriate, in other words, how the content is structured and whether it is relevant. Since Moodle-based learning materials are developed, which consist of activities based on *Numbers, Operations and Relationships*, set out in CAPS (2011) it will be evaluated as to whether it covers the content set out in CAPS(2011) and to what extent these Moodle-based learning materials assist Deaf learners in their understanding of mathematics problems. It will also be evaluated for the sequencing of the content based on Gagne's (1985) nine instructional events discussed in chapter 2. The sequencing of the content refers to whether the Moodle-based learning materials are structured and provide for meaningful learning experiences for Deaf Grade 9 learners.

3.5.2.1.3 Technology

The technology is evaluated according to its “functional errors such as typographical, spelling, grammar, punctuation and word usage” (Davidson-Shivers and Rasmussen, 2006:136). In the current research report, technology indicates the Moodle-based learning environment which consists of all the tools used in Moodle. Furthermore it also includes the online learning content as well as the structure of the Moodle-based content. In other words are there any problems with the Moodle learning environment that might be problematic for the learners' online experience? Is everything in the learning environment working as it is supposed to work? Since this research report makes use of different tools in Moodle, it must be tested beforehand to see whether it works as it was designed to work and whether it adheres to the constructivist model set out by Murphy (1997). Since the tools in Moodle will be used to represent the particular mathematics content, these tools must also be evaluated for its consistency to represent the mathematics content. Furthermore, since Moodle is web-based, internet connections need to be checked for consistency, plugins like *JAVA*, *Geogebra* and *WIRIS* need to be installed so that learners can access some of the content and construct their own representations of the mathematics content.

3.5.2.1.4 Message Design

“The message design is evaluated in terms of whether the media is aesthetically pleasing and integral to the instructional message” (Davidson-Shivers and Rasmussen, 2006:137). This means that the presentation of the content, i.e. graphics, video, animations, text and images are reviewed to determine whether they enhance instruction and assist learners in achieving the instructional goals. Since this research report makes heavy use of multimedia mathematics materials that consist of mathematics videos, flash animations, images and graphics, the teacher researcher must

ensure that the relevant plugins like *Flash*, *QuickTime* and *JAVA* are installed to represent the content in the correct format.

To ensure that these Moodle-based mathematics problem-solving materials will adhere to a constructivist based pedagogical model as well as provide a meaningful learning experience for Deaf and H/H Grade 9 learners, it was deemed necessary to evaluate it against Murphy's (1997) constructivist based pedagogical model for online learning and Gagne's (1985) nine instructional events for structured learning, discussed in chapter 2.

3.5.3 Third phase – production formative evaluation

The third phase is called the production formative evaluation phase. During this phase the three Deaf and H/H Grade 9 learners were given opportunities to engage in the Moodle-based mathematics problem-solving activities. For this reason, the one-to-one evaluation was used. The one-to-one evaluation involves one learner per cycle to evaluate the material (Tessmer, 1993).

3.5.3.1 Data collection

Firstly, the data was collected by making use of personal interviews with all three Deaf and H/H learners. The data extracted from the personal interviews with Deaf Grade 9 learners acted as evidence and informed adjustments made to the original Moodle-based intervention. Therefore an interview schedule was used to capture the data (Addendum A). The teacher researcher translated the written questions of the interview schedule into Sign Language, which the learners could understand and the learners' answers were video recorded and transcribed the same day into readable text. Paulsen and Dailey (2002) argue that interviews are very valuable since they provide descriptive information on the way in which the intervention is being applied and highlight the successes and drawbacks of the intervention.

Secondly, direct observation was also used and administered by the teacher researcher. Direct observation entails observing how the intervention unfolds right in front of your eyes (Tessmer, 1993). Since Moodle-based learning materials and Moodle tools will be evaluated in this research report, direct observation will give the researcher "tangible evidence" of the "implementation and progress" of the intervention (Paulsen and Dailey, 2002:13). For example, by observing Deaf Grade 9 learners while they are interacting with the Moodle-based learning material, the teacher researcher might gain useful data to adjust the original prototype. Paulsen and Daily (2002) further posit that a successful observation instrument is one that: 1) generates data that is specific to the individual and 2) obtains comparable data. The kind of observation instrument that will be used in this research report is one based on capturing cases as they unfold and recording them by making use of an observation schedule (Addendum B). Field notes were taken as part of the

classroom observation process. The purpose of these field notes was to capture the interactions of learners and the events with regard to the issues being investigated.

3.5.4 The Fourth phase

Flagg (1990) coined the fourth phase as the implementation formative evaluation phase. This phase relates to how the intervention or the program is implemented in its intended environment. In other words the program is launched to evaluate the local impact it has on the users. Essentially this means that Grade 9 Deaf learners at “*school zee*” will interact with the revised prototype.

3.5.4.1 Data collection

Firstly, the teacher researcher closely observes the learners’ interaction with the learning materials. Notes are made by the teacher researcher which act as field notes and are transcribed as well as imported within MAXQDA. Secondly, records and documents which include reports on planning, logs on web activities, time spent on activities, quiz results and interaction reports (Tessmer, 1993) are also collected as data. These documents and reports can be useful in providing the researcher with evidence of the progress learners make while engaging in activities. Accordingly, login information, the time learners spent on the Moodle activities, the tools they used, their quiz scores and their engagement in forums and Wikis will all add to data being collected. Capturing this data is crucial since it will give the researcher an indication of which Moodle-based learning activities Deaf Grade 9 learners preferred.

Thirdly, since learners will be making use of Moodle tools and designing their own representations of mathematics problems in Moodle, it acts as artefacts that can be used to add to the knowledge base, meaning the construction of these representations based on mathematics problem-solving and making use of the tools in Moodle will provide the researcher with the data that is needed to answer the research question.

Data from individual interviews with learners as well as the observation from the teacher researcher informs further adjustments to the prototype. This phase is crucial for further developments and it also informs the teacher researcher how the program or intervention will be received by the intended users. This will be the final phase of the Moodle-based intervention and from here final adjustments will be made to the prototype. Figure 3.1 below depicts the life cycle of the current research report.

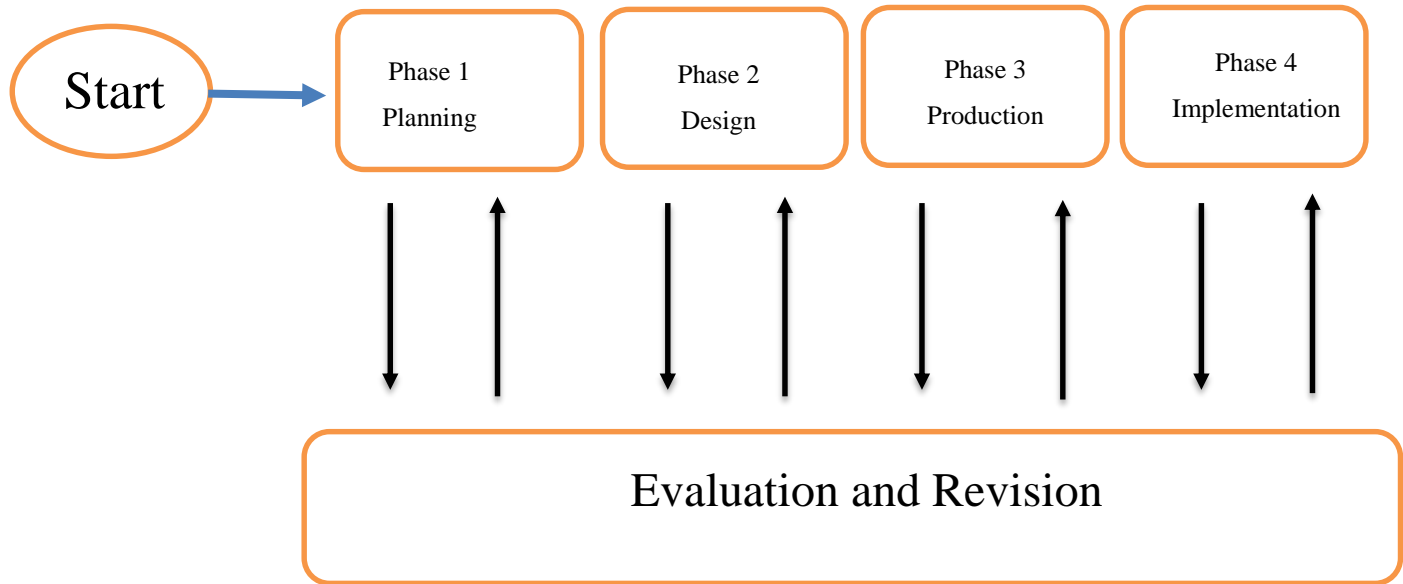


Figure 3.1: The different phases of the life cycle as it was implemented within the current research report.

3.6 Data analysis

The data retrieved from the observation done by the teacher researcher as well as the field notes from all the phases will be uploaded to MAXQDA, a qualitative data analysis software. The data will be read through in search of overarching concepts and themes. These concepts will be codified and grouped according to themes.

Since the personal interviews were video recorded, using Sign Language, these video chunks needed to be transcribed into readable text. This textual data will be uploaded to MAXQDA, a qualitative data analysis software. Within MAXQDA the data will be read in search of concepts and overarching themes. These concepts in the form of text units (TU) will be codified and grouped according to themes found. The data recorded within Moodle, which consists of activities, journal writings, forum discussions as well as comments in the Glossary module, will also be analysed and grouped within MAXQDA. All the above data will be further analysed within MAXQDA, for overarching themes and then be grouped for further analysis. The illustrations below depicts the data analysis process (figure 3.2) and the stages of data analysis (Table 3.4) for the current research report.

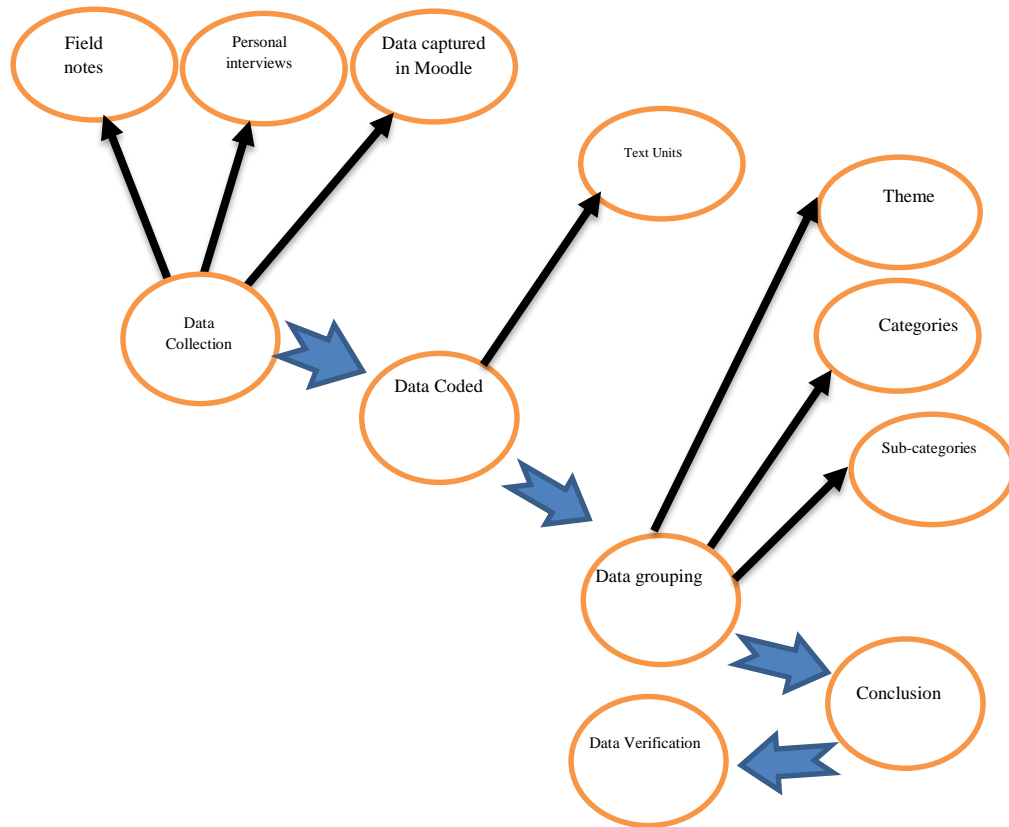


Figure 3.2: Data Analysis Process that was followed throughout this research project

3.6.1 Stages of data analysis

No.	Process of data analysis	Software used
1.	Transcribing: Interview and observation data transcribed.	Microsoft Word
2.	Coding 1: Each answer, comment, field note, text was coded with text units.	MAXQDA
3.	Coding 2: Each text unit was compared with other text units to examine concepts and themes that emerged. Categories and subcategories were determined.	MAXQDA
4.	Patterns and themes were established.	MAXQDA
5.	Conclusion was made.	Microsoft Word
6.	To verify the conclusion it was compared to the original data.	

Table 3.4: The stages used to analyse the data within the current research project.

The analysis of the data gave the teacher researcher more insight about how the Deaf and H/H Grade 9 learners experienced the Moodle-based mathematics problem-solving activities.

3.7 Limitations of this study

The purpose of this study was to examine the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle. Because only one content area, i.e. Numbers, Operations and Relationships was covered and represented via Moodle, it cannot be generalised across the other three content areas and further investigations are needed. Only three Deaf and H/H learners and one teacher took part in this study which further limits the outcome of the study. Further research is needed in the case of the possibility of Moodle to multi represent the mathematics curriculum as set out in CAPS (2011).

Another limitation that came to mind near the end of this study was the possibility of using participatory action research as a research design since Deaf and H/H Grade 9 learners were already engaging with the Moodle-based mathematics problem-solving activities.

3.8 Validity

The validity of this research study was guaranteed by obtaining ethical clearance from the university's ethics committee. Furthermore, permission to conduct the study was obtained from the Western Cape Education Department (WCED). Moreover, the learners were asked, in the form of consent forms, to take part in this research study. The aim of the study, which is to examine whether Moodle-based learning materials can assist Deaf and Hard of Hearing learners with mathematics problem-solving, was explained to the learners. The researcher also explained to the learners that their participation in this research study would assist the teacher researcher in developing Moodle-based learning materials that could assist them with difficulties in mathematics problem-solving.

The confidentiality of the data obtained was explained to the learners. Since data based on Deaf and Hard of Hearing Grade 9 learners' interaction with Moodle-based learning materials was collected, the teacher researcher explained to all the participants that the data will be kept secure. The data was kept secure through a 128 bit encryption on my laptop's hard drive which is also password protected.

Due to the sensitive nature of the data, Deaf and Hard of Hearing learners were provided with pseudonyms. Since three learners were selected to take part in this research report, the learners were registered as *user 01*; *user 02*; and *user 03*. The learners cannot be identified in any other way.

3.9 Summary

In order to answer the research question i.e. *What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?* It is imperative to formatively evaluate Moodle as a LMS. In other words, Moodle as an online learning environment will be formatively evaluated in relation to a social constructivist online learning environment. The Moodle-based online course will be formatively evaluated against Murphy's (1997) constructivist based pedagogical model for online learning. Furthermore the Moodle-based learning materials will be structured and evaluated according to Gagne's (1985) nine events of instruction. Moreover, the tools in Moodle will be evaluated according to Ainsworth's (2006) multi-representational model. All of the criteria used to structure and evaluate the Moodle-based learning material used in the current research report will contribute to modifying the original design to conform to the criteria set out by the different literatures. Additional tools that will be used to extract the data needed are that of direct observation, expert and one-to-one reviews as well as personal interviews with the Deaf Grade 9 learners.

Chapter 4: The Moodle-based tasks used: data collection and data analysis

4.1 Introduction

This chapter includes findings based on learners' experiences with the Moodle-based learning materials as well as personal interviews, expert reviews, teacher researcher observations and the results of the formative evaluation of the LMS. Firstly, the chapter includes the formative evaluation of Moodle-based learning materials and whether it is in line with Ainsworth's (2006) multi-representational model. Secondly, this chapter looks at the design of the online learning program based on the criteria of Murphy's (1997) constructivist based pedagogical model. Thirdly, the structure of the Moodle-based course design is evaluated against Gagne's (1985) nine instructional events. The chapter concludes with the results of the personal interviews as well as the expert observation about learners' interaction with the Moodle-based learning materials.

4.1.1 Formative evaluation of the tools in Moodle

In order to determine the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle, the representational features of the tools in Moodle are evaluated according to Ainsworth's (2006) multi-representational design model discussed in chapter 2. Accordingly, each tool will be evaluated to check whether the tools in Moodle do indeed adhere to what constitutes as crucial to multi-representational designs. The section below describes the design dimensions of a multi-representation model and how the tools in Moodle comply with these dimensions.

4.1.1.1 Number of representations

This dimensions refers to the number of representations a system can employ (Ainsworth, 2006). Table 4.1 below demonstrates the number of representations the tools in Moodle can employ.

Design Dimension		Modules in Moodle					
1.	Number of representations	Glossary	Lesson	Forum	Wiki	Quizzes	Assignment
		2+	2+	1	2+	2+	2+

Table 4.1: The number of different representations that can be used within the modules of Moodle.

As illustrated, all of the tools in Moodle except one, the Forum module, can employ more than two interactive representations of mathematics problems. Since these tools were used to represent

mathematics problems, the question was how many of the mathematics problems these tools can represent in an interactive way. Not only was it possible to depict more than two representations of mathematics problems within one module of Moodle, but learners could use the Glossary, Wiki and Assignments tools to construct their own number of representations and represent mathematics problems either simultaneously or one by one. Ainsworth (2006) posits that when a learning environment can multi-represent content, it provides opportunities for learners to work with their preferred representation. This is prevalent in the current research study as well, since learners used the Glossary and Assignments tools where they could use their own preferred representation of mathematics problems. This, however, is not the case for the Forum module since only one interactive representation per discussion in the Forum module could be used.

4.1.1.2 The way in which the information is distributed

This dimension refers to how the information, in the case of this research report, the representation of mathematics problems, is distributed across the Moodle platform (Ainsworth, 2006). Besides the fact that the representations of mathematics problems could be duplicated between modules in Moodle, the mathematics content could be linked, which meant that learners could experience the same information regarding mathematics problems more than once. For example, the Glossary tool which consists of all the terminology regarding ratio and rate and the different representations thereof, could be linked to the quizzes and the Lessons module. Each time the learner found it difficult to understand a mathematics problem, they could click on the link and it took them to examples or definitions instantaneously. On the other hand, when learners found it difficult to grasp one representation of the mathematics problems, they could use a different representation (Ainsworth, 2006).

4.1.1.3 Form of representational system

This dimension refers to the online system presenting information in a multimedia format, i.e. text, video, graphs, tabular, equations, animations and pictures (Ainsworth, 2006). The current Moodle-based course made heavy use of multimedia representations, since the online system will be used by Deaf and Hard of Hearing learners, who are more dependent on their visual sense of perception than any other senses. Hence multi-representations of mathematics content in general and mathematics problems in particular are presented in Moodle by means of graphs, tables, equations, video, animations and text. However, these multi-representations are not used individually; they are either used in conjunction with other representations of the same mathematics problem or to support another representation. The reason for this is to present learners with as many options as possible for them to decide with which representation they feel comfortable. The discovery that was made through the current research report was that every module in Moodle could be used for different forms of representations.

4.1.1.4 Sequence of representations

This dimension refers to the sequence in which the representation should be constructed (Ainsworth, 2006). For example, the potential order the mathematics content is presented online as well as how it should be used with other representations. In the current research report the sequencing of representations is achieved through quizzes after each lesson. The Grade 9 Deaf and Hard of Hearing learners interacted with the representations in the Lessons module and engaged in the quiz at the end of the Lessons module. Their response to the questions in the Quizzes module determined whether they could move onto a new representation or whether they needed to interact further with the same representation in order to strengthen their understanding. Learners that answered the questions in the quiz correctly could move onto the next representation of the mathematics problems based on ratio and rate.

4.1.1.5 Support for translation between representations

This dimension refers to the relation between multiple representations (Ainsworth, 2006). For instance, while learners were busy interacting with an animation based on distance, time and speed in the Lessons module, they had to interpret the textual representation by interacting with the graph. For example, they could either use the graph to manipulate values or input new values to manipulate the graph. Another example was when the Deaf and H/H Grade 9 learners had to construct their own graph and tabular data based on a mathematics sentence. This activity was done in the Assignments module and learners had to create a question and then represent the question in two different formats. All three of them chose to represent it in a tabular and graph format. By constructing the graph and table in Moodle, based on their questions, the Deaf and H/H learners could see how the questions they created took shape in other formats and hence could move between these different representations.

4.1.1.6 Summary

As seen from the above findings, it is possible to represent Grade 9 mathematics content in general and mathematics problems in particular within Moodle. Although only one representation could be used and discussed in the Forum module, it helped learners focus their attention on only one representation of a mathematics problem which in turn could be discussed in detail. All the tools used in Moodle could represent Grade 9 mathematics content in different formats and learners could choose a preferred format for representing mathematics content. Another feature was the fact that learners could move between representations of mathematics problems. This feature helped learners to see one problem represented in different formats and they could move between these formats in order to understand the problem better and solve the problem with understanding.

4.2 Formative evaluation of the design of the learning program

In the next section the design of the learning program will be evaluated according to a constructivist-based pedagogical model. As stated, the design of the Moodle-based learning materials was informed by the characteristics of the constructivist based pedagogical model suggested by Murphy (1997).

Since these Moodle-based learning materials were designed for Deaf and Hard of Hearing Grade 9 learners in particular, it is crucial to note that it makes heavy use of multimedia content due to Deaf and Hard of Hearing learners' dependency on their visual perceptions. The next section includes Murphy's (1997) constructivist based pedagogical model and how the Moodle-based learning course was evaluated according to the criteria set out by this model.

4.2.1 The Constructivist-based Pedagogical Model

4.2.1.1 Multiple perspectives and representations of concepts and content are presented and encouraged.

Multiple perspectives refer to the different views and opinions learners are exposed to (Murphy, 1997). When learners are engaged in the Forum, Wiki and Glossary module in Moodle, they are exposed to other learners' views on mathematics content, specifically ratio and rate. They can either adopt these views or express their own views via comments or discussions. The multiple representations of concepts and content were discussed in the previous section.

4.2.1.2 Goals and objectives are derived by the student or in negotiation with the teacher or system.

This dimension refers to the learner being part of the design team in constructing the learning goals and objectives (Murphy, 1997). This means that it is not the objectives that determine whether the learners learnt anything during the learning process but *what* the learners learn and *how* they learn during the learning process. For example, in the current research report the learning objective was how learners must solve problems in context based on ratio and rate within Moodle. What emerged through the study were objectives set on simplifying fractions and additive and multiplicative relationships. These were new objectives that emerged while Deaf and Hard of Hearing Grade 9 learners were interacting with the Moodle-based learning materials. Furthermore as learners constructed new knowledge through exploration (interactive activities in the Moodle-based modules) and self-reflection (in their own journal), it presented the teacher researcher with insight about how learners obtained new knowledge.

4.2.1.3 Teachers serve in the role of guides, monitors, coaches, tutors and facilitators.

The teacher is always there to act as a guide, monitor, coach, tutor and facilitator (Murphy, 1997). This means that the teacher monitors the students and provides assistance where needed. For this reason the teacher researcher provides links between different modules in Moodle as well as an individual Wiki where learners are provided with help if they need it. The teacher researcher also directs discussions in the Forum module by posing questions that will challenge learners' critical thinking and problem-solving skills.

4.2.1.4 Activities, opportunities, tools and environments are provided to encourage metacognition, self-analysis, -regulation, -reflection and -awareness.

“Reflective thinking involves analysing and making judgments about what happened in the past as a way to give a situation new meaning” (Dabbagh & Bannan-Ritland, 2005 in Van Rooyen, 2011:14). This means that the online learning environment should create space for learners to reflect on what worked and what did not work. In the current research report this is done through the use of forum discussions and by means of learners keeping an online journal. Reflection also occurs when learners review other learners' glossary entries and make comments where needed. On the other hand self-directed learning is defined as “the skill of learning how to learn or being metacognitively aware of your own learning” (Dabbagh & Bannan-Ritland, 2005 in Van Rooyen, 2011:15). This means that the online learning environment should create space for learners to continually direct their own learning. This is reflected in the current research report through forum discussions, where learners become aware of their own way of thinking as well as through the Assignments module which uses a rubric. Learners must evaluate their own assignment through a set of rubrics designed by the teacher. This further strengthens self-evaluation.

4.2.1.5 The student plays a central role in mediating and controlling learning.

As stated before, the goal with this research report is not so much learners obtaining the learning goals but to examine how Moodle can assist Deaf and Hard of Hearing learners with mathematics problem solving. Through observation done by the teacher researcher, it became apparent that learners struggle with simplifying fractions as well as additive and multiplicative relationships. The teacher researcher had to go back and make sure to adjust the Moodle-based learning materials in order to provide opportunities for learners to acquire these skills before they could advance to the next section which is ratio and rate. Essentially the learners are in control of the learning process since the aim is to meet their needs.

4.2.1.6 Learning situations, environments, skills, content and tasks are relevant, realistic, and authentic and represent the natural complexities of the 'real world'.

Authentic learning involves learners engaging in real world activities that are relevant to their context (Murphy, 1997). Since this research report focusses on Deaf and Hard of Hearing Grade 9 learners and overcoming their struggle with mathematics problem-solving it was deemed necessary to expose them to content that they will encounter in their everyday lives. For this reason the Assignments module includes planning an overseas trip. The learners have to work out flight departures, flight seating and meal costs, etc. all based on ratio and rate problems. Learners are thus forced to make decisions based on the budget they need to follow.

4.2.1.7 Primary sources of data are used in order to ensure authenticity and real-world complexity.

The complexity of the real world makes it difficult to represent it statically. Hence multimedia and dynamic content is used in this current research report to overcome this difficulty. Geogebra content included in the Forum and Quizzes modules, includes representations of real world problems, presenting learners with authentic activities. Learners are also engaged in activities that they can relate to, such as making syrup, the scores of rugby games, scales of charts, a recipe for preparing a turkey, learners' test scores, etc. Furthermore, Phet simulations in the Assignments module make it possible for learners to interact with the simulations as they are in real life, which presents learners with a realistic view of how ratios are presented in real life.

4.2.1.8 Knowledge construction and not reproduction is emphasized.

The online learning environment should promote knowledge construction and not merely reproducing what the teacher did (Murphy, 1997). This means that learners should be provided with ample opportunities to construct their own knowledge. In the current research report learners are engaged in Moodle-based learning materials based on mathematics problem-solving. In the Lessons, Forum and Quizzes modules, learners are asked to interact with the simulation and from their interaction they have to draw conclusions. Not only can they construct knowledge from their own interactions with these activities, but they can also draw from other learners' opinions in the Forum and Glossary module. Moreover, knowledge construction also happens through feedback from the Quizzes module. After each quiz the learners are presented with their response on questions as well as the correct answers with appropriate feedback. The aim of the feedback is to assist learners in their knowledge construction.

4.2.1.9 This construction takes place in individual contexts and through social negotiation, collaboration and experience.

The online learning environment should promote social negotiation and collaboration (Murphy, 1997). This means that learners must be provided with opportunities to construct their knowledge individually as well as through interaction with their peers. Social negotiation and collaboration is reflected in the current research report through learners taking part in forum discussions, where they can raise their voices on issues related to ratio and rate problems. Furthermore, it also takes place through individual Wikis, where learners construct their own knowledge through interaction with the teacher.

4.2.1.10 The learner's previous knowledge constructions, beliefs and attitudes are considered in the knowledge construction process.

The online learning environment should provide a link between learners' previous knowledge and their new found knowledge. This means that the online learning course should create space for learners to draw from previously-acquired knowledge and link this to the new undiscovered knowledge. The Moodle-based online course creates space for learners to draw from their previously acquired knowledge since it introduces learners, by means of the Lessons module, to problem-solving principles and strategies, which were taught in the previous lesson. Learners are provided with slides which include all the information based on problem-solving and examples learners can complete on their own. This lesson acts as a bridge between the previous knowledge and the new knowledge based on ratio and rate, since learners need to use these problem-solving strategies to assist them in the new mathematics problems.

4.2.1.11 Problem-solving, higher-order thinking skills and deep understanding are emphasised.

The online course design should promote problem-solving, higher order thinking skills and should emphasise deep understanding. The focus should be on conceptual understanding and not merely following steps to solve problems. Examples of this are reflected in the use of the Glossary, Lessons and Quizzes modules. Learners must use the Glossary module to add their own entries about ratio and rate as well as link their entries to other modules. They also need to draw on feedback from the Quizzes module and re-take the quiz in order to adjust their wrong way of thinking. Additionally the learners should also think critically about solving representations based on ratio and rate while interacting with simulations in the Lessons module.

4.2.1.12 Errors provide the opportunity for insight into students' previous knowledge constructions.

The online learning course should provide learners with sufficient opportunities to rectify misconceptions and errors in their previous knowledge construction. This means that the online

learning course should provide learners with the opportunity to adjust their misunderstanding of concepts. Firstly, this is reflected in the Moodle-based online course through the use of the Quizzes module. After the quiz is administered, learners have access to their test scores as well as a detailed outline of their responses and the right and wrong answers. This is accompanied by detailed feedback based on their responses. The feedback directs learners to misunderstandings in their knowledge and hence assists them in rectifying these misunderstandings.

Secondly it is reflected through the Glossary module. Learners are provided with opportunities to review and make comments on other learners' entries. The final review is done by the teacher and learners are provided with opportunities to make adjustments to their entries.

4.2.1.13 Exploration is a favoured approach in order to encourage students to seek knowledge independently and to manage the pursuit of their goals.

The online course should promote exploration through self-discovery. For example, learners should be encouraged to explore new ways of doing things, try out new strategies and discover information on their own. The current research report brings discovery of new knowledge to life through making use of the lesson module. In the Lessons module learners are encouraged to interact with the simulations to comprehend or discover new knowledge. In the Forum module the teacher poses various questions in order to trigger learners' discovery senses and to force them to look at information in different ways. Through the use of the real time simulations in the Lessons and Forum modules, learners could play with value handles where they could increase or decrease the values which further influence other values in the simulation. Through these discoveries, learners could draw conclusions and add to their new knowledge base.

4.2.1.14 Learners are provided with the opportunity for apprenticeship learning in which there is an increasing complexity of tasks, skills and knowledge acquisition.

The Assignments and the Quizzes modules provide learners with complex tasks where they have to construct their own WIRIS answers based on randomised question types as well as plan a holiday vacation by making use of problem-solving skills obtained during their interaction with the Moodle-based activities. Although apprenticeship learning does not take place, learners are challenged with more complex problems.

4.2.1.15 Knowledge complexity is reflected in an emphasis on conceptual interrelatedness and interdisciplinary learning.

While learners are engaging in the Forum module they bring their own previous knowledge and perceptions to these discussions. This becomes evident in their reactions during these discussions. While the Deaf and Hard of Hearing Grade 9 learners are exposed to the other

learners' opinions and views, the conceptual interrelatedness and interdisciplinary learning becomes evident.

4.2.1.16 Collaborative and cooperative learning are favoured in order to expose the learner to alternative viewpoints.

The online learning environment should promote collaboration and cooperation between groups of learners, and learners and teachers. This is reflected in the current research report through the Forum and Glossary module. Since learners can post discussions and evaluate and assess other learners' forum posts, cooperation and collaboration takes place. The teacher on the other hand only acts as a coach or a mentor who provides feedback and guidance and directs the discussion for incidental learning to take place (Pagliaro, 2006).

4.2.1.17 Scaffolding is facilitated to help students perform just beyond the limits of their ability.

The online learning environment must promote scaffolding. This means that the online learning environment must create space to assist learners in completing the activities to acquire some knowledge and skills in order for them to complete it on their own. This is achieved in the current research report through the use of the Lessons, Glossary and Quizzes modules. Firstly, each lesson in the Lessons module builds on the previous one. This means, in order for learners to progress from one lesson to another they have to acquire the knowledge and skills of the preceding lesson. Secondly, links to every module in Moodle are created in the Glossary module which means that when learners have trouble understanding the concept in a module, they can click on the link and it will take them to the explanation of that particular concept. Finally, the Quizzes module can be set to different modes (discussed previously), which can provide immediate feedback to learners' responses.

4.2.1.18 Assessment is authentic and interwoven with teaching.

The online learning environment should promote authentic assessment and it must be interwoven in the teaching. The Assignments and Quizzes modules provide for authentic assessment which is interwoven with teaching. This means that content in the Assignments and the Quizzes modules are based on mathematics problems that consist of ratio and rate problems. Learners have ample opportunity to take the quiz and re-take the quiz in order to understand the mathematics content better. They can also re-submit their edited assignments.

4.2.1.19 Summary

As discussed above, the online learning environment does comply with the characteristics of the constructivist-based pedagogical model suggested by Murphy (1997). The following checklist was proposed by Murphy (1997) in order to give teachers and researchers guidance in examining

whether the online course does comply with the constructivist model. The grey area indicates what is supported by Moodle with relation to mathematics problem-solving.

CHARACTERISTICS		SUPPORTED	NOT SUPPORTED	NOT OBSERVED
1.	Multiple perspectives			
2.	Student-directed goals			
3.	Teachers as coaches			
4.	Metacognition			
5.	Learners control			
6.	Authentic activities & context			
7.	Knowledge construction			
8.	Knowledge collaboration			
9.	Previous knowledge construction			
10.	Problem-solving			
11.	Consideration of errors			
12.	Exploration			
13.	Apprenticeship learning			
14.	Conceptual interrelatedness			
15.	Alternative viewpoints			
16.	Scaffolding			
17.	Authentic assessment			
18.	Primary sources of data			

Table 4.2: Includes a checklist of the characteristics of a constructivist online learning environment and which characteristics are present within the current research project (adapted from Murphy, 1997:13).

4.3 The structure of the Moodle-based course

To ensure that the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle will be highlighted, it was important that the structure of the Moodle-based learning materials adhere to certain criteria, specifically Gagne's (1985) nine events of instruction, to ensure that learners are provided with a structured learning experience. The Moodle-based course consisting of mathematics content, which covers *Numbers, Operations and Relationships*, with the sub section of *ratio and proportion* (CAPS, 2011), were

designed. The nine instructional events of Gagne (1985) and how it was integrated in this research report will now be discussed.

4.3.1 Gain attention

The first instructional event is to gain learners' attention. The researcher used the Glossary module in conjunction with the games tool which is a supporting feature of the glossary tool. This feature of the glossary module uses the information in the Glossary module, in this case, mathematics problems and builds game-like activities based on these problems. At first Deaf and Hard of Hearing Grade 9 learners were given ample opportunity to add entries based on ratio and rate in the Glossary module. In addition, the learners could also add their own representations with these entries. Afterwards the teacher researcher created three games from the glossary, i.e. *who wants to be a millionaire*, *hangman* and a *crossword puzzle*. This really caught their attention, because they could interact with these three games for quite an extended time. Figure 4.1 and Figure 4.2 below depict what is discussed above.

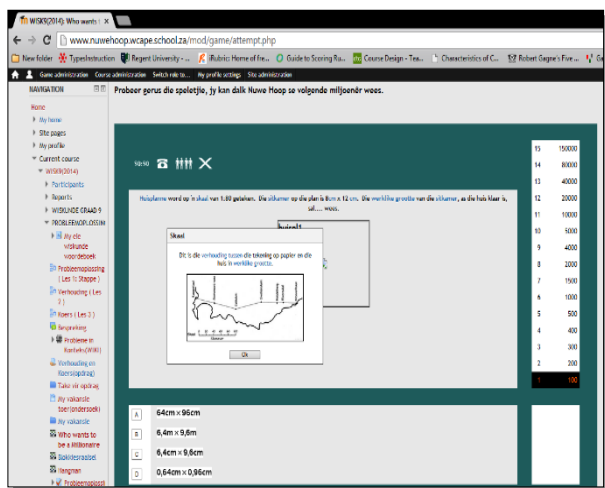


Figure 4.1: Who wants to be a millionaire.

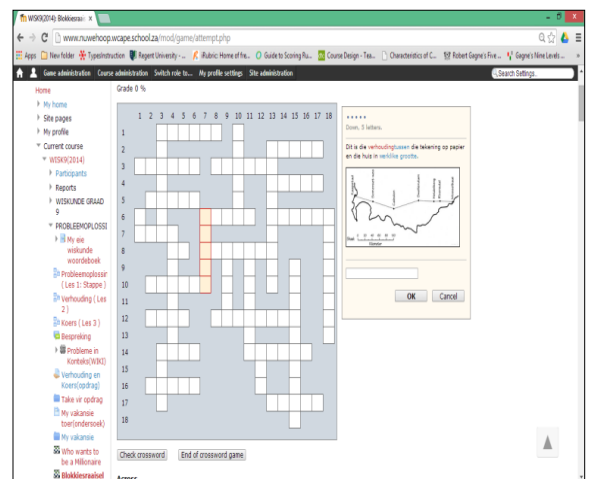


Figure 4.2: Blokkiesraaisel

Figure 4.1 and 4.2 represent the game feature of the glossary tool where concepts can be learnt in a game-like manner.

4.3.2 Inform learners of objectives

The Curriculum and Assessment Policy Statement (CAPS, 2011) for Mathematics for Grades 7-9 was used to determine what content should be covered for the design of the Moodle-based learning materials. For this reason *Numbers, Operations and Relationships* were selected as the content area. Furthermore, ratio and rate were selected, a division of the content area, as is set out in CAPS (2011). Since the mathematics content and the outcomes of what learners should know at the end of Grade 9 are prescribed by CAPS (2011), it is necessary for teachers in South Africa to follow this policy document. Moreover, CAPS (2011) highlights that all Grade 9 learners should be able to solve problems in context with relation to ratio, rate and proportion.

Table 4.3 below illustrates how the mathematics content based on ratio, rate and proportion which are prescribed by CAPS (2011) is integrated into the Moodle-based course.

The Deaf Grade 9 learners should be able to solve problems in context involving:	
Compare 2 or more quantities of the same kind (ratio).	Forum discussion Quizzes Assignments
Compare two or more quantities of different kinds (rate).	Lessons Quizzes module Assignments
Sharing in a given ratio where the whole is given.	Quizzes module Assignments
Increasing or decreasing a number in a given ratio.	Lessons Quizzes Assignments
Represent story problems based on ratio, rate and proportion in different formats (multiple representations).	WIKI Glossary Assignments
Move between representations of problems (translations).	Lessons Assignments
Explain/describe different representations of problems.	Forum WIKI
Evaluate representations of problems through interaction.	Assignments Forum
Simplify problems by making use of representations.	Lessons Assignments
Construct their own representations based on ratio, rate and proportion.	Forum Assignments WIKI

Table 4.3: Grade 9 mathematics content and what learners should know as prescribed by CAPS (2011:14).

4.3.3 Stimulate recall of prior learning

This event should assist learners in recalling prior knowledge and can be very informal. For this reason the researcher chose the Lesson module. With the help of the Lessons module the learners are presented with different kinds of mathematics problem-solving techniques learnt in the previous lesson. Through the PowerPoint presentations learners can view Polya's (1945) four problem-solving principles and techniques in action. These principles and techniques are

presented through different examples of mathematics problems. Figure 4.3 depicts how the principles and techniques are presented using the Lessons module.

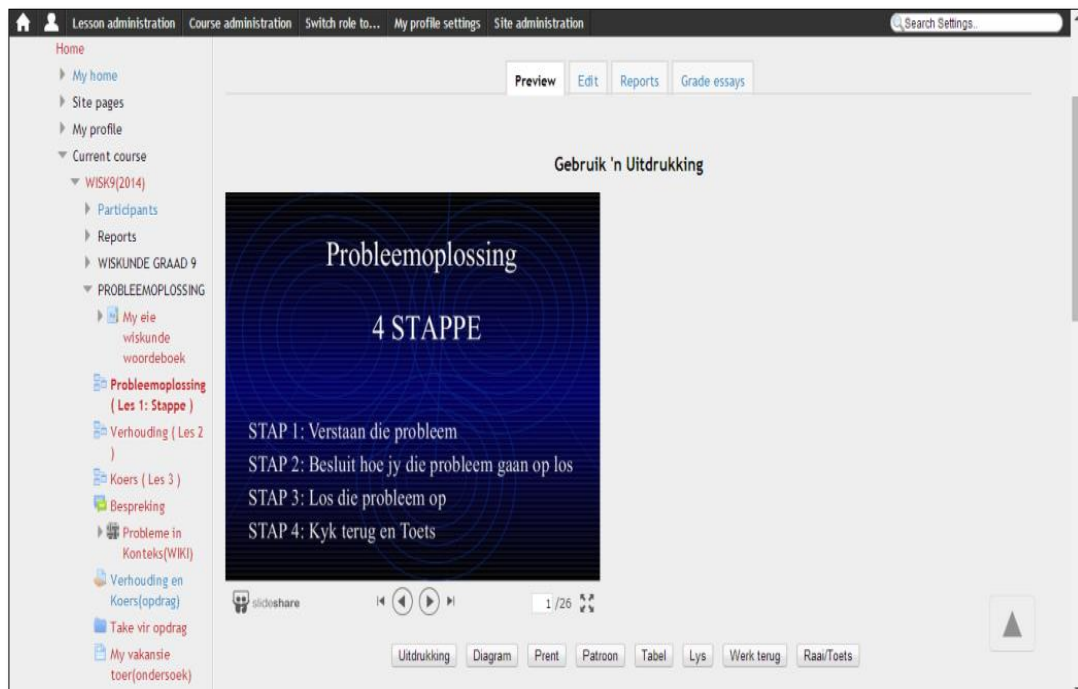


Figure 4.3: Polya's (1945) principles and techniques of problem-solving represented visually within a slideshow with examples and interactive activities.

Each of the buttons (Uitdrukking, Diagram, Prent, Patroon, Tabel, Lys, Werk terug, Raai/Toets) are links to different PowerPoint presentations of the principles and techniques used in mathematics problem-solving. Learners are given ample opportunities to watch the presentations. Furthermore, links are created throughout Moodle, within each of the modules, for learners to return to these presentations whenever they experience difficulties using the different techniques. At the end of each presentation, learners are presented with examples they need to work out by using the different principles and techniques. This, of course, is not an indication that learners are taught that problem-solving is a linear process, but to present them with different options to choose from when representing mathematics problems. Figure 4.4 depicts examples of problems learners need to solve by using the principles and techniques of Polya (1945).

Figure 4.4: Examples and practice exercises learners need to do while using the principles and techniques of Polya (1945).

4.3.4 Presenting the stimulus

This event refers to presenting the information in an effective way. Effective in this context means that mathematics content should be organised logically and learners should find it easy to follow and understand. Accordingly, a stimulus was presented in this research report by making use of multimedia elements and accommodating different learning styles. Figure 4.5; 4.6; 4.7 illustrate how different multimedia elements are used to present stimulus to learners.

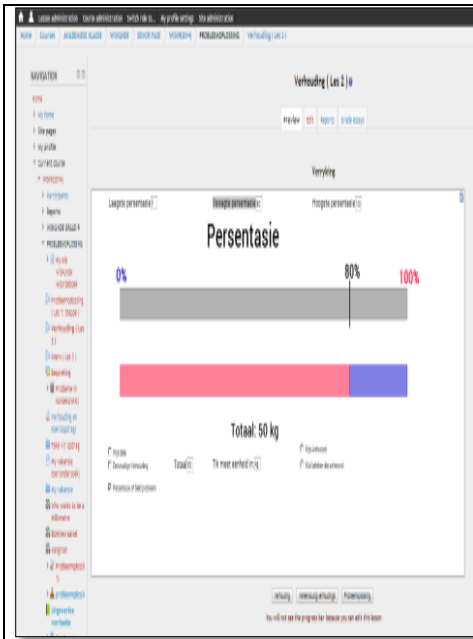


Figure 4.5: visual representation of ratio and rate

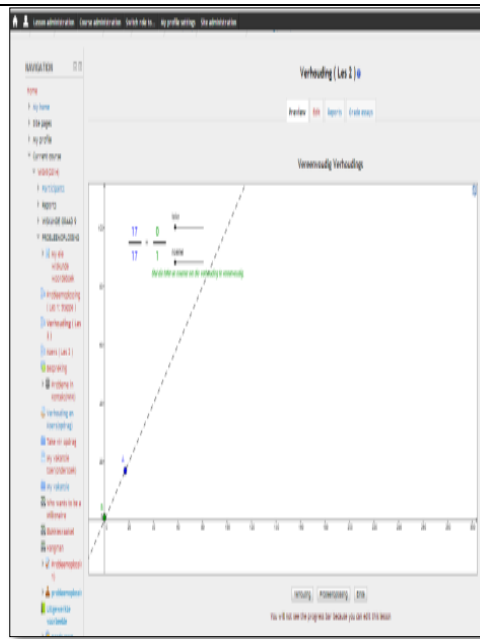


Figure 4.6: visual/textual representation of ratio and rate

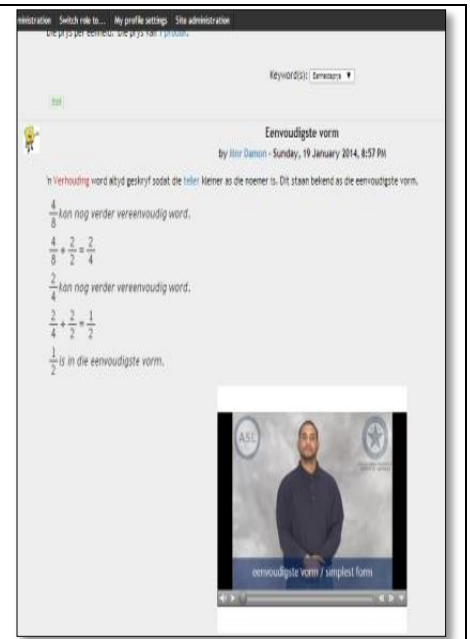


Figure 4.7: algebraic/video representation of quiz questions based on ratio and rate

4.3.5 Providing learning guidance

This event refers to helping learners retain what you want them to learn by providing them with alternative learning experiences. This event was achieved in the current research report by making use of the Glossary, Lessons and Forum modules.

The Glossary module consists of definitions of mathematics key concepts based on ratio, rate and proportion (CAPS, 2011). Not only are these mathematics concepts linked throughout the Moodle website, which means learners can access the mathematics content any time in any module, but it also means that learners can add their own representations of these mathematics concepts. The learners can also make comments on other learners' entries or rate their entries.

The Lessons module provides learners with a step by step guide to solving ratio and rate problems as well as an interactive assignment, which learners can play with while searching for the answers to mathematics problems. The Lessons module also has a scaffolding feature built into the module. For example, after each lesson, learners are presented with a quiz; if they answer the questions correctly, they will be presented with the next lesson. However, wrong answers will take them back to review the lesson.

Probleemoplossing

Wys/Steek weg Help

In Resep om 'n vrugtesap te maak benodig water en vrugtesap in die verhouding 4:1. Indien 45 koppies vrugtesap gemaak gaan word, hoeveel koppies water word benodig?

Stel letter waarde

WATER

STROOP

Stel nommer waarde

WISKUNDIGE DENKWYSE

Gebruik die model

Eerste teil ons 4 en 1 byrekenaar om 5 eenhede te kry

Deel dan 45 ÷ 5, en ons kry 9 koppies

Om uit te vind hoeveel koppies water benodig word, moet ons 4 x 9 om 36 koppies te kry.

Verhouding

$$\frac{4}{5} = \frac{w}{45}$$

$$4 \times 45 = 5 \times w$$

$$180 = 5 \times w$$

$$36 = w$$

Gebruik die tabel

WATER	TOTAAL
4	5
36	45

Verhouding Toets jou kennis Toets jou kennis 2 Vereenvoudig

Figure 4.8: Step by step guide to solving ratio and rate problems where learners can interact with features of the representation like changing the ratio or finding similar problems.

Probleemoplossing

Gryp die pers sirkel by SPOED om die spoed te verander.
Kyk hoe die SPOED en die Tyd altyd die afstand gee wat jy gestel het.

33.32 x 10.51 = 350

Spoed

Tyd

33.32 kmph

10.51 ure

Afstand (vast)

350

Stel die vaste AFSTAND hier.

Om die waarde te verander en die waarde te verander, klik op die pers sirkel om te verander. Indien dit nie met sukses geluk het, klik op die pers sirkel om te verander. Die waarde die tyd die SPOED is geset, en afstand die afstand is geset.

Formules Afstand Spoed Tyd Koers Ende van les

Figure 4.9: Interactivity in the Lessons module where learners can increase either the speed, time or distance and experience how distance speed and rate is calculated.

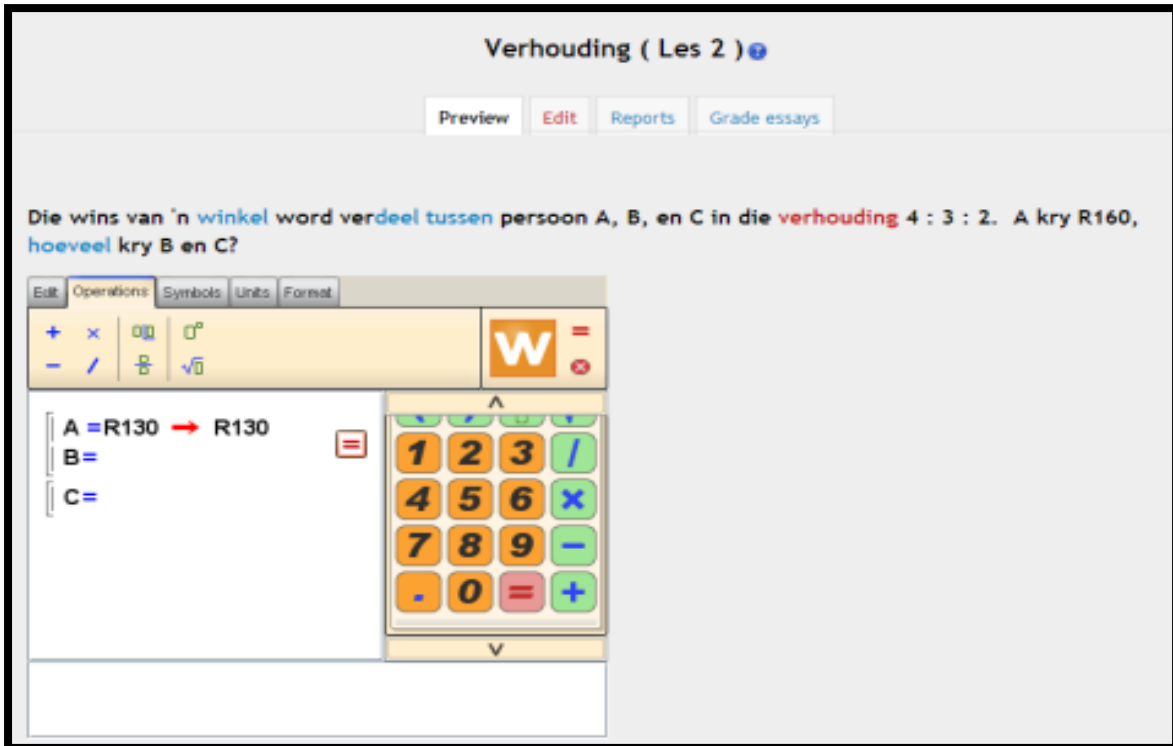


Figure 4.10: Scaffolding feature in the quiz module where learners have immediate access to a CAS to assist them with representing ratio and rate.

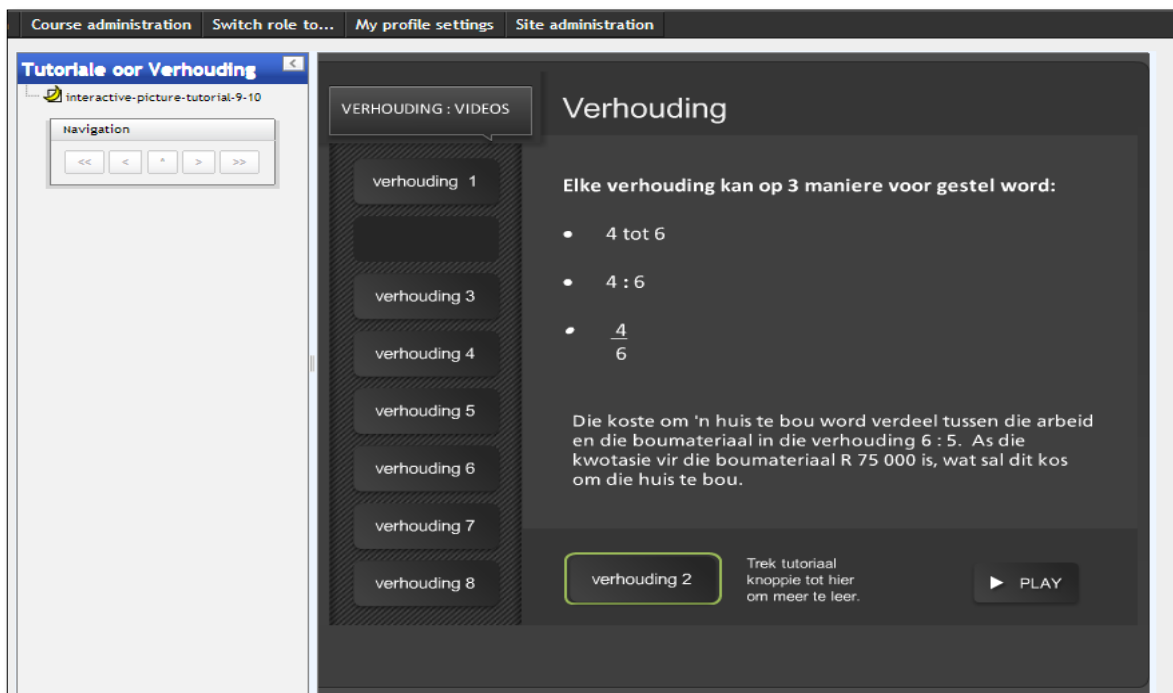


Figure 4.11: video and textual representation of ratio and rate problems

The final approach is making use of the Forum module. The Forum module is used in this research report to guide the discussions by posing different questions based on the mathematics problems. Further approaches include the video tutorials which illustrate different approaches to mathematics problem-solving which learners can follow. The snapshots above and beneath illustrate the different approaches used to guide the learning process.

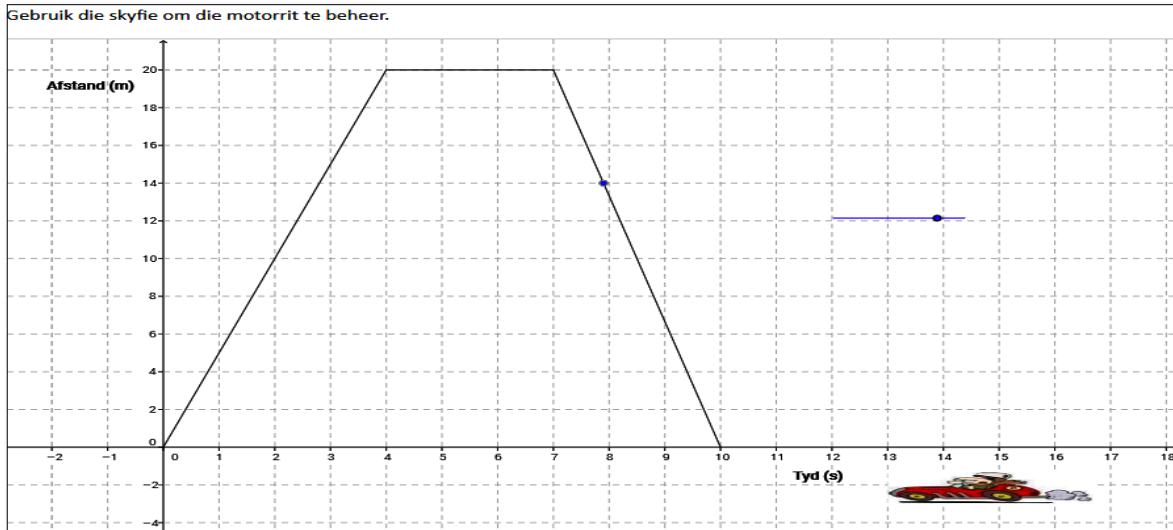


Figure 4.12 represents a graph model of rate problems where learners can interact with the graph by moving the car back and forth and simultaneously increasing or decreasing the time or the distance.



Figure 4.13 represents the verbal/sign language representation of ratio and rate problems.

4.3.6 Eliciting performance

This event refers to how well learners can demonstrate what they have learnt. The current research report makes use of the Quizzes and Assignments modules to provide opportunities for learners to demonstrate what they have learnt. The Quizzes module provides learners with questions based on ratio and rate problems for which the correct answers must be provided. When learners provide the answers, they move on to the next question. At the end of the quiz, learners are provided with the correct answers and the score they achieved. Learners are given feedback on their answers and they are provided with opportunities to better their understanding by taking the quiz again. Figure 4.14 illustrates how this feature is used in Moodle.

Question 24
Not answered
Marked out of 2
Edit question

Deel R560 tussen Alan, Brian en Ester in die verhouding 2:5:1. Hoeveel kry Brian?

R560

ALAN	BRIAN	ESTER
2	5	1
R x		

Brian: $\frac{5}{8} \times 560$
 $\frac{5}{1} \times \frac{70}{1}$
 = R350

The correct answer is: $\frac{5}{1} \times \frac{70}{1}$
 R 350

Question 37
Not answered
Marked out of 3
Edit question

Wil jy liever R840 per week (vir 8 uur per dag) of R40 elke 3 uur betaal word?

R 480	R 40
7 DAE (8 UUR PER DAG)	ELKE 3 UUR
IS DIE BESTE ????	IS DIE BESTE ???

Bereken albei eers as 'n koers per uur.
 R860 per week = R860 + 7 dae = R860 + (7 × 8)h = R15,36 per uur
 R40 vir 3 uur = R40 + 3uur = R13,33 per uur

Weeklikse betaling is beter, want ek kry meer.
 $R860 + (7 \times 8) = R15,36$

The correct answer is: $R40 + 3 = R13,33$
 weekliks

Figure 4.14: Quizzes module in Moodle is used to assess learner's performance and provide learners with immediate feedback.

The Assignments module provides learners with real world examples of mathematics problems learners must solve. During this Moodle-based assignment activity, learners are presented with a travelling exercise in which they have to solve different ratio, rate and proportion problems. They must also demonstrate their understanding of concepts relating to ratio and rate by representing the mathematics problems in multiple representations, i.e. algebraic, graphical, tabular, pictorial illustrations and text.

Course administration Switch role to... My profile settings Site administration

Beplanning en bespreking van vakansie.



Plekke van my vakansie:

Ek gaan my somer vakansie vanaf Engeland na Frankryk na Kanada na Australie spandeer in die verhouding:

14 : 7 : 21 : 21

Vereenvoudig hierdie verhouding in sy eenvoudigste vorm.

_____ : _____ : _____ : _____

Ek het R 28 000,00 spandeer op vlugte in die volgende verhouding.

(Engeland tot Frankryk : Frankryk tot Kanada : Kanada tot Australie)

1 : 3 : 4

Figure 4.15: The Assignments module used to assess learner's performance in ratio and rate

4.3.7 Providing feedback

This event consists of feedback given to users after they have demonstrated what they have learned. This is demonstrated in the current research report by making use of the Quizzes module.

The Quizzes module provides learners with instant feedback (figure 4.16) on answers to questions which means that learners can learn from their mistakes. Since the Quizzes module can either be set to *deferred feedback*, which means that after completing the quiz, learners are provided with the correct answers which they can review, or it can be set to *immediate feedback*, in which case after they have selected an answer they are provided with immediate feedback on whether the answer is correct or wrong and then provided with feedback on that answer. Another option is the *interactive with multiple tries*, which means that learners are given ample opportunities to give the correct answer. The questions in the Quizzes module are also linked to the Glossary module, which means that when learners do not understand the question being asked, they can click on the link which will take them to the definition of the word or the representation of the concept.

The screenshot shows a Moodle quiz question interface. At the top, there are navigation links: 'administration', 'Switch role to...', 'My profile settings', and 'Site administration'. The question text reads: 'Johan is 10 jaar oud. Sy tweelingsusters is 4 jaar oud. R109,80 moet tussen hulle verdeel word in die verhouding van hul ouderdom. Hoeveel kry elke suster?'. Below the text is a diagram with three cartoon characters: 'JOHAN' (a boy) with '10' below him, 'SUSTER 1' (a girl) with '4' below her, and 'SUSTER 2' (a girl) with '4' below her. Above the girls is the text 'R 109,80'. Below the diagram is a mathematical input field with a toolbar containing symbols like $\sqrt{\quad}$, $\sqrt[3]{\quad}$, $\frac{\square}{\square}$, π , and σ . Below the input field is a feedback panel with a red 'X' icon and the following text: 'Verhouding: 10 : 4 : 4', '5 : 2 : 2', 'Elke suster: $\frac{2}{9} \times 109,80$ ', 'R24,40', and 'The correct answer is: $\frac{2}{9} \times 109,80$ ' followed by 'R 24,40'.

Figure 4.16: Feedback feature of the Quizzes module where learners are provided with instant feedback based on their answers.

4.3.8 Assessing performance

This event focusses on assessing learners' knowledge and understanding of the particular content. The current research report makes use of the Quizzes and Assignments modules to assess learners' performance on the Moodle-based learning materials.

The Quizzes module can be used for online assessment (Dougiamas, 2001). The Quizzes module consists of different question types which can be used to assess learners. Question types include: Essay, Matching, Multiple choice, Cloze, Short answers, True or False, Drag and Drop, Calculated, etc. Another feature of the Quizzes module is that the questions can be randomised, which means that each learner, though doing the same test or examination, can be presented with different questions. This is possible since variables are used in some of the question types, i.e. Cloze, Calculated, Multiple choice, True or False and Matching question type. Furthermore, this means that a pool of questions can be designed, making use of variables. Each time the question is accessed by the learners, it represents a different numerical value of what is asked which gives learners more opportunities to understand the mathematics content. Figure 4.17 illustrates the question types as well as the question pool within Moodle.

Question types

Question pool

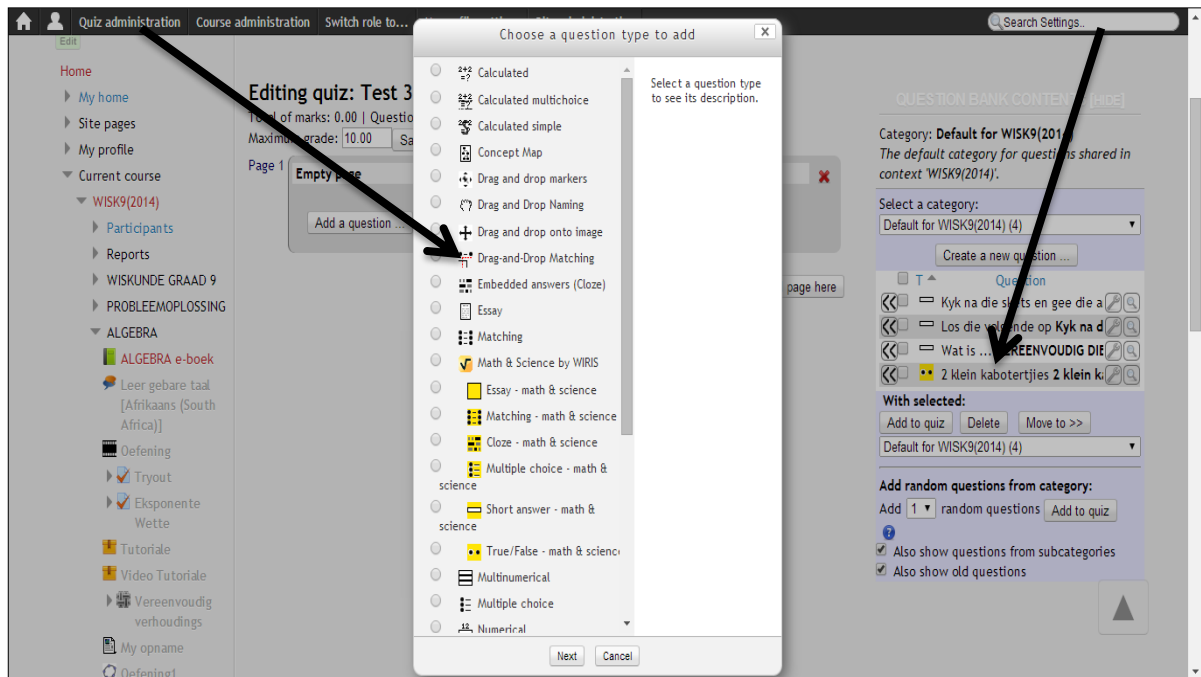


Figure 4.17: different question types and the question pool within Moodle where question types can be selected and question can be imported from the question pool

At the end of the quiz, learners can access the marks they scored. Not only can they see how they performed in the quiz, but they can also see which questions they answered correctly and incorrectly. Furthermore learners can access the feedback on each question as well as the correct answer for each question. It also means that they realise the level of their own knowledge and understanding of the mathematics content.

4.3.9 Enhancing retention and transfer

During this event learners should demonstrate that they retain what they have learnt by using the knowledge and skills they have acquired and apply it to a different situation. For this reason the Assignments and Wiki modules were used. Firstly, in the Assignments module learners must use their skills and knowledge to match, construct and depict their own representations of ratio, rate and proportions. The teacher provides learners with an example where learners have to use the example and construct their own questions and representations of these questions. Furthermore learners must also use different representation techniques to represent mathematics problems, based on ratio rate. Figures 4.18 to 4.20 depict the activities in the assignment module.

Pass die waardes in die tabel, grafiek en vergelykings van die 3 verskiedende verhoudings. Vul ook die wat ons

x	y
0	0
1	4
2	8
3	12
4	16
5	20

Verhouding _____

x	y
0	0
1	0.75
2	1.5
3	2.25
4	3
5	3.75

Verhouding 2 : 3

Verhouding 4 : 3

Verhouding 2 : 5

$y = 4x$

$y = 1.5x$

$y = \frac{3}{4}x$

Figure 4.18: matching exercise in the Assignment module that is used to assess learner's performance on ratio and rate.

Figure 4.19: multi-representation of ratio problems that is used to represent ratio problems in different formats.

Beskrywing in woorde	Verhouding																																				
Die winkel verkoop 2-liter bottels koeldrank vir R1.30 elk.	oorspronklike $\frac{ppp}{ppp}$ = $\frac{1}{1}$																																				
Grafiek	Tabel																																				
	<table border="1"> <tr><th>x (liters)</th><th>y (R)</th><th>ppp</th></tr> <tr><td>0</td><td></td><td></td></tr> <tr><td>1</td><td></td><td></td></tr> <tr><td>2</td><td>R1.30</td><td></td></tr> <tr><td>3</td><td>R2.10</td><td></td></tr> <tr><td>4</td><td></td><td></td></tr> <tr><td>5</td><td></td><td></td></tr> <tr><td>6</td><td></td><td></td></tr> <tr><td>7</td><td></td><td></td></tr> <tr><td>8</td><td></td><td></td></tr> <tr><td>9</td><td></td><td></td></tr> <tr><td>10</td><td>???</td><td></td></tr> </table>	x (liters)	y (R)	ppp	0			1			2	R1.30		3	R2.10		4			5			6			7			8			9			10	???	
x (liters)	y (R)	ppp																																			
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10	???																																				
Gesels hieroor																																					
1. Wat sal die ppp van 6 liter koeldrank wees?																																					

Figure 4.20: Interactive template within the Assignment module where learners can construct their own representations of the ratio and rate problems.

Secondly, in the Wiki module learners must create pages based on ratio and rate by following the teacher's example. Each page should represent a different feature of the mathematics content and should be aimed at applying what they have learnt and demonstrating it by making use of the Wiki tool. The learners have to construct their own pages based on the headings given by the teacher. Figures 4.21; 4.22 and 4.23 illustrate the Wiki module.

Verhouding

1. Definisie:
2. Voorbeelde:
3. Hoe vereenvoudig ek 'n verhouding:
3. Waar kan jy dit gebruik:

vorige bladsy volgende bladsy

Figure 4.21: representation of ratio in the Wiki module.

Koers

1. Definisie
2. My eie voorbeelde: eenheidskoers, eenheidsprys
3. Hoe bepaal jy Afstand:
4. Hoe bepaal jy Tyd:
5. Hoe bepaal jy spoed:
6. Waar gebruik jy dit:

vorige bladsy volgende bladsy

Figure 4.22: representation of rate in the Wiki module.

Probleemoplossing

1. Definisie(gee die definisie van probleemoplossing in jou eie woorde).
Definisie:
2. Stappe(gee die stappe wat jy kan volg om 'n probleem in konteks op te los. (Onthou jou eie woorde).
Stapper:
3. Gee die verskillende soorte metodes wat jy kan gebruik om 'n probleem op te los met voorbeelde by elkeen.
Metodes met voorbeelde:
vorige bladsy volgende bladsy

Figure 4.23: representation of problem-solving steps in the Wiki module.

4.3.10 Summary

As seen from the above analysis, it is possible to construct a Moodle-based course in line with Gagne's (1985) nine events of instruction. However, efficient time and planning is needed to construct such a Moodle-based course. Furthermore, teachers must have the technical know-how to use the tools within Moodle to construct such a course. Moreover, ample time and opportunity must be given to learners to find their way around Moodle and to use and access the modules themselves.

The next section describes the personal interviews conducted with the three Deaf and H/H learners as well as the observation done by the teacher researcher.

4.4 Interview and observation of learners' interaction with the Moodle-based learning materials

4.4.1 Introduction

This section of the research report covers the personal interviews with Deaf and H/H Grade 9 learners as well as an observation conducted by the teacher researcher and how the data was presented for analysis. Firstly, this section describes the views of learners extracted from the personal interviews as well as the observation done by the teacher researcher, while the learners were engaged in the Moodle-based online course. Secondly, it presents the analysis by means of categories and subcategories and illustrates how these are integrated with respect to the use of Moodle to assist Deaf and H/H Grade 9 learners with mathematics problem-solving. This section ends with a detailed discussion of how Moodle use with respect to mathematics problem-solving and the representation of mathematics problems via Moodle should be administered to provide meaningful learning experience based on the learners' views as well as the observation by the teacher researcher.

The unit of analysis as identified by the research question is Moodle. During the Deaf and H/H Grade 9 learners' interaction with these Moodle-based mathematics learning materials they encounter a series of obstacles. These obstacles were captured through the use of personal interviews and an observation schedule by the teacher researcher. The personal interviews were video recorded and transcribed by the teacher researcher. Three protocols surfaced through the transcription (user 01; user 02 and user 03). These views were then transferred to a computer qualitative data analysis software called MAXQDA. MAXQDA is a computer software tool which can be used for qualitative and mixed methods research (Kuckartz, 2011).

As stated earlier, at the end of the first engagement with the Moodle-based learning materials by the Deaf and H/H Grade 9 learners, they were asked to participate in semi structured interviews. The interviews consisted of short open ended questions in which learners had to give explanations for their answers based on their interaction with mathematics problems within Moodle. The interviews were conducted individually after normal classroom time. Similarly, the teacher researcher observed the interaction of Deaf and H/H Grade 9 learners with the mathematics problems within Moodle and recorded his observation by making use of an observation schedule. The observation schedule consisted of open-ended questions based on learners' experience and interaction within Moodle. Both the data extracted from the interviews and observation schedule were uploaded to MAXQDA and coded as the teacher researcher analysed it. The following results were found.

4.4.2 Findings

The aim of analysing the text was to construct concepts from the data. This was done by firstly breaking the data down into smaller pieces to make it more manageable. These manageable pieces were analysed for the meaning they represent. These meanings were given names in the form of concepts. Essentially these concepts represent the meanings. The whole analytic process was done by searching for "words or sentences" that best describe the concepts. Essentially this means that categories and subcategories were identified. The most important subcategories identified which surfaced from the personal interviews and the observation schedule and which also correspond to text units (TU) were either words or sentences. Table 4.4 illustrates the categories together with the subcategories and the text units.

Category	Subcategory	TU TOTAL	TU (%)
Weaknesses	Language	66	32.67
	Interpretation	31	15.35
	Reading ability	57	28.22
	Higher order thinking	6	2.97
	Apply new knowledge	28	13.86
	Experience	14	6.93
	<i>total</i>	202	100
Potential Strengths	Multimedia Instruction	63	27.75
	Multi-representation	93	40.97
	Interactivity	71	31.28
	<i>total</i>	227	100
	Sign Language	66	22.76

Learner Suggestions	Interactivity	71	24.48
	Help	40	13.79
	Practice	12	4.14
	Follow examples	34	11.72
	Step by step guide	4	1.38
	Multi-representations	63	21.72
	<i>total</i>	290	100

Table 4.4: Categories and Subcategories that surfaced from the interview and observation analysis using MAXQDA together with the corresponding text units.

Code-ID	Position	Parent code	Code	All coded segm...
18	1		Weaknesses	0
1	2	Weaknesses	Language	66
10	3	Weaknesses	interpretation	31
5	4	Weaknesses	reading ability	57
14	6	Weaknesses	higher order thinking	6
12	7	Weaknesses	apply new knowledge	28
2	8	Weaknesses	Experience	14
17	9		Possible Strengths	0
3	10	Possible Strengths	Multimedia Instruction	63
6	11	Possible Strengths	Multi representations	93
9	12	Possible Strengths	interactivity	71
20	13		Learners' Suggestions	0
19	14	Learners' Suggestions	Sign Language	66
22	15	Learners' Suggestions	Interactivity	71
13	16	Learners' Suggestions	help	40
15	17	Learners' Suggestions	practise	12
8	18	Learners' Suggestions	follow examples	34
7	19	Learners' Suggestions	step by step guide	4
21	20	Learners' Suggestions	Multi representations	63

Figure 4.24 Coding process of the data within MAXQDA after categories and subcategories were identified

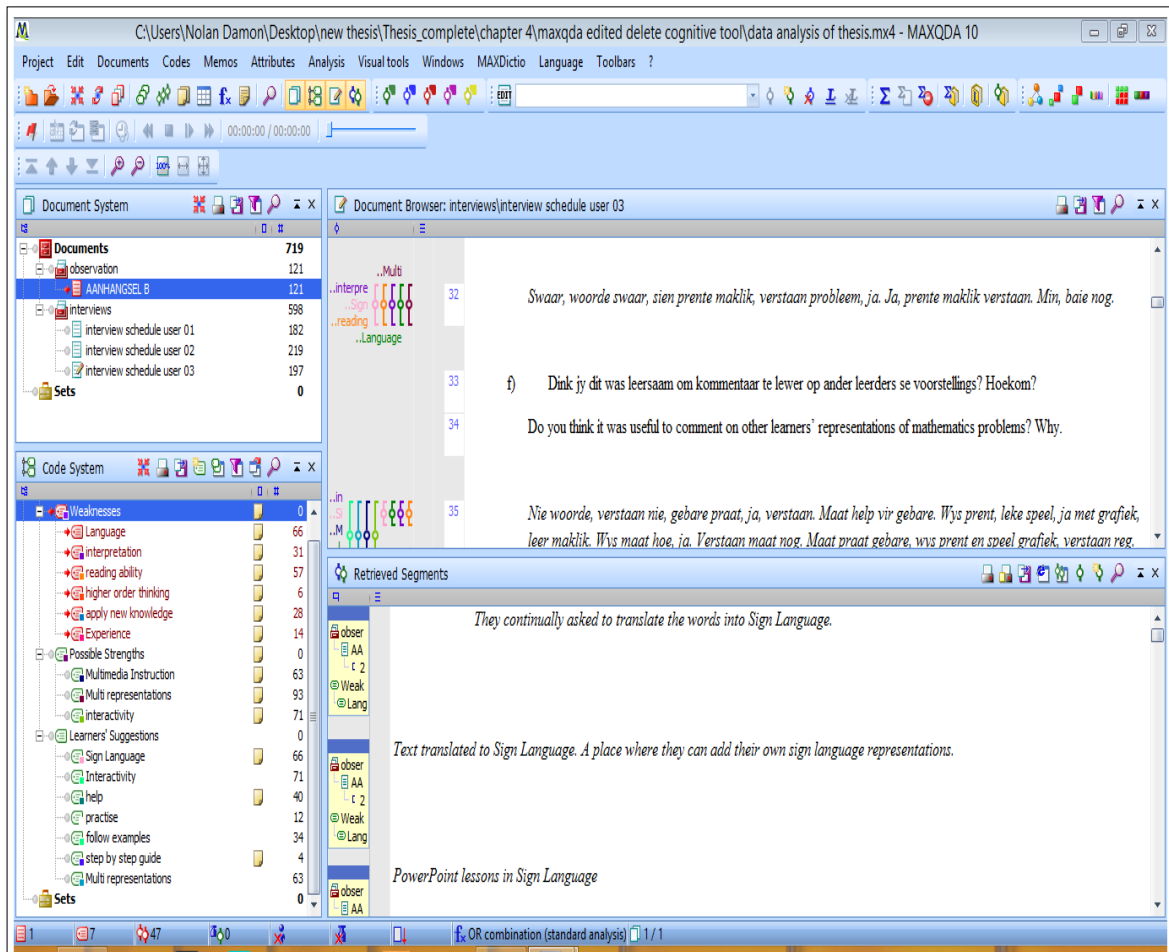


Figure 4.25: Frequency of Codes and the identification of themes in MAXQDA.

Both the views of the learners and the observation of the teacher researcher were coded within MAXQDA. The data was coded as “Weaknesses”, “Possible Strengths” and “Learner Suggestions” with respect to the use of Moodle to assist Deaf and H/H learners with mathematics problem-solving. These themes did not surface from the first analysis of the data but through deeper analysis from the teacher researcher. The smaller concepts that did surface from the beginning were grouped under the overarching themes and analysed accordingly. Next I will present the categories for analysis.

4.4.2.1 Category 1: Weaknesses

As noted in table 4.4 in the “Weaknesses category”, 202 TU in total were coded. Furthermore, the users’ answers included the subcategory “Language” the most (TU = 32.67%) followed by “Reading ability” (TU = 28.22%) and “Interpretation” (TU = 15.35%). For example, user 01’s views indicates that language is a major problem while doing the Moodle-based learning activities. This user continually asked for words and sentences to be translated into Sign Language. Furthermore, the user 02 experienced difficulties in interpreting mathematics concepts that should have been dealt with in previous grades. User 01’s answers to most of the questions from the interview included words like: “*woorde is swaar, moeilik, sukkel met woorde, min*

woorde asseblief, woorde beteken wat (words are difficult to understand, difficult, struggle with words, less words, please, what is the meaning of words) (user 01, Grade 9 Deaf learner) etc.

User 02 posed the same views as user 01. Not only did user 01 find it difficult to follow the sentence discussion in the Forum module but the user also could not interpret the questions correctly and hence posted no related answers. Furthermore, this user 01 depended heavily on Sign Language and asked for translations of every word or sentence. Moreover, during the very first engagement of user 02 in the Quizzes module, the user found it difficult to answer the questions since they were represented in written language. Comments like: *nie woorde nie, woorde moeilik, verstaan nie kinders skryf, gebare wys, nee vol woorde moeilik verstaan, lees vol sukkel, niks gebare nie, woorde niks/leeg (no words, please, words are difficult, don't understand what learners write, Sign Language, please, difficult to understand words, reading a lot of words is difficult, there are no Sign Language, no words, please, only Sign Language)* (user 02, Grade 9 Deaf learner), etc. further strengthened the user's struggle with reading and interpretation of words and sentences.

User 03 also experienced difficulties with understanding and interpreting the sentence format of the Moodle-based activities. Not only did user 03 ignore certain questions posed in the Quizzes and Assignments module but this user preferred not to answer the questions that user 01 did not understand. The activity in the Wiki module was completely misinterpreted which further indicates the users struggle with written language. Comments like: *“vraag probleem gebare asseblief, woorde verstaan nie, moeilik woorde, weet nie woorde, vrae nog nie verstaan”* (a question consisting of Sign Language, please, words are difficult to understand, difficult words, don't know the words, don't understand the questions) (user 03, Grade 9 Deaf learner), etc. were posed by this user.

Based on the “experience” subcategory, user 01's view indicates that the user had little experience with mathematics concepts. The user continually asked for assistance with everyday mathematics concepts. In addition, the user asked for examples to follow and was dependent on doing exercises over and over. Moreover, this user preferred learning to take place in a linear fashion, i.e. the teacher explained the content, gave examples, lets the user practise some examples with assistance from the teacher and then moved on to the next section.

User 02's views were similar to user 01's in that the user continually asked for assistance with everyday mathematics concepts which can either be learnt at home while watching television or while visiting the grocery store, i.e. “incidental mathematics learning” (Pagliaro,2006:34). Although this user does not live in the hostel and is exposed to the normal environment of seeing

things either on television or in shops, the user still needed a lot of assistance with familiar mathematics concepts.

User 03's views were in line with both user 01 and user 02's views. This user asked for assistance and examples with every mathematics problem. This user needed assistance in each module of Moodle. For example, this user explicitly asked for examples and practice with each question in the Quizzes module. During the Forum Module, this user could not follow the discussion and only answered questions that were already answered. Additionally, this user could not recognise familiar mathematics concepts and asked for assistance even with such problems. What was also significant in all three users' interaction was the fact when they were asked to apply the knowledge learnt in the previous exercises to new exercises they found it difficult to do so. Furthermore, they wanted to know what steps to take in order to solve the mathematics problems and each time wanted to use these steps. Not only did all of them leave the more difficult mathematics problems blank, but they also skipped the problems where they had to use the WIRIS input bar to insert their own answers

Based on the observation done by the teacher researcher, the following was noted:

- Users asked that words must be translated into Sign Language
- They wanted a place where they could add their own sign language representations
- They wanted to post comments in the Forum module by making use of signs
- They experienced difficulties in interpreting written text
- They continually complained about too much text and too few signs/imagery
- They experienced difficulties in reading and understanding questions
- They lost track of original discussions
- The users continually asked for the meanings of words and sentences
- They experienced difficulty in understanding words that are used in everyday life, words or meanings that we hear on television, at shops or in conversations with others
- Users found it difficult to apply knowledge learnt to new situations
- Users wanted help in constructing their own representations
- When higher order thinking was required for more difficult problems, users either left it blank or misinterpreted the questions
- Learners were continually asking for the signed translation of mathematics problems and focussed more on linguistic aspects of the mathematics problems than on the mathematics content
- Users preferred multi-representations of mathematics problems above written representations of mathematics problems,

4.4.2.2 Category 2: Potential strengths

The potential strengths as noted in table 4.4, were coded with 227 TU in total. The users responses included “Multi-representation” (TU = 40.97%), “Interactivity” (31.28%) and “Multimedia Instruction” (27.75%). These figures were based on the answers user 01 presented during the interview session. For example, it became apparent that user 01 preferred to do the interactive activities above all other activities. These interactive Moodle-based mathematics activities included either multiple representations of mathematics problems, interactive content where learners could play with different representations in search for solutions to mathematics problems or video representations of mathematics problems. Comments like: “*maklik prente, muis beweeg op prente, prente ja prente help, muis beweeg ja verstaan wiskunde probleem*”, etc. (*questions with different representations are easy to understand, interactive content help in understanding mathematics better*) is an indication that the user preferred to be taught using either interactive content or multiple representations of mathematics content and that these representations assist the user in solving the mathematics problems.

User 02 also preferred the interactive Moodle-based activities. Not only did user 02 spend more time doing the interactive, multiple representations of mathematics problems in Moodle but the user assisted other users in doing these type of activities. According to user 02’s comments which included: “*maklik muis speel wiskunde, verstaan probleem, muis speelprente verander sien hoe, hou van muis speel prente, verander grafiek ja verstaan*” (*interactive content help in solving mathematics problems*). (User 02, Grade 9 Deaf learner) etc. Based on the user’s answers, the interactive content and the multi-representation of mathematics problems assisted the user in solving the mathematics problems with understanding.

User 03’s views are similar to those of user 01 and user 02 in that this user also preferred the Moodle-based mathematics materials which consists of interactive content and multiple representations of mathematics content. Although this is the case when asked to choose between the old way of teaching mathematics and the new way of teaching mathematics, which included Moodle-based online learning, this user preferred the old way. Comments like: “*muis speel prente verstaan wiskunde maklik, prente vol wiskunde speel, hou van speel muis prente, speel muis prente lekker, leer gou/vining, sien verander help verstaan, Wiskunde probleem antwoord gou kry speel muis prente, maar nie woorde*” (*interactive content and content which are illustrated by means of different representations help them in solving mathematics problems*) (user 03, Grade 9 Deaf learner) etc. These comments provide evidence that the multi-representation of mathematics content within Moodle assisted the user in mathematics problem-solving.

4.4.2.3 Category 3: Learner suggestions

The learners' suggestions as noted in table 4.4 were coded with 290 TU. The learners' suggestions included the subcategories: "Interactivity" (TU = 71%), "Sign Language" (TU = 22.76%), "Multi-representations" (TU = 21.72%) and "Help" (TU= 13.79). Based on the figures above, all three users, i.e. user 02, user 01, and user 03 preferred more interactive content with worked out examples to watch before they tried answering the questions in the Quizzes module. All three of them asked for more practice exercises which must include signs and video tutorials on how to answer these questions. Moreover when asked to construct their own representations they all insisted on using *GeoGebra* to assist them.

In addition, all three users asked for more multi-representations of mathematics problems. Accordingly they claim that because of the multi-representation of mathematics problems they could understand the problem better. Besides the fact that they struggled to comprehend the text instructions, they also failed the first attempt in the Quizzes module, since it was only a textual representation of the mathematics problems.

In the same way all three learners wanted help in each of the modules. Although the teacher researcher adapted the Moodle-based learning materials to include more multi-representations of mathematics problems, the users still insisted on a help feature. Moreover they wanted a help button to click when they experience any problems especially with the interpretation of textual representations of mathematics problems.

Based on the observation done by the teacher researcher the following was noted:

- The users were asking for video instruction and video questions making use of sign language
- The users asked for sample step-by-step videos which focus on worked out examples
- The users needed more help and assistance from the teacher and their peers
- They asked for more interactive activities and less text
- They asked for more multi-representations of mathematics problems
- They asked for visual organisers instead of text
- They liked it when they could insert their own representations

4.4.3 Discussion

The discussion focusses on the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle. The discussion starts with comments on weaknesses, potential strengths and learner suggestions. It is followed by a discussion on the effects these categories have on Moodle use and in what way Moodle-based

learning materials should be constructed in order for it to provide for meaningful learning experiences for Deaf and H/H Grade 9 learners.

Teachers who want to teach mathematics through the use of Moodle and representing mathematics content through Moodle must take into account the views Deaf and H/H Grade 9 learners pose with reference to their experience with Moodle-based learning materials. Deaf and H/H learners have “limited informal learning experiences” which poses problems when they are faced with solving mathematics problems (Pagliaro, 2006:34) within Moodle. This means that while Hearing learners hear mathematics concepts outside the formal classroom i.e. rate, ratio, distance, speed etc. either while watching television or playing outside, Deaf and H/H learners do not have that luxury. Therefore words or concepts that seem simple and an everyday occurrence to the Hearing learner, the Deaf and H/H learner struggles to interpret. This limited experience results in Deaf and H/H learners continually asking for definitions of mathematics concepts, worked out examples, the translation of written words into sign language or even video examples. Therefore, teachers of the Deaf and H/H should focus on learners’ current mathematical knowledge and not assume what the learners should know.

In the case of the current research report, the teacher did not use appropriate experiences to build on learners’ current mathematical knowledge, hence learners continually asked for explanations of mathematics concepts they had never experienced before. For this reason the Glossary module in Moodle was used to familiarise users with definitions of mathematics concepts and examples. These mathematics concepts were also linked throughout the entire Moodle site which means that users could access it through any module. Moreover, the glossary entries became the bridge between what learners did not know yet or had not experienced yet and what they needed to know.

Another major issue that came to light through the users’ interaction with the Moodle-based learning materials was *language*. NAPMERD highlights the importance of clear and accurate communication in the case of mathematics concepts as well as the use of the correct technical signed terms (Pagliaro, 2006). It is well documented that not only reading ability but also comprehension levels of Deaf and H/H learners plays a major role when doing mathematics in general and mathematics problem-solving in particular. This has become apparent in the current research report where users continually asked for words or sentences to be translated into Sign Language, a language they can understand.

Since mathematics questions cannot be directly translated into Sign Language because of the difference in structure of Sign Language and written language, it resulted in further confusion,

which is also apparent in the current research report. Although some parts of the questions within the modules were translated into Sign Language, the users still found it difficult to interpret.

Ansell and Pagliaro (2001) posit that mathematics teachers of Deaf and H/H learners should be aware of the language and the structure of the mathematics word problems so that when signed, it has the same meaning for the Deaf and H/H as when it is in written format.

An astonishing discovery that was made was the distinctive feature of the Glossary module. Not only did the Glossary module assist Deaf and H/H learners with definitions of unfamiliar words, but it also helped in representing words in different formats, i.e. Sign Language, images etc. This was very helpful for the Deaf learners since they could at any time click on an unfamiliar word and a popup would appear with either the definition of that word or the sign for that word. In other words, no matter where the learners found themselves whether in the Forum, Wiki, Quizzes, Assignments or Lessons module, they had immediate access to definitions of words or sentences or different representations of words. This was very helpful for the Deaf and H/H learners, since it gave them confidence to engage in all the activities.

Although all three users indicated that they enjoyed doing mathematics problem-solving within Moodle, by making use of either interactive content or multi-representations, they still asked for examples to follow. This exposes the fact that Deaf and H/H learners are used to memorising facts and formulas as well as drill and practice exercises (Pagliaro, 2006). Not only was this the case while all three users were engaged in the Moodle-based mathematics learning activities but all the users preferred to work from an example presented by either the teacher or a video tutorial. So, although they had been introduced to new instructional strategies in the form of Moodle use for mathematics problem-solving, they tended to prefer direct instruction from the teacher as well.

A frequent occurrence within the current research study was that Deaf and H/H Grade 9 learners first wanted the meaning of every word in the mathematics word problems. Instead of focusing on the mathematics concepts they wanted definitions of words in Afrikaans as well as the sign for that particular word. Kelly, Lang and Pagliaro (2003) posit that the reason for this can be due to teachers making less use of true problem-solving and focusing more on practice problems rather than problem-solving strategies. These researchers claim that mathematics teachers of the Deaf and H/H tend to skip mathematics word problems due to the linguistic difficulties of mathematics word problems and this in turn limits learners' experience with true mathematics problem-solving. Although this is true in many cases, the current research report's aim was to introduce learners to true mathematics problem-solving as well as mathematics problems they can relate to.

Chapter 5: Conclusion and Recommendations

5.1 Conclusion

The current study tried to answer the following research question: *What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?* It made use of formative evaluation research in order to evaluate mathematics learning materials created in an online learning environment, Moodle. Although the research findings indicate that potential strengths of Moodle use exists which can assist Deaf and H/H Grade 9 learners with mathematics problem-solving, other factors like language, limited learning experiences of Deaf and H/H learners with basic mathematics vocabulary and concepts as well as instructional strategies, must gain attention in order to influence Deaf and H/H learners understanding of mathematics problem-solving specifically while using Moodle. These inferences, i.e. that Deaf and H/H learners struggle with linguistic aspects of mathematics problems, the limited mathematics vocabulary of Deaf and H/H learners and their dependency on visual representation of mathematics content, became noticeable through the personal interviews conducted with the Deaf and H/H learners and the observation done by the teacher researcher.

The categories on the findings that emerged from the interviews and observation schedule included Weaknesses, Potential Strengths and Learner Suggestions. These categories included subcategories which further describes the main categories. Since MAXQDA (MAX Qualitative Data Analysis), a qualitative data analysis software was used to codify the data, each word segment that was coded could be analysed according to each user's answers and then analysed against the observation done by the teacher researcher. Through further analysis of the categories, other themes emerged, i.e. experiential factors, linguistic difficulties, instructional problems and mathematics problem-solving skills.

As stated in the Findings section of this research report, Deaf and H/H learners struggle to comprehend mathematics word problems due to different factors. These factors include sentence construction of Afrikaans mathematics problems, which poses difficulties since Deaf and H/H learners find it difficult to comprehend due to linguistics issues discussed previously. Furthermore, Deaf and H/H learners do not have access to basic mathematics vocabulary that hearing learners learn informally unless it is taught to them through the use of Sign Language. Another difficulty Deaf and H/H learners experience is means of communication. Since they have limited vocabulary and are only able to construct simple sentences, mathematics communication is limited. This was noticeable especially within the Forum module. Another difficulty Deaf and H/H learners experienced was the construction of knowledge. Since they were so used to rote-learning or memorisation concepts and formula or mathematics ideas, they were continually waiting for examples to follow or step-by-step instructions.

Although Deaf and H/H learners struggled with the mathematics problems, the interactive content, multi-representations of mathematics problems and the multimedia instruction proved promising (“Interactivity” :TU = 71%, “Sign Language” : TU = 22.76%, “Multi-representations” : TU = 21.72%). Moreover, when the difficulties Deaf and H/H Grade 9 learners experienced, i.e. experiential factors, for example, limited experience with mathematics vocabulary or concepts; linguistic difficulties, for example, the sentence construction of mathematics problems; instructional problems, for example, teacher-directed learning and memorisation of mathematics concepts and formula, as well as problem-solving skills, for example reasoning, were addressed through the adaptation of the Moodle-based learning materials, it created opportunities for them to construct their own mathematics knowledge.

The role the Glossary module played within these Moodle-based activities should also gain attention. Deaf and H/H learners could access unknown concepts, definition of unfamiliar words and different representations of mathematics word problems through the Glossary module. This became a bridge between existing knowledge and new knowledge. This became visible through the construction of their own representations of mathematics problems. It also became apparent through the personal interviews and observation done by the teacher researcher as well as the data captured through Moodle (chapter 4 page 87).

Another finding that came to light was that the more Deaf and H/H Grade 9 learners were exposed to the mathematics problems, the more comfortable they became in approaching and solving the problems (page 87 -88). This could be due to the fact that whenever they got stuck, they could click on the help button for assistance. However, this was not the case while commencing with the Moodle-based mathematics problem-solving activities. They easily got frustrated when they could not do some of the Moodle-based mathematics problem-solving activities and were willing to give up while experiencing obstacles. In addition, the same inferences can be drawn from the Lessons module. At first learners rushed through the PowerPoint slides just to get it over and done, but when they realised how it could assist them in approaching and solving the mathematics problems, they used it with more appreciation of its value. A conclusion that could be drawn is to expose Deaf and H/H more frequently to Moodle-based mathematics problems in order to empower them to become comfortable in solving such problems.

A conclusion that can be drawn from this research report is the dependency of Deaf and H/H learners on others for their cognitive development. This means that Deaf and H/H learners, process information differently from their hearing counterparts and they (Deaf and H/H learner) need more assistance with this information processing. Furthermore it means that teachers of Deaf and H/H learners need extensive training in how to assist Deaf and H/H learners in their

information processing. What seems to be promising and what the current research report emphasised is the pedagogical principles Moodle is built on, for example, social constructivism, which could assist teachers in guiding learners with their cognitive development. The question that should be asked is how Deaf and H/H learners learned, and not what they learnt.

In conclusion, this research report sets out to answer the following research question: *What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?* The formative evaluation of the tools in Moodle, the personal interviews conducted with three Deaf and H/H Grade 9 learners from school zee as well as the observation done by the teacher researcher highlights that Moodle can be used to assist Deaf and H/H Grade 9 learners with mathematics problem-solving. Additionally, this research report not only highlights the weaknesses while using Moodle for mathematics teaching, specifically mathematics problem-solving, but presents recommendations to minimize these weaknesses. Table 5.1 below highlights the strengths and weaknesses of using Moodle for teaching mathematics problem-solving and also provides recommendations to minimize the current weaknesses.

Tools in Moodle		Strengths	Weaknesses	Minimizing Weaknesses
1.	Forums	<ul style="list-style-type: none"> Fostering mathematics discussions. 	<ul style="list-style-type: none"> Only one interactive representation is possible. Difficult to communicate. Difficult to understand other learners' explanations. Difficult to follow discussions. Difficult to read and comprehend sentences. 	<ul style="list-style-type: none"> The use of Moodle to record, follow and understand discussions, since Moodle makes it possible for learners to answer questions or take part in quizzes through the use of Sign Language. A Global Glossary is needed. Give attention to the structure of the forum by allowing nested views.
2.	Wiki	<ul style="list-style-type: none"> Learners can construct their own representations. Learners can comment on other learners' representations. 	<ul style="list-style-type: none"> Discussions are problematic due to language, reading and comprehension difficulties. 	<ul style="list-style-type: none"> The use of videos in the Wiki Module to assist learners with comprehension difficulties. Global glossary is needed.

		<ul style="list-style-type: none"> • Different representations can be used. • Individual attention can be given to each learner through private Wiki's 		
3.	Glossary	<ul style="list-style-type: none"> • Can be used for definitions and explanations. • Can be linked course or site wide. • Learners can insert own vocabulary. • Learners can comment on other learners' entries. • Different representations can be used. • Learners can access the meaning or representation of mathematics problems anywhere within the site. 		<ul style="list-style-type: none"> • Learners must record their own vocabulary using Poodll and upload it.
4.	Quizzes	<ul style="list-style-type: none"> • Quizzes can be set to different formats. • Quizzes can provide immediate feedback for learners. • Different question types can be used. • Learners have immediate access to test scores. • Different representations can be used within the quizzes. 	<ul style="list-style-type: none"> • Wiris inputs are problematic and thorough understanding is needed for latex inputs. • Algebra inputs are also problematic. 	<ul style="list-style-type: none"> • Give ample opportunities for learners to practice Wiris question types. • Give assistance in the form of sign language video tutorials to show learners how these type of questions are answered. • Interactive question types within the quiz module i.e. Geogebra question type, Stack question type.
5.	Lessons	<ul style="list-style-type: none"> • Scaffolding can be done by presenting content in small chunks. 	<ul style="list-style-type: none"> • PowerPoint slideshows and Slideshare slideshows cannot be linked to 	<ul style="list-style-type: none"> • Use the presentation plugin within Moodle because only then can

		<ul style="list-style-type: none"> • Learners are forced to only move to the next section when they achieved the goals set in the previous lesson. • Interactive content can be imported into the Lesson module. • Learners can follow the lesson at their own time and pace. 	<p>the Glossary module and further presents comprehension difficulties.</p>	<p>it be linked to the Glossary module.</p>
6.	Assignments	<ul style="list-style-type: none"> • Learners can construct their own representations. • Learners can use GeoGebra to construct their assignments, interactions which cannot be achieved when using paper and pencil exercises. • Different representations can be used in the assignments module 	<ul style="list-style-type: none"> • Difficulty in downloading and uploading of assignments. 	<ul style="list-style-type: none"> • Provide video tutorials with sign language instruction of how to upload and download assignments.

Table 5.1 illustrates the strengths and weaknesses of using Moodle for mathematics problem-solving.

5.2 Recommendations

The current study includes three Deaf and H/H Grade 9 learners which is a small scale study. Since it is impossible to generalise the current study, further research needs to be done by means of including a bigger sample size of Deaf and H/H Grade 9 learners. Although Moodle consists of an array of modules and plugins and since the current study only made use of the Glossary, Forum, Assignments, Quizzes, Wiki and Lesson modules in Moodle, a recommendation for further studies could be to include more modules like the Database, Webpage, Blogs Book, SCORM (Sharable Content Object Reference Model, for creating interactive quizzes and learning content outside of Moodle) and IMS content packages as well as plugins like HOTPOT, with its different question types i.e. JCloze, JMatch, JQuiz, JCross, JMix and JMasher, in order to examine how it could assist Deaf and H/H Grade 9 learners with mathematics problem-solving.

Since this study only focused on one content area, namely *Numbers, Operations and Relationships*, and ratio and rate as a sub category, all other content areas need to be examined with regard to how Moodle can represent it and whether it can assist Deaf and H/H learners in their understanding of mathematics in general. Since only a certain amount of time is allocated for each content area, more time is needed for the fully-packed mathematics curriculum.

Another issue that was discovered in this research report is the value of mathematics discussion. This is extremely difficult, especially while teachers of the Deaf and H/H do not have the strategies and skills to administer such practices. Through recent developments of plugins in Moodle, the Poodll plugin was designed which makes it possible for Deaf and H/H learners to answer questions while recording their Signs.

My conclusion, then, is that Moodle has the potential to assist Deaf and H/H Grade 9 learners at school *zee* with mathematics problem solving. Although different weaknesses were identified by this research project, the potential strengths could provide learners with opportunities to construct their own mathematical knowledge with regard to ratio and rate problems. Furthermore, the obstacles, some of the learning materials within Moodle pose for the Deaf and H/H Grade 9 learners, can be addressed through installing the relevant plugins. This, however, highlights the urgent need for a Moodle based support system, one in which teachers can find help and support on the pedagogical use of Moodle.

Addendum A (Skedule vir Onderhoud)

Die moontlikheid van Moodle om Dowe en Hardhorende graad 9 leerders te ondersteun met wiskunde probleemoplossing.

Nolan Damon

16888146

MEd: Kurrikulum Studies (Wiskunde onderrig)

Hierdie navorsingsprojek het ten doel om die moontlikheid van multi voorstellings van wiskunde in Moodle te ondersoek en in hoe 'n mate dit Dowe en Hardhorende graad 9 leerders met wiskunde probleemoplossing kan help.

Die doel is om vas te stel wat, hoekom en hoe die modules in Moodle gebruik kan word om wiskunde probleme voor te stel sodat dit Dowe en Hardhorende leerders kan ondersteun met wiskunde probleemoplossing.

Om die bostaande vas te stel, is die volgende vrae gestel:

- Watter Moodle modules kan gebruik word om wiskunde probleem op verskillende maniere voor te stel,
- Hoe om die modules te gebruik om wiskunde probleem voor te stel,
- Hoekom moet die modules gebruik word om wiskunde probleem voor te stel?

Hoof navorsingsvraag:
What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle? <ul style="list-style-type: none">i. What strengths and weaknesses were identified by the Deaf and H/H Grade 9 learners?ii. What strengths and weaknesses were identified by the teacher researcher?
<ul style="list-style-type: none">• Algemene vrae word gestel om die atmosfeer te skep.

Vraag	Rede vir die vraag
<p>1. Die Woordelys Module</p> <p>a) Het jy dit moeilik gevind om woorde te lys? Hoekom? Hoekom nie? Did you find it difficult to add entries? Why or Why not?</p> <p>b) Het jy die inskrywings van ander leerders leersaam gevind? Verduidelik? Did you find the entries of other learners useful? Why?</p> <p>c) Het jy dit leersaam gevind om verskillende voorstellings van wiskunde problem in te voeg o.a. in woorde, in 'n table, grafies of algebraies? Hoekom/ Hoekom nie? Did you find it useful to add different representations of mathematics problems i.e. verbal, tabular, graphical, algebraic etc.? Why or why not?</p> <p>d) Het die idee om wiskunde problem in verskillende formate voor te stel jou gehelp om die problem op te los? Verduidelik? Did the idea of representing mathematics content in different formats assist you in solving mathematics problems? How?</p> <p>e) Indien hierdie aktiwiteite sonder die hulp van voorstellings onderrig word, sou dit moeiliker of makliker wees? Hoekom?</p>	<p>To find out the strengths and weaknesses of the Glossary tool. These questions are also posed to find out whether their understanding of mathematics problems became clearer.</p>

<p>If these activities were taught without the different representations, would it be easier/harder to do understand? Why?</p> <p>f) Dink jy dit was leersaam om kommentaar te lewer op ander leerders se voorstellings? Hoekom? Do you think it was useful to comment on other learners' representations of mathematics problems? Why?</p> <p>g) Watter verandering wil jy graag sien in hierdie module? Hoekom? What changes would you like to see in this module? Why?</p> <p>h) Die feit dat hierdie module 'n skakel deur die hele webwerf en na ander modules het en voorstellings het, het dit jou enigsens gehelp? Verduidelik? The fact that this module has an auto link function to other representations, was this helpful? Explain your answer.</p>	
<p>2. Die Les Module</p> <p>a) Het jy dit maklik/moeilik gevind om die lesse te volg in hierdie module? Did you find it easy or difficult to follow the lessons in this Module?</p> <p>b) Wat het dit moeilik/maklik gemaak? What made it easy/hard to follow?</p>	<p>To find out the strengths and weaknesses of the Lesson tool.</p>

<p>c) Het die verskillende voorstellings van wiskunde problem jou gehelp? Hoekom/ Hoekom nie? Was it helpful that different representations of the mathematics problems were used? Why or why not?</p> <p>d) Dink jy die verskillende voorstellings van die wiskunde problem het jou gehelp om die problem op te los? Hoe? Do you think that the different representations of mathematics problems assists you in solving the mathematics problems? How?</p> <p>e) Indien hierdie aktiwiteite sonder die verskillende voorstellings aangebied word, sou dit makliker of moeiliker gewees het? Hoekom? If these activities were taught without the different representations, would it be easier/harder to do understand? Why?</p> <p>f) Watter veranderinge sou jy graag wou sien in hierdie module wat jou sal help om wiskunde problem op te los? Hoekom? What changes would you like to see in this module? Why?</p> <p>g) Was die vrae na elke les leersaam? Hoekom? Were the questions after the Lessons module helpful? Why?</p>	
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<p>h) Hoe het dit jou leer beïnvloed deur terug te beweeg wanneer jy die vrae verkeerd gekry het? How did it influence your learning when you had to go back to previous lessons, when you answered the questions wrong?</p> <p>i) Het dit gehelp dat die inhoud opgebreek was in kleiner eenhede? Verduidelik? Is it helpful that the content is broken down into small pieces and not presented as one whole lesson? Explain your answer.</p>	
<p>3. Die Forum Module</p> <p>a) Was die besprekings van die voorgestelde problem leersaam? Verduidelik? Were the discussions about presented problems useful? Give an explanation.</p> <p>b) Het ander leerders se idees jou eie idees rondom die problem laar verander? Verduidelik? Did discussions from other learners change your knowledge about the problems that were presented? Explain you answer.</p> <p>c) Was dit leersaam dat hierdie besprekings ook verskillende voorstellings van problem ingesluit het? Hoekom?</p>	<p>To find out the strengths and weaknesses of the Forum tool.</p>

<p>Was it helpful that these discussions included different representations of mathematics problems? Why?</p> <p>d) Waarvan het jy in hierdie module gehou/ nie gehou nie? What did you like/dislike about this module?</p> <p>e) Watter veranderinge wil jy graag in hierdie module sien? What changes would you like to see in this module?</p>	
<p>4. Die Opdrag Module</p> <p>a) Kon jy die opdrag in Moodle oplaai of het jy problem ervaar? Verduidelik? Did you have any difficulty uploading your assignments? Explain.</p> <p>b) Wat het jy van gehou/nie van gehou nie, in hierdie module? What did you like/dislike about this module? Why?</p> <p>c) Watter veranderinge sou jy graag wou sien in hierdie module? Hoekom? What changes would you like to see in this module? Why?</p>	<p>To find out the strengths and weaknesses of the assignment tool.</p>
<p>5. Die WIKI Module</p>	<p>To find out the strengths and weaknesses of the Wiki tool.</p>

<p>a) Was die geslote besprekings met die onderwyser leersaam? Verduidelik? Were the closed discussions with the teacher helpful? Explain why?</p> <p>b) Het jy dit leersaam gevind om inligting te verander en om jou eie voorstellings te maak van die wiskunde problem? Hoekom? Did you find it useful to change information and put in your own representations in the WIKI? Why?</p> <p>c) Het jy enige veranderings in jou verstaan van die problem ervaar terwyl jy met die verskillende voorstellings gewerk het? Veduidelik? Did you experience any changes in your understanding while changing the representations of mathematics problems? Explain.</p> <p>d) Het die multi voorstellings van wiskunde probleme dit makliker/ moeiliker gemaak om die wiskunde probleme te verstaan? Verduidelik? Did the multi-representations of mathematics problems in this module influence your understanding of mathematics problems? How?</p> <p>e) Waarvan het jy gehou/nie van gehou in hierdie module nie? What did you like/dislike about this module?</p>	
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<p>f) Watter verandering sou jy graag wou sien in hierdie module? What changes would you like to see in this module? Why?</p>	
<p>6. The Quizzes Module</p> <p>a) Het hierdie module jou gehelpmet wiskunde probleemoplossing? Verduidelik. Did the Quizzes module assist you with mathematics problem-solving? Explain.</p> <p>b) Het die multi voorstellings van wiskunde probleme jou gehelp met moeilikheid wat jy ervaar met wiskunde probleemoplossing? Verduidelik. Did the multi-representations of mathematics problems assist you in difficulties you experienced with mathematics problem-solving? Explain.</p> <p>c) Het die feit dat jy met die voorstellings interaktief kon besig wees jou gehelp in hierdie module? Verduidelik. Was it helpful that you could interact with the representations in this module? Why?</p> <p>d) Het die terugvoering na elke vraag jou gehelp om te leer? Verduidelik. Did you find the feedback after each answered question useful? Why?</p>	<p>To find out the strengths and weaknesses of the Quizzes tool.</p>

<p>e) Het die tweede of selfs die derde kans om die toets te doen jou gehelp om die inhoud beter te verstaan? Verduidelik.</p> <p>Did the second or even third chances to take the quiz influence your understanding of the content? Explain.</p> <p>f) Watter veranderinge sou jy graag wou sien in hierdie module? Hoekom.</p> <p>What changes would you like to see in this module? Why?</p>	
<p>7. Overall experience in Moodle</p> <p>a) Het jou ondervinding in Moodle veral die multi voorstellings van wiskunde problem jou gehelp om wiskunde probleemoplossing makliker/moeliker te maak? Verduidelik.</p> <p>Did your experience in Moodle, especially using multi-representations of mathematics problems, help you in making problem-solving in mathematics easier/harder? Why?</p> <p>b) Indien jy moet vergelyk die ou manier van wiskunde aanbieding met hierdie nuwe manier van leer, watter een verkies jy? Hoekom.</p> <p>If you compare the old way of presenting mathematics problems with this new way, which do you prefer? Why?</p>	<p>To find out learners' overall experience with the Moodle-based learning material.</p>

<p>c) Sal hierdie oefening jou help indien jy toegang tuis of enige ander plek behalwe die skool het? Hoekom. Will these modules be useful if you can do them at home or anywhere else outside the school? Why?</p> <p>d) Vir wie dink jy sal hierdie aktiwiteite tot hulp wees? To whom do you think these modules/activities would be useful?</p> <p>e) Was die voorbeelde wat gebruik is op jou vlak? Can you relate to the examples that were used in these activities?</p> <p>f) Indien daar een iets is wat jy kan verander van hierdie aktiwiteite wat sal dit wees? Hoekom. If there was one thing you could change about all of these modules/activities, what would it be?</p> <p>g) Was daar op enige stadium wat jy meer voorbeelde, verduidelikings en voorstellings wou hê. Was there anywhere that you would have preferred more examples, more explanations, and more representations about the topic?</p> <p>h) Kon jy jou eie voorstellings maak in enige van hierdie modules, sonder die hulp van die onderwyser?</p>	
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<p>Could you represent mathematics problems in all of these modules without any help from the teacher?</p>	
<p>8. Is daar enige ander opmerkings of kommentaar wat jy wil maak? Are there any other comments, recommendations that you would like to make?</p>	

Addendum B (Observasie Skedule)

Die moontlikheid van Moodle om Dowe en Hardhorende graad 9 leerders te ondersteun met wiskunde probleemoplossing.

Nolan Damon

16888146

MED: Kurrikulum Studies (Wiskunde onderrig)

Hierdie navorsingsprojek het ten doel om die moontlikheid van multi voorstellings van wiskunde in Moodle te ondersoek en in hoe 'n mate dit Dowe en Hardhorende graad 9 leerders met wiskunde probleemoplossing kan help.

Die doel is om vas te stel wat, hoekom en hoe die modules in Moodle gebruik kan word om wiskunde probleme voor te stel sodat dit Dowe en Hardhorende leerders kan ondersteun met wiskunde probleemoplossing.

Om die bostaande vas te stel, is die volgende vrae gestel:

- Watter Moodle modules kan gebruik word om wiskunde probleem op verskillende maniere voor te stel,
- Hoe om die modules te gebruik om wiskunde probleem voor te stel,
- Hoekom moet die modules gebruik word om wiskunde probleem voor te stel?

Hoof navorsingsvraag:	
<p>What are the strengths and weaknesses of teaching mathematics problem-solving to Deaf and H/H Grade 9 learners through the use of Moodle?</p> <p>i. What strengths and weaknesses were identified by the Deaf and H/H Grade 9 learners?</p> <p>ii. What strengths and weaknesses were identified by the teacher researcher?</p>	
<ul style="list-style-type: none"> • Algemene vrae word gestel om die atmosfeer te skep. 	
Vraag	Rede vir die vraag

<p>1. Die Woordelys Module</p> <p>a) Wat was die tyd oor die algemeen wat leerders aan hierdie aktiwiteit spandeer het? What was the overall time spent on this module?</p> <p>b) Het leerders hierdie aktiwiteit maklik/moeilik gevind? Hoekom? Did learners find it easy / difficult to use this tool to construct representations of mathematics problems? Why?</p> <p>c) Wat het die leerders van gehou/nie van gehou nie i.v.m hierdie aktiwiteit? Hoekom? What did the learners like/dislike about this module? Why?</p> <p>d) Gebasseer op leerders se reaksie in hierdie module, wat moet verander om hierdie module meer toeganklik en leervriendelik om sodoende leerders te help met wiskunde probleemoplossing. Based on learner's response in this module, what should change to make this module more accessible and useful to provide assistance in mathematics problem-solving?</p>	<p>Om uit te vind wat leerders maklik en moeilik gevind het in hierdie module. Ook hoe dit gebruik is en hoekom leerders dit gebruik het asook om vas te stel of dit leerders gehelp het met wiskunde probleemoplossing.</p> <p>To find out the strengths and weaknesses of the Glossary tool. These questions are also posed to find out whether their understanding of mathematics problems became clearer.</p>
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<p>2. Les Module</p> <p>a) Wat was die tyd oor die algemeen wat leerders aan hierdie aktiwiteit spandeer het? What was the overall time spent on this module?</p> <p>b) Het die leerders enige belemmerings ervaar om die verskillende voorstellings van wiskunde problem te interpreter/analiseer? Hoekom? Did learners experience any difficulty in analysing/interpreting representations of mathematics problems in this module? Why?</p> <p>c) Wat het leerders leersaam gevind in hierdie module? What did learners find useful in this module?</p> <p>d) Gebasseer op leerders se terugvoering, wat volgens hulle moet in hierdie module verander? Hoekom? Based on the learners' feedback, what changes must be made to this module?Why?</p>	<p>Om uit te vind wat leerders maklik en moeilik gevind het in hierdie module. To find out the strengths and weaknesses of the Lesson tool.</p>
<p>3. Die Forum Module</p> <p>a) Wat was die tyd oor die algemeen wat leerders aan hierdie aktiwiteit spandeer het? What was the overall time spent per learner on this module?</p> <p>b) Het leerders dit moeilik gevind om aan die besprekings deel te neem? Hoekom?</p>	<p>Om uit te vind wat leerders maklik en moeilik gevind het in hierdie module. To find out the strengths and weaknesses of the Forum tool.</p>

<p>Did the learners find it difficult to take part in the forum discussions? Why?</p> <p>c) Het leerders voordeel geput uit die voorstellings eienskappe van hierdie module? Hoekom?</p> <p>Could learners benefit from the representational features of the Forum module? How?</p> <p>d) Wat spesifiek het leerders van hierdie besprekings gehou? Hoekom?</p> <p>What did the learners like about these discussions? Why?</p> <p>e) Gebasseer op die leerders se terugvoering, wat volgens hulle moet in hierdie module verander? Hoekom?</p> <p>Based on the learners' feedback, what changes must be made to this module? Why?</p>	
<p>4. Die Opdrag Module</p> <p>a) Wat was die tyd oor die algemeen wat leerders aan hierdie aktiwiteit spandeer het?</p> <p>What was the overall time spent per learner on this module?</p> <p>b) Watter moeilikhede het leerders in hierdie module ervaar?Hoekom?</p> <p>What difficulties did learners experience within this module? Why?</p> <p>c) Waarvan het die leerders gehou/ nie gehou nie, in hierdie module?</p> <p>Hoekom?</p> <p>What did the learner like/dislike about this module? Why?</p>	<p>Om uit te vind wat leerders maklik en moeilik gevind het in hierdie module.</p> <p>To find out the strengths and weaknesses of the Assignment tool.</p>

<p>d) Gebasseer op die leerders se terugvoering, wat moet volgens hulle verander in hierdie module? Hoekom? Based on the learners' feedback, what changes must be made to this module? Why?</p>	
<p>5. The WIKI Module</p> <p>a) Wat was die tyd oor die algemeen wat leerders aan hierdie aktiwiteit spandeer het? What was the overall time spent per learner on this module?</p> <p>b) Watter moeilikhede het leerders ervaar in hierdie module? Hoekom? What difficulties did learners experience within this module? Why?</p> <p>c) Kon leerders die voorstellings eienskappe van hierdie module gebruik? Hoe het hulle dit gebruik? Could the learners use the representational features of this module? How?</p> <p>d) Waarvan het die leerders gehou/nie gehou nie, in hierdie module? Hoekom?</p>	<p>Om uit te vind wat leerders maklik en moeilik gevind het in hierdie module. To find out the strengths and weaknesses of the Wiki tool.</p>

<p>What did the learner like/dislike about this module? Why?</p> <p>e) Gebasseer op die leerders se terugvoering, wat volgens hulle moet verander in hierdie module? Hoekom? Based on the learners' feedback, what changes must be made to this module? Why?</p>	
<p>6. The Toets Module</p> <p>a) Wat was die tyd oor die algemeen wat leerders aan hierdie aktiwiteit spandeer het? What was the overall time spent per learner on this module?</p> <p>b) Watter moeilikhede het leerders in hierdie module ervaar? Hoekom? What difficulties did learners experience within this module? Why?</p> <p>c) Het die voorstellings eienskappe die leerders in enige opsig gehelp? Hoe? Did the representational features of this module assist learners in any way? How?</p> <p>d) Waarvan het die leerders gehou/nie gehou nie in hierdie module? Hoekom? What did the learner like/dislike about this module? Why?</p> <p>e) Gebasseer op leerders se terugvoering, wat moet volgens hulle in hierdie module verander? Hoekom? Based on</p>	<p>Om uit te vind wat leerders maklik en moeilik gevind het in hierdie module. To find out the strengths and weaknesses of the Lesson tool.</p>

<p>the learners' feedback, what changes must be made to this module? Why?</p>	
<p>7. Leerders se ervaring met Moodle</p> <p>a) Het die leerders dit moeilik gevind om rond te beweeg binne Moodle? Hoekom? Did the learners find it difficult to roam around Moodle? Why?</p> <p>b) Waar het leerders vasgehaak tydens hulle interaksie? Hoekom? Where did learners get stuck during their interaction? Why?</p> <p>c) Watter aktiwiteite, gebasseer op die voorstellings eienskappe van problem het leerders meer geniet om te doen? Hoekom? What activities based on representational features did the learners find more interesting than other? Why?</p> <p>d) Kon die leerders hulle eie voorstellings mak van wiskunde problem binne die verskillende modules sonder die hulp van die onderwyser? Could the learners construct representations of mathematics problems in these modules without the assistance of the teacher?</p>	<p>Om uit te vind wat leerders se algemene ervaring was met hulle interaksie in Moodle. Kon dit leerders help met wiskunde probleemoplossing. Het die voorstellings 'n verskil gemaak in leerders se verstan van wiskunde problem. To find out whether learners' experience within Moodle did provide them with a sufficient learning experience and whether the multi-representational features within Moodle assist Deaf and Hard of Hearing learners with their understanding of mathematics problems. To find out what the overall strengths and weaknesses are.</p>

<p>e) Watter module het hulle meer geleenthede gegee om tussen voorstellings te beweeg? What module provided them with more opportunities to translate and move between representations?</p> <p>f) Wat was die meoilikste deel van hulle ervaring binne Moodle? Hoekom? What was the most difficult part of their experience within Moodle? Why?</p>	
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Addendum C (Research Approval Letter from the WCED)



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: 20140227-25590
ENQUIRIES: Dr A T Wyngaard

Mr Nolan Damon
4 Hennie Ferrus Crescent
Parkersdam
Worcester
6850

Dear Mr Nolan Damon

RESEARCH PROPOSAL: ON THE FEASIBILITY OF MOODLE USE TO ASSIST DEAF AND HEARING IMPAIRED GRADE 9 LEARNERS WITH MATHEMATICS PROBLEM SOLVING IN SOUTH AFRICAN SCHOOLS

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 21 July 2014 till 30 September 2014
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: 14 July 2014

Lower Parliament Street, Cape Town, 8001
tel: +27 21 467 9272 fax: 0865902282
Safe Schools: 0800 45 46 47

Private Bag X9114, Cape Town, 8000
Employment and salary enquiries: 0861 92 33 22
www.westerncape.gov.za

Addendum D (Stellenbosch University Consent to participate in research)



UNIVERSITEIT • STELLENBOSCH • UNIVERSITY
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STELLENBOSCH UNIVERSITY CONSENT TO PARTICIPATE IN RESEARCH

On the feasibility of Moodle use to assist Deaf and Hard of Hearing Grade 9 learners with mathematics problem solving in South African schools.

You are asked to participate in a research study conducted by Nolan Damon, BEd Honours Degree, from the Curriculum Studies Department at Stellenbosch University. You were selected as a possible participant in this study because the study revolves around Deaf and hard of hearing learners' struggle in mathematics problem solving and how the use of Moodle can assist you in your struggle. Since you are deaf/hard of hearing and struggle with mathematics problem solving, you are eligible to participate in this study.

1. PURPOSE OF THE STUDY

The aim of this study is to evaluate Moodle use with respect to Grade 9 Deaf and Hard of Hearing learners specific to mathematics problem solving, to determine:

How can the use of multiple representations within Moodle assist Deaf and Hard of Hearing learners overcome any barriers mathematics problem solving present?

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

The Moodle activities based on mathematics problem solving were designed making use of 6 tools within Moodle i.e. Glossary, Lesson, Forum, Wiki, Assignment and the Quiz tool. Grade 9 learners at Nuwe Hoop Centre, a school for the Deaf and Hard of Hearing, will participate in this research study. The online experience consists of 2 stages.

Stage 1

Firstly you will be asked to participate in an online learning environment by interacting with mathematics problem solving learning material designed in Moodle. These learning materials are part of the Grade 9 mathematics curriculum set out in CAPS. Your interaction within these activities will be recorded and closely monitored by the researcher/teacher. The knowledge acquired from your first interaction will form your baseline knowledge of the content. The results of your interaction in these activities will be recorded within Moodle and used to adjust the

activities according to your individual needs. An interview will be conducted individually and in groups for further recommendations and comments. Furthermore data from research literature will also be used to adjust the activities within Moodle to eliminate any barriers these learning activities presented to Grade 9 learners. Stage 1 will take approximately 3 weeks in which Grade 9 learners will have adequate time to interact with the learning material.

Stage 2

In the second stage you will be asked to participate in the adjusted activities. Here the results will be analyzed to see whether the adjusted activities within Moodle had any effect on your performance in mathematics problem solving. The second stage will last approximately 3 weeks in which the learners will interact with the adjusted activities.

Both stages will take place at Nuwe Hoop Centre, in the Computer Lab, room C.012. The project will run from the 14th of April 2014 up until the 30th of May 2014. The classes will also be administered outside of the normal mathematics classes between the hours of 14h00 and 15h00 each day.

3. POTENTIAL RISKS AND DISCOMFORTS

The learning environment learners will engage in presents no foreseeable risk since it is safe and user-friendly. Since I have been teaching computer practice to these learners from Grade 7, most of them know the learning environment and how to keep themselves safe in front of the computer.

A potential discomfort might be that some learners aren't too comfortable in front of the computer. This discomfort will be rectified through continual exposure to the computers by means of educational games. Learners, especially the deaf learners loves games and this I will use not only to familiarize learners with computers as a learning tool but also to remove any anxiety they might experience when working with computers.

Furthermore, there are no significant physical or psychological risks to taking part in the study which will result in the researcher terminating the study. What this mean is that in no way will any of the learners be mistreated or their rights be violated, since this will result in a failed research project. In addition to ensure that there is no inconvenience to the learners, the study will not be conducted within the normal mathematics classes.

Moreover the activities are designed in line with the Curriculum and Assessment Policy Guidelines (CAPS) specific to the Grade 9 mathematics curriculum which is specified by the Department of Education.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

The potential benefits of this research study to school mathematics for deaf learners will be of great value. Not only will it highlight why deaf learners struggle with mathematics problem solving, but it will also try to examine how the barriers deaf learners experience in mathematics problem solving can be overcome through the use of Moodle as a Learning Management System.

Furthermore, the research will point out what mathematics learning material in Moodle should look like in order for it to complement and enrich the school mathematics curriculum for the deaf learners.

In addition the research will highlight how deaf/hard of hearing learners are able to construct their own mathematical knowledge by making use of the tools in Moodle. Moreover, the study will also have great benefits for the deaf /hard of hearing community since improvements in the performances of Deaf learners in school mathematics might guarantee them access to higher education and possible career advancements.

5. PAYMENT FOR PARTICIPATION

No payments will be given to any of the subjects. The study will be conducted with participants out of their own free will.

6. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of : Coding Procedures and Safeguarding of data.

- **Coding Procedure**

The ethical integrity of this study will be maintained by conducting the study under the auspices of the ethics committee of the University of Stellenbosch. Moreover, the privacy, anonymity and confidentiality of the Grade 9 learners' records will be secured in my research report by replacing their real identities with pseudonyms. The researcher will thus code the data using the pseudonyms especially in the case of publication. Furthermore I will institute the maximum effort and exercise caution in order to protect the identity of the learners. The Grade 9 learners will thus remain anonymous.

- **Plans to safeguard the data**

The biographical data as well as the transcribed interviews of the learners will be kept safe on my personal computer's hard drive. No one except me have access to my personal computer which is password protected.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact the following research personnel:

Principal Investigator:

Name: Nolan Damon

Contact Information: Home: 0233474372
Cellphone: 0711789322

Address: 4 Hennie Ferruscrescent
Parkersdam
Worcester
6850

Supervisor

Name: Faalz Gierdien

Contact Information: tel: 27 21 808 2289 (O)
fax: 27 21 808 2295

Address: Dept of Curriculum Studies
Faculty of Education
Stellenbosch University
Private Bag X1
Matieland
7602
South Africa

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to [*me/the subject/the participant*] by Mr. N Damon in Sign Language and [*I am/the subject is/the participant is*] in command of this language or it was satisfactorily translated to [*me/him/her*]. [*I/the participant/the subject*] were given the opportunity to ask questions and these questions were answered to [*my/his/her*] satisfaction.

[*I hereby consent voluntarily to participate in this study/I hereby consent that the subject/participant may participate in this study.*] I have been given a copy of this form.

* Denzil
Name of Subject/Participant

* Amalie
Name of Legal Representative (if applicable)

* a. Plasjee 9/3/14
Signature of Subject/Participant or Legal Representative Date

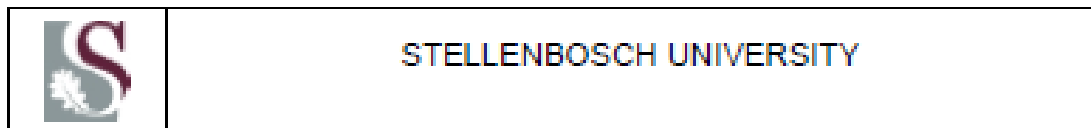
SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to DENZIL [*name of the subject/participant*] and/or [*his/her*] representative AMALIC [*name of the representative*]. [*He/she*] was encouraged and given ample time to ask me any questions. This conversation was conducted in [*Afrikaans/*English/*Xhosa/*Other*] and [*no translator was used/this conversation was translated into Sign Language*] by Nolan Damon.

Nolan
Signature of Investigator

9/03/2014
Date

Addendum E (Participation information leaflet and assent form)



PARTICIPANT INFORMATION LEAFLET AND ASSENT FORM



TITLE OF THE RESEARCH PROJECT: Moodle use in Mathematics problem solving

RESEARCHERS NAME(S): Nolan Damon

ADDRESS: 4 Hennie Ferrus Crescent, Parkersdam, Worcester, 6850

CONTACT NUMBER: 0711789322

What is RESEARCH?

Navorsing is iets wat ons doen om nuwe inligting te vin deur hoe dinge(en mense) werk. Ons gebruik navorsingsprojekte of studies om meer te leer oor siektes . Navorsing help ons ook om beter maniere te vind om siek kinders te help of te behandel.

What is this research project all about?

Hierdie navorsingsprojek handel oor Moodle en wiskunde probleemoplossing. Omdat Dowe leerders sukkel met wiskunde probleem somme, het ek dit goed gedink om 'n manier te ondersoek om Dowe leerders te help sodat hulle wiskunde probleme kan oplos.

Why have I been invited to take part in this research project?

Jy is uitgenooi om deel te neem aan hierdie navorsingsprojek omdat jy Doof is en omdat jy sukkel om wiskunde probleme op te los, veral as dit wiskunde woordprobleme insluit. Die moontlikheid word dus ondersoek og die gebruik van Moodle jou kan help met wiskunde probleemoplossing.

Who is doing the research?

Ek is Mnr. Nolan Damon. Ek is 'n onderwyser by Nuwe Hoop Sentrum, 'n skool vir Dowe en gehoorgestremde leerders. Ek onderrig wiskunde en rekenaarvaardighede. Ek het die afgelope 10 jaar ervaar dat Dowe leerders dit geweldig moeilik vind om wiskunde woordprobleme op te los. Hulle sukkel gedurig om wiskunde woordprobleme te verstaan en kry dit die meeste van die gevalle verkeerd. Dit is hoekom ek dit belangrik gesien het om die navorsingprojek te doen om uit te vind hoe tegnologie en spesifiek Moodle, Dowe leerders kan help.

What will happen to me in this study?

Van jou word verwag om die aktiwiteite wat deur myself opgestel is, te doen. Die aktiwiteite is gebaseer op wiskunde probleemoplossing. Hierdie aktiwiteite is ontwikkel in Moodle wat 'n eLeer omgewing is. Hierdie aktiwiteite maak gebruik van die gereedskap in Moodle o.a. die Les module wat gebruik gaan word om leer in kleiner dele af te breek om jou sodoende die geleentheid te gee om bietjie vir bietjie die inhoud te verstaan. Daarna beweeg jy na die Forum module. Hierdie module sal jou help om te praat, kommunikeer oor wat jy verstaan wat gewra word om sodoende terme en begrippe te verstaan. Daarna beweeg ons na die WIKI module waar ek individuele aandag aan jou probleem sal gee. Dit is 'n geslote gespreksruimte tussen jou en die onderwyser op grond van wat uit die Forum module gekom het. Hierma sal van jou verwag word om 'n opdrag te doen in die vorm van 'n "webquest". 'n Webquest is 'n opdrag in die vorm van 'n alledaagse probleem wat jy moet oplos. In die geval sluit die probleem 'n vakansie toer in. Jy moet gebruik maak van konsepte soos verhouding, koers en eweredigheid om vakansie planne te maak. Aan die einde van die Les moet jy 'n toets(quiz) neem. Hierdie toets handel oor die hele onderwerp en sluit vrae in wat jy op jou eie moet beantwoord. Daar is deurgaans hulp d.m.v prente, gebare en visuele voorstellings. Om die hele onderwerp nie so gespanne te maak nie, het ek ook 'n Speletjie module ingesluit wat handel oor werk wat gedek is.

Can anything bad happen to me?

Daar is geen risiko's aan verbode in hierdie projek nie.Dit beteken dat jy in geen gevaar sal verkeer tydens jou deelname aan die projek nie.

Can anything good happen to me?

Wat kan plaasvind is dat jy stelselmatig geleel gaan word om moeilike inhoud te verstaan. Jy gaan ook geleel word om problem op jou eie op te los wat jou die vrymoedigheid gaan gee om alledaagse problem op te los. Jy sal ook agterkom dat 'n problem nie net een spesifieke metode het op opgelos te word nie en dat jy problem op verskillende maniere kan voorstel om dit sodoende op te los.

Will anyone know I am in the study?

Inligting sal ten alle tye op 'n vertroulike basis gehanteer word. Die uitslag van die navorsingsprojek gaan aan die einde aan die skool bekend gemaak word. Jou vertroulikheid sal onder geen omstandighede geskend word nie. Slegs die inligting rakende die uitslag van die projek gaan gepubliseer word om sodoende die geldigheid van die projek uit te lig.



Who can I talk to about the study?

Jy kan ter enige tyd my, Mnr. Damon, kontak by 0711789322 of selfs by 0233474372.. Jy kan ook Mnr Erasmus kontak by 0233482200 of Mnr Humphreys by 0233482200.

What if I do not want to do this?

Jy kan nie in die moeilikheid kom deur te wyl om aan die projek deel te neem nie. Indien jy wêld deel neem in die navorsingsprojek, kan jy ter enige tyd onttrek uit die projek uit. Jy sal dus nie verplig word om verder aan die projek deel te neem nie.

Do you understand this research study and are you willing to take part in it?

Has the researcher answered all your questions?

Do you understand that you can STOP being in the study at any time?

G. ADELMAAR
Signature of Child

9/3/2014
Date

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