Design integration of interactive whiteboards in an open distance mathematics programme

Hermina Hendrina Dreyer

21168040

Dissertation submitted for the degree Magister Educationis in Curriculum Development at the North-West University, Potchefstroom Campus

Supervisor:	Prof. Dr. A. Seugnet Blignaut
Co-supervisor:	Prof. Hercules D. Nieuwoudt
Assistant supervisor:	Dr. Hendrik D. Esterhuizen

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Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

_____

Signature

5 December 2014

_____

Date

Acknowledgements

This dissertation is dedicated to:

- My family, friends and colleagues who are painting the picture of my life and always encourage and let me be the best me

The following people need to be acknowledged:

- Prof Seugnet Blignaut: Thank you so much, Prof! You have really gone beyond to keep me on track when I thought this study was never going to realise. I appreciate and admire you as academic and will always be grateful that you were my supervisor during this study.
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- Dr Suria Ellis: Thank you for your assistance in analysing the data and for the kind manner you do your job.
- Mathematics teacher-students of UODL: Thank you for participating in the study. Keep up the good work out there and always strive to improve and enhance your own understanding of mathematics.
- Thank you Dear Lord for saving me through many things and letting me complete this study. Use me as an instrument and let me use my newly gained knowledge wisely to make a difference in other people's lives. Amen.

Abstract

Worldwide, people who are unable to study full-time at residential higher education institutions choose distance education as their mode of study. Such students who are mostly employed adults with multiple responsibilities face many challenges in the process. Students majoring in Mathematics often struggle to master the mathematics content of the major modules and therefore have to attempt the examination several times. The UODL at the Potchefstroom campus of the NWU incorporated IWBs as learning technology in order to improve the communication and support to their students. This study aims to determine how scaffolding of mathematics concepts can be facilitated via IWBs in order to enhance the learning experience of teacher-students towards their understanding of the fundamental principles of mathematics.

The study is based on the Stoner model for implementing ICT learning technologies and the focus of the study relates specifically to the design integration phase of the Stoner cycle.

The population for the study consisted of all OLG teacher-students who were registered for NWPK 512—a mathematics major module within the ACE programme. A group of ten participants attending at the White River centre and a control group of ten participants from another centre were used during the study. The study followed a mixed-method research design and was performed according to a Kirkpatrick evaluation for training programmes which involves evaluation on five different levels, namely reaction, perception whether learning occurred, change in behaviour, results and return on investment.

The qualitative data were analysed through ATLAS.ti ™ augmented with descriptive statistical techniques. Descriptive statistical techniques and effect sizes were calculated to analyse the quantitative data. Reliability and validity of the instrument were calculated. Findings of the study indicated that scaffolding of mathematical concepts via IWBs enhanced students' understanding of the fundamental concepts of mathematics. The group of participants performed significantly better after they have attended the scaffolding IWB sessions.

The introduction to and incorporation of scaffolds for learning mathematics over distance can create an environment of effective mathematics education for all teacher-students as well as for the students in their respective classrooms.

Keywords: Mathematics education; open distance learning; technology-enhanced learning; learning with technology; interactive whiteboard; scaffolding; constructivism; teaching strategy; Kirkpatrick evaluation.

Opsomming

Wêrelwyd kies persone vir wie dit nie moontlik is om aan residensiële opvoedingsinstansies te studeer nie, afstandonderrig as mode om hul kwalifikasies te verbeter. Hierdie studente is oorwegend volwassenes wat reeds in 'n beroep staan met gepaardgaande verantwoordelikhede en ervaar dikwels struikelblokke gedurende die proses. Studente met Wiskunde as hoofvak gebruik dikwels meer as een eksamengeleentheid om 'n module te slaag omdat hulle sukkel om die inhoud te bemeester deur middel van afstandonderrig.

Die Eenheid vir Oopafstandsleer (OAL) op die Potchefstroom kampus van die NWU het interaktiewe witborde as leertegnologie geïnisieer om daardeur die kommunikasie en ondersteuning aan hul studente te verbeter.

Die doel van hierdie studie is om te bepaal hoe die "scaffolding" van wiskundige konsepte deur middel van en met behulp van interaktiewe witborde oor afstand gefasiliteer kan word met die doel om die leerervaring van Wiskunde studente te verbeter.

Die studie is gebaseer op die Stoner model om IKT leertegnologieë te implementeer en die fokus van die studie het spesifiek betrekking op die ontwerp-en-integreer fase van die Stoner siklus.

Die navorsingsontwerp van die studie is 'n gemengde ontwerp en is volgens die Kirkpatrick evaluering van opleidingsprogramme gedoen. 'n Kirkpatrick evaluering behels evaluering op vyf verskillende vlakke naamlik: reaksie, leer-persepsie, gedrag, resultate en opbrengs op belegging. Die kwalitatiewe data-analise is gedoen deur middel van ATLAS.ti™ en beskrywende statistiese tegnieke. Beskrywende statistiese tegnieke en effekgroottes is bereken om die kwantitatiewe data te analiseer. Die betroubaarheid en die geldigheid van die instrument is bereken.

Bevindinge van die studie dui daarop dat "scaffolding" van wiskundige konsepte deur middel van interaktiewe witborde bydra dat afstandonderrig studente die fundamentel konsepte van wiskunde beter verstaan. Die groep deelnemers aan die studie het betekenisvol beter presteer nadat hul die gekonseptualiseerde witbord sessies bygewoon het.

Die bekendstelling tot en inkorporasie van "scaffolds" vir wiskundige konsepte via interaktiewe witborde, met die doel om wiskunde beter te leer en te verstaan in afstandonderrig, kan 'n omgewing vir effektiewe wiskunde onderrig skep vir die onderwysstudente van die EOAL asook vir hierdie studente se leerlinge in hul onderskeie klasse.

Sleutelwoorde: Wiskunde onderrig; oop-afstand leer; tegnologie-ondersteunde leer; leer deur middel van tegnologie; interaktiewe witbord; konsep steierwerk; konstruktiwisme; leerstrategie; Kirkpatrick-evaluering.

Certificate of Proofreading

H C Sieberhagen	*Translator and Editor*
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CERTIFICATE ISSUED ON 5 DECEMBER 2014

I hereby declare that I have linguistically edited the dissertation submitted by Mrs Hermina Hedrina Dreyer for the MEd degree.

Design integration of interactive whiteboards in an open distance mathematics programme

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Ethical Clearance Certificate

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ETHICS APPROVAL OF PROJECT

The North-West University Research Ethics Regulatory Committee (NWU-RERC) hereby approves your project as indicated below. This implies that the NWU-RERC grants its permission that provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: Design integration of interactive whiteboards in an open distance mathematics programme

Project Leader: Prof AS Blignaut
Student: H Dreyer

Ethics number: NWU-00033-14-A2

Approval date: 2014-03-06 **Expiry date:** 2019-03-05

Special conditions of the approval (if any): None

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- *The project leader (principle investigator) must report in the prescribed format to the NWU-RERC:*
  - *annually (or as otherwise requested) on the progress of the project,*
  - *without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.*
- *The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-RERC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.*
- *The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-RERC and new approval received before or on the expiry date.*
- *In the interest of ethical responsibility the NWU-RERC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the project;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the project are revealed or suspected,*
    - *it becomes apparent that any relevant information was withheld from the NWU-RERC or that information has been false or misrepresented,*
    - *the required annual report and reporting of adverse events was not done timely and accurately,*
    - *new institutional rules, national legislation or international conventions deem it necessary.*

The Ethics Committee would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the Ethics Committee for any further enquiries or requests for assistance.

Yours sincerely

Linda du Plessis

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Prof Linda du Plessis
Chair NWU Research Ethics Regulatory Committee (RERC)

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List of Acronyms

ACE	Advanced Certificate in Education
CCM	constant comparison method
CDLP	California Distance Learning Project
CG	control group
CMC	computer-mediated communications
DE	distance education
DL	distance learning
EG	experimental group
FP	foundation phase
HEI	higher education institution
ICT	information and communication technology
IMM	interactive multimedia
IP	intermediate phase
IWB	interactive whiteboard
LT	learning technology
n	group of research participants
N	population
NCTM	National Council of Teachers of Mathematics
NPDE	National Professional Diploma in Education
NWU	North-West University
ODL	open distance learning
OLG	Open Learning Group
ROI	return on investment
SMS	short message service
SP	senior phase
UODL	Unit for Open Distance Learning
ZPD	zone of proximal development

Chapter One

Introduction and Statement of the Problem

1.1 Introduction

In South Africa and many other countries, people are, for various reasons, prohibited to study full-time at residential higher education institutions (HEIs) and therefore choose distance education (DE) as their mode of study. These students are mostly employed adults who are subjected to the multiple responsibilities brought about by family responsibilities, working and studying simultaneously. However, with good planning and support it is possible for students to further their professional development via distance learning (DL) and augment their qualifications while studying at home in their own time, while employed, and supporting their families (Ferreira & Venter, 2010). They do, however, face many challenges and sacrifices and also have to put in much effort in order to succeed (Mdakane, 2011).

Modern learning technologies bridge some of these challenges in DE. Information and communication technology (ICT) can support diversity, personalise learning and provide tele-collaboration between course participants. However, no single ICT-based learning technology[1] (LT) can address all the learning needs of diverse South African distance students. Selecting a LT from a spectrum of LTs is an important decision for a HEI in order to foster multi-modal learning (Blignaut & Esterhuizen, 2011) in order to enhance student support. An example of modern LTs used at the Unit for Open Distance Learning (UODL) at the North-West University (NWU) is the use of interactive whiteboards (IWBs). IWBs provide two-way ICT communication, multiple user touch screen interaction, and assist in overcoming the physical distance between lecturer and students: "An IWB set-up involves the image generated by a computer being projected onto a touch-sensitive screen the size of a conventional whiteboard, where the touch of a pen is the equivalent to a mouse click" (Kent, 2006, p. 25). IWBs can be used in a variety of ways. They can be used as mere presentation tools, but their additional affordances should be optimally employed in terms of interactivity between the lecturer and students (Koenraad, 2008). The Management and academic personnel at the UODL are committed to evaluate and improve on the use of its extensive investment in IWBs in order to ensure the added value of using IWBs as part of their teaching and learning cache, as well as to establish best practices for the use of IWBs in open distance learning (ODL).

Various models for the implementation of ICT learning technologies are available. Examples are *inter alia* the ADDIE model (Zimnas, Kleftouris, & Valkanos, 2009), the Dick and Cary model (Akbulut, 2007), the Reeves model (Hennesy, Harrison, & Wamakote, 2010), and the Stoner model (Stoner, 1996). This study selected the Stoner Systems Life Cycle of Learning Technology (Stoner, 1996) as

[1] "Learning technology is the broad range of communication, information and related technologies that can be used to support learning, teaching, and assessment" (Association for Learning Technology, 2010b).

it explicitly describes curriculum design aspects as part of the design of integrating LT for teaching and learning (Figure 1.1).

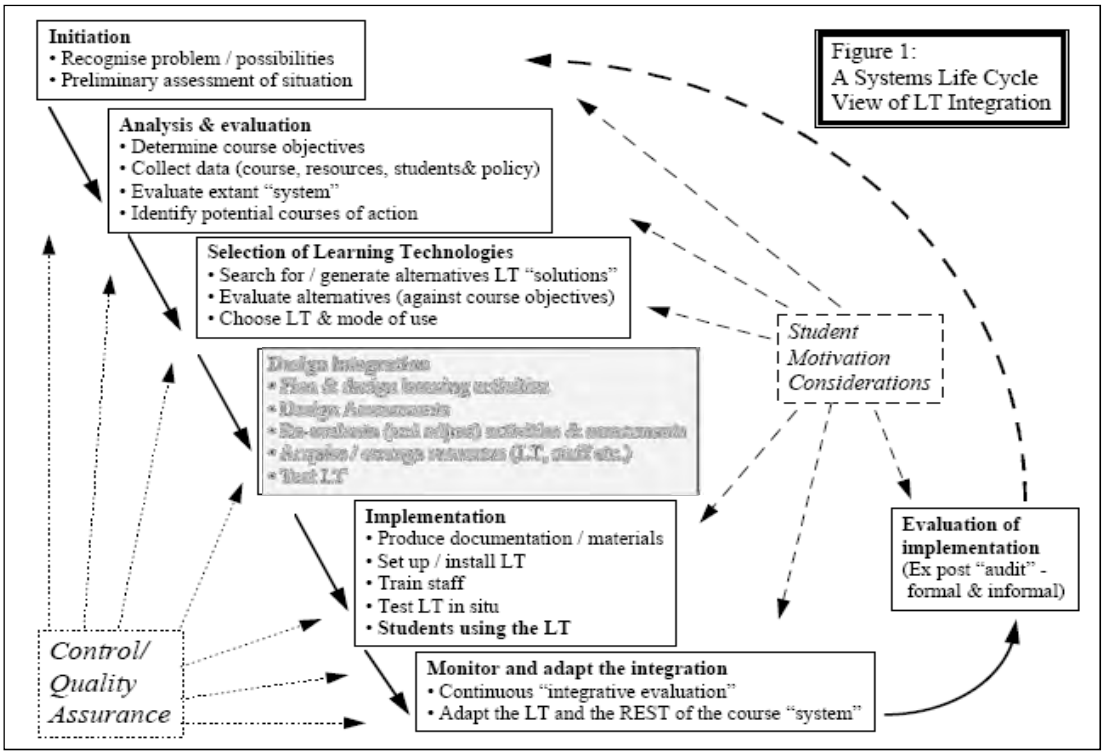


Figure 1.1: Stoner (1996) model of learning technology integration

Although the Stoner model seems like a linear process, it comprises a set of interrelated stages encompassed by the evaluation of the implementation of the LT, as well as through quality assurance aspects. As the process unfolds, the model describes the change that takes place, and it also ensures that students meet their learning objectives in an appropriate manner (Stoner, 1996). Figure 1.1 indicates that recognising the instructional problems or possibilities of using the LT *initiates* the evaluation of implementation of the learning technology. Reflecting on how IWBs could be *initiated* and optimally used as scaffolding[2] of DL mathematics programmes presents simultaneous instructional and research possibilities and challenges. The UODL extensively uses IWBs for course facilitation. Consequential steps of Stoner's cycle of LT integration are to *analyse* why changes to design integration should be made, and describe the role of LTs needed within the teaching and learning of DE students (Benade, 2013). Aspects to consider during the *analysis* phase are determining course objectives, collecting data relating to the course and resources, data on the students and policy, evaluation of the extant system, and identifying a potential course of action for integrating the LT.

A *selection of LTs* is imperative as the aim of using an LT is about enhanced learning and not about the affordances of the technology. If the integration of the LT is effective, the process of learning is also enhanced (Taylor, 2001). IWBs should not merely support teaching functions, such as to

[2] Scaffolding within the theory of constructivism is a teaching strategy, used by a facilitator, to assist a student in his process of learning in such a way that he becomes more self-regulated and independent (Valkenburg, 2010).

explain, demonstrate and present instruction and thereby promoting teacher-centred instruction (Nieuwoudt, 2006) while students remain passive receivers of knowledge, but students should also be challenged, because effective education implies independent learning and co-construction of knowledge (Koenraad, 2008).

Design integration relates to planning and designing learning outcomes, designing assessments, re-evaluating and adjusting learning activities, acquiring learning resources, and testing the LT (Figure 1.1). To enhance learning, one should ensure that the LT is readily available to students and technical problems should be excluded for the smooth and uninterrupted use of the LT. Therefore, IWBs should be used to increase interactivity instead of merely reading documents behind glass. Re-evaluation and adjustment of teaching and learning strategies should take place on a continuous basis, taking into consideration students' learning experiences (Stoner, 1996). The teaching staff should be trained, and the LT should be tested *in situ*. The focus of this study relates to the phase of *design integration* of the Stoner cycle because the UODL, in its process of adopting learning technologies for ODL, currently places design integration of learning technology at the centre of attention. The study specifically involves the *design integration* of scaffolding and understanding of fundamentals of Algebra.

When the *implementation* of the LT takes place, lecturers should ensure that the students are motivated, and that they know how to learn with the help of LTs (Stoner, 1996). *Monitoring as well as adaptation* maintains the technology integration. Continuous integrative evaluation should take place throughout the course and adaptations should be made continuously so that problems can be rectified before students' learning has been compromised (Stoner, 1996). After an initial implementation, an *evaluation of the implementation* should take place. This evaluation will provide answers to the success of the LT integration. Such an evaluation could be of formative or summative nature, or a combination thereof (Stoner, 1996).

A key consideration to LT integration is the establishing of *student motivation*. Motivating students to make the change, to use LT for learning, is vital to the success of the project. Motivation of students has the potential to affect all the aspects of the LT integration life-cycle. *Quality assurance* and *evaluation of implementation* converge to provide evaluation of outcomes, and also to ensure the quality of learning with technology (Stoner, 1996).

The study has as its aim to evaluate the scaffolding of mathematics concepts via IWBs at the UODL. The research focuses on the design integration of IWBs at the UODL in order to determine whether the scaffolding of mathematics concepts in a mathematics module contributes towards the learning experience of teaching-students. The extended Kirkpatrick evaluation model for evaluating training programmes guided the data collection strategies and analysis of the data. The model involves evaluation on four different levels followed by a fifth level which Phillips added to the original

Kirkpatrick model (D. L. Kirkpatrick, 1998; Phillips, 2003; Simonson, 2007). The model is described in more detail in § 1.4.

1.2 Context of the study

The UODL on the Potchefstroom campus of the NWU has extended the scope of distance learning in South Africa by offering *open* distance learning for the professional development of in-service teachers. The UODL offers continuous teacher professional development to the numerous unqualified and under-qualified teachers in South Africa and Namibia. This model involves that teacher-students do not have to enrol specifically at the beginning of a year, but at any time of the year. They may also write examinations when it suits them best. NWU offers two examination opportunities for each module during the year. Teacher-students are therefore involved in the management of their learning and academic progress.

A large section of the teacher-students live and teach in distant and deep rural areas. Many grew up in disadvantaged communities and did not have opportunities for higher education owing to the distance to HEIs. They are practising teachers who support their immediate and extended families, and are therefore unable to enrol for qualifications at residential HEIs. Embarking on DE is for many the only way to further their studies and obtain additional professional qualifications (Bansilal & Rosenberg, 2011).

The UODL offers non-compulsory contact classes at 56 learning centres across the country. DL qualifications include the *National Professional Diploma in Education* (NPDE), various options for the *Advanced Certificate in Education* (ACE), the *BEd* and the *BEdHons*. The ACE in Mathematics is one of seventeen ACE-programmes that the UODL offers. However, many students struggle to pass the mathematics major modules that mainly comprise mathematical concepts at their first attempt. About fifty per cent of students who write examinations in this module fail the module at their first examination attempt (OLG, 2011). To succeed in this module teacher-students require a deep understanding of concepts like algebraic reasoning, polynomials, indices, basic operations and rules of operations, factorisation of polynomials, simplifying algebraic fractions and solving linear and elementary quadratic equations. Teacher-students have to master this module with a deep understanding of the concepts to obtain the qualification and to enable them to successfully teach their own learners at their respective schools. Students often take the examination two or three times before they pass, as many of them do not have a grounded understanding of mathematics—due to their own inadequate education when growing up.

Teacher-students experience challenges other than academic problems and these add to their insufficient understanding of mathematics concepts (Mdakane, 2011). Students who study through ODL often study alone due to time and distance concerns. They receive their study material delivered

to their door step and then they face the responsibility for studying by themselves (Ferreira & Venter, 2010). Most of the teacher-students live far from their peers in distant rural areas where support is limited. These students, in spite of great costs and serious time constraints, often travel long distances to attend contact classes. This also causes that attendance of classes is generally low (OLG, 2011)—in the order of fifteen to thirty per cent (Redelinghuys, 2012). Most DL teacher-students do not have their own transport and have to rely on public transport. Mostly, English is not their first language—an aspect that causes serious challenges. Students are of the opinion that contact sessions are too short and that tuition during contact classes does not cover the entire curriculum. Students spend much time to master learning content on their own and in their free time. Classes for some modules are overcrowded. Sometimes classes are presented in foundation phase classrooms where chairs are small and uncomfortable for adults to sit on. The UODL appoints facilitators at the learning centres to support teacher-students with academic and logistical issues, but teacher-students maintain that the facilitators are not always helpful (Mdakane, 2011).

It is the researcher's experience that DE students are capable to master most of the modules on their own, but many grapple to master the mathematics major modules without additional support. From this experience as a mathematics lecturer, my premise is that students perform better in examinations if concepts have been explained to them in person where they can interact with the lecturer. This is, however, not feasible with DE. However, the Internet contains an enormous number of web-based activities based on fundamental concepts of mathematics that students could engage in which are also free of charge. These web-based activities include learning activities, PowerPoint presentations, games, simulations, and models on all mathematics concepts which could interactively be linked to at any time convenient to the student. The different web-based activities could therefore scaffold the mathematics concepts in order to support and enhance the students' understanding of the fundamental concepts of mathematics. From the learning theory of constructivism, scaffolding is a teaching strategy facilitators can use to assist students during their learning in order for them to become more self-reliant and independent learners (Valkenburg, 2010). Teacher-students can visit and re-visit these sites individually or as a group in order to deepen their understand relating to different mathematics fundamentals. The deeper the understanding the teacher-students attain of the fundamental concepts of mathematics, the better they will be able to interact with the concepts in their own teaching practices, and the more they could can contribute towards their learners' understanding of mathematics (Ball, 2003). The reverse may also be true.

1.3 Research problem, purpose and research questions of the study

Research projects originate from a certain problem which subsequently drives the research. This section identifies the research problem, the purpose of the research, the main research question, as well as the subsequent sub-questions that this study aims to address.

1.3.1 Research problem

Many teacher-students are unable to study full-time at residential HEIs for reasons such as insufficient funds; fulltime employment, adults with family responsibilities; or living in rural areas far away from HEIs (Mdakane, 2011). A significant number of the teacher-students in South Africa relate to this scenario, and in order to promote their professional development they have to study over distance. However, some mathematics courses are not easy to complete over a distance and teacher-students consequently do not gain in-depth understanding of the mathematics concepts when studying on their own with little or no support from facilitator or tutor. This researcher is a mathematics lecturer, responsible for several mathematics modules at the UODL. She is confronted with the challenges that DE teacher-students face during the teaching and learning of mathematics. She therefore aims to address some of these challenges in this study. This research aims to evaluate whether a LT—IWBs—could scaffold the teaching and learning of mathematics across distance.

1.3.2 Purpose of the study

The purpose of the study is to evaluate how the scaffolding of mathematics concepts via IWBs contributes towards the design integration of a learning technology at the UODL at the NWU (Figure 1.1).

1.3.3 Research questions

From the purpose of the study, the following research question emanates: *How can IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme?*

Collectively, the following five sub-questions, in accordance with the extended D. L. Kirkpatrick (1998) evaluation method used during the study (§ 1.4), culminate to address the above main research question:

(a) How do students react to mathematics facilitation via IWB scaffolding? (Level 1)
(b) How do students perceive learning that takes place through scaffolding of mathematics via IWBs? (Level 2)
(c) How do the teacher-students' immediate supervisors (line managers) perceive changes in their on-the-job behaviour as a result of the successful completion of the concerned mathematics module? (Level 3)
(d) How did teacher-students' results change during a post-test as a result of attending mathematics scaffolding during IWB sessions? (Level 4)
(e) What was the return on investment (ROI) of employing IWBs for the concerned Mathematics course? (Level 5).

1.4 Research design and methodology

In order to describe the research design and methodology for this study, this section discusses the (i) worldviews of social research in order to place the research within a specific paradigm with the aim to make sound decisions relating to research design and methodology; (ii) the extended evaluation model of Kirkpatrick; (iii) the data collection strategies used during the study; and (iv) the data analysis used during this study.

1.4.1 Worldview

People view the world in different ways and therefore have different perspectives of approaches to social research assumptions. Burrell and Morgan (1979) structured the way people view their worlds and organise understanding of research into two axes from subjectivity to objectivity on the x-axis and from no or little control to high control on the y-axis. Figure 1.2 represents the four social quadrants representing their respective paradigms.

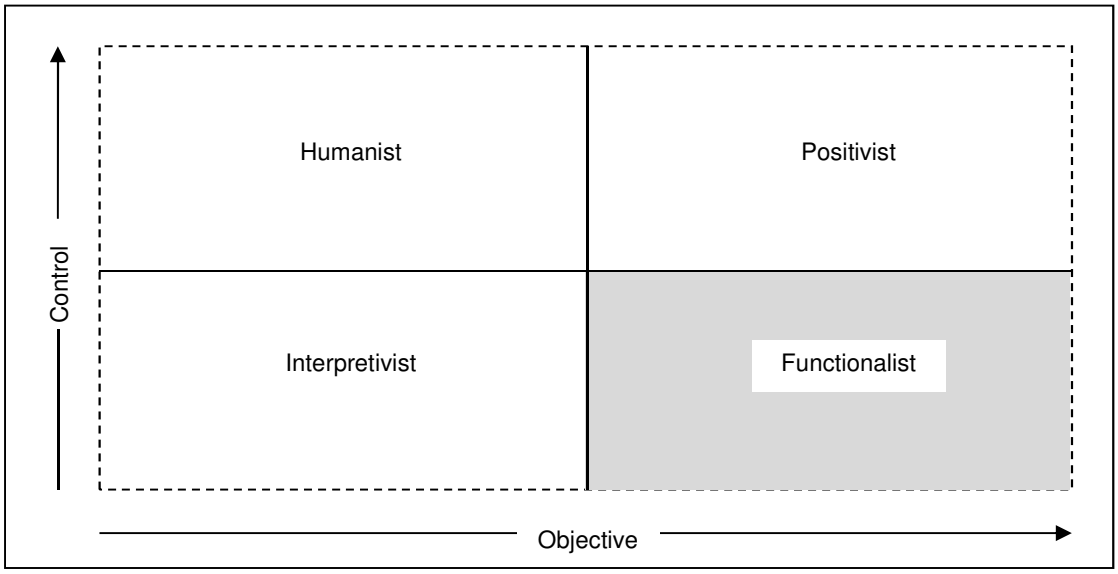


Figure 1.2 Four paradigms used in social research (adapted from Burrell and Morgan (1979)

The top right quadrant relates to the positivist or post-modern paradigm and refers to aspects that already have strong societal structures which are highly controlled. The objectivity of relating studies are consequently also high. Large-scale surveys typically relate to the positivist paradigm. The top left quadrant relates to the humanistic paradigm. Studies conducted from this world view are typically more subjective of nature, but relate to societal structures well in place. They often relate to issues of human interest. Feminist studies, studies of political nature and equity issues are examples of studies conducted from the humanistic paradigm (Burrell & Morgan, 1979).

However, not all societal structures are well-developed or contain issues that could be measured objectively. The bottom left quadrant relates to issues relatively unknown to the society. The interpretivist paradigm relates to studies where initial aspects should be determined through methods which are more subjective of nature. The bottom right quadrant of the model involves issues with a higher degree of objectivity, but where all structures are not yet formalised (Burrell & Morgan, 1979). The functionalist or pragmatic paradigm often addresses issues of programme evaluation where courses are well-structured, but other issues still require evaluation. The research question, with its subsequent sub-questions, relates to this quadrant. Therefore, this study will follow the obligations from the functionalist quadrant that determines that mixed-methods research will be used to address the research questions due to the characteristics of lower societal control and high objectivity regarding the issues in question.

1.4.2 Kirkpatrick evaluation model

From the selected paradigm for this study it follows that a mixed-methods research design is followed. Although various programme evaluation methods are available, the extended Kirkpatrick model (D. L. Kirkpatrick, 1998; Phillips, 2003; Simonson, 2007) is a good fit to the main research question. The Kirkpatrick model comprises two mainly qualitative levels and two mainly quantitative levels, as well as the fifth quantitative level that Phillips added to the existing model (Simonson, 2007). Figure 1.3 represents the extended Kirkpatrick evaluation model (D. L. Kirkpatrick, 1998; Phillips, 2003).

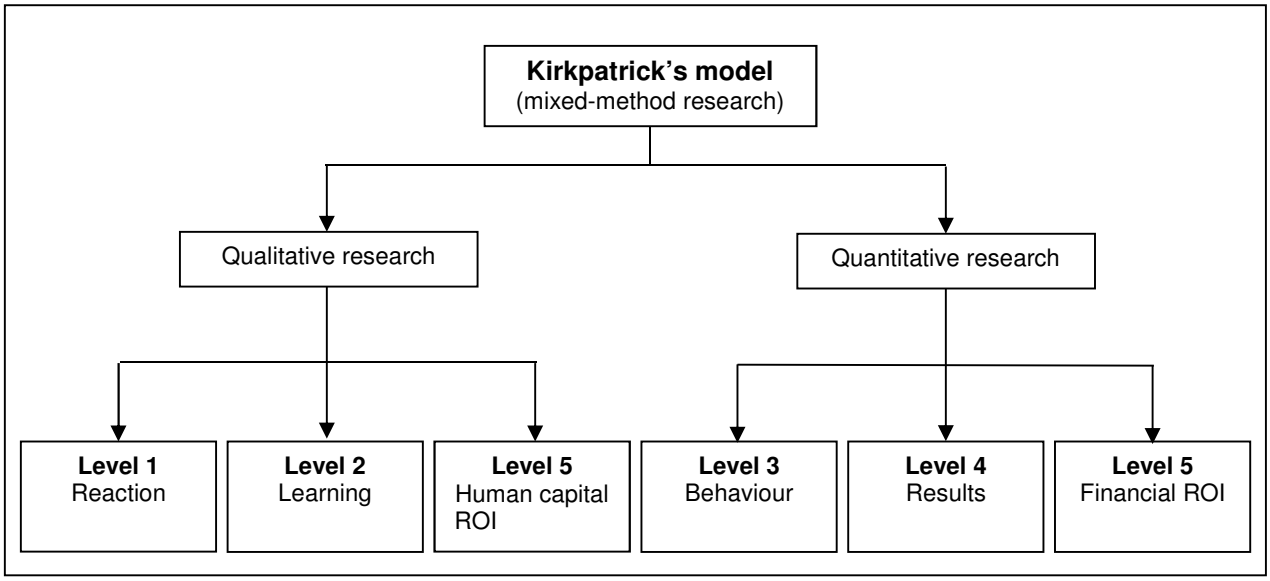


Figure 1.3 Extended evaluation model of D. L. Kirkpatrick (1998) and Phillips (2003)

The original Kirkpatrick model was founded more than fifty years ago with the aim to evaluate training programmes on four different levels. Levels 1 and 2 relate to students' internal drivers namely their satisfaction with the course and their perception of learning that occurred. These two levels are attained according to qualitative measures. Levels 3 and 4 relate to students' external drivers namely

the application of their acquired skills and its impact on their learning results. Levels 3 and 4 are attained according to quantitative measures. Phillips (2003) added a fifth level to Kirkpatrick's four levels—return on investment (ROI) relating to the financial costs, as well the human effort the intervention demanded. The level therefore relates to quantitative and qualitative measures. The concerned course relates to NWPK 512.

1.4.3 Research participants

The selected research site for this study was the White River learning centre in Mpumalanga. The White River student population is a true representation of the general teacher-student population of the UODL as they comprise students (i) arriving at the centre with their own transportation; (ii) who have ready access to resources; (iii) who make ends meet without too many challenges; (iv) who live in rural areas and experience severe challenges with respect to transport; and (v) who have diverse study needs.

The concerned module that this research relates to is NWPK 512, a mathematics major module in the Advanced Certificate in Education (ACE) programme. The module covers most of the fundamentals of Algebra in the senior phase. This study aims to determine how scaffolding of mathematics concepts can be facilitated via IWBs in order to enhance the learning experience of teacher-students[3] towards their understanding of mathematics concepts in order to improve the pass rate of NWPK 512 students.
NWPK512 is an example of one such major module and involves the fundamentals of Algebra for the senior phase.

1.4.4 Data collection strategies

Various data collection strategies were used during the study. They match the requirements as described by the Kirkpatrick model (Table 1.1).

Table 1.1 Data collection instruments

Level	Research design	Data collection instruments
Level 1	Qualitative	• Observation schedules for researcher and coordinator at centre • Focus group interview
Level 2	Qualitative	• Interviews
Level 3	Quantitative	• Questionnaires (Likert-scale) for participants and their peers or supervisors
Level 4	Quantitative	• Pre-test-post-tests for participants and control group
Level 5	Qualitative Quantitative	• Open-ended questionnaires to peer Mathematics lecturers • Monetary costs of modes of delivery obtained from UODL

[3] Teacher-students refer to under- and unqualified practising teachers in South Africa and Namibia who are enrolled students of NWU in order to further their professional development and obtain qualifications.

1.4.5 Data analysis

Atlas.ti™, a computer assisted qualitative data analysis system assisted in the analysis of the qualitative data obtained from Levels 1 and 2 of the Kirkpatrick model. Levels 3 and 4 comprise mainly descriptive statistical techniques in order to analysing the subsequent quantitative levels in order to address the main research question with its relating sub-questions. Level 5 comprises both qualitative and quantitative data. Atlas.ti™ assisted in the analysis of the qualitative data and a comparison was done to analyse the differences relating to the ROI. The reliability and the validity of the quantitative data and findings were calculated.

1.5 Presentation of the study

Chapter one provides a description of the context of the study and an overview of the study by placing it into the functionalist paradigm; it describes design integration as one of the steps in the Stoner Life Cycle of Learning Technology; it identifies specific characteristics and challenges of the participants of the study. It describes the research design and methodology of the study by stating the research problem, the purpose of the study and the research question, as well as the five sub-questions which relate to the five levels of the extended Kirkpatrick evaluation method; and it describes the data collection strategies as well as the data analysis.

Chapter two provides an extended overview of relevant literature relating to mathematics education—specifically distance and technology enhanced learning. The review of the literature relates to: learning with technology; learning mathematics with technology; IWBs as ICT tool for learning mathematics; scaffolding as teaching strategy as well as constructivist strategy; and scaffolding of mathematics.

Chapter three describes the research design and methodology by referring to aspects relating to a mixed-method research approach. It provides a detailed description of the Kirkpatrick evaluation model, the five levels of evaluation and the evaluation cycle of a programme or course. It describes the researcher's role during the research and reports on the qualitative as well as the quantitative parts of the research by describing the participant selection, the data selection strategies on the different levels, and the analysis of the data. The chapter also lists some challenges the researcher encountered during the study and reports on ethical aspects of the research.

Chapter four refers to and provides a list of scaffolds (Addendum 4.1) which were used during the study. It states that scaffolding as teaching strategy originates from the Vygotskian school of thought and that it could enhance students' zone of proximal development (ZPD). It provides a description of the general characteristics and operation of scaffolding activities and scaffolding instruction. It also

explores the approach of a specific interactive activity used as a scaffold during the study, and gives a detailed description thereof.

Chapter five comprises a presentation and analysis of the data that were collected by evaluating the five levels of the extended Kirkpatrick evaluation model. The data are analysed both qualitatively and quantitatively to answer the research question: whether IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme. The chapter concludes by discussing the main trends of the data.

Chapter six summarises the findings and the most important aspects of the study which have affected scaffolding of mathematics via IWBs in an ODL programme. It describes potential scaffolding of other learning areas in ODL before it concludes with recommendations for further research.

Chapter Two

Literature Review

2.1 Introduction

The design and integration of ICT for ODL is simultaneously exciting and challenging (Bansilal & Rosenberg, 2011; Collins & Halverson, 2009; Ferreira & Venter, 2010; Mdakane, 2011). This chapter reports on aspects relating to the design and integration of IWBs in ODL with special reference to the use of scaffolding of teaching and learning during the facilitation of fundamental mathematics concepts through technology. The literature review unpacks pertinent concepts: (i) mathematics education, (ii) distance education and open distance learning, (iii) teaching and learning with technology, (iv) teaching and learning mathematics with technology, (v) interactive whiteboards, and (vi) scaffolding. Figure 2.1 represents a wire-frame for the chapter.

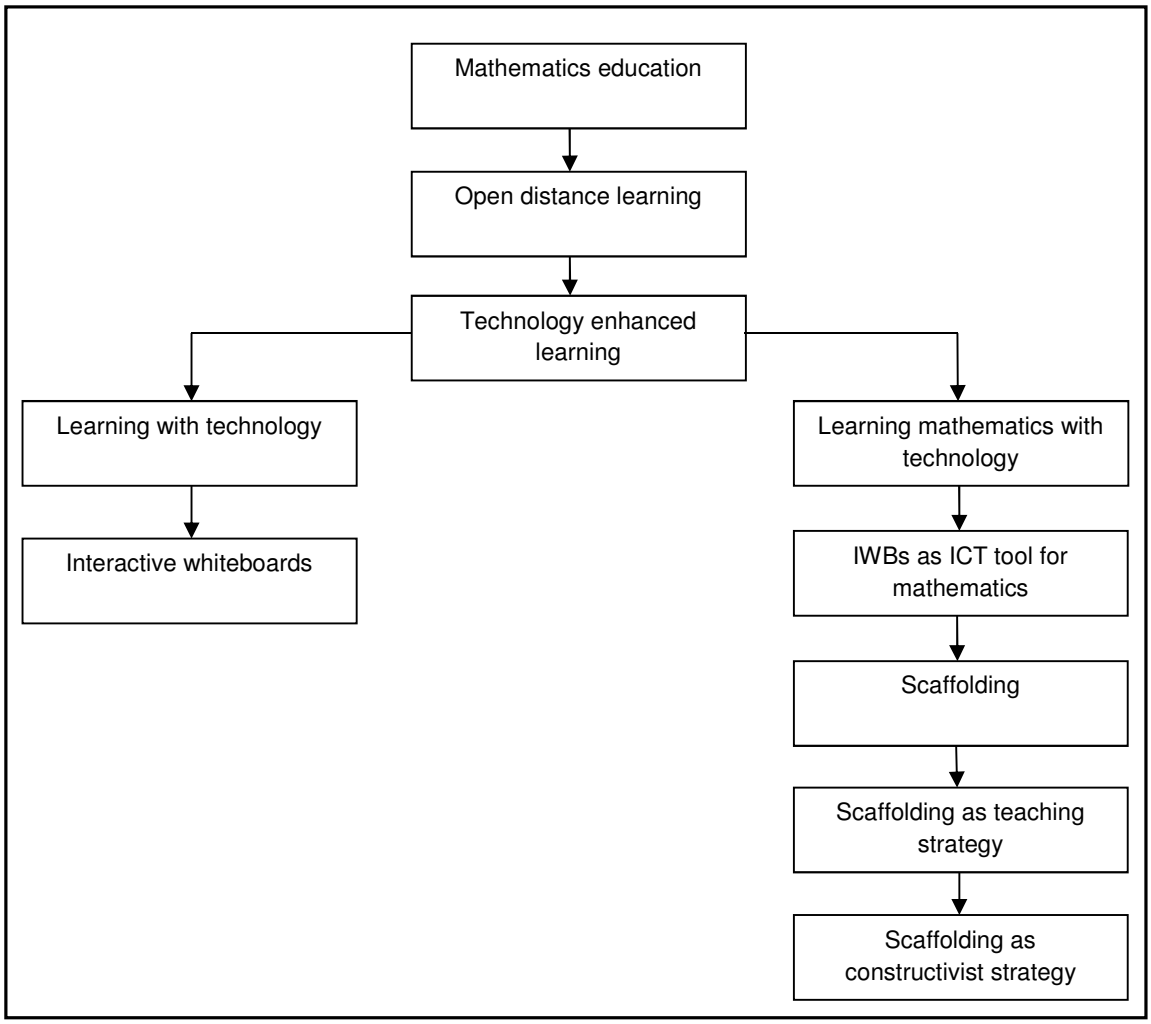


Figure 2.1 Wire-frame of literature review

2.2 Mathematics education

Mathematics has been around since the beginning of time and we live in a world where mathematical concepts have become universal (The Universal Language, 2013). People do not invent mathematical concepts—they discover them. All cultures have developed mathematical models which have spread and transferred amongst different cultures (Joyce, 1998). For thousands of years people have used the same mathematical principles across countries and continents. The language of mathematics is unlike English, Afrikaans or Setswana, but a universal language of numbers. Understanding the language of numbers daily assists people in performing everyday tasks. People use mathematics when building or decorating a house, following a recipe, sailing a boat, or buying a car (The Universal Language, 2013).

During a plenary presentation at National Council of Teachers of Mathematics (NCTM), Parker (2007) defined mathematics education as *mathematical engineering* and he specifically claims that he does not use engineering as a metaphor. He describes engineering as the customisation of abstract scientific principles to satisfy human needs. Abstract mathematics is the mathematics that meets the needs of students and teachers inside classrooms. The task of the mathematics educator is to engineer abstract mathematics for students and teachers (Parker, 2007). The two extremes, between which engineering mathematics education should mediate, are inviolable scientific principles and user-friendliness of the final product. The inviolable principles cover five basic characteristics of mathematics: precision, definitions, reasoning, coherence, and purposefulness.

Precision entails that mathematics statements are clear and unambiguous—it's clear what is known and what is not known. Basic *definitions* form the foundation of mathematics and therefore no definitions imply there is no mathematics. The lifeblood of mathematics is embedded in *reasoning* which is the core of problem solving. *Coherence* is a basic property of mathematics because every concept and skill builds on previous knowledge, and it helps students to get the bigger picture. The fifth basic property of mathematics lies in its *purposefulness* and that it is goal-oriented: the purpose of mathematics is that it solves specific problems. No mathematical engineer can function without knowing the basic characteristics of mathematics. Mathematicians who function in isolation from educators lead to deterioration of mathematics in mathematics education (Parker, 2007).

Edwards and Ward (2004) found that undergraduate students often misuse mathematical definitions as a result of their misunderstanding of these definitions. Lecturers blame this on the students' non-mathematical use, or insufficient experience of, connotations of concepts and terms. Correct understanding and use of fundamental definitions and concepts of mathematics is of the utmost importance in teaching and learning mathematics (Parameswaran, 2010).

Another major challenge in mathematics education is the role of affect (Ignacio, Blanco, & Barona, 2006). Ignacio et al. (2006) claim that effective learning of mathematics has become a necessity for

an individual's full development in the complex society of today. This supports the idea of people living in a mathematical world (Joyce, 1998). Despite the utility and importance of mathematics, most people's perception of mathematics is that it is difficult and boring, very abstract, not very practical, and not within everyone's reach. Many learners experience mathematics as a source of frustration, discouragement and anxiety instead of one of satisfaction (Ignacio et al., 2006).

McLeod (1990) describes the affective domain in mathematics education as a broad range of beliefs and emotions, which are different from pure cognition. The following four axes relate to beliefs: mathematics (the object); one self; mathematics teaching; and, the context in which the mathematics is educated (the social context). The two categories of beliefs that influence learners' mathematics learning are (i) their beliefs about mathematics, and (ii) their beliefs about themselves and how they relate to mathematics (McLeod, 1990). The latter include beliefs concerning confidence, self-concept and their attribution of causes to academic success or failure. Pupils' self-concepts relate to their attitude, their perspective of the world of mathematics, and their social identity. Self-concept is one of the variables with the biggest influence on the teaching and learning of mathematics (Ignacio et al., 2006). Ignacio et al. (2006) define the mathematics self-concept as a person's image of himself with respect to how s/he is perceived and valued within a mathematics learning context. A pupil's self-concept is a basic descriptor of his/her affective domain in mathematics and it relates to emotions, attitudes, motivation, personal expectations and attributions. Pupils who have negative beliefs about themselves as mathematics learners, often do not improve their mathematical performance because they believe that they are not capable in mathematics, and that mastering mathematical concepts is beyond their capabilities (McLeod, 1994). It is therefore important that the role of affect has to be taken into consideration when teaching and learning mathematics (Ignacio et al., 2006).

Although mathematics is often seen as difficult and destined for few to excel in, it plays an important part in our daily lives. It is crucial for everyone to have an understanding of general mathematics because we live in a world where mathematics is a universal concept. People are spread all over the world and often live distances apart—therefore education and learning over a distance has become crucial area for investigation. The next paragraph relates to education over distance in general and the development of different generations thereof. It also refers to distance education in an open system where students do not have to enrol at specific times.

2.3 Distance education and open distance learning

Traditionally distance learning (DL) provides access to instructional programs for students who are physically separated from an instructor. DL is any educational or learning process or system in which the instructors are separated geographically or in time from their students; or in which students are separated from their peer students, or educational resources. ICT and the Internet allow for rich interactive DL experiences that often surpasses the interactivity of traditional classrooms. A

workgroup of adult educators from The California Distance Learning Project (CDLP) (Neuhauser, 2002) comprehensively described DL support as an instructional delivery system that connects learners with educational resources. DL provides educational access to learners not enrolled in educational institutions and can augment the learning opportunities of current students. Simonson (2007) claims that distance education (DE) always involves the following four components: it is institutionally based; teachers and students are separated; interactive telecommunication takes place; and it involves sharing of data, voice and video learning experiences. The implementation of DL is a process that uses available resources and incorporates emerging technologies:

> Education and learning over a distance therefore can be described as the delivery of instruction to the right group of people at the right time in the right place. Distance education (DE) has come a long way and the rapid technological advances have created a paradigm shift in education and in distance learning as such. Technology eliminates the walls and boundaries to education. Distance Education therefore uses today's technologies to reach more students in more locations with fewer instructors. Previous technologies are becoming common place today and new and better technologies are being developed constantly (Bingham, Davis, & Moore, 1999).

South Africa has large numbers of unqualified and underqualified teachers. Hawker (2013) states there are 7 076 unqualified and 2 642 underqualified teachers teaching South African children. The almost 10 000 inappropriately qualified teachers, as a portion of the total number of around half a million teachers, is a small yet significant number. Especially in the learning area Mathematics, numerous unqualified teachers are compelled to teach the subject due to a shortage of qualified teachers. These teachers often teach in distant and deep rural areas; many of them grew up in disadvantaged communities themselves and did not have opportunities for further development. Being practising teachers who are supporting their families and generally far from higher education institutions (HEIs), they are unable to enrol for qualifications at residential HEIs. Embarking on distance education is therefore often the only way they can further their studies or obtain additional qualifications (Bansilal & Rosenberg, 2011). Very few have degrees or any other additional training in mathematics, and their own understanding of fundamental mathematical concepts is therefore limited. This is crucial as their jobs often depend on their training qualifications. DE, in many cases, is indeed the only option available for unqualified and underqualified practising teachers to further their professional development. However, they experience many challenges (Ferreira & Venter, 2010; Mdakane, 2011). For most teacher-students, English is not their first language—an aspect that causes additional challenges. They often live far apart and therefore have to study on their own, despite of their preference of working together (Du Toit, 2011). Practising teachers can further their own qualifications successfully only with proper planning and support (Mdakane, 2011).

The incorporation of ICT in teaching and learning is one way to combine distance and proximity and it has become part and parcel of ODL in many countries (Ferreira & Venter, 2010). Although the use of learning technologies (LTs) in HE has become commonplace, the UODL's teacher-students have had little previous exposure to LTs. They have to become LT confident to benefit from the affordances of learning with technology. Learning, however, and not the technology, has to be the focus and what the activity is about. Learning always has to drive the technology and not the other way round

(Picciano, 2002). Learning takes place when individuals bring their background knowledge, experience and interests to the learning situation in order to make unique connections while creating new ideas and building new knowledge. Learning therefore is a change in meaning, constructed from experience (Tam, 2000).

Many HEIs use advanced technologies which result in classrooms being metamorphosed into unrecognisable education spaces or sites. Karen Cator, director of the Office of Educational Technology of the U.S. Department of Education, encountered such an education space when she visited Mooresville Graded School in North-Carolina and she could not tell where the front or the back of the classroom was (Scherer, 2011). The one side of the room had an IWB; another side had a regular whiteboard; and the teacher's desk was along a third side. The whole space was occupied as a learning environment and technology was just part of the infrastructure. Learners were all engaged and were active partners in the education process that the teacher was facilitating.

In order to succeed in DE, and therefore add to its effectiveness, the use of technology could significantly help to transform the way DE is delivered (Tam, 2000). In DE settings, where students are not necessarily in close physical proximity to the instructor or other students, there is a strong need for the construction of technology-supported learning environments in which students are required to be self-determined, self-directed and self-controlled. Students are required to work collaboratively with one another; and to move the lecturer from podium to side so that he/she becomes a facilitator who supports the making of personal meaning (Tam, 2000).

The needs and characteristics of students and their teachers are continually changing. Especially for success in DE, role players have to assess their own scenarios in order to adjust and customise their mode of delivery to benefit students. Technology has also changed drastically and continuously over the years, and therefore learning at a distance has gone through various generations (Fozdar & Kumar, 2007) (Table 2.1).

Table 2.1: Generations of learning at a distance*

Generation	Mode	Mode of Delivery
First	Correspondence mode	Printed media
Second	Multi-media mode	Printed media, audio tapes, video tapes, computer-based learning, interactive video
Third	Tele-learning mode	Audio tele-conferencing, video-conferencing, audio-graphic-communication, broadcast of television and radio
Fourth	Flexible learning mode	Interactive multimedia (IMM) online, internet-based access to www resources, computer-mediated communications
Fifth	Intelligent flexible learning mode	Interactive multimedia (IMM) online, internet-based access to www resources, computer-mediated communication using automated response systems, campus portal access to institutional processes and resources

* Fozdar and Kumar (2007)

Taylor (2001) identified the first four generations of learning at a distance. The first generation was identified as the correspondence mode where the mode of delivery was mainly via printed media. The second generation operated via multi-media modes and occurred via printed media, audio- and video-tapes, computer-based learning and interactive videos. The tele-learning mode of the third generation involved audio tele- and video-conferencing, audio-graphic communication and broadcasts on television and radio. When approaching the fourth generation a more flexible learning mode realised and it resulted in interactive multi-media usage online, internet-based access to www-resources and computer-mediated communications (CMC). Fozdar and Kumar (2007) identified a fifth generation for teaching and learning at a distance in 2007. They referred to it as the "intelligent" flexible learning mode and it involved all the delivery modes of the flexible learning mode as well as CMC using automated response systems and campus portal access to institutional processes and resources.

The first four generations mainly involve synchronous technologies which require real-time communication (Branon & Essex, 2000). It does not necessarily mean face-to-face interaction, but mediating technologies like phones, faxes and the Internet require students to be online at the same time. Within the fourth and towards the fifth generations, communication technologies are more asynchronous and interactivity does not have to occur in real time. Branon and Essex (2000) recommend instructors to use synchronous tools when: (i) meeting with smaller groups of students online; and (ii) providing frequent and multiple chat times for team-decision making, brainstorming and community building. Instructors should use asynchronous tools when: (i) they have students working in teams; (ii) provide feedback in summary form rather than trying to respond to each individual; and (iii) have students provide peer feedback. Limitations of using synchronous tools are: (i) getting students online at the same time; (ii) moderating large-scale conversations; (iii) addressing insufficient reflection of students; and (iv) limiting poor typing skills. Limitations of using asynchronous communication tools are: (i) insufficient immediate feedback; (ii) students not checking in often enough; (iii) lengthening the time necessary for discussion in order for the discussion to reach maturity; and (iv) students feeling a sense of social disconnection (Branon & Essex, 2000).

The UODL currently relates to both the first and third of the Fozdar and Kumar (2007) generations—communicating with students through printed media and the tele-learning model, where *teaching and learning* could take place in many different ways. Although the UODL's main mode of delivery is via IWBs, the manner in which they currently apply the IWBs does not offer much interactive communication between facilitator and students or between students and other students. The UODL cannot schedule lengthy sessions for all modules because teacher-students are all practising teachers and can only attend sessions over weekends and holidays. If students cannot interact freely with the lecturer or with other students during IWB sessions, the sessions are merely presentations by the lecturer. Integrating the use of IWBs successfully as an interactive tool with immediate response in communication, and also seeing the other person while interacting, could assist the UODL to move towards the next generation of learning at a distance.

Price, Richardson, and Jelfs (2007) studied the experiences of students taking the same course by distance learning in two different ways of delivery. One group of students was supported conventionally (using limited face-to-face sessions with some contact by telephone and email) and another group was supported online (using a combination of computer mediated conferencing (CMC) and email). In the Price study, the students who received only online tuition reported poorer experiences and lower performances than those in a blended mode of tuition environments (Price et al., 2007). Self-regulated students normally claim that they are more in control of their learning process when they can learn wherever and whenever it suits them best. They report rich learning experiences, even without face-to-face contact sessions (Picciano, 2002). Furthermore, self-regulated students who do not depend on face-to-face tuition adjust to DE easier and may have richer learning experiences (Kennewell, Tanner, Jones, & Beauchamp, 2008; Roffe, 2002). Students who opted for the online only mode of the Price study, rated their tutors less favourably with respect to their competence and training even though experienced tutors were providing appropriate training and support (Price et al., 2007). It is therefore unlikely that the unfavourable ratings were due to characteristics of the tutors involved in the online only mode of Price et al. (2007). The students highlighted the importance of face-to-face contact and rejected online communication to completely substitute the personal contact—it made them feel like just another (student) number (Price et al., 2007). The traditional and new modes of delivery at the UODL of the North-West University's Potchefstroom campus are similar to the two modes that Price et al. (2007) compared. The combined face-to-face and online mode of Price et al. (2007) provided face-to-face support as well as telephonic and email support—this corresponds with the traditional mode of the UODL where face-to-face contact classes were offered together with telephone, fax and email support. The online version of Price et al. provided support by electronic mail and computer conferencing—this corresponds with the new delivery mode of the UODL where IWB-sessions are substituting the face-to-face contact classes.

Price et al. (2007) reveal that development activities for online tutors should focus on communicative or pedagogical aspects and not only on technical aspects of online tuition. Students and teachers should understand the nature of online communication and how to achieve effective online interaction before they deem online tuition as effective as face-to-face tuition. The UODL, however, is constantly striving towards a blended mode of delivery in order to ensure effective tuition.

Quality ODL requires interactive communication between students and lecturers. With the aid of modern LT it would be possible. However, much is still needed to enable students to board the technological train. The cost of technology for students plays a major role in developing countries. When selecting LTs, e.g. for communicating with students, the cost implications for students should also be considered as many students have no other option than to study through DE. They are separated from HEIs and the facilitators, and the need for appropriate technology development has become a relevant issue of attention (Ferreira & Venter, 2010).

When implementing new technologies for teaching and learning in distance education programmes, the technology should be based on seven principles. It should (i) encourage contact between students and facilitators; (ii) develop reciprocity and cooperation among students; (iii) use active learning techniques; (iv) provide prompt feedback; (v) emphasise time on task; (vi) communicate high expectations; and (vii) respect diverse cultures, talents and ways of learning (Beldarrain, 2006; Mdakane, 2011). Students enrolled in DL are normally separated from their teachers and from one another, and they experience many challenges as a result thereof. The following section describes how incorporating technology in DE affects learning over a distance.

2.4 Technology enhanced learning

South Africa faces many developmental problems and is one of the more complex societies in the world. Ethnic inequality and discrepancies result in a digital divide between different sectors (Ndlovu & Lawrence, 2012). S.J. Howie, Muller, and Paterson (2005) indicate that only thirteen per cent of more than 26 000 schools in South Africa had one or more computers on site in 2005. Only two per cent of the schools were highly resourced. Sarah J Howie and Blignaut (2009) claimed that the main constraints of implementing ICT in South African schools at that stage were financial constraints, insufficient computer literacy amongst teachers, insufficient training regarding integration of computers into different learning areas, and the absence of a properly developed curriculum for teaching computer skills. There was a growth rate of 59% in the number of schools with computers between 2000 and 2003, but despite the huge growth rate, only 39% of South African schools have computers and 26% use them for teaching and learning. More than fifty per cent of schools in SA do not have any computer facilities for students (Ndlovu & Lawrence, 2012). Law, Pelgrum, and Plomp (2008) report that SITES 2006 found that by then 38% of South African schools had access to computers and 68% of these schools also had access to Internet. In 2013 Wild (2013) reported that the Internet penetration in SA occurs sluggish due to the high cost of connectivity in SA. The number of Internet users in the country has increased from 100 000 in 1994 to 11.2 million in 2012. In reality, it is still only one fifth of the population who have ready access to the Internet.

Despite the disparities in access to ICT countrywide, powerful digital applications are more readily available and offer new opportunities to students to communicate and augment their mathematical thinking. This implies the possibility of less teacher-centred and more exploratory environment for teaching and learning interaction (Goos, Galbraith, Renshaw, & Geiger, 2001). Technology enters into teaching and learning according to four different roles which are metaphorically listed as the *master*, *servant*, *partner* or an *extension of the self* (Goos et al., 2001). When technology is implemented at first, it's often in a role of *master* of teacher and students because they have very little expertise in using it. Today's students, however, are often better users of technology than some of their teachers. When classroom activities remain unchanged and technology is only used as a

supplementary tool to amplify cognitive processes and not to creatively change the nature of activities, it is merely playing a *servant* role. It is used as a fast, reliable replacement for mental pen and paper calculations—nothing creatively. Technology in a *partner* role is used creatively to increase the power that students exercise on their own learning. The use of ICT helps students to overcome particular difficulties that they encounter in teaching and learning interactions, and this allows them to build assurance and confidence for future use (Ruthven & Hennesy, 2003). Teachers can use technology to teach effectively, to get students engaged in their own learning process and to add to their understanding of fundamental concepts. The next section relates to the implications for learning when teaching occurs with the aid of technology and educators become facilitators rather than traditional teachers.

2.4.1 Learning with technology

Traditionally teachers were the main source of knowledge which they conveyed to students who had little or no knowledge at their avail—they were regarded as blank slates to be filled. Discourse in the classroom comprised one-way communication where the teacher talked and students listened. Students were passive with little opportunity to engage or contribute their own ideas (Tanner, Jones, Kennewell, & Beauchamp, 2005). Constructivists, however, believe that interactive whole-class teaching is a two-way process in which students have to actively take part by pondering questions, contributing points to discussions, and explaining and demonstrating their methods to the whole class (Tanner et al., 2005). Effective learning occurs when interaction occurs between a student and the context. Therefore students have to actively engage and use their own ideas to create new ideas (Tanner et al., 2005).

Cobb (2012) defines *learning* as the lifelong process of transforming information and experience into knowledge, skills, behaviours and attitudes and describes different ways to become a better learner. Although classes and courses can be useful tools for learning, learning does not depend on them. Learning requires activities like practice, reflection, interaction with the environment and social interaction. In particular, social interaction, facilitated by a range of technologies for communication and collaboration are available for such activities (Cobb, 2012). Learning is also described as a relatively permanent change in behaviour based on an individual's interactional experience with its environment (Atherton, 2013).

Learning is a constructive activity. Constructivists describe learning as a change in meaning constructed from experience (Tam, 2000). Therefore constructivism is an appropriate point of departure when thinking about the nature of knowing, of learning and therefore also of teaching. Constructivists believe that people construct knowledge and truth, and that knowledge and truth do not exist outside the human mind. To the objectivists, knowledge and truth are objective and exist outside the minds of people. It is assumed that a particular finite body of knowledge exists and that it has to be transmitted to the learner. Objectivists view the process of learning as the acquisition and

accumulation of a finite set of skills and facts. Constructivists, however, view the process of learning as personal and not as some objective body that exists out there. Tam (2000) claims the difference between objectivists and constructivists is that constructivism emphasises the construction of knowledge while objectivism is mainly concerned with the object of knowledge.

Learning is an active process and the key idea is that students should actively construct their own knowledge. Although information may be imposed on students, understanding must come from within. A student's learning is determined by the complex interplay among such student's existing knowledge and the problem to be solved within a certain social context. Constructivists claim two common characteristics central to effective learning: (i) real-life problems to stimulate the exploration and necessary reflection for knowledge construction, and (ii) collaboration as students learn better through interaction with others (Tam, 2000).

Technology has the capacity to organise and amplify our thoughts, teaching, and learning processes. In order to make changes to traditional teaching methods in the teaching and learning context, technology can be used as a powerful tool (Yushau, Mji, & Wessels, 2005). We use technology tools to develop skills in our daily lives and in our occupations. The Oxford dictionary (Simpson & Weiner, 1989) defines *technology* as "the application of scientific knowledge for practical purposes, especially in industry." BusinessDictionary.com (2014) defines technology as "the purposeful application of information in the design, production and utilisation of goods and services, and in the organisation of human activities." Technology is a way of solving problems through the application of knowledge from multiple disciplines. Although most people have the preconception that technology is something new and relates mostly to computers, examples of earlier school-related technologies are binders, back-packers, pens and pencils, paper and paper clips. People have become so familiar with the use of technologies that they no longer recognise them as such (Teacher's Guide, 2010). For this study, however, the focus is on a learning technology, namely the interactive whiteboard that involves the use of computers.

Learning with technology focuses on the use of technology to support teaching and learning innovations. Learning technology is the broad range of communication, information and related technologies that can be used to support learning, teaching and assessment (Association for learning Technology, 2010a). To learn with technology means that one uses some form of learning technology. It includes the use of educational multimedia, web-based learning and in general, learning that is assisted by a computer (Oliver, 2000). Computers and other computer-related peripherals are used in all areas of our lives. Technologies in education add to stronger performance by students. Learning should always be the goal—technologies are mere delivery systems (McKenzie, 2001; Picciano, 2002). Using computers in and for instruction has become almost inevitable nowadays. The versatility and accessibility of computers help to shift the focus from knowledge-as-possession to knowledge-as-construction and from learning as an outside-guided activity to a self-guided activity (Salomon & Perkins, 1998). Computing technology, together with

constructivism, brings about new learning possibilities to almost all teaching learning situations; including traditional classroom teaching, distance learning and self-learning. This study specifically relates to the use of computer technology in the form of IWBs in DL. Advantages of learning with technology are: to read, reason, and write more powerfully; to communicate productively with members of a global community; and to make sense of a confusing world and an ever-swelling tide of information. If technology applications are designed appropriately, students benefit from them in two ways: (i) emphasis is more on learning than on teaching; and (ii) students can learn independently, regardless of time and place (McKenzie, 2001).

Learning with technology, however, also has its shortfalls. McKenzie (2001) argues that students can get into a kind of cut-and-paste thinking and this could undermine their ability to think. Implementation of technologies has financial implications to HEIs, as well as to students. Users of technology have to be trained to use it effectively. Despite the disadvantages of learning with technology, the concept relates to the use of technology in order to support the teaching and learning expected to take place.

The previous section describes technology, the application of technologies in education processes and the potential value of technology in education. The following section refers to IWBs as an ICT tool and the integration of IWBs as learning technology when teaching and learning with technology.

2.4.1.1 Interactive whiteboards

An IWB system is an ICT tool, comprising three components of technological equipment that aim to support teachers' teaching and learners' learning in ODL. When a computer, a data projector and an interactive board are combined, the board becomes a large touch-sensitive computer screen that allows interaction between multiple students and the computer. "An IWB set-up involves the image generated by a computer being projected onto a touch-sensitive screen the size of a conventional whiteboard, where the touch of a pen is the equivalent to a mouse click" (Kent, 2006, p. 25). Koenraad (2008) maintains that IWBs may merely support teaching functions, i.e. to explain, to demonstrate, to present and to instruct, and therefore promote teacher-centred teaching where students are passive receivers of knowledge. He continues by saying that challenging and effective education implies independent learning and (co)construction of knowledge. ICTs can support diversity, personalised learning and tele-collaboration. Figure 2.2 presents a representation of a combined IWB system, starting at the IWB, using the Internet in order to reach multiple students at the centres.

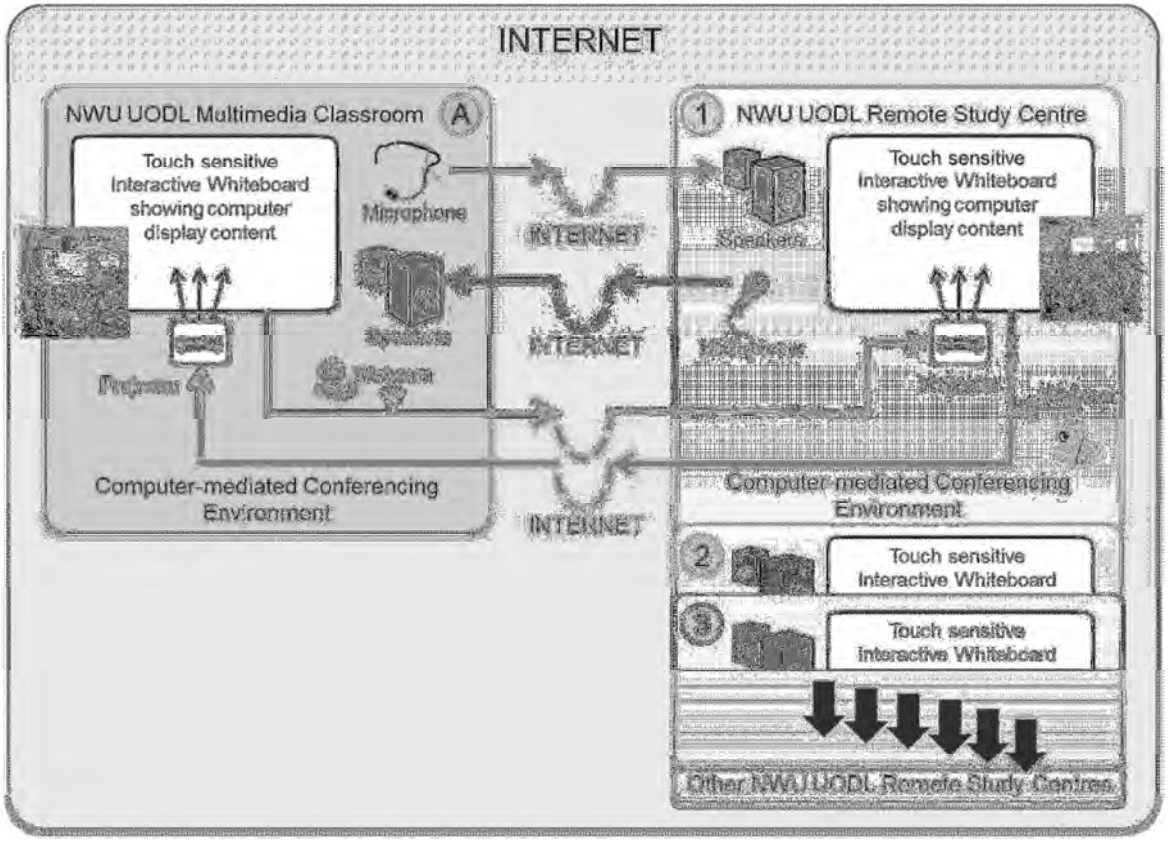


Figure 2.2: Schematic representation of interactive whiteboard-system (Esterhuizen, 2014b)

Teachers using IWBs at school, use them interactively to facilitate the teaching of students in order to support their learning. They move away from a didactical pedagogy to a more interactive one (Kent, 2006). When connected to the Internet, teachers can use real world examples captured via a digital camera, or live data from the Internet in order to respond to and to engage students in their learning process (Kent, 2006). IWB lessons can be saved for future reference or for students to revisit them if necessary. The value of IWBs with respect to pedagogical practices in classrooms is endless if teachers do not use them as presentation tools only—the interactivity feature is what distinguishes them from normal blackboards (Kent, 2006). The fact that teacher and students are not separated from one another adds endless opportunities for teaching and learning to occur via IWBs.

The UODL at NWU's Potchefstroom campus applies IWBs in an innovative and different way. The UODL offers various courses which are mostly facilitated via DE because their students live all over the country and many are from rural areas. These students do not all have access to the Internet. Interactivity is therefore not a common feature of IWBs that they can trust or rely on. The UODL at first opted for IWBs because of interactivity—so that students can communicate with the lecturer as well as with one another countrywide. Although this is possible and the ideal, the UODL does not currently operate their sessions as such. IWB sessions become chaotic when students from different centres want to interact simultaneously. It is also time consuming, and sessions are already not long

enough. The UODL addresses this challenge by closing centres' microphones during the sessions. Students may, however, send their queries to the presenter via short message service (SMS) or they may write their queries on the IWB. The presenter then attends to the queries during or at the end of the session. The UODL continuously strives to customise and better the facilitation via IWBs in order to extend the service and support rendered to their students (Esterhuizen, 2014a).

2.4.1.2 Interactive whiteboards as information and communication tool

One of the main characteristics that distinguish IWBs from other ICT tools is its interactivity. IWBs should therefore not only be used as presentation tools, but for their additional possibilities in terms of interactivity (Koenraad, 2008). Interactivity is a keyword in effective whole-class teaching. Tanner et al. (2005) define *interactivity* as the function of ICT which enables rapid and dynamic feedback and response. Using ICT enables students to sustain two-way communication with learning resources and environments in support of learning (Kennewell et al., 2008). IWBs, like all computer-driven instruments, do not determine pedagogy by themselves. Pedagogical teacher practices depend on the teacher's ability, confidence and competence with technology. It promotes learner-centred teaching where students are active constructors of their own knowledge. Interactivity involves that students attending IWB sessions countrywide are able to interact with the lecturer or facilitator presenting the session as well as with students attending elsewhere. Some teachers prefer to teach from within their own comfort zones but with the world around us changing so rapidly no one can afford to remain static (Van Wyk, 2011). Teachers often claim that they became teachers because they wanted to make a difference, be instrumental in effecting a change in the circumstances of children (Van Wyk, 2011). Therefore teachers have to be lifelong learners who would want to master the use of new technology in order to enhance themselves and to let their students benefit from it (Van Wyk, 2011). The basic use of IWBs does not differ much from the blackboard that teachers regularly use and are used to (Van Wyk, 2011). The IWBs do, however, offer a lot more.

2.4.1.3 Use of interactive whiteboards

Benefits of IWBs are reported from studies such as the BECTA (2003) report and the study from SMART Technologies (2004). These general benefits include that IWBs allow flexible use for all ages; they provide more opportunities for interaction and contribute to concentration and motivation of students and teachers. Beauchamp and Parkinson (2005) distinguish between benefits to students versus benefits to teachers. From the student's perspective, IWB technology provides more opportunities to participate and cooperate, it promotes meta-cognition, it facilitates the re-use of material, and the multi-modal and kinaesthetic possibilities deepen learning (Beauchamp & Parkinson, 2005). Brown (2010) states, from a student's perspective, that IWBs allow them to absorb information more easily; to participate in group discussions by freeing them from note-taking; to work collaboratively around a shared task; and to rapidly provide learner feedback. Benefits from a teacher's perspective include that IWB technology supports the integration of ICT in teaching and the

re-use of lessons; it makes teaching more stimulating and contributes to the teacher's professional development (Beauchamp & Parkinson, 2005). Kennewell et al. (2008) identify reasons for teachers to adopt IWBs: flexibility and versatility; multimedia/multi-sensory presentation; saving on printing work; efficiency; planning and saving lessons; teaching ICT; interactivity; and participation of students.

The use of IWBs has also revealed disadvantages (Koenraad, 2008). IWBs certainly have physical and financial limitations, and the novelty of the technology sensation often wears off after a while. Students and teachers sometimes avoid using the IWBs owing to their lack of confidence, frustrations originating from technical glitches, or insufficient training in IWB teaching skills. Brown (2010) argues the following disadvantages of IWBs: they are more expensive than conventional whiteboards or projector-and-screen combinations; their surfaces can become damaged and this necessitates expensive replacement; fixed-height boards are often mounted too high for users to reach the top or too low to be readily visible by all users; free-standing boards are more difficult to secure and need to be realigned every time they are moved.

The previous section provides detailed information of IWBs as an ICT tool, incorporating them as learning technology in teaching and learning and advantages and disadvantages of IWBs. The next section focuses on the learning and understanding of specifically mathematics concepts and fundamentals when using technology.

2.4.2 Learning mathematics with technology

Effective mathematics teaching implies that learning of mathematics concepts occurs. Anthony and Walshaw (2009) claim that several aspects affect students' learning: classroom community, classroom discourse, kinds of tasks that enhance students' thinking, and role of the teacher. Effective teachers truly care about the engagement of their students because they know that they are members of the learning community. Students should feel safe to get involved so that their positive attitudes raise their comfort levels—it enlarges their knowledge bases and gives them greater confidence in their capacity to learn and make sense of mathematics. The teacher has to provide students with working arrangements that are responsive to their needs (Anthony & Walshaw, 2009).

Communication in the Mathematics class has to focus towards mathematical argumentation—students should be able to explain and justify their answers by showing proper understanding of mathematical language. Appropriate tasks that enhance students' thinking should influence how students come to view, how they develop, use and make sense of, mathematics. Effective tasks should provide opportunities for students to struggle with important mathematical ideas and it should help them to learn about the value of mathematics in society and its contribution to other disciplines. Effective mathematics teachers set tasks through which they support students to create connections—between different ways of solving problems, between different mathematical topics and between mathematics and everyday experiences. Through making these connections the students

develop better conceptual understanding and conceptual flexibility. In order for mathematics teachers to initiate learning and to act responsively towards the mathematical needs of their students, they have to have sound content knowledge of mathematics themselves, and know how to extend and challenge their students' thinking (Anthony & Walshaw, 2009). Therefore teachers need substantial pedagogical content knowledge and a grounded understanding of students' conceptions and misconceptions of mathematics concepts.

2.4.2.1 Interactive whiteboards as information and communication tool for mathematics education

Many students find mathematics boring and they do not like it at all. They do not see the relevance of mathematics to their lives, and they experience mathematics as difficult to learn (Sedighian & Sedighian, 1996). In any learning activity motivation plays a crucial part: in order to motivate students to learn mathematics it is important to understand their needs (Dweck, 1986). To learn mathematics is merely a remote need for students—they do not experience it as an immediate, necessary need they have to satisfy. Playing games and communicating via technology, however, has become an inevitable part of daily life for most students. Sedighian and Sedighian (1996) claim that people use artefacts to extend their abilities to perform tasks. It therefore makes sense to provide students with cognitive artefacts when assisting and motivating them to learn mathematics. As early as 1996 scholars established the contribution of educational computer games and other artefacts on the learning of mathematics (Sedighian & Sedighian, 1996). Students learn mathematics better in a context where they find the learning meaningful and useful. Sedighian and Sedighian (1996) experimented with well-designed computer-based mathematics games and super tangrams and found that learning mathematics is affected by:

i) *Meaningful learning*: Today's students relate to playing electronic games—it is an integral part of their culture. They feel that doing mathematics from a book is boring, whereas playing a game keeps them focussed and interested.
ii) *Goal*: When playing games, or engaging in other interactive activities, students accomplish goals while they experience excitement. With pen-and-paper activities, mathematics students get frustrated because they seldom feel that they experience or achieve meaningful goals.
iii) *Success*: Students want to feel successful in their social environment. Before they are ready to learn new mathematical concepts, they need to experience some mathematics success first.
iv) *Challenge*: Students get bored if there is no challenge in what they have to learn or do. Tasks should, however, not be beyond what they could handle. Therefore effective computer-based activities should become progressively more challenging.
v) *Cognitive artefact*: For artefacts to have a cognitive inclination, they have to be interactive and provide communication. Students claim that you cannot move things in a text book and the text book does not talk to you.
vi) *Association through pleasure*: Students feel they learn and remember more effectively when they associate the learning with pleasant memories.

vii) *Attraction:* students need to be put in learning environments which are attractive for them to be stimulated to think about mathematics and to allow them to experience the joy of learning it.

viii) *Sensory stimuli:* Black and white graphics with no sound and background music does not keep students interested for long. Students claim that fancy colourful graphics and other sensory stimuli add flavour to the mathematics and make the learning of mathematics more enjoyable and memorable (Sedighian & Sedighian, 1996).

Whether IWBs contribute to increased achievement of learning outcomes can still not be answered with certainty. Koenraad (2008) states that the technology itself cannot perform miracles and that the expected added value can only be realised with the help of the professionalism of the teacher. The UODL uses IWBs to facilitate classes for students countrywide and also to train facilitators at the different centres. After my extensive exposure to IWBs at the UODL, I propose that IWBs could play a major role in supporting mathematics students out there. IWB facilities at learning centres are in place and teacher-students are dedicated and determined to acquire qualifications because their jobs and promotion depend on it. During IWB sessions students get the opportunity to use their prior and existing knowledge to (co-)construct new knowledge while lecturers provide the necessary support. When the UODL started to present their contact classes via IWB during the July 2011 vacation school, facilitators and students at the learning centres reported that the mathematics sessions seemed to have been very successful (OLG, 2011). This study aims to specifically establish the effect that scaffolding of mathematics concepts, facilitated via IWBs, has on the learning of mathematics in ODL, as well as to provide some answers relating to the value of using IWBs in teaching and learning over distance.

The UODL at the NWU invested in IWBs for the teaching and learning of students who are spread all over South Africa and Namibia. The focus of this study is to investigate whether IWBs could act as a tool in scaffolding the teaching and learning of NWPK 512, a mathematics major module offered by the UODL, and by so doing enhance the learning of mathematics in an open distance programme.

Distance students who are enrolled for mathematics are often challenged by the fundamental mathematical concepts. The previous section describes IWBs as an ICT tool specifically for the learning of mathematics. Students need to find the mathematics they have to learn interesting and meaningful. They learn best if they enjoy what they do and if they are supported while doing it. The following section elaborates on scaffolding as a teaching strategy and as a constructivist strategy in supporting students in their understanding of mathematics. It relates to the value of scaffolding mathematics concepts to assist students with an in-depth understanding of mathematics.

2.4.2.2 Scaffolding

The concept of *scaffolding* originates from the Vygotskian school of thought. Vygotsky emphasises concept forming in the cognitive development when he develops his *Zone of Proximal Development*

(Minick, 1999). Vygotsky describes the difference between a particular cognitive level at which people can perform a task by themselves, and a higher level at which they are able to perform in cooperation with others. A student's development level therefore consists of two parts: the actual development level and the potential development level. The difference between these two levels is referred to as the *Zone of Proximal Development* (ZPD). Vygotsky believed that learning always proceeds development in the ZPD, i.e. after a student has learnt something, development follows.

2.4.2.2.1 Scaffolding as teaching and learning strategy

Scaffolding is a teaching strategy that teachers at all levels could use to improve student learning (Van der Stuyf, 2002). "Scaffolding is a bridge used to build upon what students already know to arrive at something they do not know. If scaffolding is properly administered, it will act as an enabler and not as a disabler" (Benson, 1997). Scaffolding is a technique that facilitators use to assist students during learning (Minick, 1999). The amount of scaffolding used will be determined by what the facilitator decides about the student's abilities and current levels of understanding (Valkenburg, 2010).

When a facilitator scaffolds the learning process of a student, s/he should assist only with the skills that are beyond the student's own capability, but still fall within the zone of proximal development. It is important that the student completes as much as possible of the task unassisted. Although the facilitator takes much of the initiative during the scaffolding process, the ultimate goal of scaffolding is that students become independent and self-regulated (Lipscomb, Swanson, & West, 2012). The scaffolding process is therefore a temporary support system—the facilitator or a more knowledgeable person temporarily provides support to assist students in performing a task which they cannot yet accomplish by themselves. The amount of scaffolding used will be determined by what the facilitator decides about the student's abilities and current levels of understanding (Valkenburg, 2010). Greenfield (1984) describes the facilitator's role during scaffolding as "the facilitator's selective intervention [that sic] provides a supportive tool for the learner, which extends his or her skills, thereby allowing the learner successfully to accomplish a task not otherwise possible." A simple structure of scaffolding assistance is built from the following four points: (i) the instructor does it; (ii) the class does it; (iii) the group does it; and (iv) the individual does it (Faculty Development and Instructional Design Centre, 2008). Vygotsky posits that cognitive development is social, and that it involves other people and the society as a whole. Therefore, social interaction in the form of dialogue, exchanging cues or gestures, plays an important role in establishing concepts and constitutes the basis of scaffolding as a teaching strategy (Minick, 1999).

Through scaffolding the teacher changes the level of support to suit the cognitive potential of a learner because the teacher wants the student to become an independent and self-regulating learner and problem-solver (Van der Stuyf, 2002). Scaffolding provides individualised support to improve the student's ability to build on prior knowledge (Amiripour, Amir-Mofidi, & Shahvarani, 2012). McKenzie

(2001) lists the following characteristics of scaffolding instruction: it provides clear direction to reduce students' confusion; it clarifies the purpose; it keeps the students on task; it offers assessment to clarify expectation; it points students to commendable sources; it reduces uncertainty, surprise and disappointment; it delivers efficiency; and it creates momentum (Coffey, 2009). Greenfield (1984) lists the characteristics of scaffolding as: it provides support; it functions as a tool; it extends the range of work; it allows the accomplishing of tasks not otherwise possible; and it assists the student where needed. Scaffolding strategies relate to questioning, encouraging comments, active listening and giving interactional support with respect to the problem that a student has to solve. Greenfield (1984) describes the scaffolding process of a student's learning as a four-step consequential strategy which includes: (i) whole-class discussion, (ii) dividing the class into groups for group work, (iii) report back, and (iv) reflecting. Students should explain and justify their solutions.

Different facilitative tools that are utilised in the scaffolding of students' learning are: breaking the task into smaller parts which are more manageable; using think-alouds; verbalising thinking processes while completing a task; cooperative learning which promotes teamwork and dialogue among peers; concrete prompts and specific questioning; coaching; and cue cards or modelling. It is important that the scaffolding should augment the student's understanding, and the specific scaffold should be relevant. If the task is too far out of reach of the student it can add to his frustration level, and tasks that are too simple have a similar effect (Coffey, 2009).

Scaffolding can only be successful if (i) the task at hand is meaningful and challenging, (ii) students participate actively in tackling the task, and (iii) the scaffold is tailored to the needs of the students (Kiong & Yong, 2001). Tutoring with the aim of solving problems is also referred to as scaffolding (Wood, Bruner, & Ross, 1976). Wood et al. (1976) believe that the acquisition of skills is an activity in which current skills are combined and shaped into higher-order skills that will meet new, more complex task requirements. Students are on different levels of understanding of a concept and therefore they should be treated differently when they are assisted by means of scaffolding. Valkenburg (2010) describes scaffolding in learning as similar to support structures during building operations where the scaffolding is removed once the job is done. Facilitators use scaffolding in the same way when they assist students to understand tasks. Once the student can independently complete the task, they remove the scaffolds which have provided additional support to the student (Blignaut & Knoetze, 2002; Valkenburg, 2010).

Four different types of scaffolding that support learning are described: (i) procedural scaffolding gives assistance with how to use the resource, (ii) conceptual scaffolding assists in focusing thinking, in prioritising information, in making connections between concepts or in simplifying complex concepts, (iii) strategic scaffolding assists by suggesting approaches or strategies directly or indirectly, and (iv) meta-cognitive scaffolding assists the students to reflect on what they have learnt (self-assess) or reflect on how they are learning (awareness of cognitive processes) (Hill & Hannifin, 2001).

2.4.2.2.2 Scaffolding as constructivist strategy

Scaffolding is an important characteristic of constructivist learning. The scaffolding process enables students to solve problems, carry out tasks, and achieve goals beyond their unassisted effort (Wood et al., 1976). Drill and practise programmes offer a co-concurrent way of the teaching and learning of mathematics, but are criticised because students easily become absent objects which only receive, store and retrieve information without understanding and constructing new knowledge (Kiong & Yong, 2001). Constructivism applies to the teaching and learning of mathematics and is based on two key hypotheses:

- One actively constructs knowledge by cognizing the subject and not passively receiving it from the environment
- Coming to know is an adoptive process that organises one's experiential world; it does not discover an independent, pre-existing world outside the mind of the knower (Kilpatrick, 1987).

Constructivists hold that learning builds upon a student's existing knowledge and experience—this means that students use their prior knowledge to construct new knowledge. Chances are better for more effective learning to take place when a student is actively involved in his own learning. Constructivist teaching has as one of its primary goals that students learn how to learn by training them to take responsibility for their own learning experiences (Bahbahani, 2006). In constructivist classrooms, students are actively involved, the activities are interactive and student-centred, the environment is democratic and the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous (Gray, 1997).

Constructivism is criticised for some limitations as a learning theory. Many educators view mathematics learning as both a collective human activity and an individual constructive activity which is subject to social influences (Confrey, 1990). Confrey (1990) maintains that people do not think in isolation. Different influences shape students' constructions. She describes two faces of mathematics: the mathematics in students' heads and the mathematics in students' environments. Mathematics education through a constructive paradigm will feature the following:

- Students are not treated as *empty vessels* or *blank slates*—they are thinking beings
- Knowledge cannot be literally transmitted
- Knowledge is changing and growing
- Students make sense of new information from their prior knowledge
- Mathematics education advocates learning with understanding
- Learning does not proceed along a fixed, preconceived plan, but along invented steps according to the student's progress, like an experiment
- It encourages dialogue, communication and reflection (Kiong & Yong, 2001).

When mathematics education is delivered from a constructivist approach, scaffolding could contribute towards ensuring success. It emphasises active participation and a greater degree of students' control of their learning (Kiong & Yong, 2001).

2.4.2.2.3 Value of scaffolding

Benefits of scaffolding include the following: it engages students in meaningful and dynamic discussions in small and large classes; it motivates learners to become better students who have learnt how to learn; it provides individualised instruction; it affords the opportunity for peer teaching and learning; scaffolds can be recycled for other learning situations; it challenges students through deep learning and discovering; and it provides a welcoming and caring learning environment (Faculty Development and Instructional Design Centre, 2008). Furthermore, students feel confident and get more of an "I can do it" attitude when they get positive feedback—this normally motivates the student so that he wants to learn more. Scaffold learning helps the student not to get frustrated while struggling with what is beyond his level of understanding, and because scaffolding is aimed at the individual, it can benefit each student.

Scaffolding, however, has some disadvantages as well. It is extremely time-consuming and because teachers do not all have the skill to implement scaffolding instruction appropriately, learners consequently do not fully benefit from it. When teachers use scaffolding as teaching strategy, they have to give up some of the control and allow their students to make errors. When appropriately dealt with, students normally learn from these errors. Furthermore, existing manuals and curriculum guides are not compiled in a scaffolding way, nor do they include examples of scaffolds that would be appropriate for the specific lesson content. The Faculty Development and Instructional Design Centre (2008) lists the following challenges of scaffolding: (i) planning for and implementing of scaffolds is time-consuming and demanding; (ii) selecting appropriate scaffolds to match the diverse learning and communication styles; (iii) establishing the abilities of students is not an easy task; and (iv) knowing when to remove the scaffold so that the student does not rely on the support forever.

This section describes the learning of mathematics with technology with specific reference to the use of IWBs as ICT tool when teaching and learning mathematics. It relates to scaffolding as teaching and constructivist strategy and to scaffolding of mathematics concepts in order to enhance understanding of mathematics in a distance learning programme. The digital scaffolds that were used during this study include examples of direct instruction, models, videos, activities, simulations and games. They relate to different levels of support to assist NWPK 512 students who struggle to master the fundamental concepts of mathematics in order to pass the module.

2.5 Chapter summary

Mathematics education over a distance faces many challenges. The incorporation of technology in distance education can address some of these challenges and can therefore not be denied. This chapter reviewed literature specifically on how IWB-technology can be used for communication between facilitator and students who are distances apart. It relates to mathematics education in an open distance programme in which learning technology is integrated in order to enhance teaching and learning. The chapter relates to IWBs as ICT tool with specific reference to teaching and learning of mathematics with technology. It highlights scaffolding of mathematics learning via IWBs as teaching strategy for teaching and learning over distance. It describes scaffolding as originating from the Vygotskian school of thought and explains how scaffolding activities could add to students' experiences of the teaching of mathematics. The chapter further states that students should be motivated to take responsibility for their own learning processes and to engage in scaffolding activities in order to enhance proper understanding of fundamental mathematics concepts. Learning, however, always has to remain the focus, and the primary aim of using scaffolds is to enhance the learning of students.

Chapter Three

Research Design and Methodology

3.1 Introduction

Chapter two considered the design integration of IWBs from the literature with specific reference to the application of IWBs as scaffolds in an ODL mathematics programme. This chapter relates to the research design and methodology used during the study in order to evaluate the effect of the design integration of IWBs as learning technology at the UODL on the Potchefstroom campus of the NWU. The chapter furthermore focuses on the specific research methods that were applied, such as sampling methods, data collection procedures, and ethical aspects, as well as data analysis procedures performed during the study.

3.2 What is research?

Activities like information gathering, documentation or self-enlightenment are examples of research. The aim of research is to discover truth—to learn what has never been known before (Leedy & Ormrod, 2005). The purpose of this study is to evaluate how LT contribute towards the success of design integration of IWBs through scaffolding mathematics in an open distance programme at the UODL at the NWU. From the purpose of this study, the following research question emanated: *How can IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme?* Collectively, the following five sub-questions, in accordance with the D. L. Kirkpatrick (1998) evaluation method used during the study, culminate to address the above main research question:

(a) How do students react to mathematics facilitation via IWB scaffolding? (Level 1)
(b) How do students perceive learning that takes place through scaffolding of mathematics via IWBs? (Level 2)
(c) How do the teacher-students' immediate supervisors (line managers) perceive changes in their on-the-job behaviour as a result of the successful completion of the concerned mathematics module? (Level 3)
(d) How did teacher-students' results change during a post-test as a result of attending mathematics scaffolding during IWB sessions? (Level 4)
(e) What was the return on investment (ROI) of employing IWBs for the concerned Mathematics course? (Level 5).

3.3 Research design and methodology

People view and experience their *being in the world* through different lenses. The lens through which a person looks at the world determines the way he/she lives in and contributes to society. To converge these lenses, Burrell and Morgan (1979) developed a structure for four worldviews of social research. They categorised these views according to their levels of objectivity and regulation or control, and put them into four paradigms, namely positivist, humanist, interpretivist and functionalist, which are used accordingly to organise and make sense out of social life. A schematic representation of the four worldviews appears in §1.4.1. The functionalist paradigm serves for researchers searching for functionality; as well as to understand the roles of things in society (Babbie, 2013). The study on the integration of IWBs in the scaffolding of mathematics in DE has as its aim to investigate whether the integration is functional, and therefore relates to the functionalist paradigm. The research took place according to a mixed methods research design and followed Kirkpatrick's model of evaluating LT programmes. Mixed methods research is defined as "a procedure for collecting, analysing and mixing both quantitative and qualitative data at some stage of the research process within a single study in order to understand the research problem more completely" (Ivankova, Creswell, & Plano Clark, 2007, p. 263). This design permits researchers to explore a topic by analysing the data qualitatively before a subsequent quantitative examination. When quantitative and qualitative methods are used in combination within one study, they complement each other in order to provide an elaborate approach to the research problem, resulting in a deeper understanding thereof.

3.3.1 Kirkpatrick's evaluation model

Education and training programmes should be evaluated in order to maximise their effectiveness. In 1959 Donald Kirkpatrick taught supervisory development courses at Wisconsin University, USA, where he wrote a dissertation on evaluating the programmes he was teaching (D. L. Kirkpatrick, 2010). The original aims of his research were to measure the supervisors' reactions towards the programme (Level 1), and also the quality of students' learning that took place during the programme (Level 2). He later extended his research to include changes in behaviour (Level 3) and results (Level 4). Phillips (2003) added a fifth level comprising the return on investment of the program. The extended Kirkpatrick model (D. L. Kirkpatrick, 1998; Phillips, 2003; Simonson, 2007) provides a good fit to the study on scaffolding mathematics via IWBs.

Donald Kirkpatrick's son Jim, suggests six reasons why education and training programmes should be evaluated: to (i) determine whether the programme should be continued; (ii) improve the programme; (iii) ensure learning compliance; (iv) maximise the value of training; (v) align training with strategy and expectations for a particular programme; and (vi) demonstrate the value of training (J. Kirkpatrick, 2007). He further states that evaluation should be deliberate and purposeful, and that effective training always begins with the end in mind. Every goal-setting philosophy should begin with a clear vision of the desired end result. The aim of evaluation therefore is to demonstrate the degree

to which expectations of a programme have been satisfied (J. D. Kirkpatrick & Kirkpatrick, 2011). Figure 3.1 represents the extended Kirkpatrick model (D. L. Kirkpatrick, 1998; Phillips, 2003).

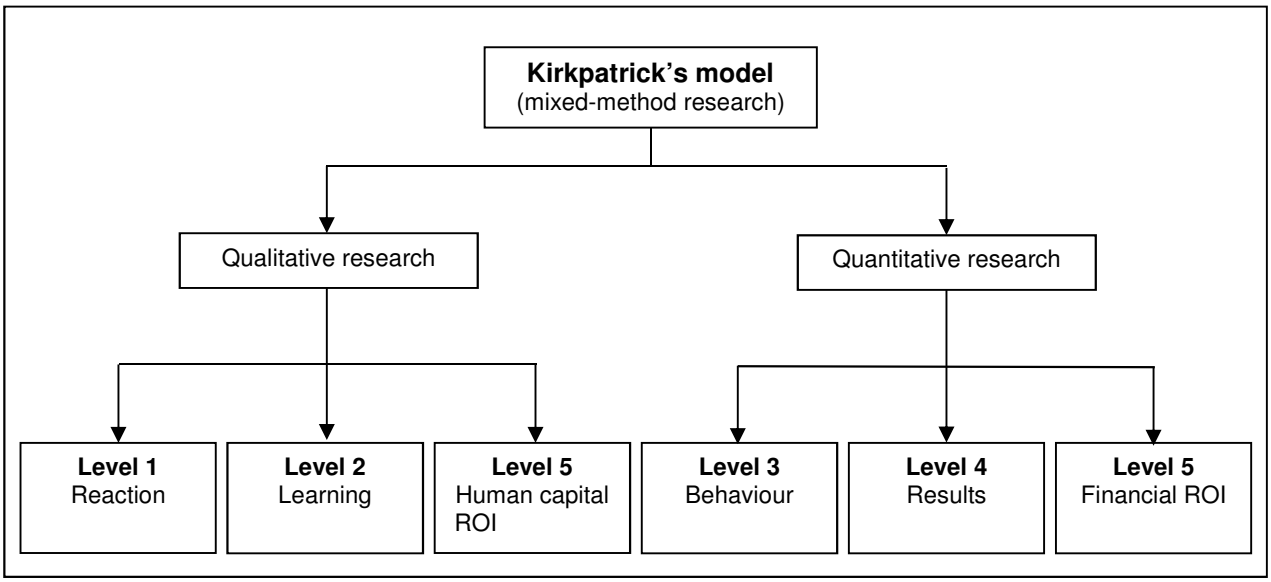


Figure 3.1: Kirkpatrick's extended evaluation model (D. L. Kirkpatrick, 1998; Phillips, 2003)

Dual mode providers of higher education (provision of face-to-face and distance delivery) should develop quality assurance and evaluation factors to demonstrate that the two deliveries are of equal quality (Roffe, 2002). Roffe (2002) claims evaluation is a process that professionals do all the time and in every discipline where they are comparing the actual or the real with the predicted or the promised. The rudimentary reason for performing evaluations is to determine the effectiveness or the appropriateness of a particular course of action. Furthermore, the success of an evaluation process is not in telling people what they have done wrong—it is most effective when it informs future decision which can improve what already exists, or better the next occurrences (Roffe, 2002).

The D. L. Kirkpatrick (1998) evaluation for the quality assurance and engagement of LT programmes has for many years been extensively used as international standard (Roffe, 2002). The approach comprises qualitative as well as quantitative components and therefore provide usable information for the improvement of programmes (Phillips, 2003). A Kirkpatrick evaluation focuses on the supportive descriptions of engagement, enhancement and execution of student learning programmes. Current quality assurance recommends the use of this approach for contexts of technology enhanced learning in distance programmes (Roffe, 2002). The managers of teaching and learning at the UODL are concerned with quality tuition, i.e. course facilitation that could be accepted, trusted and respected. Therefore, the investigation on how scaffolding of mathematics contributes towards the design integration of IWBs at the UODL followed the extended Kirkpatrick methodology of programme evaluation.

Although Kirkpatrick founded his evaluation model more than fifty years ago, various authors have over the years contributed to it in order to extend the scope of its usefulness (Simonson, 2007). The

model evaluates training programmes on four levels and concerns itself with the *results* rather than with the *mechanisms* of programmes (Horton, 2005). While levels 1 and 2 evaluation findings of the Kirkpatrick model relate to students' internal drivers, levels 3 and 4 findings relate to external drivers and provide information on the application of acquired skills, as well as on the impact of the acquisition of these on learning results (Basarab, 2011). Phillips added a fifth level to Kirkpatrick's original four levels—the return on investment (ROI) (Simonson, 2007). Evaluation at this level indicates the relationship between the amount of money spent on the training and the benefits of the training (Peak & Berge, 2006). Level 5 evaluation provides information on the impact that the training programme has on the financial viability of the training (Peak & Berge, 2006). The Phillips-augmented model receives increased attention as the cost of programmes should be in line with the outcomes of the programmes in order to provide evidence for curriculum-based decisions (Simonson, 2007). Actual costs, as well as human effort are considered (Phillips, 2003). In summary, the Phillips-augmenting model determines whether:

- students like to experience teaching in the proposed way
- learning takes place
- students use the knowledge they gain through the programme at their place of work
- students' results are determined by attending the training programme
- investment in the LT is financially worthwhile, also in terms of the effect on human capital (Phillips, 2003; Simonson, 2007).

Figure 3.2 represents the typical cycle of evaluating a programme (D. L. Kirkpatrick, 1998; Phillips, 2003).

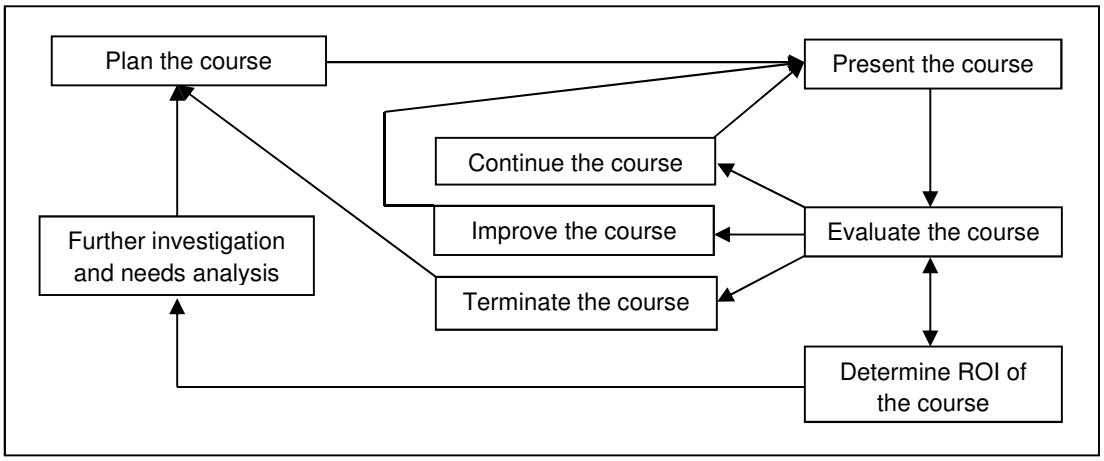


Figure 3.2: The Kirkpatrick evaluation-cycle of a course (adapted from D. L. Kirkpatrick (1998) and Phillips (2003))

The value of Kirkpatrick's evaluation model lies in that it does not only evaluate on one set of criteria— which can lead to biased conclusions—but evaluates on five different levels in order to minimise such bias (Galloway, 2005). The model also offers some flexibility. It encourages researchers to borrow approaches, techniques and methods from others and to understand the

difference between proof and evidence of training results. Kirkpatrick's model is based on a systematic matching of goals and outcomes which is beneficial to the company because all of these can be determined and customized by the company and its trainers before training begins. The model, however, allows researchers to extrapolate from the model in order to enhance strategic alignment (Galloway, 2005).

During the study, levels 1 and 2 were evaluated according to an interpretive approach according to qualitative measures. The researcher collected data on students' satisfaction with the course and their perceptions on learning experiences of mathematics fundamental concepts during the course. A section of level 5 related to qualitative measures when the researcher collected data on colleagues' experiences of presenting mathematics via IWBs in order to determine the ROI in terms of human capital. Data from levels 3, 4 and the financial ROI-section of level 5 related to quantitative measures.

3.3.2 Researcher's role

The researcher in this IWB-study is the Mathematics lecturer at the UODL who is responsible for the module NWPK 512. She was involved in and responsible for the whole process. She designed the research, obtained permission, identified and briefed the participants, facilitated the IWB sessions, collected the data via observations, interviews, questionnaires and pre- and post-tests, analysed the data, and finally compiled a research report of findings and recommendations. Therefore, the researcher played an active and participative role during the entire study (Nieuwenhuis, 2007a).

Gall, Gall, and Borg (2007) claim that the qualitative researcher is personally involved in the phenomenon under study as she/he is responsible for the data collection and has to interact with the participants in order to understand their experience of the phenomenon. The researcher of this study was the primary measuring instrument and was personally involved in the phenomenon under study as she carried out the data collection and interacted with the participants in order to understand their learning experiences (Gall et al., 2007; Maree, 2007). The qualitative researcher studies a phenomenon as it presents itself in real life context, and researcher subjectivity is accepted and should be explained and managed (Nieuwenhuis, 2007b). Nieuwenhuis (2007b) states the involvement of qualitative researchers is essential as they capture the lived experiences of research participants. A qualitative researcher has different ways of ensuring quality research (J.W. Creswell, 2003). The quantitative researcher confirms or rejects premises posed during the study. She/he aims to answer questions about relationships among measured variables, specifically with the purpose of generalising, explaining, predicting and controlling phenomena (Leedy & Ormrod, 2005). Maree and Pietersen (2007) state that quantitative researchers have to use much discretion when working with numerical data from only a selected sample from a population as findings can seldom be generalised to a whole population, especially in cases of small samples. The qualitative approach is elucidated in § 3.3.3 and the quantitative approach in § 3.3.4.

3.3.3 Research design: Qualitative research approach

The first two levels and part of the fifth level of Kirkpatrick's evaluation (Table 3.1) constituted the qualitative component of the study. An interactive qualitative design collected data on the participants' lived experiences in their natural settings. While Level 1 documented the participants' satisfaction with the programme, Level 2 documented the participants' perceptions of learning experiences that occurred relating to their knowledge, skills and attitudes (Phillips, 2003). Mathematics colleagues of the researcher participated in the qualitative section of Level 5 where return on investment in terms of human capital was documented.

3.3.3.1 Participant selection

Merriam (2009) defines purposeful sampling on the assumption that the researcher wants to understand and describe a specific phenomenon. The logic and power of purposeful sampling lies in the selection of information-rich participants who are then studied in depth (Merriam, 2009). The researcher was responsible for selecting a specific sample from which the most insight could be gained (Leedy & Ormrod, 2005). It is not compulsory for students of the UODL to attend contact classes. The result was that different students attended the IWB sessions for the concerned module. The researcher therefore selected participants according to convenience purposeful sampling, from a group of students who attended a specific session on a specific day. The participant group comprised ten students registered for NWPK 512 and who attended all the sessions at the White River tuition centre.

3.3.3.2 Data collection strategies

This section describes the different strategies related to qualitative data that were used during the study. J.W. Creswell (2003) distinguishes three types of data collection procedures in qualitative research: *observations, interviews* and *documents* which also includes *audio-visual documents*. An *observation* relates to the systematic process of recording behavioural patterns of participants, without necessarily questioning them (Nieuwenhuis, 2007b). The researcher should take field notes on the behaviour and activities of individual participants at the research site during an observation (J.W. Creswell, 2003). An *interview* is a two-way conversation in which the interviewer asks the participant questions in order to collect data on the phenomenon under study (Nieuwenhuis, 2007b). Focus group interviews have similar aims, and should not include more than about eight participants per group (J W Creswell & Plano Clark, 2011). The researcher aims to see the world through the eyes of the participants. *Documents* as a technique to gather data relates to all types of written communications that may shed light on the investigated phenomenon. It includes letters, reports, email messages, newspaper articles or any documents connected to the research, and may be published or unpublished (Nieuwenhuis, 2007b). The first two levels and part of level 5 of

Kirkpatrick's augmented five-level evaluation model relate to qualitative data collection. Table 3.1 provides an overview of the qualitative data collection components used during the study.

Table 3.1: Summary of qualitative data collection instruments used during this study

Levels of evaluation	Approach	Strategies
Level 1: Reaction	Qualitative	1. Observation schedule for the learning centre coordinator to observe the reaction of students during the IWB session (Addendum 3.1) 2. Observation schedule for the researcher (Addendum 3.2) 3. Focus group interviews with students after completion of the IWB session (Addendum 3.3)
Level 2: Learning	Qualitative	1. Interviews with participants after IWB sessions (Addendum 3.4)
Level 5: ROI	Qualitative	1. Open-ended questionnaire to peer lecturers presenting Mathematics modules (Addendum 3.5)

Level 1: Reactions (Interviews and observations)

The first sub-question of the study is whether students like to be taught via IWBs: How did they feel about sitting in a classroom, interacting through an electronic device instead of talking directly to a person? The aim of this level of evaluation was to determine the participants' reactions to the IWB facilitation. Although learning is not guaranteed by positive reactions to a programme, the inverse is almost a certainty (J. Kirkpatrick, 2007). Frequent evaluations help to keep participants positively informed and to reduce the number of dropouts before students reach the end of their course (Horton, 2005).

The following strategies were used to capture Level 1 data during this study: (i) the coordinator at the centre (Addendum 3.1) as well as the researcher (Addendum 3.2) observed participants with the assistance of an observation schedule to record aspects such as (a) did students arrive on time; (b) did students come prepared; (c) did students pay attention during the presentation; (d) did students participate by asking questions and making comments; (e) what were their experiences of the session; and (ii) the researcher conducted focus group interviews (Addendum 3.3) with some of the participants in order to obtain feedback on their satisfaction with the session, as well as with the programme as a whole.

Level 2: Learning (Individual interviews)

The aim of evaluation at Level 2 is to determine whether the participants perceive that learning has taken place. Learning involves a change in knowledge, skills and attitudes. The researcher interviewed the students to establish their own perspective on whether they had learnt some fundamental aspects of mathematics as a result of attending the IWB sessions. The data were collected through individual interviews (Addendum 3.4).

Level 5: Return on investment (Open-ended questionnaire)

Evaluation at ROI took place in terms of human capital. The data were collected through open-ended questionnaires (Addendum 3.5) which were completed by the researcher's peer mathematics lecturers who had experienced both modes of delivery: teaching via IWBs as well as teaching students in person at centres countrywide. The peer lecturers shared their experiences by completing the questionnaires.

3.3.3.3 Data analysis

Qualitative data analysis is an inductive process. Nieuwenhuis (2007a) describes qualitative data analysis as ongoing and iterative—a non-linear process which implies that collecting, processing, analysing and reporting data are intertwined, and not merely a number of successive steps. Themes and patterns emerge through the analyses to describe and explain the students' reactions and learning experiences. The aim is to summarise the data to capture the common words, phrases, themes or patterns that would aid the researcher's understanding and interpretation of the data (Nieuwenhuis, 2007a). Qualitative data are textual and the researcher wants to interpret and make sense of these—he/she does not want to measure the data.

J.W. Creswell (2003) argues that qualitative analysis involves preparing the data for analysis and conducting different analyses. To move deeper into understanding and representing qualitative data, he suggests the following six steps for a generic process of data analysis:
Step 1: Organise and prepare the data for analysis
Step 2: Obtain a general sense of the data and reflect on the overall meaning
Step 3: Begin the detailed analysis with a coding process
Step 4: Generate a description of the setting or people as well as of categories or themes for analysis
Step 5: Give a description to convey the findings of the analysis
Step 6: Give an interpretation of the data.

The data of this study were captured in an integrated hermeneutic way where the understanding constantly took place from the whole to the part and back to the whole. The collected data had to be textually rich in order to make sense of the bigger picture or the whole (Nieuwenhuis, 2007a). To enhance validity and trustworthiness of the study, the researcher made use of triangulation to judge whether separate pieces of information all point to the same conclusion (Leedy & Ormrod, 2005). A content analysis with ATLAS.ti™ identified data categories and themes. ATLAS.ti™ is a powerful workbench for analysing large bodies of textual, graphical, audio and video data. It helps to explore complex phenomena hidden in qualitative data in order to manage, extract, compare and reassemble meaningful pieces from the data in creative, flexible, systematic ways. The process starts with creating a project, the hermeneutic unit, and is followed by adding documents to the project. The next step is to identify interesting ideas in the data and code them. Hereafter, writing memos and

comments to codes, analysing and querying the data and developing and visualising models, are not done in a specific sequence. By moving back and forth between coded parts of the data and the whole, data are viewed from different perspectives which may give enhanced meaning to data. The aim of analysing data is to build theory on the main ideas of the data. Theory building already starts during coding and further develops when asking specific questions on how different ideas are related (ATLAS.ti, 2013). Figure 3.3 illustrates the main steps of working with Atlas.ti™.

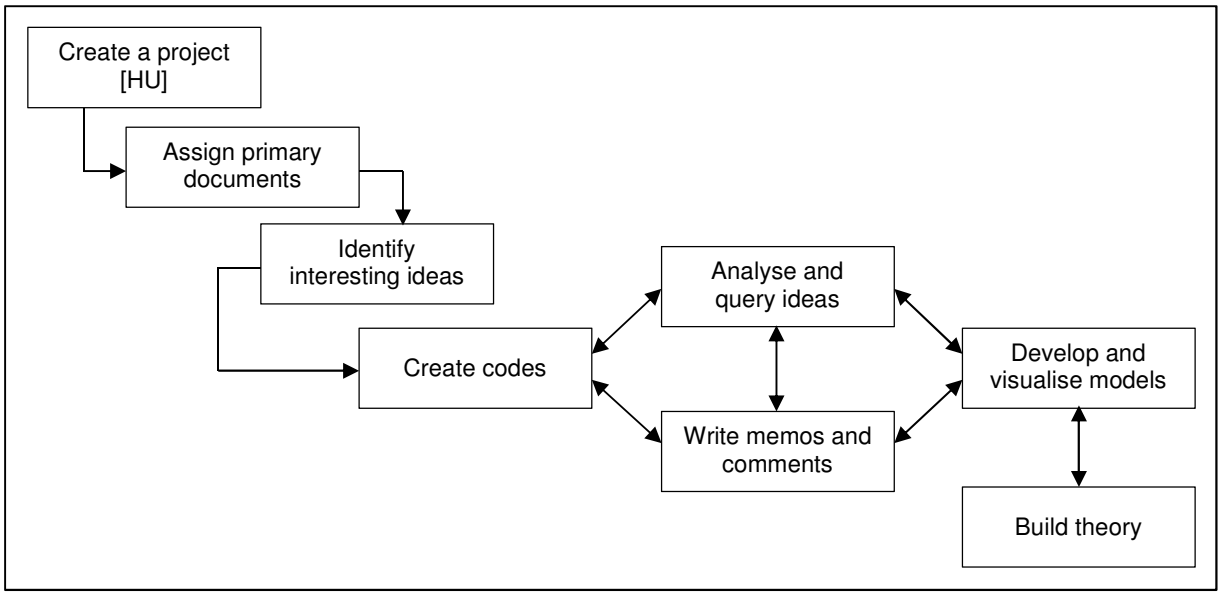


Figure 3.3: The ATLAS.ti™ workflow-diagram

The step-by-step approach of the Constant Comparison Method (CCM) of Boeije (2002) in analysing qualitative interviews supports the Atlas.ti™ analysis in systematising the analysis process in order to increase traceability and verification thereof. *Comparison* is the dominant principle and main intellectual tool or activity within the analysis process (Boeije, 2002). The researcher has to form categories and establish boundaries for them; assign segments to categories and summarise the content of each category in order to discover patterns within the data. The method further relates to *fragmenting* and *connecting* pieces within the analysis process. During *fragmenting* the researcher codes in terms of different themes that emerge from the data and during *connecting* the researcher link different pieces to each other as well as to the whole through accentuating the context and the richness of the data (Boeije, 2002). The researcher of this study followed the cycle of comparison and reflection several times, working from the whole to the part and back to the whole, until categories were saturated and no more new information came to light.

The analysis of the qualitative data is available as an integrated dataset in Atlas.ti™ (Addendum 3.6).

3.3.4 Research design: Quantitative research approach

The key concepts in quantitative research are objectivity, numerical data and ability to be generalised (Maree & Pietersen, 2007). Maree and Pietersen (2007) define quantitative research as "a systematic and objective approach in its ways of using numerical data from only a selected subgroup of a population to generalise the findings to the population that is being studied." Table 3.2 provides an overview of the research design quantitative data collection components used during the augmented Kirkpatrick evaluation of the study.

Table 3.2: Summary of quantitative data collection instruments used during this study

Levels of evaluation	Approach	Strategies
Level 3: Behaviour	Quantitative	1. Questionnaires to evaluate the change with respect to the value that the students obtained from the module. The questionnaires were addressed to: (i) the research participants (Addendum 3.7) (ii) the supervisors of the participants at their respective schools (Heads of Departments or Principals) (Addendum 3.8)
Level 4: Results	Quantitative	1. Pre-test-post-test to determine the students' change with respect to their understanding of mathematics (Addenda 3.9 and 3.10)
Level 5: ROI	Quantitative	1. Descriptive statistical comparison of monetary costs of the two modes of delivery

Levels 3 and 4 and part of level 5 constitute the quantitative section of Kirkpatrick's evaluation. The researcher determined the success of the training programme in terms of increased productivity and improved quality at level 3 by getting feedback from the participants (Addendum 3.7) as well as from their supervisors (Addendum 3.8). At level 4 the researcher compared the participants' results of the pre- and post-tests (Addenda 3.9 and 3.10). The results of the participants were also compared to the pre- and post-test results of a control group who had not been exposed to the scaffolding sessions via the IWB. This was to check for any indication of the probable impact that the scaffolding via IWBs had on the understanding of mathematics in an ODL programme. Determining the financial ROI when doing evaluation at level 5 was an important component of the quantitative part of the study. It comprised the comparison of the monetary costs of the two modes of delivery and the numeric data generated at this level was analysed and interpreted quantitatively.

The following section refers to the three levels of Kirkpatrick's evaluation that involve quantitative data.

3.3.4.1 Level 3: *Behaviour*

Evaluation at level 3 attempts to measure the success of the training or teaching programme in terms of increased productivity and improved quality (Simonson, 2007). The aim is to determine whether participants have changed their on-the-job behaviour as a result of participating in the course. D. L. Kirkpatrick (1998) describes four requirement criteria as part of change. Students should have a

desire to change, know what to do and how to do it, work in a climate that is conducive, and receive rewards for changing. The first two requirements can be accomplished by creating a positive attitude towards the desired change and by scaffolding the appropriate knowledge and skills. The third requirement refers to the participants' supervisors at work. Kirkpatrick distinguishes five typical climate environments that influence motivation: preventing, discouraging, neutral, encouraging and requiring. The fourth requirement refers to receiving rewards which can be intrinsic, extrinsic, or both. Intrinsic rewards relate to feelings of satisfaction and pride, while extrinsic rewards can include praise from the lecturer, headmaster or significant others, and even monetary awards.

J. Kirkpatrick (2007) refers to level 3 evaluation as the key to maximizing training and development effectiveness. He claims that training as well as learning means nothing unless they are applied. Simonson (2007) describes evaluation at level 3 as an attempt to determine whether the skills, knowledge and attitudes that were learnt as a result of the training, are being transferred to actual learning activities. It is, however, critical and problematic to time the evaluation at this level, since it is difficult to know when transfer actually occurs. Another reason why evaluating at level 3 is difficult is because the changes that are measured seldom have only a single cause and they do not necessarily happen within a certain time after the training programme was attended (Horton, 2005). This is why Horton (2005) suggests that the researcher may have to trade accuracy for credibility when evaluating at level 3. When evaluating one has to decide what is important. Horton's advice is to determine the single most important measure of success for the top management of the company before designing the evaluation programme. Secondly, his advice is to find ways to estimate the value of learning with technology. Best is to ask the students themselves, their peers and their supervisors because they should give a reasonably accurate picture of the value of what has been learnt. For this study the participants as well as their supervisors completed Likert-scale questionnaires (Addenda 3.7 and 3.8) to determine whether there was any change in the participants' understanding of mathematics and in their behaviour as a result of it. The researcher in the end has to estimate how much of the change is due to attending the IWB sessions and also how confident she is in this estimate.

3.3.4.1.1 Participant selection

The population (N) of the study consisted of the NWPK 512 students who were registered through the Open Learning Group (OLG). Purposeful convenience selection of participants applied to the qualitative first phase of the study and because the quantitative second phase of the study involved the same respondents, purposeful convenience selection also applied to the quantitative phase of this study. The participants for evaluation on level 3 were the participants and their supervisors (direct line managers). The study group of participants (n) for the complete study, after it had been narrowed down, consisted of ten students who attended IWB-sessions at White River and who met the selection criteria (§ 3.4).

3.3.4.1.2 Variables

The independent variable at level 3 was the scaffolding facilitation of NWPK 512 via IWBs. The dependent variable at this level was the change in the students' on-the-job behaviour as a result of attending the IWB-facilitation.

3.3.4.1.3 Measuring instruments: Questionnaires

Questionnaires on a Likert-scale collected data relating to the value that the participating teacher-students got from attending the IWB-facilitation. Questionnaires (Addendum 3.7) were addressed to the participating students and to their supervisors (Addendum 3.8) at their respective schools. Obtaining feedback on the change in behaviour from their supervisors as well, added to the validity and reliability of the research (Leedy & Ormrod, 2005).

3.3.4.1.4 Data Analysis

Data collected from evaluating at level 3 were analysed by using descriptive statistics. Descriptive statistics is a collective name for a number of statistical methods that are used to organise and summarise data in a meaningful way (Maree & Pietersen, 2007). The analysis of the data was done by the Statistical Support Services of the NWU through dependent t-tests and frequency comparisons.

3.3.4.2 Level 4: *Results*

The aim of the evaluation at this level is to determine whether the programme has adhered to the expected final results. Kirkpatrick defines *results* to be the final results participants obtain as a result of having attended a programme (D. L. Kirkpatrick, 1998). The single most important measure of success in the study of IWBs acting as scaffolds for mathematics students in ODL is defined as their mathematics' performance thereafter. The participants' performances in the pre-tests and post-tests were compared to one another as well as to the performances of the control group. This was to search for an indication of any contribution towards their understanding of mathematics. If the participants performed significantly better in the post-test which was written after they had attended the IWB sessions, the researcher could claim that IWBs most probably contributed towards learning of mathematics in ODL.

3.3.4.2.1 Participant selection

The population (N) of the study consisted of all NWPK 512 students who were registered through the Open Learning Group (OLG). Purposeful convenience participant selection applied to the qualitative first phase of the study and because the quantitative second phase of the study involved the same

respondents, purposeful convenience selection also applied to evaluation at level 4. The participants (n) consisted of ten students who attended IWB-sessions at White River and who met the selection criteria (§ 3.4). The participants in the control group were randomly selected from registered NWPK 512 students at another centre.

3.3.4.2.2 Variables

The independent variable at level 4 was the scaffolding facilitation of mathematics concepts of NWPK 512 via IWBs. The dependent variables were the performances of the participants in the pre-test-post-tests, and the comparison of the participants' test results to the test results of the control group.

3.3.4.2.3 Measuring instruments: Pre-test-post-test

The change with respect to the learning and understanding of mathematics was measured by using a pre-test-post-test evaluation. The students wrote a pre-test (Addendum 3.9) on the fundamental mathematics aspects that are dealt with in NWPK 512 before the training programme commenced. An exact test was written as a post-test (Addendum 3.10) after the completion of the course. Evaluation at this level had as its aim to determine whether participants performed better in the post-test. This could be an indication of the effect of taking part in the training programme. A randomly-selected control group of ten registered NWPK 512 students from another centre also completed the pre-test-post-test. Their results were compared to the results of the participants. This was performed to contribute to the validity, reliability and trustworthiness of the study.

3.3.4.2.4 Data analysis

Test results were analysed through descriptive statistics and dependent t-tests. The relationships between IWB facilitation and mathematics performance were determined using a non-parametric Wilcoxon signed-rank test, which is appropriate for comparing two variables within a small group of participants. Cohen's effect size indicated whether meaningful differences between the different sets of test results existed. The analysis of the data was performed by the Statistical Support Services of the NWU.

3.3.4.3 Level 5: *Return on investment*

Evaluation at level 5 involved that learning with technology activities is converted into monetary values for the comparison of two models of delivery: a model in which contact with students mainly occurs via IWBs versus a previous model where lecturers visited learning centres to meet students in person. The latter involved not only high costs for travelling and accommodation, but also implied many hours spent travelling. The researcher took these human factors into consideration when the average annual cost of the model without IWBs was calculated. The annual cost of running the

programme via IWBs involved not only installation and maintenance costs; the financial implications of extra staff members to be responsible for the technical operation and continuous support of the IWBs were also considered. The ROI was finally calculated when the researcher compared these two sets of costs.

3.3.4.3.1 Participant selection

The quantitative part at this level involved monetary costs and therefore no participants were selected for evaluation at level 5. The collected data for evaluation at this level were obtained from the financial and administrative departments of the UODL and OLG.

3.3.4.3.2 Variables

No definite independent or dependent variables were defined for evaluation at level 5 because the two modes of delivery contained specific financial implications which were compared.

3.3.4.3.3 Measuring instruments: Cost analysis of delivery modes

The data collection strategy for capturing the quantitative data at level 5 was a cost analysis of running the current mode of delivery (with IWBs) compared to the previous mode of delivery (without IWBs). Financial data were obtained from the administration sections of the UODL and OLG.

3.3.4.3.4 Data Analysis

Descriptive statistics were used to indicate the monetary differences between the two models (Addendum 3.11).

3.4 Constraints

The researcher experienced some logistical challenges during the study on how scaffolding of mathematics contributes towards the design integration of IWBs at the UODL. Attending IWB sessions is not compulsory for students of the UODL. This results to never having the same group of students attending sessions for a specific module. The scheduled sessions are also not long enough for scaffolding different mathematical concepts interactively. The researcher, therefore, had to narrow down the sample population to registered NWPK 512 students who attended at a specific centre on a specific day. Furthermore, the duration of the IWB session on that day was extended from the standard thirty to forty minutes to a five-hour session. Addressing these challenges, a group of participants was selected according to convenient purposeful participant selection.

3.5 Ethical aspects

Ethical aspects (Addendum 3.12) that were applied throughout the study were that participants were protected from any harm and the research data remained confidential at all times (Fraenkel, Wallen, & Hyun, 2012). The necessary ethics application forms were completed and submitted to the North-West University's ethics committee who granted permission to commence the research. Every prospective participant of the study was requested to complete a letter of consent which provided the researcher with permission to continue with the study. This letter (Addendum 3.13) ensured participants that participation was voluntary, that they were free to withdraw from the study at any time, that withdrawal would not jeopardise their studies in any way, and that all information was treated confidentially. Since names were not required in any of the questionnaires or pre- or post-tests, the students remained anonymous. All results will be reported to the participating students and to the coordinators and mathematics facilitators at the IWB centres countrywide.

The text of this dissertation was submitted to Turnitin.com to check for the misuse of literature resources. The report is available as Addendum 3.13.

3.6 Summary

In this chapter the research design and methodology were explained and the essential components of the research methodology were discussed in more detail. The researcher's role during the research process was described, the measuring instruments were discussed and the population and selection of participants were described. The data collection procedures were presented and the data analysis techniques were described. Lastly, certain constraints the researcher experienced during the study and ethical aspects applied throughout the study were reported.

Chapter Four

Scaffolds Relating to Fundamental Principles of Mathematics

4.1 Introduction

Chapter two (§ 2.4.2.2) referred to the use of scaffolds in this study. This chapter further unpacks the concept and provides an overview of the scaffolds used during the study (Addendum 4.1). The process of selecting scaffolds suited to this study does not relate to the scope of the research process of this study. This chapter describes the scaffolds used and the motivations in choosing these, to clarify the setting for interpreting the research results.

The researcher explored different educational sites in order to find applicable resources on mathematics concepts that relate to the content of the NWPK 512 module of the ACE in Mathematics. She sifted through many resource sites and selected appropriate activities to use as scaffolds during the teaching and learning of the module. Numerous scaffolds of various types relating to the fundamental concepts of mathematics are available on these resource sites—many can be accessed for free while the user has to register for others at a fee. The aim of this study is not to classify or recommend specific scaffolds for certain mathematical concepts, but to introduce DE students of mathematics to the many resource sites where they could get scaffolding support to assist them in mastering the content of mathematics major modules. According to the researcher's experience, DE students often struggle with mastering fundamental concepts when studying on their own. Studying over a distance limits support by the lecturer for every individual student's needs. Scaffolding support, freely available via the Internet, could improve understanding of mathematics for DE students because they could engage as often and as much as they want in these activities. This way, teaching and learning of mathematics could be personalised to fit each student's needs. The researcher therefore does not attempt to recommend specific scaffolds as if these are considered to be the best in certain circumstances; students should engage in as many different scaffolds supporting a specific concept they may need in order to feel comfortable about that concept in the end. In the next sections the researcher discusses typical characteristics and outcomes of these e-activities, gives examples of scaffolds for the different mathematical concepts of the module, and describes one in detail. The researcher also refers to various types of scaffolds DL students can engage in and reports on ways the exemplar scaffolds address the module outcomes of the concerned mathematics module.

4.2 Scaffolding

The concept of *scaffolding* originates from the Vygotskian school of thought. Vygotsky emphasises concept forming during cognitive development when he develops his *Zone of Proximal Development*

(Minick, 1999). Vygotsky describes the difference between a particular cognitive level at which people can perform a task by themselves, and a higher level at which they are able to perform a task in cooperation with others. A student's development level therefore consists of two parts: the actual development level and the potential development level. The difference between these two levels is referred to as the *Zone of Proximal Development*. Vygotsky believed that learning proceeds development in the ZPD, i.e. after a student has mastered the learning, development follows.

Scaffolding is one of a variety of teaching strategies that educators could use to improve student learning (Van der Stuyf, 2002). "Scaffolding is a bridge used to build upon what students already know to arrive at something they do not know. If scaffolding is properly administered, it will act as an enabler and not as a disabler" (Benson, 1997, p. 126). Minick (1999) describes scaffolding as a technique that facilitators use to assist students during learning. The amount of scaffolding used is determined by what the facilitator decides about the student's abilities and current levels of understanding (Valkenburg, 2010). This study involved students who study through distance learning which comprises few contact sessions which are not even compulsory. This limited contact between lecturer and student results in many students struggling to master the fundamental principles of Algebra, and consequently results in a low success rate for the concerned module NWPK 512. The researcher therefore introduced students to the educational scaffolds on Internet they can engage in. She included many of these mathematics activities as scaffolds during her teaching of NWPK 512 via the IWB. She also advised students to revisit and engage in the activities when they experience hurdles in their mathematics courses.

Characteristics of teaching and learning with scaffolds are: (i) it provides clear direction to reduce students' confusion; it clarifies the purpose; it keeps the students on task; (ii) it offers assessment to clarify expectation; (iii) it points students to worthy sources; (iv) it reduces uncertainty, surprise and disappointment; it delivers efficiency; (v) it creates momentum during learning; (vi) it provides support; (vii) it functions as a tool; (viii) it extends the range of work; (ix) it allows the accomplishment of tasks not otherwise possible; and (x) it assists the student where needed (Coffey, 2009; Greenfield, 1984). It is important that the scaffoldings should fall within the student's field of understanding, and they should be relevant. If the task is unfamiliar, it could add to the frustration of the student. Tasks that are too simple could have a similar effect (Coffey, 2009). Scaffolding can only be successful if the task at hand is meaningful and challenging, if students actively interact with the task, and if the scaffold is tailored to the needs of the students (Kiong & Yong, 2001).

The scaffolds used during the study are listed in Addendum 4.1. They comprise teaching and learning in simulated classrooms, as well as PowerPoint presentations, and mathematical activities like models, videos, interactive activities, simulations and games. These scaffolds offer different levels of support in order to assist NWPK 512 teacher-students in their understanding and mastering of the fundamental Algebra principles.

Students who study mathematics over a distance often face many challenges (Ferreira & Venter, 2010; Mdakane, 2011). Living far away from contact centres and working as fulltime teachers make it difficult for them to attend contact classes offered by the university. The NWU does not offer extended lectures or IWB sessions to cover the complete content of modules of their open distance learning programmes. DE therefore leaves students with many hours of self-study and effort to succeed. The researcher identified relevant scaffolds that students could use on their own and at times that suited themselves, and linked them to the presentations via the IWB. Typical examples of some of these scaffolds for different mathematics concepts are illustrated in this chapter (§ 4.3). The scaffolds provide additional support to students to assist them in their mastering and understanding of Algebra fundamentals.

These scaffolds are available on Internet, are easy to access and are mostly free to use. They are generally dynamic and colourful, come with voice and tunes, attractive and interactive so that students engage as participants in action. Many of these activities offer various levels of complexity; students can repeat the different levels until they fully understand or feel satisfied; and students can select their own levels to interact with. This potentially leads to students taking responsibility for their own learning, and supports the constructive nature of this study and the learning of mathematics in general.

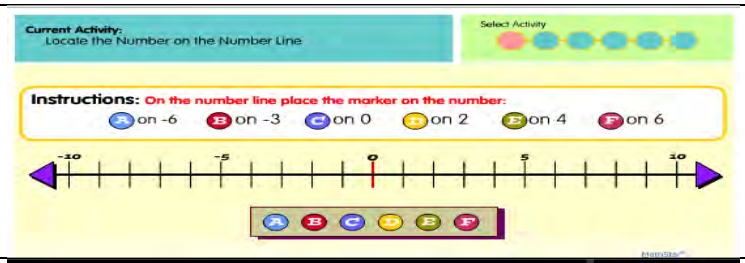
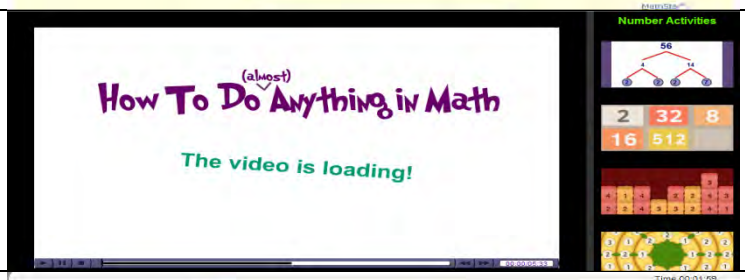
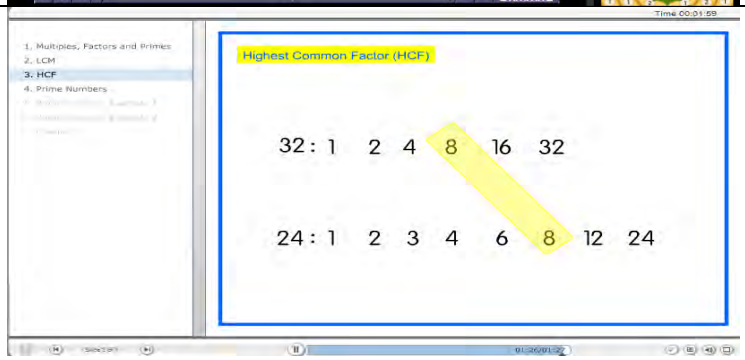
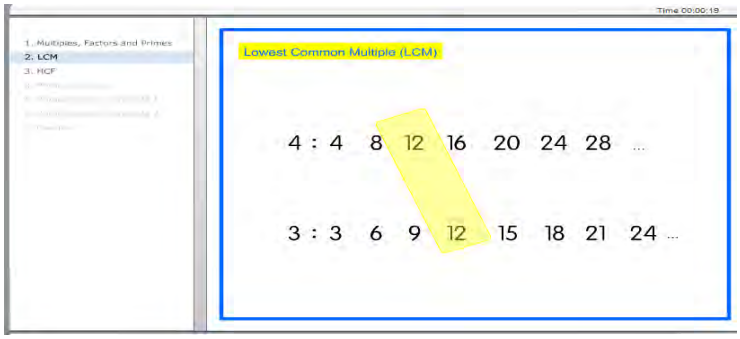
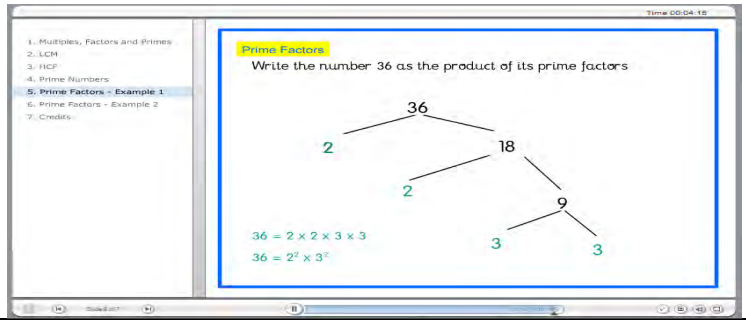
Students normally experience these mathematics activities as fun and games and they love to play around with them. Furthermore, teacher-students get many original ideas from the activities which they can creatively use in their own classes later on. Teachers' own students therefore benefit from it when the teachers themselves have better understanding of the fundamentals of Algebra. For this study, the researcher supported students as a group during IWB sessions although individual support was also possible via the IWB. The Smart™ presentation with all the links connected to it for the presentation of NWPK 512 is available as Addendum 4.2.

4.3 Examples of scaffolds suited to Mathematics education of fundamental aspects

The "big idea" of mathematics in the module concerned is *Number, Pattern and Relationship*. A complete list of all scaffolds that the researcher linked to the different concepts of mathematics dealt with within NWPK 512 is included in Addendum 4.1. It is, however, not at all a static list—right through the study the researcher encountered more and even better links. This list should be seen as an open-ended, never-ending list. Students could also have discovered other activities and sites which they benefitted from, but which do not appear on the list. The main aim was that students became aware of and got introduced to different sites and ways they could enhance their understanding of the mathematics concepts related to the content of NWPK 512. Students, and particularly DE students, should strive to become self-regulated learners and therefore have to take

responsibility for their own studies. Tables 4.1 to 4.5 illustrate typical examples of these scaffolding activities.

Table 4.1: Typical scaffolds for numbers and number lines

Numbers and number lines This activity is an interactive game. Player has to drag the letter to the number it represents on the number line. Next level of this activity is to put correct number to letter at specific place on number line (Salinas, 2004).	
Primes, odds and evens This activity is in the form of a video that explains which numbers are the primes, odds and evens (King, 2002b).	
Factors and multiples This video activity consists of different parts in which the presenter first illustrates what factors and multiples are and then how to determine the LCM and HCF of any two numbers. He further illustrates the concepts by doing examples and how to write any number as a product of its prime factors by using factor trees (McCourt, 2007).	  

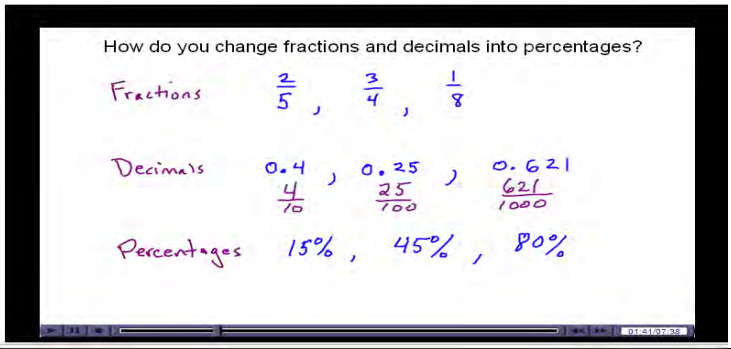
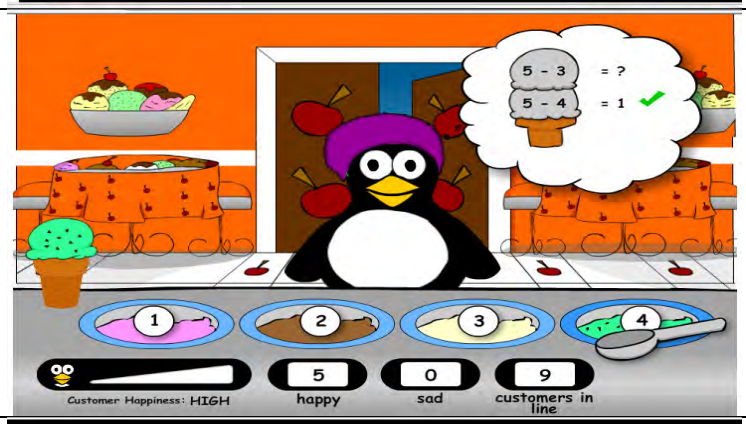
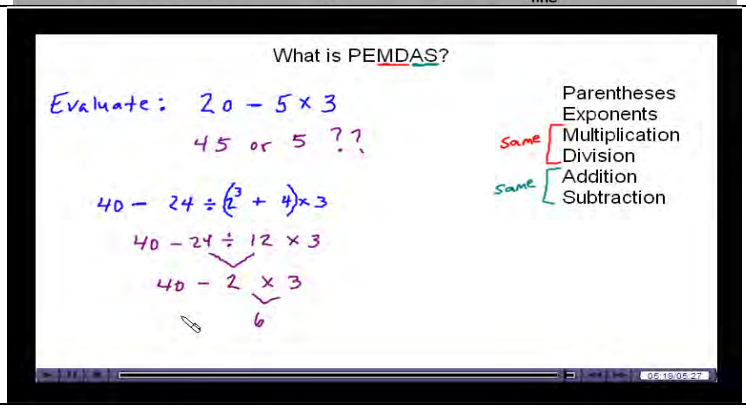
Integers This activity involves positive and negative numbers and is an interactive game that the student engages in. S/he has to type in a positive or negative number that the space coupe has to move in order to take out the pops. To help the student determine the correct number there is a vertical number line on the left side of the picture (PBS Kids Programs, 2003).	
Rational numbers The activity on fractions, decimals and percentages as different notations of rational numbers is a video presentation with explanations and examples (King, 2002b).	
Operations with numbers This interactive activity is a game in which the student has to use subtraction in a way to keep a line of customers in an ice cream shop happy and not sad. Levels of difficulty relate to the number range that is specified before starting the game (Walker, 1982).	
Order of operations The activity on PEMDAS is a video presentation in which the presenter explains typical mistakes students make when they do not know in what order they should do calculations and operations with numbers (King, 2002b).	

Table 4.2: Typical scaffolds for growing patterns, functions and algebraic language

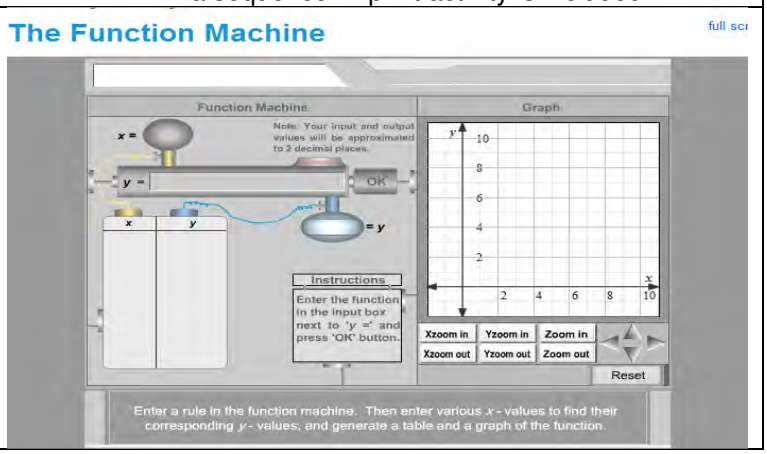
Patterns This video shows how rhythm is made up of a sequence of patterns. A tap dancer illustrates a sequence of routines developing into a full tap dance (Junior High Math Interactives, 2006b).	 **Exploring Patterns Video (Video Interactive)** This multimedia mathematics resource illustrates how math is used to develop and analyse dance routines. An interactive component helps students explore random number patterns and predict the next terms in a sequence. A print activity is included.
Functions This simulated interactive activity consists of a function machine that shows visually that when a number x is put into the machine, undergoing the function, y is brought out as the output. It further records all x and y coordinates in a table and simultaneously plots each point on the graph (Hotmath Inc, 2000).	

Table 4.3: Typical scaffolds for exponents

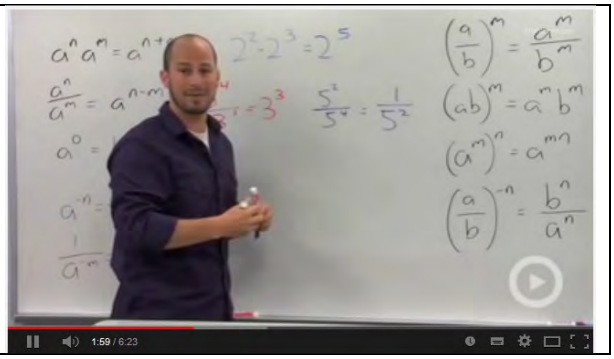
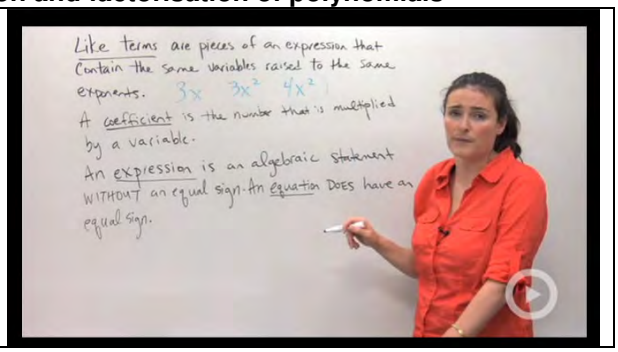
Definitions and laws of exponents The videos in this activity relate to the definitions and laws of exponents. Videos build onto one another and students can watch the videos over and over again until they feel comfortable about the specific definition or law (Brightstorm, 2008).	

Table 4.4: Typical scaffolds for simplification and factorisation of polynomials

Simplification A real class presentation on algebraic expressions and the simplification of these by explaining exactly what like-terms and coefficients are (Fong, 2008).	

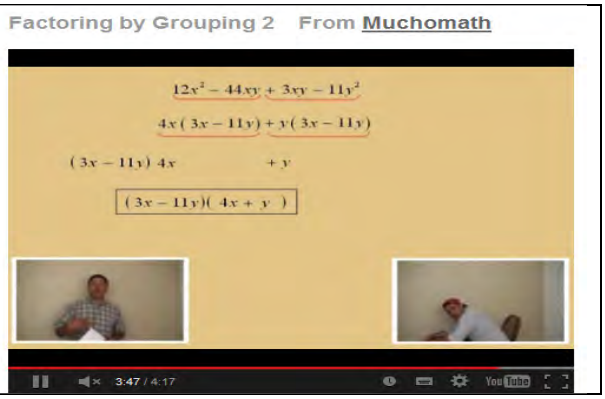
Factorisation A model of real class teaching where the teacher teaches and the student is actively engaged in the classroom. Several expressions are factorised in order to assist students in the concept of factorisation as well as with the act of factorising (Perez, 2007).	

Table 4.5: Typical scaffolds for solving equations

Solving equations This interactive activity involves word problems which the student has to solve and it offers a check facility as well as a help facility (King, 2002a).	

The module outcomes of the concerned module NWPK 512 are:

After completion of this module the student should be able to:

a. represent, generalise and formalise patterns in all aspects of mathematics

b. understand the thinking and reasoning process throughout the grades

c. have an oversight of the set of number systems, the operations defined in the number systems and the properties ruling the operations

d. have a thorough knowledge of algebra fundamentals such as:

i. evaluating polynomials

ii. operations with polynomials

iii. factoring

e. be competent in applying these fundamentals in simplifying polynomial expressions

f. solve linear equations and simple inequalities

g. solve quadratic equations by using the property of zero products.

Table 4.6 represents ways in which the exemplar scaffolds in table 4.1 to table 4.5 address the module outcomes.

Table 4.6: Ways in which exemplar scaffolds address module outcomes

Examples of scaffolds	Characteristics of teaching and learning with scaffolds: *provides direction*	*offers assessment*	*points to sources*	*reduces uncertainty*	*creates momentum*	*provides support*	*functions as a tool*	*extends range of work*	*task accomplishment*	*assistance*	NWPK 512 Module outcomes
Typical scaffolds for numbers and number lines											
Numbers and number lines	√	√		√	√	√	√	√	√	√	a, b, c
Primes, odds and evens	√	√	√	√		√		√	√	√	a, b, c
Factors and multiples	√	√	√	√	√	√	√	√	√	√	a, b, c
Integers	√	√	√	√	√	√	√	√	√	√	a, b, c
Rational numbers	√	√	√	√	√	√	√	√	√	√	a, b, c
Operations with numbers	√	√		√	√	√	√	√	√	√	a, b, c
Order of operations	√	√		√	√	√	√	√	√	√	a, b, c
Typical scaffolds for growing patterns, functions, algebraic language, and simplification and factorisation of polynomials											
Patterns			√	√			√	√		√	a, b, c
Functions	√	√	√	√	√	√	√	√	√	√	a, b, c, d, e
Definitions and laws of exponents	√		√	√	√	√	√	√	√	√	a, b, c, d
Simplification	√		√	√	√	√	√	√	√	√	a, b, c, d, e
Factorisation	√		√	√	√	√	√	√	√	√	a, b, c, d, e,
Typical scaffolds for solving equations											
Solving equations	√	√	√	√	√	√	√	√	√	√	b, c, d, e f, g

In the following section the researcher reports on one of the interactive activities (Figure 4.1) in more detail to illustrate the involvement of the student and the comprehensiveness of the activity.

Digging up dinosaurs: Exploring Laws of Exponents

Exploring Laws of Exponents (Object Interactive)

This interactive mathematics resource uses the scenario of a paleontological dig to allow the user to explore the laws of exponents. The resource also includes print activities, solutions, and learning strategies (Junior High Math Interactives, 2006a).

Figure 4.1: Activity on laws of exponents

The activity relates to a real-life context of digging up dinosaurs and offers four different digs, each with its own level of complexity, to explore the laws of exponents. It is vital to fully understand the definitions and laws of exponents in order to succeed in learning Algebra and therefore, to succeed in

NWPK 512. Getting involved in this resource, students have to apply different laws of exponents correctly to be rewarded by acquiring skeleton bones of some prehistoric dinosaur. After all activities within the resource had been completed successfully the student gains the opportunity to put the bones in the puzzle which builds the dinosaur. Figure 4.2 represents the page where students select the dig they want to enter.

Figure 4.2: Four different activities in Dinosaur-Dig

The first dig, for example, gives the following information before the dig is entered:

Location:	Red Deer River Valley, Brooks, Alberta	
Suspected Dinosaur:	Euoplocephalus	
Dinosaur Info:	Pronunciation:	You-oh-ploe-seff-ah-luss
	Period:	Late Cretaceous
	Main Group:	Ankylosauria
	Length:	6-7 metres (19.5-23 feet)
	Weight:	2 000kg (4 400 pounds)
	Diet:	Plants.

The following laws of exponents will be addressed using positive values

- Product Law
- Quotient Law
- Power of a Power Law
- Power of a Product Law
- Zero exponent Law.

When entering the dig a matrix of 32 (8 x 4) squares appear. The student has to click on anyone of the squares for a problem to be revealed. A typical problem to solve in this activity can be:

$$(8)^3 \times (8)^3 = (8)^{3 \square 3}$$

The student has to select the correct sign from a table of possible signs that appears on the screen, where-after s/he has to drag it to the placeholder box. If she/he selects the correct operation sign from the table, three possible solutions appear on the screen of which she/he has to select one. If the student does not select the correct operation sign, a list of the different exponential laws and examples appears. When clicking on the relevant law, an explanation of it follows so that the student can recap and continue with the activity. Most of the activities are user-friendly and if one can read, it should be possible to engage with it. The fact that a computer only does what one tells it to do contributes to the development of the student's logical thinking. Every problem is evaluated and if the student has selected the correct answer it gives a tick (√) and a "continue" which means the student may proceed to the next problem. After all the problems of Dig 1 have been solved correctly, the student gets a "Well done! You may build the dinosaur now or enter a new dig" (Figure 4.3).

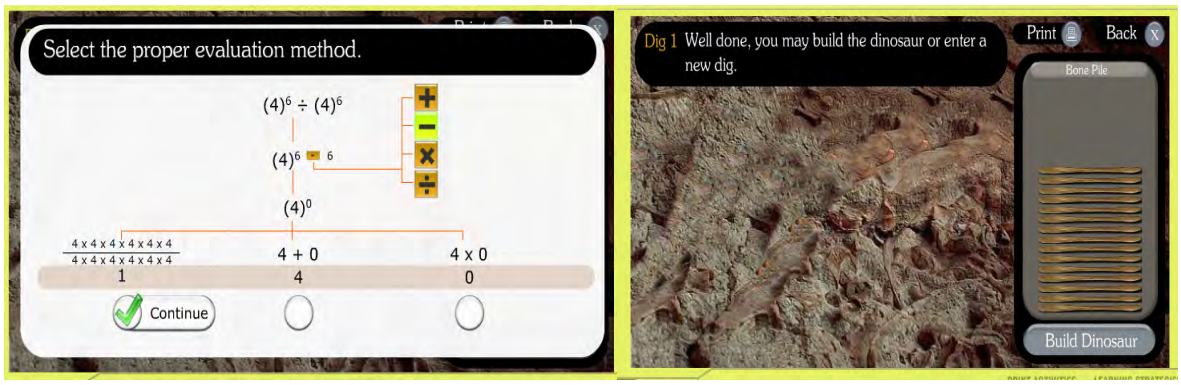


Figure 4.3: Engaged in the activity

Figure 4.4 represents the last part of the activity where the student is busy building the dinosaur. After s/he has completed this part, another dig can be entered or this dig can be entered again.

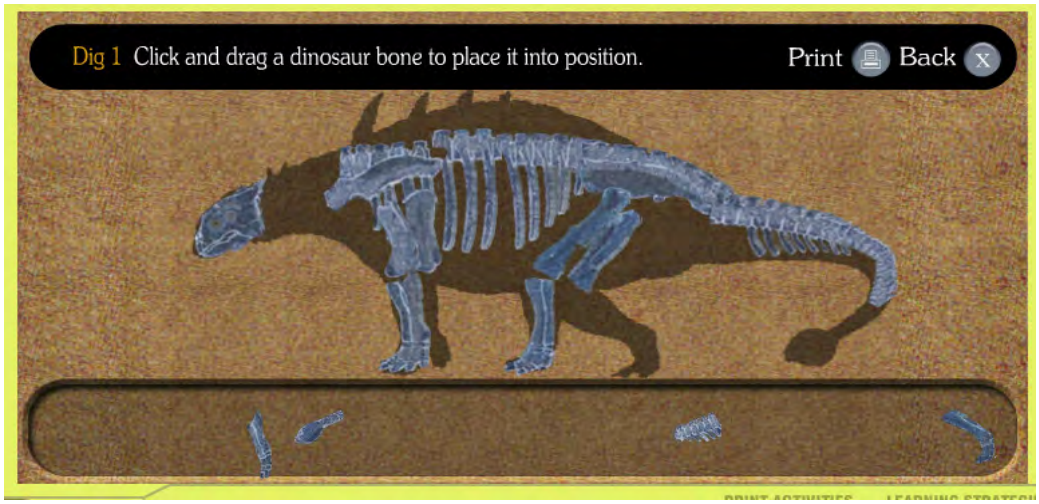


Figure 4.4: Building the dinosaur

Digs 2 and 3 dig up dinosaurs at other sites and relate to laws of exponents using negative values. The information page of Dig 4 indicates that the problems involved on this level use both positive and negative values to address all the different laws of exponents. The information on the dinosaur-dig of Dig 4 is given as:

Location:	Devil's Coolee, Warner, Alberta	
Suspected Dinosaur:	Corythosaurus	
Dinosaur Info:	Pronunciation:	Ko-rih-thoe-sore-uss
	Period:	Late Cretaceous
	Main Group:	Ornithopoda
	Length:	10 metres (33 feet)
	Weight:	up to 4000kg (8 800 pounds)
	Diet:	Omnivore.

The following laws of exponents will be addressed using positive and negative values

- Product Law
- Quotient Law
- Negative Exponent Law
- Power of a Power Law
- Power of a Product Law
- Power of a Quotient Law
- Zero exponent Law.

Students therefore do not only learn about laws of exponents by engaging in the activities—they also learn about real-life applications of mathematics from the context of the activity. The real value of an activity like the Dinosaur-dig is that students can visit and revisit the dig until they feel comfortable with applying the different laws of exponents with both positive and negative values. The activity refers the student back to the relevant law when s/he makes mistakes while digging. This supports the constructive nature of applying these activities as scaffolds in the teaching and learning of mathematics over distance.

4.4 Conclusions

This chapter reported on the mathematics activities like PowerPoint or interactive presentations, games, models and activities which are freely available on Internet for anyone to use. The researcher introduced the teacher-students to these Internet sites during IWB sessions. They were advised and encouraged to revisit and explore these sites to scaffold their understanding of fundamental principles of mathematics in order to master the concerned module NWPK 512. The researcher included relevant and appropriate links for all concepts covered by the NWPK 512 module, and conveyed them to the students during the IWB sessions. She did, however, encourage them to take responsibility to

explore other relevant sites and to continuously expand the list of scaffolds. The next chapter reports the analysis of the data and aims to answer the five sub-questions subjective to the main research question of the study.

Chapter Five

Analysis of Data according to Kirkpatrick's Five Levels

5.1 Introduction

This chapter reports on the analysis of the data gathered according to the procedures outlined in Chapter 3 in accordance with the outlines of the Kirkpatrick evaluation process (§ 3.3.1). The overarching research question that guides this research is: How can IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme? The five questions relating to the outlines of Kirkpatrick are: (i) How do students react to mathematics education facilitation via IWB scaffolding? (Level 1); (ii) How do students perceive their learning that takes place through scaffolding of mathematics via IWBs? (Level 2); (iii) Do the students' supervisors note any change in their on-the-job behaviour as a result of learning mathematics augmented with scaffolding during IWB classes? (Level 3); (iv) Do students perform better in the post-test than in the pre-test after attending mathematics scaffolding during IWB sessions? (Level 4); and (v) How does the return on investment (ROI) of not using mathematics scaffolds on IWBs compare to facilitation with mathematics scaffolds on IWBs? (Level 5)

This chapter is presented according to the following sections: the demographics of the participants; qualitative analysis; quantitative analysis; analysis of data according to Kirkpatrick's five levels; reliability; validity; and a chapter summary.

5.2 Demographics of the research participants

This section reports on the gender, age and teaching phase of the participants who participated in the experimental and control groups. These participants were teachers at various schools (Table 5.1).

Table 5.1 Gender, age and teaching phase of research participants

Aspect	Experimental Group		Control Group	
	M	F	M	F
Age 25-40	1	2	0	2
Age 41-50	4	1	5	2
Age 51+	0	2	0	1
Total:	5	5	5	5
Intermediate phase (IP) teacher	1	4	2	3
Senior phase (SP) teacher	4	1	4	1
Total:	5	5	5	5

In South Africa the gender distribution of the teacher population reflects a ratio of almost three female teachers to every male teacher. In primary and secondary schools the ratio is even more skewed towards female teachers as many young male teachers quit teaching within their first five years of

teaching (Peltzer & Shisana, 2014). This may be due to the fact that in South Africa, teaching is not regarded as a highly respected or paid occupation (Bauer, 2011). Traditionally, male teachers were more readily promoted to heads of departments, vice principals and principals, resulting in male teachers often occupying manager posts while female teachers remaining in classrooms (Moloi & Chetty, 2011). The gender distribution of this study reflects an equal number of male and female participants for both the experimental and control groups.

The age distribution of the participants for the experimental group related to three participants between the ages of 25-40; five participants between the ages of 41-50; and two participants older than fifty. The corresponding figures for the control group were two, seven and one. The gender ratios within the age groups of the experimental group were 1:2 for the 25-40 group; 4:1 for the 41-50 group; and both teacher-students in the 50+ group were females. The gender ratios within the age groups of the control group showed similar trends. Furthermore, the gender ratios within the teaching phases for the experimental group were 1:4 in the Intermediate Phase (IP) and 4:1 in the Senior Phase (SP), and the corresponding figures for the control group were 2:3 and 4:1. The ACE in Mathematics programme prepares students to teach Mathematics from Foundation Phase (FP) through IP up to SP, but FP-students seldom register for this course. At the UODL less than ten per cent of registered students in the ACE programme are majoring in mathematics (OLG, 2011). The participants of this study for both the experimental and control groups were teacher-students in either the Intermediate Phase or the Senior Phase.

5.3 Qualitative analysis

The transcribed data of the individual and focus group interviews were captured in the computer-assisted qualitative data analysis system, Atlas.ti™ as an integrated dataset which linked all the datasets as a holistic hermeneutic unit (§ 3.3.3.3). The analysis resulted in 24 codes and four themes. The four themes were: (i) reaction; (ii) barriers; (iii) learning, and (iv) return on investment (ROI) in human capital, in accordance with the main themes of a Kirkpatrick evaluation (Figure 5.1). The number of times a certain code was noted (code density), is also displayed in Figure 5.1.

Quotations of participants display a reference, e.g. (P2:12-13). While P2 corresponds to the second primary document assigned to the integrated dataset in the hermeneutic unit in Atlas.ti™, 12-13 refers to the line numbers in the specific primary document. The integrated dataset is available as Addendum 3.6 on the CDROM included at the back of the dissertation.

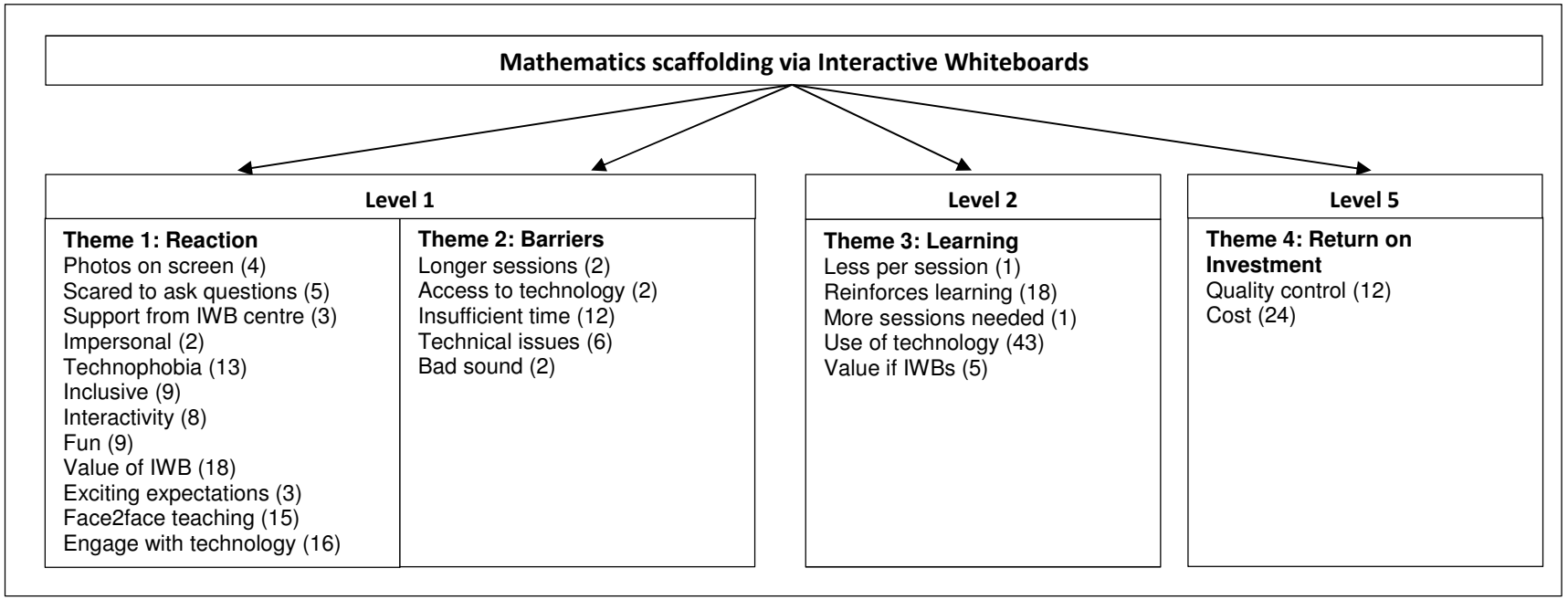


Figure 5.1 Themes, codes and code density of the qualitative data analysis

5.4 Quantitative analysis

Quantitative data were obtained through Likert-scale questionnaires to participants and their supervisors, pre- and post-tests and a comparison of monetary costs of the two modes of delivery. The analysis of the quantitative data was performed by the Statistical Support Services of the NWU and presented as descriptive statistics, dependent t-tests and frequency comparisons. The relationships between IWB facilitation and mathematics performance were determined using a non-parametric Wilcoxon signed-rank test and Cohen's effect size indicated whether meaningful differences between the different sets of test results existed. Descriptive statistics refer to meaningful organisation and summaries of data and are represented graphically or numerically (Pietersen & Maree, 2007c).

The five research sub-questions are addressed in the following sections:

5.5 Sub-question 1: How do students react to mathematics education facilitation via IWB scaffolding? (Level 1)

5.6 Sub-question 2: How do students perceive their learning that takes place through scaffolding of mathematics via IWBs? (Level 2)

5.7 Sub-question 3: Do the students' supervisors note any change in their on-the-job behaviour as a result of learning mathematics augmented with scaffolding during IWB classes? (Level 3)

5.8 Sub-question 4: Do students perform better in the post-test than in the pre-test after attending mathematics scaffolding during IWB sessions? (Level 4)

5.9 Sub-question 5: How does the return on investment (ROI) of not using mathematics scaffolds on IWBs compare to facilitation with mathematics scaffolds on IWBs? (Level 5)

5.5 Sub-question 1: How do students react to mathematics education facilitation via IWB scaffolding? (Level 1)

The first sub-question relates to Kirkpatrick's Level 1 evaluation which determines the research participants' reaction to scaffolding mathematics facilitation via IWBs. The collected data relate to the data that emanated from the focus group and individual interviews with the research participants (Addenda 3.3 and 3.4), as well as from the completed questionnaires (Addenda 3.7 and 3.8). Two themes of the qualitative analysis related to Level 1 of the Kirkpatrick evaluation: reaction and barriers.

Figure 5.2 depicts the network of codes as generated in Atlas.ti™ relating to reaction of students towards the use of mathematics scaffolds via IWB facilitation. The two themes illustrate two sides of a coin (reaction) where participants either feared the technology, or they eagerly engaged with technology presented to them.

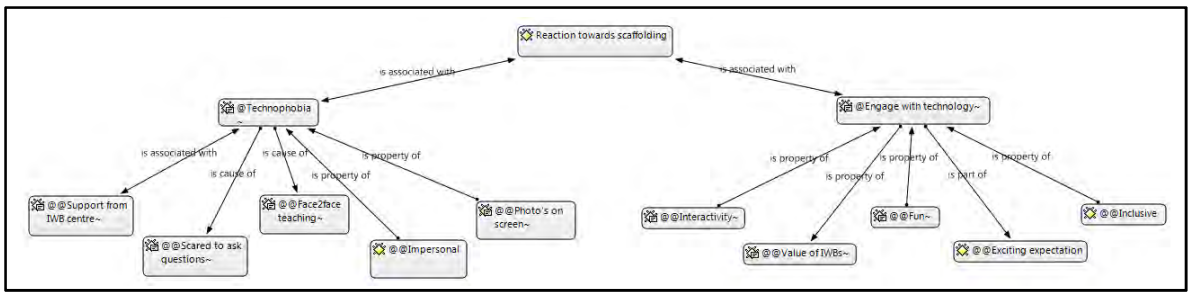


Figure 5.2: Codes corresponding to the theme reaction of students' lived experiences of mathematics scaffolds via interactive whiteboard facilitation

5.5.1 Technophobia

Five codes related to the theme of *technophobia* while learning with technology: (i) support from IWB centre; (ii) scared to ask questions; (iii) face-to-face teaching; (iv) photos on screen; and (v) impersonal.

South Africa faces many developmental inequalities which contribute to the digital divide (Ndlovu & Lawrence, 2012) (§ 2.4). When IWBs were introduced at the UODL in 2010, they were new and unfamiliar to most students. Technophobic students from this study mentioned that they were scared to ask questions via the IWB as it was their first experience of learning with technology and they experienced it as impersonal. They asked for an on-screen photo of the lecturer in order for them to know that they were talking to a real person and to make the experience more personal; resembling face-to-face teaching. Anthony and Walshaw (2009) remind us that students should feel safe in the learning environment in order to make sense of mathematics and to enlarge their capacity to learn. Utterances of research participants that illustrate their feelings of technophobia were:

> *I'm a bit scared when I'm there but if you are here I would ask you as many questions as possible but there it's a bit scary there so that's the only problem I'm having (P1:59)*
>
> *I don't remember in all the courses that I attended someone here in Nelspruit in White River going to that computer and asking something (P3:32)*
>
> *You find adults who tell themselves how am I going to use that computer or how am I going to use that tape-recorder or whatever machine that is there because they tend to get this thing of I'm too old (P2:9)*
>
> *Since we have a backlog of people saying I don't have access to internet I don't have access to a computer or whatever then it becomes more difficult and then he becomes more scared why?... because I don't have these things why should I follow this because of I don't have it (P2:10).*

5.5.2 Engage with technology

After some time, the research participants overcame their initial technophobia. They became more familiar with the concept of communicating with the lecturer and one another via the IWB and experienced that they could better engage with each other through IWB technology. Five codes related to the theme of *engage with technology*: (i) interactivity; (ii) value of IWB; (iii) exciting expectation; (iv) fun; and (v) inclusive.

When the participants started to engage with the technology, they revealed emotions of excitement of learning with technology (Dukes, 2014). They were amazed by the interactive feature of the whiteboards. It astonished them that their peers from centres all over the country could join in and engage in the same learning experience and that this could happen simultaneously without physically being in the same place. Koenraad (2008) and Kennewell et al. (2008) are of the opinion that interactivity is a keyword in effective whole-class teaching with technology (§ 2.4.1.2). The more participants engaged during IWB sessions, the more they enjoyed the mathematics teaching. The scaffolding activities provided them with fun experiences of mathematics. It was at this point when they started to voice their appreciation about the value of IWBs. This finding relates to the work of Sedighian and Sedighian as early as 1996, which indicated that educational computer games and other electronic artefacts had positive effects on the learning of mathematics (§ 2.4.2.1). Utterances which related to the research participants' positive experiences towards the use of the IWBs were:

> *I always learn something new. It can help me a lot to improve my maths (P1:4)*
>
> *It motivates me a lot and it makes mathematics fun and easy and simple (P1:8)*
>
> *Those scaffolds are fun and make it more easier for maths to be easy and fun. I find it very easy and interesting (P1:12)*
>
> *It makes things our lives easier because the more you know you can get information from the internet and you can go whatever you want and whatever you want from the internet then in that way we can say the technology part can be used to into the fullest for now people won't have that fear to use this internet or technology things that are used to them (P2:12)*
>
> *Actually my impression was so high why? because it was the first time I ever see eh the facilitator or an educator can teach someone from let me say Limpopo whereby he or she was in North West. It was so I was so amazed the whole whiteboard uh thing. I can even ask even if I'm in Limpopo I can even ask a question any question that I want to ask and the facilitator can give me that answer directly so as if she was in front of me (P2:16).*

5.5.3 Barriers that affected participants' reactions towards learning with technology

The participants' reactions were affected by several barriers that they encountered during learning with IWB technology. These barriers related to issues of technical nature and insufficient time. Figure 5.3 represents a network of codes relating to the barriers that affected the reaction of participants towards teaching via IWBs.

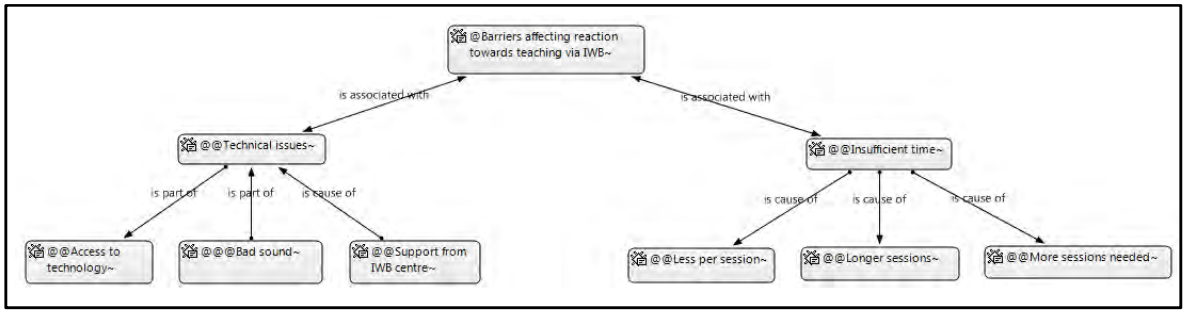


Figure 5.3: Codes corresponding to the barriers that affected participants' reactions to the scaffolding via interactive whiteboards

5.5.3.1 Technical issues

Three codes related to challenges due to *technical issues*: (i) access to technology; (ii) bad sound; and (iii) support from the IWB centre.

In 2013, Wild (2013) reported that the Internet penetration in SA was sluggish due to the high cost of connectivity in SA. Although the number of Internet users in the country has increased from 100 000 in 1994 to 11.2 million in 2012, it is in reality, still only one fifth of the population who have ready access to the Internet (§ 2.4).

Participants reported that facilitators often left once a session had started, and when technical issues arose during sessions, there was no one to address their problems. Though regular IWB sessions took place at more than fifty UODL regional centres during the study/research with few interruptions, Internet connectivity could at times be inadequate. Congestion on the Internet network in the vicinity of a regional centre may result in poor sound quality during the IWB conference meeting at the particular centre. Internet failure on the part of the Internet service provider, power interruptions which affect the equipment at the regional centre, or human failure which results in improper technological procedures, may all influence the success of an IWB session negatively. The UODL is progressively implementing quality assurance procedures to improve the technological performance and experiences of students and staff partaking in IWB sessions. Participants reported times when the sound at their centre was so bad as a result of poor Internet connectivity that they had to change to silent mode. Poor sound and interruptions as a result of poor Internet connectivity caused frustrations and negative reactions to teaching and learning with technology. Students often travelled far to attend broadcasts at remote centres and they experienced disappointment when the learning opportunity failed due to technical issues. Research participants perceived that the technology had failed them, while they were ready to engage with the learning technology system. McKenzie (2001) argues that implementation of technology has to be stable and users have to be trained to use the technology effectively (§ 2.4.1). Utterances of participants on technical issues were:

> *Sometimes when you speak to us through the WB we cannot hear you clearly and sometimes when we ask questions you cannot hear us. (P1:29)*
>
> *Because like you find that some of the students are making a noise maybe the chairs or something so we cannot hear you clearly sometimes. (P1:33)*
>
> *I apologise if maybe I'm saying something wrong there are days when we are just left there in the centre ne with the laptop there no one to uh show us that if you want to do this come ye they just moved you there and go away then you're just sitting there (P3:35)*
>
> *we couldn't hear you properly we were at that centre and there was no one to help us we just had to go forward uh go nearer and then listen to you because no one was there to help us We ask someone to up the volume but [ja] but no one helped us (P3:37).*

When students from different centres attempt to use the interactivity feature of the IWB by simultaneously writing requests on the IWB, chaos may result. In order to prevent such occurrences, specific steps are needed to coordinate student participation from different centres. This, however, creates and adds to issues relating to time insufficiency.

5.5.3.2 Insufficient time

Three codes generated by Atlas.ti™ related to challenges due to *insufficient time*: (i) more sessions needed (ii) less content or fewer concepts per session, and (iii) longer sessions.

Many students experienced Mathematics difficult to master—even more so when they are doing it over distance. They generally need a lot of support and timeous instruction to understand the mathematical concepts. The UODL at the Potchefstroom Campus of the NWU offers various courses of which several modules have to be facilitated via IWBs. Student-teachers are employed adults and can therefore not attend IWB sessions at any time. The participants requested longer sessions for Mathematics modules. Alternatively they suggested more sessions during which the lecturer could deal with fewer concepts at a time. Utterances of participants on time inefficiency were:

> *Just longer sessions, you can take only an hour and a half maybe Yes. That will be much appreciated (P1:24)*
>
> *If you can please ask them for time most of the time we do maths later where early in the morning we start with the other modules (P1:16)*
>
> *The fact that we have many questions but it is time is very limited because there's another lecturer coming in so she said she has to stop even if all the questions were not answered (P3:18)*
>
> *The sessions are too short for students to interact (P5:16).*

5.5.4 Supporting responses from questionnaires relating to students' reaction

Participants' responses from the questionnaires revealed more about their reaction towards mathematics education via IWBs. Two questions (questions 2.1 and 5.1, Addendum 3.7) in the student questionnaire related to reaction and the researcher reported the corresponding frequencies in Table 5.2.

Table 5.2: Students' reaction towards mathematics education via interactive whiteboards

Question number	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1.2	The IWB sessions met my expectations	4	6	-	-	-
5.1	I would recommend the IWB sessions to other students of the module NWPK 512	8	2	-	-	-

Table 5.2 indicates that the participants were generally in favour of scaffolding mathematics facilitation via IWBs. Six out of ten participants agreed that the sessions met their expectations while the rest strongly agreed. Eight out of ten participants strongly agreed and two agreed that they would recommend the sessions to their peers.

5.6 Sub-question 2: How do students perceive their learning that takes place through scaffolding of mathematics via interactive whiteboards? (Level 2)

The aim of education is learning; therefore an education process is only successful when learning occurs. Learning is a continuous process and students learn by building new ideas onto existing ideas in order to broaden their range of knowledge. Learning therefore is an active process during which students learn better when they are actively involved in the process. Constructivists like Tanner et al. (2005) believe that teaching no longer comprises one-way communication, but that it is a two-way process in which students actively take part (§ 2.4.1). Tam (2000) describes learning as a change in meaning constructed from experience (§ 2.4.1). It is a personal process which emphasises the construction of knowledge.

The qualitative data relating to students' perceptions of their learning were collected through individual and focus group interviews as well as questionnaires. Figure 5.4 depicts the network of codes relating to the theme of perceived learning of participants as generated in Atlas.ti™.

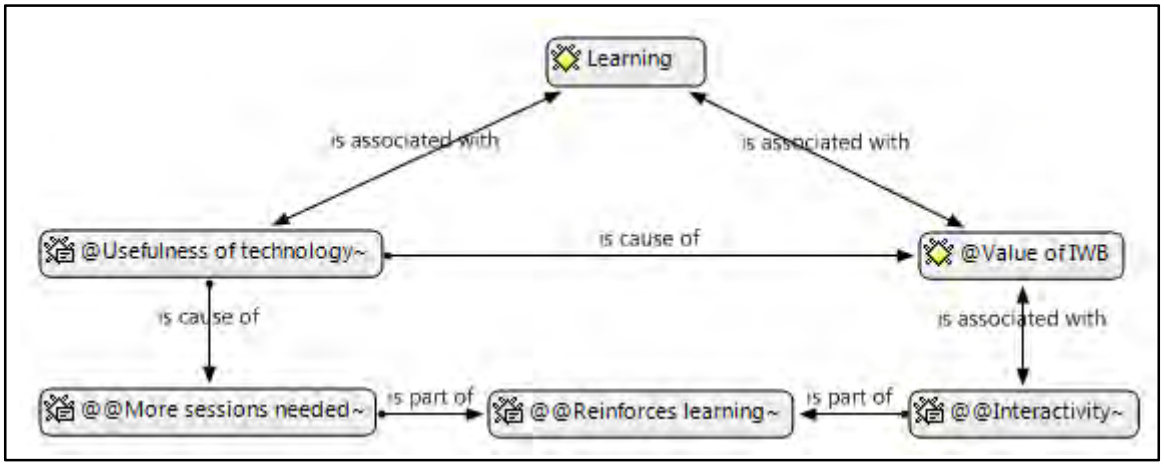


Figure 5.4: Codes corresponding to students' perceived learning that occurred as a result of scaffolding mathematics facilitation via interactive whiteboards

The two themes associated with students' perceived learning were the usefulness of technology and more specifically the value of IWBs. Three inter-related codes associated with the themes were that more sessions were needed with better interactivity in order to reinforce learning.

5.6.1 Usefulness of technology

Two codes related to the *usefulness of technology* within this study: (i) more sessions were needed, in order to (ii) reinforce learning.

The researcher identified from the interviews that participants were willing to engage in technology once they had overcome their initial technophobia. They commented that technology could profitably

be used in education. Participants did, however, request more sessions to be broadcast during which the lecturer could explain the mathematical concepts of the module. They claimed that more and/or longer sessions would support the reinforcement of their learning. Some students had their own laptops and individual access to the Internet. When students experienced fun while learning, they were motivated to learn more. In 1996 Sedighian and Sedighian established that educational computer games and other artefacts contributed to the learning of mathematics (§ 2.4.2.1). To become self-directed, students had to portray intrinsic motivation and strive to shift the focus from knowledge-as-possession to knowledge-as-construction (Dweck, 1986). Salomon and Perkins (1998) state the affordances of computers assist in shifting the focus from learning as an extrinsic guided activity to a self-guided activity (§ 2.4.1). Utterances of participants on the usefulness of technology to specifically reinforce learning were:

> *It helps me a lot, it even helps me to practise, it motivates me a lot (P1:8)*
>
> *I think those games are very helpful even though they are fun, they make it easier for maths to be easy and fun (P1:12)*
>
> *It reminds us of lots of things we forgot long time ago so it brings them back (P1:72)*
>
> *If a learner or an adult can teach or accept the way technology brings things to us and it makes our lives easier because the more you know you can get information from the internet then in that way we can say the technology part can be used into the fullest (P2:12)*
>
> *When you are learning something you see the pictures and stuff they can learn more [hmm] and get more understanding I think (P3:42)*
>
> *Also it gives different kind of method how to deal with problems (P2:5).*

The participants in general were excited to learn with technology and claimed that it supported their learning.

5.6.2 Value of interactive whiteboards

Two codes related to the *value of IWBs*: (i) interactivity and (ii) reinforce learning.

The participants requested more interactivity during teaching and learning sessions. They wanted their learning experiences to be more like familiar face-to-face teaching. Interactivity is an important feature which distinguishes IWBs from other technologies like overhead projectors and scanners. It enables participants who join a meeting to communicate interactively with one another without physical proximity. Research supports the importance and contribution of interactivity in ICT. Beauchamp and Parkinson (2005) and Brown (2010) claim that interactivity enables students to sustain two-way communication with rapid and dynamic feedback and response (§ 2.4.1.2). Participants also reported that the IWBs supported and reinforced their previous learning. They could watch recorded sessions again and again in order to clarify certain concepts they do not grasp well. They could also engage with scaffolds on specific topics through the Internet when needed. Utterances of participants on the value of IWBs and the reinforcement of their learning experience were:

> *It can help me a lot to improve my maths (P1:4)*
>
> *Did not understand something then you stop it then you go back (P3:20)*

It reminds us of lots of things we forgot long time ago so it brings them back (P1:72)

My impression was so high why? because it was the first time I ever see the facilitator can teach someone from let me say Limpopo whereby he or she was in North West (P2:16)

Students want to become more involved during the session (P6:21)

I can even ask any question that I want to ask and the facilitator can give me that answer directly so as if she was in front of me (P2:16).

The participants reported a positive attitude towards the scaffolding of mathematics via IWBs and they claimed that their learning was reinforced through their engagement. They enjoyed engaging in the activities because they had fun while learning mathematics through the activities which were enhanced with colour, sound and interactive remarks. The participants also claimed that they could learn from one another while performing the activities provided with the scaffolds. The researcher is of the opinion that the value of the IWBs at the UODL would increase significantly if the interactive facilities of the IWBs would function properly during broadcasting sessions.

5.6.3 Supporting responses from questionnaires relating to learning

Students' responses in the questionnaires revealed positive perceptions of their learning. This could be because their reaction towards teaching and learning via IWBs had already changed from initial scepticism to being more open to technology. The participants reported that the scaffolding sessions enabled and supported them in mastering basic mathematics concepts. Previous researchers describe scaffolding as a teaching strategy and technique that facilitators use to assist students during learning (§ 2.4.2.2.1). They define scaffolding as a bridge which facilitators use to build upon what students already know, to arrive at something they do not know. These opinions relate to the work of Benson (1997), Minick (1999) and Van der Stuyf (2002).

Six out of 24 questions in the questionnaire (Addendum 3.6) related to learning. Frequencies of the students' responses are summarised in Table 5.3.

Table 5.3: Students' perception of their learning

Question number	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1.1	The IWB instruction was effective	8	2	-	-	-
1.3	The IWB sessions addressed the issues I needed at the time	3	7	-	-	-
2.3	I gained more confidence in teaching mathematics	6	4	-	-	-
2.4	My own understanding of the fundamental principles of Algebra improved	3	6	1	-	-
3.6	I used the information and skills I learnt from the IWB sessions in dealing with my students	8	2	-	-	-
4.2	I improved in understanding my own understanding of the fundamentals of Algebra	3	7	-	-	-

The students' perceptions on whether learning occurred as a result of attending the IWB sessions were mostly positive and 59 out of sixty responses either agreed or strongly agreed that learning

indeed occurred. Only one student responded neutrally on her/his own understanding of the fundamental principles of Algebra, but s/he replied positively on all other questions related to learning. The participants claimed to have gained more confidence to teach Mathematics, and replied that their understanding of the fundamentals of Algebra, as well as their metacognitive skills, i.e. understanding of their own understanding, had improved. The researcher therefore deduced from the responses to the questions that participants generally perceived that learning had occurred as a result of attending the scaffolding IWB sessions.

5.7 Sub-question 3: Do students' supervisors note any change in their on-the-job behaviour as a result of learning mathematics augmented with scaffolding during interactive whiteboard classes? (Level 3)

The third sub-question determines the degree to which the students' supervisors noted a change in their on-the-job behaviour as a result of the scaffolding IWB sessions. The researcher addressed the variable "change in behaviour" by compiling a frequency table and a graph to represent the variable graphically. The supervisors' responses were used to report and discuss the on-the-job change in behaviour of the teacher-students.

According to J. Kirkpatrick (2007) the key to training and development effectiveness is the application of what was learnt. This means that learning is worthless if it is not applied and does not bring about a change in behaviour. The questions of the questionnaire were formatted to specifically determine the change in behaviour of the students as a result of having attended the IWB sessions and were addressed to the participants as well as their supervisors. Twelve of the 21 questions on the supervisor questionnaire (Addendum 3.8) related to the change in behaviour of the participants. Frequencies of the supervisors' responses are summarised in Table 5.4.

Table 5.4: Students' changes in behaviour as observed by their supervisors

Question number	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1.1	The student's own understanding of fundamental principles of Algebra improved	6	3	-	-	-
1.2	The student is motivated to succeed in his/her studies	7	2	-	-	-
2.1	The student uses the information and skills in dealing with his/her co-teachers	5	4	-	-	-
2.2	The student uses the information and skills in dealing with his/her peer mathematics teachers	8	2	-	-	-
2.3	The student uses the information and skills in dealing with the public	3	5	1	-	-
2.4	The student uses the information and skills in dealing with his/her community	3	6	-	-	-
2.5	The student uses the information and skills in dealing with his/her family	4	4	1	-	-
3.1	The student is more competent in understanding him/herself and others	5	3	-	-	-
3.4	The student improved in listening more effectively	9		-	-	-
3.5	The student improved in solving problems	4	5	-	-	-

3.7	The student improved in motivating students to excel in mathematics	9	1	-	-	-
3.8	The student is more competent in changing people's attitudes towards mathematics	9	1	-	-	-

The frequency table, representing data generated by the supervisors' questionnaire, reveals the following responses relating to the change in behaviour of participants after they have attended the IWB-sessions. Nine out of ten supervisors claimed that the student's own understanding of the fundamental principles of Algebra had improved; the tenth supervisor did not comment about it. Most supervisors noted that students were motivated to succeed in their studies and therefore also in their careers as mathematics teachers. Furthermore the students applied their newly gained information and skills in dealing with their fellow teachers, the public and their communities, their families, and they motivated their own learners to have positive attitudes towards mathematics in order to excel in mathematics. Figure 5.6 represents the distribution of the change in behaviour of the participants as it was noted by their respective supervisors.

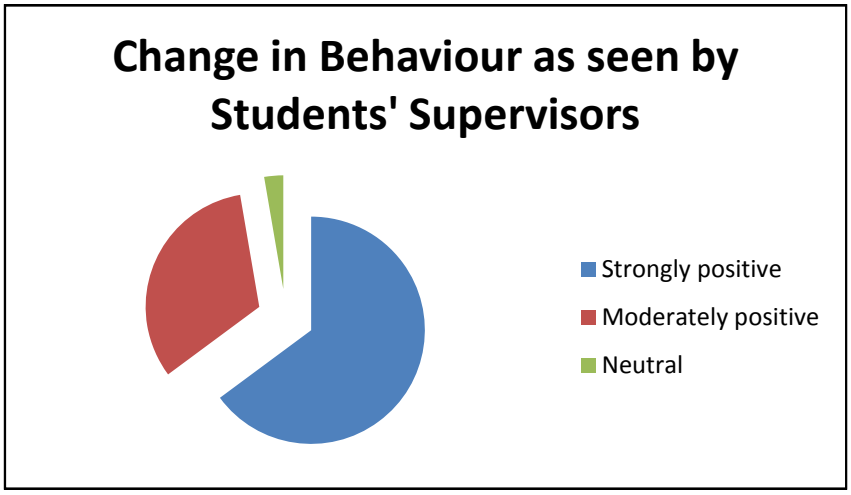


Figure 5.5: Students' change in behaviour as reported by their supervisors

In summary students' supervisors indicated that teacher-students' on-the-job behaviour changed dramatically after having attended the IWB-sessions. The address to the sub-question on change in behaviour therefore is the participants' behaviour has changed for the better.

5.8 Sub-question 4: Do students perform better in the post-test than in the pre-test after attending mathematics scaffolding during interactive whiteboard sessions? (Level 4)

The fourth sub-question determines whether students performed significantly better in the post-test than in the pre-test, and the researcher will discuss this by referring to the findings of descriptive statistics, the results of the paired t-test as well as the non-parametric Wilcoxon signed-rank test. Numerically, quantitative data are represented in three ways: through location (the mean, mode and median), through dispersion (the range, inter-quartile range, variance and standard deviation) and through measures of shape (the skewness or kurtosis) (Pietersen & Maree, 2007c). Widely used

graphs to represent quantitative data are the histogram, the bar graph, the frequency polygon and the box-and-whisker plot. A big advantage of representing data graphically is that the main characteristics of the distribution can immediately be observed. The five-point summaries of the raw test marks for the pre- and post-tests of the experimental (EG) as well as the control group (CG) are represented in Figure 5.7. When looking at the graph it seems as if there is a slightly bigger shift within the experimental group than within the control group. The tests were marked out of thirty.

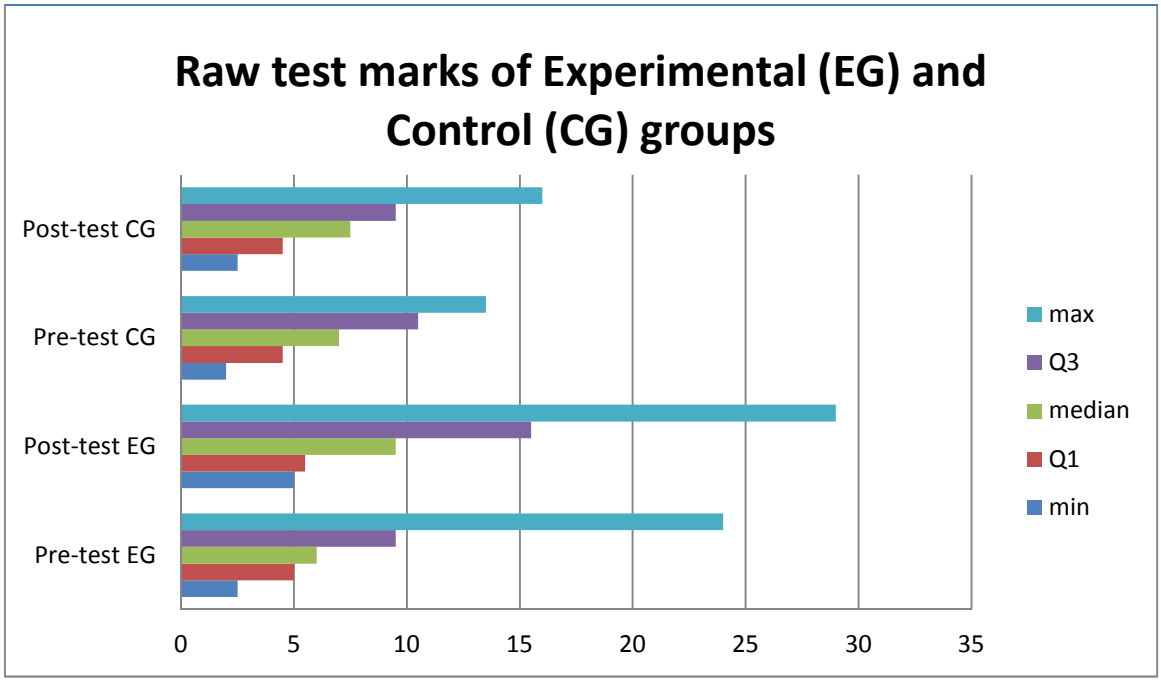


Figure 5.6: Five-point summaries of pre- and post-tests

Although the evaluation of results of attending the IWB sessions were determined by the participants' performances in the pre- and post-tests, three of the questionnaire questions (Addendum 3.7) also related to performance of participants after having attended the IWB sessions. The researcher is of the opinion that performance goes beyond change-in-behaviour only and therefore addressed these questions at level 4 and not at level 3. The response frequencies for these questions are presented in Table 5.5.

Table 5.5: Students' results and performances

Question number	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1.5	The IWB sessions enhanced my understanding of the fundamental principles of Algebra	3	7	-	-	-
4.3	I improved in communicating more clearly in writing	4	6	-	-	-
4.6	I improved in communicating more effectively in speaking	5	3	2	-	-

On questions relating to results or their performances, participants did not report positively on only two of the responses. Two of the ten participants were neutral about improvement in spoken communication. All the participants were positive about improving their written communication as well as enhancement of their understanding of the fundamental principles of Algebra, as done in NWPK 512.

The results for the pre- and post-tests of the experimental group were analysed to check for statistical significance against the results of the pre- and post-tests of the control group. A normal parametric t-test was performed, but because the participants were less than thirty, the researcher could not assume that the test marks were normally distributed within the population. The statistician suggested that a non-parametric test would be more accurate. Therefore the quantitative data generated by the pre- and post-tests were analysed according to the Wilcoxon signed-rank test. This non-parametric test is similar to the t-test where two variables are compared in a single sample (Pietersen & Maree, 2007a). The paired samples statistics calculated by the t-test are nevertheless reported on and are presented in Table 5.6.

Table 5.6: Paired sample statistics from parametric t-test

Student group	Test	Mean	Standard deviation	p-value	Effect size
Experimental group	Pre-test	8.75	6.56	0.02	0.39
	Post-test	11.30	7.39		
Control group	Pre-test	7.50	3.47	0.55	0.13
	Post-test	7.95	4.46		

The mean was 8.75 and the standard deviation was 6.56 for the pre-test; for the post-test the mean was 11.30 and the standard deviation was 7.39 for the experimental group. The corresponding means and standard deviations for the control group were 7.50 and 3.47 for the pre-test versus 7.95 and 4.46 for the post-test. These statistics yielded a p-value of 0.02 for the experimental group and 0.55 for the control group. The p-value indicates the level of statistical significance of the improvement. A p-value less than 0.05 indicates significant improvement, and a p-value greater than 0.05 indicates no significant improvement. The calculated effect sizes of the two groups of students were 0.39 for the experimental group and 0.13 for the control group. Effect sizes of variables tell whether the improvement is significant in practice and guidelines of significance are given as 0.20 for small effect and 0.50 for medium effect. The researcher therefore deduces from the t-test statistics that the

improvement of the experimental group participants' results might be significant in practice, but will extend the analysis to a non-parametric test in seeking more reliable indication thereof.

The statistics generated by the non-parametric Wilcoxon signed-rank test will therefore be interpreted in order to determine whether the improvement was significant in practice. The two variables concerned in the study were the differences between the pre-and post-tests of the experimental group compared to the differences between the pre-and post-tests of the control group. The researcher wanted to determine whether test results for the two groups had significantly improved. The statistics generated by the non-parametric Wilcoxon signed-rank test are presented in Table 5.7.

Table 5.7: Statistics from non-parametric Wilcoxon signed-rank test

Variable	Ranks	Mean Rank	Sum of Ranks	p-value	Effect size
Experimental group [Post-test-pre-test]	Negative	4.00	4.00	0.02	0.54
	Positive	5.67	51.00		
Control group [Post-test-pre-test]	Negative	6.63	26.50	0.92	0.02
	Positive	4.75	28.50		

The Wilcoxon test yielded p-values equal to 0.02 and 0.92 respectively, and effect sizes equal to 0.54 for the experimental group and 0.02 for the control group. The non-parametric guidelines of practical significance are given as 0.10 for small effect and 0.30 for medium effect and 0.50 for large effect. This clearly showed that the results improved significantly from pre-test to post-test within the experimental group, and did not improve significantly within the control group.

5.9 Sub-question 5: How does the return on investment of not using mathematics scaffolds on interactive whiteboards compare to facilitation with mathematics scaffolds on interactive whiteboards? (Level 5)

5.9.1 Return on investment related to human capital

The ROI in human capital refers to the enrichment of both lecturers and students, with respect to enhanced competency and valued education. Figure 5.5 depicts the network of codes relating to ROI in human capital as generated in Atlas.ti™.

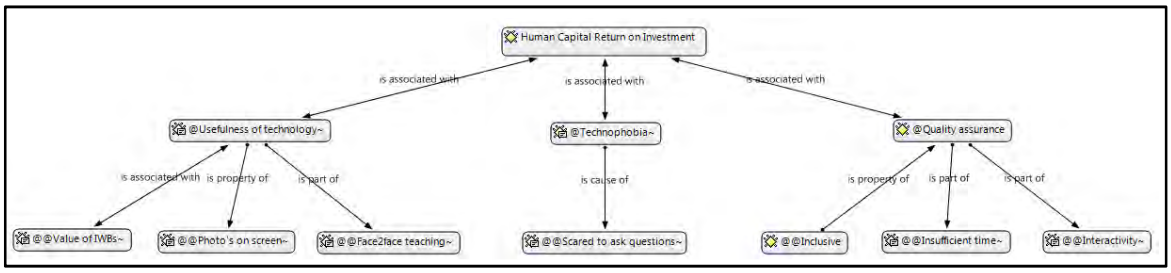


Figure 5.7: Codes corresponding to lecturers' as well as students' return on investment in human capital

The three themes associated with ROI in human capital were the use of technology, technophobia and quality assurance. Three codes which related to the use of technology, one which related to technophobia and three which related to quality assurance, were generated in Atlas.ti™.

5.9.1.1 Usefulness of technology

The three codes relating to ROI and which related to the *usefulness of technology* were: (i) value of IWBs, (ii) teaching face-to-face, and (iii) photos on screen. Although the participants and the lecturers were used to and were comfortable with face-to-face mode of teaching, they were positive about using technology and claimed that education via technology was the way forward. Improved technology made it possible for the lecturer, who was the specialist of the module, to teach all students at the same time, with the same enthusiasm, offering the same quality. The technology therefore enhanced the engagement of students with their own learning experiences in order for learning to become less teacher-centred and more exploratory in nature (Goos et al., 2001). Utterances of participants on the use of technology during their learning experiences were:

> *My impression was so high why? because it was the first time I ever see the facilitator or an educator can teach someone from let me say Limpopo whereby he or she was in North West (P2:16)*
>
> *I still prefer face-to-face, but for students who never got taught by the actual lecturer, it is good for them to have lessons presented by the lecturer rather than facilitator (P5:41)*
>
> *I like the face-to-face contact, but realise that more could be achieved with IWBs if it could work more effectively (P6:41)*
>
> *No, I don't have a problem with the WB, seeing the lecturer on the screen because for me it's another method of study and learning (P1:53)*
>
> *I like using technology and think it is important for the way forward (P5:8).*

5.9.1.2 Technophobia

The participants, as well as lecturers experienced *technophobia* when they were first exposed to learning with technology (§ 5.5.1). A single code relating to the ROI in human capital and which related to technophobia was generated in Atlas.ti™: (i) scared to ask questions. Participants' responses in the questionnaires also revealed that they were scared to ask questions during IWB sessions. They claimed that they did not want everybody to hear when they asked stupid questions. Utterances of participants on their technophobia were:

Sometimes I become sceptical just go and there at the mike and then I answer the question or ask something it's not like it is when you are here with us (P3:30)

I think many fear the technology and don't interact because they don't know how or are scared to say something silly that everybody will hear (P6:35)

I don't remember in all the courses that I attended someone here in Nelspruit in White River going to that computer and asking something I mean in the modules that I'm doing (P3:32).

5.9.1.3 Quality assurance

Three codes related to the theme *quality assurance*: (i) inclusive, (ii) insufficient time, and (iii) interactivity.

In order to make changes to traditional teaching methods in the teaching and learning context, technology could be used as a powerful tool (Yushau et al., 2005). Technology provides the opportunity to organise and amplify thinking, teaching, and learning processes. Quality assurance determines whether teaching and learning occurs successfully. Factors like equal opportunities for all students, student-lecturer interactivity, and optimal teaching time during sessions are vital to the quality of the process. Utterances of participants on control of quality were:

Lecturers can at same time reach many centres and not only the one centre s/he is visiting in person (P4:7)

There is more control that all students receive the same and equal quality lecture (P4:9)

For students who never got taught by the actual lecturer, it is good for them to have lessons presented by the lecturer rather than facilitator (P5:41)

It is time is very limited because there's another lecturer coming in so she said she has to stop even if all the questions were not were not answered (P3:18)

I can even ask even if I'm in Limpopo I can even ask a question any question that I want to ask and the facilitator can give me that answer directly so as if she was in front of me (P2:16).

5.9.2 Return on investment related to monetary expenses

This sub-question relates to the financial ROI, the monetary benefit that the UODL got from implementing the new mode of delivery when compared to the monetary expenses it showed in the previous face-to-face mode of delivery. The comparison will be represented numerically and narratively.

The centre manager of the UODL revealed the figures in Table 5.8 which demonstrate elementary monetary implications for the UODL.

Table 5.8: UODL's costs for face-to-face training versus interactive whiteboard training

Year	Budget	Cost Items	Number of centres
2010	R900 000	Travelling and accommodation	26 centres
2014	R420 000	Internet and bandwidth	36 centres

The UODL claims everyone involved in the IWB setup benefits from it: lecturers do not have to travel far and be away from home so often; a lecturer teaches students across the country who are joined in the meeting simultaneously; students are taught by the lecturer who is the expert on that module and not only by facilitators who might have different approaches; and a centre manager has annual meeting with 51 coordinators of centres at the same time. Although the centre manager claims that students get more and better quality education for R420 000, students' replies did not quite reveal that.

The IWB mode of delivery urges the UODL to spend money on doing quality control at centres. This amount aggregates to less than one eighth of the previous face-to-face model because only one or two people from the UODL visit centres to do quality control—in the previous model all lecturers were sent to centres in order to do quality control. To control quality of programmes and IWB sessions, all broadcasts are recorded and could be checked and revisited. The UODL furthermore ensures quality control by letting students and facilitators complete questionnaires semesterly.

The UODL keeps attendance registers of all IWB sessions. Table 5.9 provides numbers of attendances at the winter school for the past two years.

Table 5.9: Winter school attendances

Year	Number of students attending IWB-sessions during Winter School	
	BEd Hons	All programmes
2013	2325	8445
2014	3025	14866

In general classes showed a fifty per cent increase in attendance numbers from 2013 to 2014. According to the centre manager of the UODL, reasons might be that at first students were sceptical about the IWBs, but when they getting more comfortable with technology, they started to prefer IWB sessions by the lecturer to face-to-face lectures by the facilitator. This, however, depends on where students lived and the degree to which they were tech-literate. Students from Johannesburg and Port Elizabeth were satisfied with IWBs only, but students living in rural areas and attending at Mthatha and Bisho, preferred a facilitator to IWB classes. Such students needed the face-to-face communication offered by the facilitator. The UODL is therefore committed to keep offering facilitator classes as the availability of facilitators at regional centres reinforces their commitment towards quality education.

5.10 Reliability

The reliability of an instrument is the extent to which it is consistent when repeated because it will be of no use if it gives different scores from one day to another. This means that if the same instrument is used at different times to different subjects from the same population, the findings should be the same (Pietersen & Maree, 2007b). The internal reliability, also referred to as internal consistency of an instrument, is determined by the degree of similarity between various items which are formulated in a specific way in order to measure a certain construct. The alpha coefficient of Cronbach gives the correlation between different items of an instrument and is used to measure this degree of similarity. A coefficient close to one is interpreted as strong correlation between the different items and a coefficient close to zero indicates that different items of the instrument do not correlate strongly. The following descriptors for Cronbach's alpha coefficient are used to interpret the reliability of an instrument: 0.9 relates to high reliability; 0.8 relates to moderate reliability; and 0.7 relates to low reliability (Pietersen & Maree, 2007b).

The measuring instrument used in this study was a pre-test that participants wrote before commencing with the programme. The pre-test consisted of ten items which were formulated to measure the participants' mathematics knowledge on fundamental principles of Algebra. Cronbach's alpha coefficient was calculated as 0.908 and therefore indicated a high degree of similarity between the ten items of the pre-test which implied high reliability and that a total score for the pre-test might be used in order to measure participants' mathematics knowledge.

5.11 Validity

A valid instrument measures what it is supposed to measure. If an instrument is not reliable it can also not be valid. Face validity relates to whether the instrument seems to be valid, and content validity refers to whether the instrument covers the complete content relating to the construct it has to measure (Pietersen & Maree, 2007b). The researcher of this study conferred with other experts in the field of mathematics and mathematics education when compiling the instrument. She incorporated their input and recommendations to ensure the validity of the pre-test.

5.12 Chapter summary

This chapter reported on the analysis of the data—both qualitatively and quantitatively. The researcher interpreted and discussed the data, managed and summarised the data, and presented it in various ways. Through analysing the data she aimed to answer the five sub-questions of the study in accordance with the Kirkpatrick evaluation method used during the study and finally offered an answer to the main research question.

The next chapter refers to conclusions drawn from results of the research, implications of the research and recommendations generated by the research and will be reported by the researcher of this research.

Chapter Six

Conclusions, Implications and Recommendations

6.1 Introduction

We live in a world where mathematics concepts have become universal (Joyce, 1998) and where most people probably use mathematics in their everyday living (The Universal Language, 2013). Mathematics and mathematics education are important and much effort is made to explore different ways of approaching mathematics education and teaching mathematics in order to make it more effective.

The purpose of *design integration of interactive whiteboards in an open distance mathematics programme* was to evaluate how the scaffolding of mathematics concepts via IWBs could contribute towards the success of design integration of a learning technology at the UODL at the NWU. Assuming that a teaching and learning technology like an IWB could enhance the scaffolding of mathematics in an ODL programme, the study involved a group of registered teacher-students of a Mathematics module at the UODL. Scaffolding is a technique that facilitators use to assist students during teaching and learning (Minick, 1999). ODL students should take responsibility for their learning; they should search for information in order to discover and construct new ideas from existing ideas (Coffey, 2009).

In order for DE teacher-students to take responsibility for their learning and to become independent learners (Tam, 2000), the researcher designed a learning space comprising *inter alia* web-based activities relating to fundamental principles of mathematics available on the Internet. These web-based scaffolds comprising learning activities, PowerPoint presentations, games, simulations and models on mathematics concepts which could interactively be linked to at any time convenient to the student. The web-based activities could therefore be used as scaffolds to support and enhance the students' understanding of the fundamental concepts of mathematics. From the learning theory of constructivism, scaffolding is a teaching strategy facilitators can use to assist students during their learning in order for them to become more self-reliant and independent learners (Valkenburg, 2010). Committed engagement in these activities could reinforce the teacher-students' understanding of mathematics, improve their Mathematics module outcomes, and ultimately result in their better understanding of the fundamental principles of mathematics, and the increased performance of their learners in their respective classrooms (Sedighian & Sedighian, 1996). Mathematics students were introduced to web-based activities as scaffolds in order to better understand the fundamental principles of Algebra. The aim was that teacher-students should consequently independently search for relevant mathematics inter-actives in order to address the respective challenges they encountered while studying (Sedighian & Sedighian, 1996).

Since many practicing teachers in South Africa are unqualified and under-qualified, it causes a vicious circle in the teaching and understanding of Mathematics (Hawker, 2013). Teachers who do not understand the fundamental principles of mathematics themselves have to teach their learners. It is almost inevitable that effective mathematics education will become difficult to achieve. For many practicing teachers, the only way to further their professional development and obtain a first or additional qualification is to embark on DE. When studying over a distance, teacher-students in mathematics face many challenges in order to succeed. Contact sessions are too few and too short and also do not cover the full content of the modules. As the teacher-students are adult learners, they experience inconveniences to attend classes in foundation phase classrooms which were designed for small children and where chairs and tables are uncomfortable. Facilitators at the learning centres are also not always helpful. In summary, mathematics students require additional support when studying over distance.

The data analysis of this study was performed in accordance with the extended Kirkpatrick evaluation model (D. L. Kirkpatrick, 1998; Phillips, 2003). Kirkpatrick's model related to the evaluation of aspects on the reaction of the students, the students' perception as to whether learning occurred, their change in behaviour, their results, and the ROI of the course delivery. This chapter comprises a report on the lens of the research, overview of the various chapters relating to the study, addressing of the main research question, conclusions, implications of the findings, recommendations of the study, the value of the research, limitations relating to the research, future research relating to the current topic, and a reflection on my research journey.

6.2 Lens of the research

People view and experience their worlds through different lenses. This determines the way they live in and contribute to society. The functionalist paradigm relates to high objectivity and low societal control which consequently provides understanding of the evaluation of the teaching and learning relating to a specific mathematics module (Burrell & Morgan, 1979).

6.3 Overview of the various chapters relating to the study

6.3.1 Chapter 1: Introduction and statement of the problem

Chapter one provided an overview of the study and stated the research question and sub questions which guided the research. The main aim of the study was to determine how scaffolding of mathematics concepts via IWBs could contribute towards the design integration of IWBs as learning technology at the UODL at the NWU. Teacher-students majoring in mathematics at the UODL struggle to master the fundamental principles of mathematics. I wanted to support them in

understanding the mathematics in order for them to teach more effectively in their respective classrooms. Therefore I introduced them to scaffolds as web-based activities relating to mathematics concepts and which were freely available on the Internet.

In order to gather the richest possible data, the participants were selected through purposive sampling. The participants were students attending contact classes at White River. Data collection took place through interviews with the research participants, questionnaires to participants, their supervisors, and centre coordinators, as well as through the use of a pre- and post-test. Data analyses were supported by Atlas.ti™ which assisted in identifying qualitative codes, categories and themes.

6.3.2 Chapter 2: Literature review

Mathematics involves inviolable principles and displays five basic characteristics: precision, definitions, reasoning, coherence, and purposefulness (Parker, 2007). Mathematics is central in our everyday lives and extremely useful on many levels. Yet, despite its importance, many people have a perception of mathematics being difficult and boring, very abstract, not very practical, and definitely not within everyone's reach. It is therefore not a surprise that many learners experience mathematics as a source of frustration, discouragement and anxiety instead of one of satisfaction and achievement (Ignacio et al., 2006).

The affective domain of mathematics is seen as a broad range of beliefs and emotions and is different from pure cognition. Here four different aspects seem to play a part in beliefs about mathematics and mathematics education: mathematics (the object); one self; mathematics teaching; and, the context in which the mathematics is educated (the social context). Learners' mathematics education is then influenced by their beliefs about mathematics and their beliefs about themselves and how they relate to mathematics (McLeod, 1990). The latter includes beliefs concerning confidence, self-concept and their attribution of causes to academic success or failure. It is further held that a learner's self-concept is a basic descriptor of his/her affective domain in mathematics and it relates to emotions, attitudes, motivation, personal expectations and attributions, academic success or failure. The role of affect has to be taken into consideration when teaching and learning mathematics (Ignacio et al., 2006).

Simonson (2007) asserts that DE usually involves the following four components: it is institutionally based; teachers and students are separated; interactive telecommunication takes place; and it involves sharing of data, voice and video learning experiences. When DL is implemented it involves a process in which available resources are used as well as the incorporation of emerging technologies. Education and learning over a distance indeed therefore can be described as the delivery of instruction to the right group of people at the right time in the right place (Bingham et al., 1999). South Africa has large numbers of unqualified and underqualified teachers (Hawker, 2013), and DE, is

therefore often the only option available to unqualified and underqualified practising teachers to further their professional development.

ICT has been incorporated in teaching and learning, and offers one way to combine distance and proximity and it has become part and parcel of ODL in many countries (Ferreira & Venter, 2010). It is crucial never to lose sight of the fact that learning, and not the technology, has to be the focus. Learning thus invariably has to drive the technology and not the other way round (Picciano, 2002). To ensure the success of DE, and to add to its effectiveness, the use of technology could significantly help to transform the way DE is delivered (Tam, 2000). Success in DE will only be achieved if the various role players consistently assess their own scenarios in order to adjust and customise their mode of delivery to benefit students. Added to this, technology has also changed dramatically and continuously over the years, and therefore learning at a distance has gone through various generations (Fozdar & Kumar, 2007) and this should not be forgotten.

Taylor (2001) identified the first four generations of learning at a distance and Fozdar and Kumar (2007) added a fifth generation for teaching and learning at a distance. The UODL currently only relates to both the first and third of the generations as identified by Fozdar and Kumar (2007). Quality ODL requires interactive communication between students and lecturers. With the aid of modern LT it would be possible. When new technologies for teaching and learning in distance education programmes are implemented, the technology should be based on seven principles. It should (i) encourage contact between students and facilitators; (ii) develop reciprocity and cooperation among students; (iii) use active learning techniques; (iv) provide prompt feedback; (v) emphasise time on task; (vi) communicate high expectations; and (vii) respect diverse cultures, talents and ways of learning (Beldarrain, 2006; Mdakane, 2011).

South Africa faces many developmental problems and is one of the more complex societies in the world. Sarah J Howie and Blignaut (2009) stated that the main constraints of implementing ICT in South African schools were: financial constraints, insufficient computer literacy amongst teachers, insufficient training regarding integration of computers into different learning areas, and the absence of a properly developed curriculum for teaching computer skills. Furthermore it must be kept in mind that technology enters into teaching and learning according to four different roles which are metaphorically listed as the *master*, *servant*, *partner* or an *extension of the self* (Goos et al., 2001). However, there is no doubt that teachers can use technology to teach effectively, to ensure students are engaged in their own learning process and as well as to add to their understanding of fundamental concepts.

Cobb (2012) defines learning as the lifelong process of transforming information and experience into knowledge, skills, behaviours and attitudes and describes different ways to become a better learner. Learning is a constructive activity and an active process. The core idea of learning is that students should actively construct their own knowledge. Constructivists claim two common characteristics central to effective learning: (i) real-life problems to stimulate the exploration and necessary reflection

for knowledge construction, and (ii) collaboration as students learn better through interaction with others (Tam, 2000). Here the role of technology should not be underestimated—it has the capacity to organise and amplify our thoughts, teaching, and learning processes (Yushau et al., 2005). Technology is a way of solving problems through the application of knowledge from multiple disciplines. Learning with technology is the broad range of communication, information and related technologies that can be used to support learning, teaching and assessment (Association for learning Technology, 2010a), and focuses on the use of technology to support teaching and learning innovations. Learning with technology, however, also has its shortfalls. McKenzie (2001) argues that students fall into a kind of cut-and-paste mentality which could undermine their ability to think. It should also be kept in mind that the implementation of technologies has financial implications for HEIs, as well as for students. Technology users should also be trained in order to ensure effective use of the technology. Despite these disadvantages of learning with technology, technology can be used in order to support the teaching and learning that is expected to take place.

An IWB system is an ICT tool, comprising three components of technological equipment that aim to support teachers' teaching and learners' learning in ODL. Koenraad (2008) states that challenging and effective education implies independent learning and (co)construction of knowledge. An IWB should not be used in such a way that it merely furthers teacher-centred education. ICTs, of which an IWB forms a part, can be extremely helpful to support diversity, personalised learning and tele-collaboration. Teachers using IWBs at school seem to use them interactively to facilitate the teaching of students in order to support their learning. This results in a move away from didactical pedagogy to a more interactive one (Kent, 2006). The UODL at NWU's Potchefstroom campus applies IWBs in an innovative and different way since it uses IWBs on such a broad scale involving large numbers of students.

One of the prime characteristics that distinguish IWBs from other ICT tools is its interactivity. This means according to Koenraad (2008), that IWBs should not exclusively be used as presentation tools, but rather for their additional possibilities in terms of interactivity as well. This places the onus on teachers to ensure that they are lifelong learners who would want to master the use of new technology in order to enhance themselves and to let their students reap the benefits of this process (Van Wyk, 2011). The strength of IWBs is that they do not differ that much from the blackboard that teachers regularly use (Van Wyk, 2011). However, IWBs do offer more than just a certain level of familiarity. They offer general benefits which include the fact that IWBs allow flexible use for all ages; they provide ample opportunities for interaction and contribute to the increased levels of concentration and motivation of students and teachers. Unfortunately it also has its disadvantages (Koenraad, 2008), such as physical and financial limitations, and the fact that the novelty of the technology sensation often wears off after a while.

Effective mathematics teachers are the ones that see to it that they set tasks through which they support students to create connections. These connections are between different ways of solving

problems, between different mathematical topics as well as between mathematics and everyday experiences. Students develop better conceptual understanding and conceptual flexibility when making these connections. Mathematics teachers will be able to initiate learning and to act responsively towards the mathematical needs of their students if they possess sound content knowledge of mathematics themselves, and know how to extend, expand and challenge their students' thinking (Anthony & Walshaw, 2009). It is vital to realize that the technology itself cannot be seen as a magic wand that performs miracles. The professionalism of the teacher causes additional value to be realised (Koenraad, 2008). Students need to find the mathematics they have to learn, interesting and meaningful. They learn best if they enjoy what they do and if they receive support while doing it (Sedighian & Sedighian, 1996).

Scaffolding is a teaching strategy that can be used at all levels to improve student learning (Van der Stuyf, 2002). Scaffolding is a technique that facilitators use to assist students during learning (Minick, 1999). The facilitator determines the amount of scaffolding used based on his or her decision about the student's abilities and current levels of understanding (Valkenburg, 2010). The following four points will construct a simple structure of scaffolding assistance : (i) the instructor does it; (ii) the class does it; (iii) the group does it; and (iv) the individual does it (Faculty Development and Instructional Design Centre, 2008). With scaffolding the teacher can change the level of support to suit the cognitive potential of a learner. This will be done to guide the student to become an independent and self-regulated learner and problem-solver (Van der Stuyf, 2002). The nature of scaffolding guarantees individualised support in order to improve the student's ability to build on prior knowledge (Amiripour et al., 2012). When one considers scaffolding strategies, it is clear that these involve questioning, encouraging comments, active listening and giving interactional support with respect to the problem that a student has to solve (Greenfield, 1984).

It is important to keep in mind that scaffolding's success is dependent on the following: (i) the task at hand is meaningful and challenging, (ii) students participate actively in tackling the task, and (iii) the scaffold is tailored to the needs of the students (Kiong & Yong, 2001). There are four types of scaffolding that support learning: (i) procedural scaffolding assists in the use of the resource, (ii) conceptual scaffolding assists in focusing thinking, in prioritising information, in making connections between concepts or in simplifying complex concepts, (iii) strategic scaffolding assists by suggesting approaches or strategies directly or indirectly, and (iv) meta-cognitive scaffolding assists the students to reflect on what they have learnt (self-assess) or reflect on how they are learning (awareness of cognitive processes) (Hill & Hannifin, 2001). Scaffolding is seen as a crucial characteristic of constructivist learning. The scaffolding process will enable students to solve problems, carry out tasks, and achieve goals beyond their unassisted effort (Wood et al., 1976). One of the primary goals of constructivist teaching is that students learn how to learn by being trained to take responsibility for their own learning experiences (Bahbahani, 2006). Constructivism is applicable to the teaching and learning of mathematics and has two key hypotheses:

- a person actively constructs knowledge by cognizing the subject and not passively receiving it from the environment
- coming to know is an adoptive process that organises one's experiential world; it does not discover an independent, pre-existing world outside the mind of the knower (Kilpatrick, 1987).

Constructivists assert that learning must build upon a student's existing knowledge and experience—new knowledge is gained by students by using their prior knowledge. Effective learning is more likely to occur when a student is actively involved in his or her own learning. In classrooms where constructivists teach, there is active student involvement, interactive activities take place and these activities are student-centred. The environment in these classrooms is democratic and the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous (Gray, 1997). Scaffolding has various benefits such as: the engagement of students in meaningful and dynamic discussions in small and large classes; learners are motivated to become better students who have learnt how to learn; individualised instruction is provided; there are various opportunities for peer teaching and learning; scaffolds can be recycled for other learning situations; it challenges students through deep learning and discovering; and it provides a welcoming and caring learning environment (Faculty Development and Instructional Design Centre, 2008). Positive feedback helps students to feel confident and have greater belief in their abilities which in turn usually motivates the students so that they want to learn more. Scaffolding learning assists the student to deal with his or her frustration if they struggle with what is beyond their level of understanding. Added to that because of the fact that scaffolding is aimed at the individual, each student can reap the benefits of scaffolding.

Scaffolding, however, has some disadvantages as well. It is extremely time-consuming and often teachers' lack of certain appropriate skills during the implementation of scaffolding instruction, results in learners consequently not fully benefitting from it. Scaffolding as a teaching strategy will also ask of teachers to give up some of the control and allow their students to make errors. If these errors are dealt with appropriately, students usually learn from these mistakes. Furthermore, often manuals and curriculum guides are not compiled in a scaffolding way, or include examples of scaffolds that would be appropriate for the specific lesson content. The Faculty Development and Instructional Design Centre (2008) also added to the following challenges of scaffolding: (i) planning for and implementing of scaffolds is time-consuming and demanding; (ii) the selection of appropriate scaffolds to match the diverse learning and communication styles; (iii) the establishment of the abilities of students is not an easy task; and (iv) knowing when to remove the scaffold so that the student does not rely on the support forever.

6.3.3 Chapter 3: Research design and methodology

The research took place according to a mixed methods research design as suggested by Kirkpatrick's model of evaluating LT programmes. The qualitative and quantitative strategies used during this study supplemented one another in order to address the research question and sub-questions. The original

Kirkpatrick evaluation model involved evaluation on four levels of which two were mainly qualitative and the other two mainly quantitative. Phillips (2003) added a fifth level which comprise qualitative as well as quantitative evaluation. The collected data from evaluating on the five levels were interpreted in such a way that the analyses intertwined with one another. Levels 1 and 2 determined the reaction as well as teacher-students' perceptions as to whether learning took place. The teacher-students comprised ten registered teacher-students enrolled for the mathematics module NWPK 512. Level 3 determined the perceptions of the supervisors of the teacher-students relating to their change in behaviour. The supervisors related to the Heads of Department of the respective schools of the teacher-students. Level 4 determined whether teacher-students' results improved from the pre-test to the post-test. This level involved the teacher-students of levels 1 and 2 as well as an equal-numbered control group which also consisted of registered NWPK 512 teacher-students. The aim of evaluation at the fifth level was to determine the ROI related to human capital as well as to monetary ROI.

6.3.4 Chapter 4: Scaffolds relating to fundamental principles of mathematics

This chapter referred to the use of scaffolds in this study. It explored the concept of scaffolding, and provided an overview of scaffolds used during the study. Scaffolding can be used as a teaching strategy to assist in improving student learning (Van der Stuyf, 2002). The various characteristics of scaffolds were discussed (Coffey, 2009; Greenfield, 1984). The scaffolds that were selected were done in such a way that they were relevant to the teacher-students' field of study.

Chapter four presented a number of exemplar scaffolds. These included examples of scaffolds in teaching the following sections: numbers and number lines; patterns, functions and algebraic language; exponents; polynomials and solving equations. Ways in which the exemplar scaffolds addressed the module outcomes were presented in a table. One of the typical interactive activities which related to the laws of exponents was presented in detail. Various screen-shots were displayed to illustrate the scaffolding that took place in the activity, as well as a detailed explanation of what the activity entailed, was presented.

6.3.5 Chapter 5: Analysis of data according to Kirkpatrick's five levels

The aim of the study was to address the research question: *How can IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme?* Five aspects related to addressing this question. They included students' reaction towards mathematics facilitation via IWBs scaffolding; teacher-students' perceptions of whether learning takes place through scaffolding of mathematics via IWBs; the teacher-students' supervisors' perceptions of change relating to on-the-job behaviour relating to classroom teaching and learning; teacher-students' learning outcomes relating to the pre-test and post-test; and the effect on the ROI while using IWBs. These five aspects were formulated into the five sub-questions.

6.3.5.1 Sub-question 1: *How do students react to mathematics facilitation via IWBs scaffolding?*

Atlas.ti™ and descriptive statistics analysed the data. The data revealed that teacher-students' reaction towards scaffolding of mathematics via IWBs was comprehensively positive. Since the teacher-students liked to engage in the scaffolds because they were having fun while learning mathematics, their reactions towards mathematics facilitation via IWB scaffolding were mostly positive. All the teacher-students indicated that they were motivated by the scaffolding IWB sessions and stated that they would recommend it to other students of NWPK 512. Teacher-students, however, also experienced some barriers which affected their reactions negatively. Although technology is becoming more and more part of our daily lives, many of the teacher-students—especially from rural areas—feared technology and were scared to use it for education. They experienced learning through technology as impersonal and when IWB sessions failed due to technical problems at centres, the students posed negative reactions. Participants claimed that IWB-sessions were too short to cover the content of the module. Overall though, the data revealed that teacher-students were willing to engage in education via IWBs and the more tech-literate they became, the better and more actively they engaged in the learning process.

6.3.5.2 Sub-question 2: *How do teacher-students perceive learning that takes place through scaffolding of mathematics via IWBs?*

Atlas.ti™ and descriptive statistics were used to address this question. The data revealed that teacher-students experienced scaffolding via IWBs as effective. Teacher-students' perceptions were that learning occurred through scaffolding of mathematics via IWBs because the scaffolds addressed the issues they needed at the time and they became more confident in doing and teaching mathematics. The teacher-students' understanding of the fundamental principles of mathematics, as well as their metacognitive skills, improved. The data further revealed that teacher-students generally felt that technology could be useful in teaching and learning mathematics over distance and that longer scaffolding sessions could add to their learning and to the value of IWBs.

6.3.5.3 Sub-question 3: *How do the teacher-students' supervisors perceive changes in their on-the-job behaviour as a result of the successful completion of the concerned mathematics module?*

This question was addressed by investigating descriptive statistics compiled by the Statistical Services Department of the NWU. Heads of departments at the teacher-students' respective schools were selected as their supervisors. Most supervisors of teacher-students noted a positive change in the teacher-students' on-the-job behaviour after mathematics facilitation via IWB scaffolding. The teacher-students functioned better at their respective schools and they also affected people around them for the better. The supervisors claimed that teacher-students were motivated to succeed in their studies and therefore also in their careers as Mathematics teachers. Most supervisors furthermore

noted that students applied their newly gained information and skills in dealing with and motivating students in their classrooms.

6.3.5.4 Sub-question 4: *How did teacher-students' results change during a post-test as a result of attending mathematics scaffolding via IWBs?*

This question was addressed and reported on by investigating descriptive statistics compiled by the Statistical Services Department of the NWU. The group of participants of the study comprised only ten registered students of NWPK 512 and therefore a non-parametric test generated the statistics. With the aid of a Wilcoxon signed-rank test the data revealed that the positive improvement of teacher-students' marks in the post-test indicated significant meaning in practice. The test marks of the control group, however, did not indicate any significant improvement.

6.3.5.5 Sub-question 5: *What was the ROI of employing IWBs for the concerned course?*

ROI relating to mathematics facilitation via IWB scaffolding was addressed by a comparison of the ROI on human capital as well as by a comparison of monetary ROI. The data revealed that the UODL spent less money with the IWB mode of delivery than with the traditional face-to-face mode. It further revealed that they serviced more students and offer better quality and opportunities through the IWB mode. Although the UODL strived to offer quality course delivery, they did not, in all cases, have control over the availability of the Internet. This indicated that teacher-students could not depend on quality delivery of presentations during all IWB-sessions. Data on the attendances of students, however, revealed that attendances of IWB-sessions started off poorly, but as students started to become used to IWBs and the use of other learning technologies, attendance rapidly increased. Teacher-students also became familiar with downloading of previously recorded classes which they could then conveniently access and view at their convenience.

6.4 Addressing the main research question

In order to address the main research question which guided the research: *How can IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme?,* the researcher made an inventory of all the research findings and categorised the findings according to the main role-players in the study. The three role-players were the teacher-student, the lecturer and the UODL. The functions of the role players emerged as those relating to teaching and learning, the academic support required during the delivery of mathematics modules, and the managerial responsibilities of the UODL relating to IWB-sessions. These role-players interacted with each other within a technological environment in order to contribute to the learning experience of teacher-students. Table 6.1 presents a summary of the patterns, themes and codes which emerged from the findings relating to the analysis of the findings relating to the main question of the study.

Table 6.1 Inventory of qualitative and quantitative findings relating to the main research question

How can IWBs enhance the scaffolding of mathematics teaching and learning in an ODL programme?	
The teacher-students: • expected academic support with their learning of mathematics • had fun while engaging with the scaffolding mathematics activities and were motivated to engage more and more in their own time • wanted teaching to be more like face-to-face teaching which they were familiar with • engaged in scaffolding activities in order to reinforce their learning of mathematics • became less technophobic as they became more familiar with IWBs • showed positive change in their on-the-job behaviour by being motivated and better prepared for teaching their respective classes • achieved better academic results in mathematics themselves • gained overall in human capital	Teaching and learning
The lecturer: • addressed the technophobia of the teacher-students in order for them to feel more comfortable in the teaching and learning environment • encouraged teacher-students to engage and become active partners in the learning experience in order to experience it as personal • planned more sessions with less content per session in order for teacher-students' understanding to improve • applied the interactivity feature of the IWBs so that students could share ideas with the lecturer as well as with other teacher-students • introduced teacher-students to relevant mathematics inter actives which they could engage in and use for scaffolding mathematics concepts • created exciting expectations with teacher-students in order to motivate them to succeed in their learning experience	Academic support
The UODL: • incorporated special cameras so that a photo of the lecturer could be visible on the IWB during IWB-sessions • was responsible for continuous technical support during IWB-sessions and also for more efficient interactivity • allowed longer time for mathematics sessions in order to address the challenge of insufficient time • investigated more IWB-sessions for mathematics classes in future • provided technical support in many ways in order to contribute to the value and usefulness of IWBs • did continuous quality assurance in order to offer quality education over distance • calculated the ROI of offering distance education classes via IWBs	Management of IWB-sessions

6.4.1 The involvement of teacher-students during the scaffolding of mathematics via IWBs

Although the study involved only a small group of participants, they were a representation of the typical teacher-student at the UODL. These mathematics teacher-students faced similar challenges with respect to their studies. They were all practising teachers with other responsibilities as well, they were living far away from study centres, English was not their mother tongue, they struggled to understand basic fundamental principles of mathematics during the short contact sessions, and they found it difficult to study mathematics without additional support.

Scaffolding of mathematics concepts through inter-actives via IWBs provided additional support to DE teacher-students. The teacher-students had fun while learning mathematics and became motivated to

revisit and explore more such web-based activities. Although the teacher-students were fearful of technology at first and they wanted direct access to the lecturer, they became familiar with the technology and soon adapted. The teacher-students' supervisors noted that teacher-students taught more effectively in their respective classes and they also shared their newly-gained skills at their schools with their peers and their learners, as well as within the communities where they lived. They also got creative ideas from interacting with the scaffolds to use during their teaching. They could therefore also explain mathematical concepts better after they have mastered the concepts themselves. The researcher is of the opinion that the teacher-students' attitudes towards mathematics changed and improved. This opinion resulted from the observations of their supervisors. The teacher-students' also achieved better academic outcomes which resulted in their obtaining of their professional qualifications.

6.4.2 The involvement of the lecturer in enhancing of mathematics education through scaffolding via IWBs

Through the use of mathematics scaffolds the lecturer was able to address many academic challenges that the teacher-students faced. The lecturer encouraged them to revisit the scaffolds on concepts they experienced challenges with until they mastered the concepts in order to continue with subsequent concepts. The researcher noticed positive reactions in the teacher-students' perspectives during their learning activities. The use of mathematics scaffolds contributed to the better academic achievements of the experimental group by (i) providing relevant activities for the scaffolding of mathematics concepts; (ii) planning IWB-sessions in such a way that teacher-students coped with the content covered per session; and (iii) promoting the interactivity during teaching and learning via IWBs. This initiated a cycle of enhancement where the teacher-students improved their understanding and became more independent students across a distance.

6.4.3 The involvement of the UODL play in enhancing the scaffolding of mathematics via IWBs

The UODL were responsible for managing all IWB-sessions by providing continuous and quality support with respect to all technical issues during IWB-sessions. The UODL addressed issues like (i) smoothing over inconsistent Internet access, (ii) addressing of poor sound issues during IWB-sessions, (iii) providing of additional time for mathematics sessions, (iv) uploading of lecturers' photos IWBs during sessions, and (v) striving to provide more interactivity during IWB-sessions. The UODL continuously calculated the ROI of incorporating IWBs as LT for the DE in order to seek for best financial and academic options for the UODL and their clients.

In summary, IWBs could be used to enhance the scaffolding of mathematics teaching and learning by: (i) creating the opportunity for teacher-students to have a positive reaction towards the use of technology in education; (ii) designing course material in such a way that teacher-students can

perceive that learning does take place through scaffolding of mathematics; (iii) creating the opportunity for supervisors to observe positive changes in the teacher-students' on-the-job behaviour; (iv) using scaffolding facilitation of mathematics in such a way that teacher-students can improve on their results; and (v) creating the opportunity to increase the ROI for the UODL.

6.5 Conclusions

The analysis and interpretation of the qualitative and quantitative data on the enhancement of scaffolding mathematics concepts via IWBs provided the researcher with the opportunity to draw relevant conclusions. The conclusions are based on data and evidence that were gathered and interpreted in this study.

Firstly, teacher-students showed positive *reactions* towards scaffolding of mathematics teaching and learning via IWBs. Teacher-students further perceived that *learning* occurred after they had attended scaffolding IWB sessions. The supervisors of the teacher-students noted positive change in their on the job *behaviour*. The academic results of teacher-students showed significant improvement after they had attended scaffolding mathematics teaching and learning via IWBs. Teacher-students therefore gained from the scaffolding of mathematics via IWBs and were more successful in improving their professional qualifications.

Secondly, the lecturer could better support teacher-students who study mathematics over distance in order for them to improve their understanding of the fundamental principles of mathematics. Scaffolding of mathematics concepts via IWBs therefore increased chances for the lecturer to succeed in Mathematics education.

Thirdly, less money was spent but more was achieved. The UODL are therefore addressing the challenge with respect to the many unqualified and underqualified teachers in South Africa and are offering quality education for these teachers to further their professional qualifications.

6.6 Implications

6.6.1 Implications relating to teacher-students

The interactive web activities which were identified as examples of scaffolds in this study, proved to be particularly valuable to teacher-students in DE. Since students who study through DE required additional support in their studies, the scaffolding via web-based inter-actives provides the support anywhere at any time. Teacher-students could therefore engage with many such examples relating to

their own course work as well as to concepts they are teaching in their respective classrooms, until they feel comfortable with the content. This can be done as their time and duties allow them to.

6.6.2 Implications relating to the lecturer

Practical implications of this study entail that mathematics lecturers should consider regularly making use of scaffolding, particularly in the form of interactive web activities relating to the relevant concepts in all mathematics modules. The study has revealed students' positive opinions as to the usefulness of such activities and the value and contribution of scaffolding as a teaching strategy IWBs are the ideal learning technology for lecturers to introduce and encourage students to use web-based interactives for their own studies and teaching.

6.6.3 Implications relating to the UODL

The infrastructure, in terms of IWBs that has already been established at the UODL provides convenient access for students to engage with this technology. The interactivity feature of IWBs is an excellent means to teach and the UODL should increase the interactivity during IWB-sessions in order to improve the quality of their DE and to offer better support to their teacher-students.

6.7 Recommendations

The researcher was firstly concerned with establishing how IWBs could enhance mathematics teaching and learning through scaffolding and secondly making recommendations using the findings of the study in order to use IWBs as ICT tool to improve the mode of delivery of DE courses offered by the UODL at the NWU. In doing so, ICT through scaffolding IWB-use can benefit teaching and learning not only at the UODL, but since the teacher-students are practicing teachers, the students in their classrooms can also benefit from these results.

6.7.1 Recommendation relating to teacher-students

The purpose of this research was to determine whether IWBs could enhance the scaffolding of mathematics teaching and learning of teacher-students in an ODL programme. By creating a space for collaboration between students on the web, on Whatsapp, or in alternative spaces they may be able to communicate with each other as well as with the lecturer with accessible and familiar technology.

6.7.2 Recommendations relating to the lecturer

To enhance the scaffolding of mathematics teaching and learning, there are a few aspects that the lecturer should take into account. Lecturers should carefully plan the scope of each of the IWB-sessions to optimally utilise the limited time available. Recordings of solutions to common difficulties in the mathematics curriculum (on the IWB) should be made available to students as learning objects, so that students could watch them on their in their own time. Facilitators at study centres should make these learning objects available to the students to download. Creating a repository of mathematics learning objects in a cloud storage space can be a useful resource for teacher-students. By making IWB recordings of typical mathematical scaffolding objects available to teacher-students, the teacher-students might be encouraged to search for such scaffolding objects themselves.

6.7.3 Recommendations relating to the UODL

The UODL currently have to apply IWBs mostly as WBs when presenting classes across the country because time is too little for students from different centres to interact simultaneously and functionality also decreases when several students want to communicate at the same time. Kent (2006), however, stated that the interactivity feature of an IWB is what distinguishes it from normal blackboards (§2.4.1.1). My recommendation is that the interactivity and duration of mathematics sessions require more investigation to fully understand the need of students and how to adapt the application of IWBs in order to improve ICT integration in Distance Education.

6.8 Value of the research

The purpose of this research project was to determine how IWBs could enhance the scaffolding of mathematics teaching and learning. Chapter 1 (§1.2) referred to almost fifty per cent of students of NWPK 512 at the UODL failing their examination opportunity the first time. This is a serious issue for the students involved as well as for the UODL. It also affects the learners who are taught by these teacher-students negatively if the teachers themselves are not confident in teaching the subject. The research project concluded that DE students do benefit from scaffolding mathematics via IWBs and by addressing the severe challenges encountered during the study, students should learn more effectively and should complete their studies sooner. The ROI for this programme also proved to be greater with the introduction of IWBs.

I believe that although the Kirkpatrick evaluation model was already founded in 1959 it proved to be appropriate and successfully served the purpose of this study (§1.4.2). The simplicity and appropriateness of the levels of evaluation provided the researcher with the basic information that was necessary to determine whether IWBs enhance the scaffolding of mathematics education in ODL.

6.9 Limitations of the research

Limitations of research relate to two levels of the research: (i) issues relating to methodology used during the study, and (ii) issues relating to the execution of the research.

Research limitations related to methodological issues:

- A small group of participants participated in this study. Although the participants reflected typical characteristics of the population, the findings could not be transferred to other cases or institutions.

Research limitations related to the execution of the research:

- Attending IWB-sessions was not compulsory for teacher-students of the UODL and therefore a different group of students could attend on any day
- The participants needed technology training. If they could have received information literacy training before, they would have been less technophobic of the web-based scaffolds
- Most teacher-students did not have Internet access at their homes. This prevented optimal engagement in further exploring of mathematics inter-actives
- only scaffolds relating to a single Mathematics module were considered.

6.10 Future research

Scaffolds related to other mathematics modules and subjects could be investigated. Such research should indicate whether electronic scaffolds on the Internet in general contribute to learning over distance and aim to answer questions like: (i) do students have sufficient access to Internet? (ii) do students know how to find and identify relevant inter-actives to support scaffolding of their individual challenges? (iii) do the web-based activities contribute to the motivation of students and support them to take responsibility for their learning in order to become more self-directed

Foundation Phase teachers who are the key mathematics educators in laying the foundation of learners' development of number and number sense, often experience mathematics anxiety and do not have proper understanding of the fundamental principles of mathematics. Research relating to scaffolding elementary number and number sense concepts that would introduce, equip and excite FP teacher-students to feel comfortable in teaching elementary mathematics to their learners, could enable FP teachers in supporting their own students to develop proper number sense.

6.11 My research journey

I have been teaching mathematics for many years and was looking forward to the opportunity to be involved with continuous teacher education when I joined the Faculty of Education Sciences of the NWU. I was specifically appointed as a Mathematics lecturer for teacher-students who were already employed teachers and therefore had to study mathematics over distance. I have always had the idea that many teachers of mathematics struggled to teach mathematics because they were not comfortable with the fundamental principles of mathematics themselves. I became convinced that this really is true in practice when I marked assignments and examination papers of mathematics students studying through the UODL. Teacher-students of the UODL come from all over the country and contact classes are not compulsory to attend. I therefore grappled to connect or have proper and effective communication with all students. I was, however, more comfortable with teaching mathematics to students who attended classes or came for face-to-face facilitation. Teacher-students who live far away from contact centres cannot be supported in this way and that is why I undertook this research in order to investigate and in the end address the challenges of teacher-students who are learning mathematics over distance.

I am delighted with the way that an IWB as learning technology scaffold and supported teaching and learning over distance. However, I believe that the interactive features are not fully utilised in all cases. I will continue to advocate the issues that emerged from this research in order for mathematics students at the UODL to receive the best possible support.

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Addendum 3.1

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

IWB Session Observation Schedule for Coordinator

Pre-Observation Questions for Instructor:

1. What are the curriculum topic units for today's lesson?
   _____

Class (module): _____

Instructor: _____

# of Students: _____

Observer: _____

Date: _____

Classroom facilities and its arrangement	**Yes**	**No**
The classroom is big enough to accommodate the students		
The furniture (chairs and desks) are comfortable for adult students		
The classroom temperature is comfortable with respect to the temperature and sufficient light		
Comments:		

Students' Actions and Reactions	**Outstanding**	**Good**	**Fair**	**Poor**
The students arrived on time				
The students came prepared for the lesson				
The students pay attention during the session				
The students participate by making comments and by asking questions				
The students are taking notes during the session				
Comments:				

Students' experiences of Session	**Yes**	**No**
Students seem to be attentive and enjoying the session		
Students seem to be bored and frustrated during the session		
Comments:		

Other comments:

_____

_____

Strengths:

_____

_____

Suggestions for Improvements:

_____

_____

_____

Addendum 3.2

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

IWB Session Observation Schedule for Researcher

Pre-Observation Questions for Instructor:

1. What are the curriculum topic units for today's lesson?
   _____

Class (module): _____

Instructor: _____

# of Students: _____

Observer: _____

Date: _____

Classroom facilities and its arrangement	**Yes**	**No**
The classroom is big enough to accommodate the students		
The furniture (chairs and desks) are comfortable for adult students		
The classroom temperature is comfortable with respect to temperature and sufficient light		
Comments:		

Students' Actions and Reactions	**Outstanding**	**Good**	**Fair**	**Poor**
The students arrived on time				
The students came prepared for the lesson				
The students pay attention during the session				
The students participate by making comments and by asking questions				
The students are taking notes during the session				
Comments:				

Students' experiences of Session	**Yes**	**No**
Students seem to be attentive and enjoying the session		
Students seem to be bored and frustrated during the session		
Comments:		

Other comments:

_____

_____

Strengths:

_____

_____

Suggestions for Improvements:

_____

_____

_____

Addendum 3.3

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Focus group Interview at end of IWB sessions

[Explain the aim of this interview to participants. Emphasize that they are the ones who had experienced this hands-on, their opinions are valued incredibly; does not have anything to do with the assessment of this module—the aim with this study is to better the facilitation of the module by using learning technology such as IWBs]

[Get them at ease and such that they would want to give feedback on attending the sessions without feeling that they have to answer only in favour of the presenter and the module]

1. **Let's talk about the structure of the presentation.**

   Give your views and experiences of the session.

   Prompts like: Are there any more positives that anyone wants to mention?

   Anything you want to recommend?

   Anything else from anyone?

Give a bit of structure by repeating (listing) what was mentioned so far and then ask if anyone else wants to make any other comments.

Take questions a bit away from them by asking whether they think that some students would feel anxious because of the technology—would some students experience techno anxiety?

Any other contributions by anyone?

Addendum 3.4

Focus group Interview at end of IWB sessions

[Explain the aim of this interview to participants. Emphasize that they are the ones who had experienced this hands-on, their opinions are valued incredibly; does not have anything to do with the assessment of this module—the aim with this study is to better the facilitation of the module by using learning technology such as IWBs]

[Get them at ease and such that they would want to give feedback on attending the sessions without feeling that they have to answer only in favour of the presenter and the module]

1. **Let's talk about the structure of the presentation.**

   Give your views and experiences of the session.

   Prompts like: Are there any more positives that anyone wants to mention?

   Anything you want to recommend?

   Anything else from anyone?

Give a bit of structure by repeating (listing) what was mentioned so far and then ask if anyone else wants to make any other comments.

Take questions a bit away from them by asking whether they think that some students would feel anxious because of the technology—would some students experience techno anxiety?

Any other contributions by anyone?

Addendum 3.5

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Feedback on the teaching of Mathematics via Interactive Whiteboards

The purpose of the survey is to obtain your inputs regarding the value and experience of presenting Mathematics via the Interactive Whiteboards. Your feedback will be helpful in customising and improving these sessions.

Section A: Please write down comments about the following questions with respect to: presentations to students via IWBs

1. What do you like when presenting to students via the IWBs?
   _____
   _____
   _____
   _____
   _____
2. What do you not like when presenting to students via the IWBs?
   _____
   _____
   _____
   _____
   _____
3. What would you like to change when presenting to students via IWBs?
   _____
   _____
   _____
   _____
   _____

Section B: Please write down comments about the following questions with respect to: the experiences of students when attending Mathematics classes via IWBs

1. What do your students like and enjoy about the presentations via IWBs?
   _____
   _____
   _____
   _____
   _____
   _____
2. What do your students not like about the presentations via IWBs?
   _____
   _____
   _____
   _____
   _____
   _____
3. Which of the two modes of delivery would you reckon works best for the students—the new IWB-mode or the old face-to-face contact class-mode? Why?
   _____
   _____
   _____
   _____
   _____
   _____

Thank you for your participation

Scaffolding of mathematics concepts via IWBs contributes towards the design integration of a learning technology at the UODL at the NWU

Generator: ATLAS.ti WIN 7.1 (Build 4)
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Original ATLAS.ti project:scaffolding of mathematics concepts via iwbs contributes towards the design integration of a learning technology at the uodl at the nwu.atlcb

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General

: Author(s): Super

Created: 07/02/2014 11:29:10 AM. Modified: 12/05/2014 10:07:08 AM.

Statistics:

- Co-Authors: 0
- Primary Texts: 6
- Quotations: 196
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- Primary Document Families: 0
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- Memo Families: 0
- Network Views: 7
- Code-Code Links: 43
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Primary Documents

:

P 1: Transcription of focus group interview in Potch.docx

File origin: Transcription of focus group interview in Potch.docx [unmanaged path] **- media type:** richtext
39 quotations

Codes (15)@@@Bad sound, @@Exciting expectation, @@Face2face teaching, @@Fun, @@Insufficient time, @@Longer sessions, @@Photo's on screen, @@Reinforces learning, @@Scared to ask questions, @@Technical issues, @Barriers affecting reaction towards teaching via IWB, @Engage with technology, @Technophobia, @Usefulness of technology, @Value of IWB

Memos (0)

P 2: Transkripsie 1 van indiwiduele onderhoud.docx

File origin: Transkripsie 1 van indiwiduele onderhoud.docx [unmanaged path] **- media type:** richtext
23 quotations

Codes (9)@@Access to technology, @@Face2face teaching, @@Fun, @@Interactivity, @@Reinforces learning, @@Value of IWBs, @Engage with technology, @Technophobia, @Usefulness of technology

Memos (0)

P 3: Transkripsie van fokus groep onderhoud in Witrivier.docx

File origin: Transkripsie van fokus groep onderhoud in Witrivier.docx [unmanaged path] **- media type:** richtext
35 quotations

Codes (13)@@Face2face teaching, @@Fun, @@Insufficient time, @@More sessions needed, @@Photo's on screen, @@Reinforces learning, @@Scared to ask questions, @@Support from IWB centre, @@Technical issues, @Barriers affecting reaction towards teaching via IWB, @Engage with technology, @Technophobia, @Usefulness of technology

Memos (0)

P 4: Interview with Centre Manager.docx

File origin: Interview with Centre Manager.docx **- media type:** richtext
62 quotations

Codes (9)@@Face2face teaching, @@Inclusive, @@Value of IWBs, @Engage with technology, @Quality assurance, @Technophobia, @Usefulness of technology, @Value of IWB, Cost

Memos (0)

P 5: Lecturer1 Questionnaire on using IWBs.docx

File origin: Lecturer1 Questionnaire on using IWBs.docx **- media type:** richtext
20 quotations

Codes (11)@@Face2face teaching, @@Impersonal, @@Inclusive, @@Insufficient time, @@Interactivity, @@Photo's on screen, @@Scared to ask questions, @@Value of IWBs, @Quality assurance, @Technophobia, @Usefulness of technology

Memos (0)

P 6: Lecturer2 Questionnaire on using IWBs.docx

File origin: Lecturer2 Questionnaire on using IWBs.docx **- media type:** richtext
17 quotations

Codes (8)@@Face2face teaching, @@Impersonal, @@Inclusive, @@Interactivity, @Barriers affecting reaction towards teaching via IWB, @Technophobia, @Usefulness of technology, @Value of IWB

Memos (0)

Codes Summary

(Commented codes are clickable)

All codes used: @@@Bad sound {2-1}~ , @@Access to technology {2-1}~, @@Exciting expectation {3-1}, @@Face2face teaching {15-3}~, @@Fun {9-1}~, @@Impersonal {2-1}, @@Inclusive {9-2}, @@Insufficient time {12-4}~, @@Interactivity {8-5}~, @@Longer sessions {2-1}~, @@More sessions needed {1-3}~, @@Photo's on screen {4-2}~, @@Reinforces learning {18-2}~, @@Scared to ask questions {5-1}~, @@Support from IWB centre {3-2}~, @@Technical issues {6-4}~, @@Value of IWBs {5-3}~, @Barriers affecting reaction towards teaching via IWB {11-6}~, @Engage with technology {16-6}~, @Quality assurance {12-4}, @Technophobia {13-7}~, @Usefulness of technology {43-7}~, @Value of IWB {18-3}, Cost {24-0}, Human Capital Return on Investment {0-4}, Learning {0-5}, Reaction towards scaffolding {0-4}, Scaffolding via Interactive Whiteboards {0-3}

Codes sorted by Alphabet:

@@@Bad sound {2-1}~
@@Access to technology {2-1}~
@@Exciting expectation {3-1}
@@Face2face teaching {15-3}~
@@Fun {9-1}~
@@Impersonal {2-1}
@@Inclusive {9-2}
@@Insufficient time {12-4}~
@@Interactivity {8-5}~

Codes sorted by Groundedness:

@Usefulness of technology {43-7}~
Cost {24-0}
@@Reinforces learning {18-2}~
@Value of IWB {18-3}
@Engage with technology {16-6}~
@@Face2face teaching {15-3}~
@Technophobia {13-7}~
@@Insufficient time {12-4}~
@Quality assurance {12-4}

Codes sorted by Density:

@Technophobia {13-7}~
@Usefulness of technology {43-7}~
@Engage with technology {16-6}~
@Barriers affecting reaction towards teaching via IWB {11-6}~ }~
Learning {0-5}
@@Interactivity {8-5}~
@@Technical issues {6-4}~
Human Capital Return on Investment {0-4}
@Quality assurance {12-4}

Commented Codes only:

@@@Bad sound {2-1}~

students cannot hear presenter and presenter cannot hear students' questions
too much noise in room where students sit

@@Access to technology {2-1}~

students who do not have much access to technology

@@Face2face teaching {15-3}~

Go teach face-to-face at students'venue

@@Fun {9-1}~

to learn something NEW is normally interesting and enjoyable

@@Insufficient time {12-4}~

sessions and time to use technology not long enough

@@Interactivity {8-5}~

to be able to communicate (asynchronous)

@@Longer sessions {2-1}~

more time per session will be better than many short sessions

@@More sessions needed {1-3}~

maths sessions are necessary

@@Photo's on screen {4-2}~

Lecturer wants to see students and students want to see lecturer during session

@@Reinforces learning {18-2}~

does more than just normal learning in first place

@@Scared to ask questions {5-1}~

do not ask questions easily

@@Support from IWB centre {3-2}~

technical assistance available

@@Technical issues {6-4}~

sond of voices not good --- both ways

@@Value of IWBs {5-3}~

student's impression of IWB

@Barriers affecting reaction towards teaching via IWB {11-6}~

problems experienced with the IWB and issues that interfere
do maths earlier in the day

@Engage with technology {16-6}~

student is willing to use technology and fells that it is useful

@Technophobia {13-7}~

scared of technology as such --- is not used to it

@Usefulness of technology {43-7}~

WB which acts as technology makes it possible to interact here

---

Primary Document Families

Code Families

Memo Families

Network Views

Nodes are prefixed with a single letter denoting its type: C= Code, M = Memo, Q = Quotation, P = Primary Document

Barriers affecting reactions

Nodes (8): CO:@@Support from IWB centre {3-2}~, CO:@@Insufficient time {12-4}~, CO:@Barriers

affecting reaction towards teaching via IWB {11-6}~, CO:@@Technical issues {6-4}~, CO:@@@Bad sound {2-1}~, CO:@@Longer sessions {2-1}~, CO:@@More sessions needed {1-3}~, CO:@@Access to technology {2-1}~

Barriers to IWB teaching

Nodes (7): CO:@@@Bad sound {2-1}~, CO:@Barriers affecting reaction towards teaching via IWB {11-6}~, CO:@@Support from IWB centre {3-2}~, CO:@@Technical issues {6-4}~, CO:@@Longer sessions {2-1}~, CO:@@Access to technology {2-1}~, CO:@@Insufficient time {12-4}~

Figure 5.1: IWBs enhance the scaffolding of Mathematics teaching and learning in an ODL programme

Nodes (22): CO:@@Technical issues {6-4}~, CO:@@Value of IWBs {5-3}~, CO:@@Support from IWB centre {3-2}~, CO:@@Scared to ask questions {5-1}~, CO:@@More sessions needed {1-3}~, CO:@Technophobia {13-7}~, CO:@Usefulness of technology {43-7}~, CO:@Engage with technology {16-6}~, CO:@@Face2face teaching {15-3}~, CO:@@Interactivity {8-5}~, CO:@Barriers affecting reaction towards teaching via IWB {11-6}~, CO:Scaffolding via Interactive Whiteboards {0-3}, CO:@@Longer sessions {2-1}~, CO:Human Capital Return on Investment {0-4}, CO:Reaction towards scaffolding {0-4}, CO:Learning {0-5}, CO:@@@Bad sound {2-1}~, CO:@@Insufficient time {12-4}~, CO:@@Reinforces learning {18-2}~, CO:@@Fun {9-1}~, CO:@@Photo's on screen {4-2}~, CO:@@Access to technology {2-1}~

Human capital ROI

Nodes (11): CO:@Technophobia {13-7}~, CO:@@Insufficient time {12-4}~, CO:@@Face2face teaching {15-3}~, CO:Human Capital Return on Investment {0-4}, CO:@@Scared to ask questions {5-1}~, CO:@@Value of IWBs {5-3}~, CO:@@Photo's on screen {4-2}~, CO:@@Interactivity {8-5}~, CO:@Usefulness of technology {43-7}~, CO:@@Inclusive {9-2}, CO:@Quality assurance {12-4}

Learning

Nodes (6): CO:@Value of IWB {18-3}, CO:Learning {0-5}, CO:@@Interactivity {8-5}~, CO:@@Reinforces learning {18-2}~, CO:@@More sessions needed {1-3}~, CO:@Usefulness of technology {43-7}~

Reaction

Nodes (13): CO:@@Value of IWBs {5-3}~, CO:@@Support from IWB centre {3-2}~, CO:@@Scared to ask questions {5-1}~, CO:@@Impersonal {2-1}, CO:@@Face2face teaching {15-3}~, CO:@@Exciting expectation {3-1}, CO:@@Photo's on screen {4-2}~, CO:@Engage with technology {16-6}~, CO:@@Fun {9-1}~, CO:Reaction towards scaffolding {0-4}, CO:@@Interactivity {8-5}~, CO:@@Inclusive {9-2}, CO:@Technophobia {13-7}~

Reactions towards scaffolding via IWB

Nodes (13): CO:@@Interactivity {8-5}~, CO:@@Fun {9-1}~, CO:@@Value of IWBs {5-3}~, CO:@@Exciting expectation {3-1}, CO:@@Photo's on screen {4-2}~, CO:@@Impersonal {2-1}, CO:Reaction towards scaffolding {0-4}, CO:@Technophobia {13-7}~, CO:@@Support from IWB centre {3-2}~, CO:@@Scared to ask questions {5-1}~, CO:@Engage with technology {16-6}~, CO:@@Inclusive {9-2}, CO:@@Face2face teaching {15-3}~

Code Neighbors List (Thesaurus)

The following is a thesaurus-style alphabetic list of all codes with their relations to other codes.

Each code-code relations is displayed in text form as a simple two argument proposition:

CODE_A < relation > CODE_B.

@@@Bad sound
<*is part of*> **@@Technical issues**
@@Access to technology
@@Technical issues <*is part of*> **@@Access to technology**
@@Exciting expectation
@Engage with technology <*is part of*> **@@Exciting expectation**
@@Face2face teaching
<*is part of*> **@Barriers affecting reaction towards teaching via IWB**
@Technophobia <*is cause of*> **@@Face2face teaching**
@Usefulness of technology <*is part of*> **@@Face2face teaching**
@@Fun
<*is property of*> **@Engage with technology**
@@Impersonal
<*is property of*> **@Technophobia**
@@Inclusive
<*is property of*> **@Engage with technology**
<*is property of*> **@Quality assurance**
@@Insufficient time
<*is cause of*> **@@Longer sessions**
<*is cause of*> **@@More sessions needed**
@Barriers affecting reaction towards teaching via IWB <*is associated with*> **@@Insufficient time**
@Quality assurance <*is part of*> **@@Insufficient time**
@@Interactivity
<*is part of*> **@@Reinforces learning**
<*is part of*> **@Barriers affecting reaction towards teaching via IWB**
<*is property of*> **@Engage with technology**
@Quality assurance <*is part of*> **@@Interactivity**
@Value of IWB <*is associated with*> **@@Interactivity**
@@Longer sessions
@@Insufficient time <*is cause of*> **@@Longer sessions**
@@More sessions needed
<*is part of*> **@@Reinforces learning**
@@Insufficient time <*is cause of*> **@@More sessions needed**

@Usefulness of technology <*is cause of*> **@@More sessions needed**

@@Photo's on screen

<*is property of*> **@Technophobia**

@Usefulness of technology <*is property of*> **@@Photo's on screen**

@@Reinforces learning

@@Interactivity <*is part of*> **@@Reinforces learning**

@@More sessions needed <*is part of*> **@@Reinforces learning**

@@Scared to ask questions

@Technophobia <*is cause of*> **@@Scared to ask questions**

@@Support from IWB centre

<*is cause of*> **@@Technical issues**

@Technophobia <*is associated with*> **@@Support from IWB centre**

@@Technical issues

<*is part of*> **@@Access to technology**

@@@Bad sound <*is part of*> **@@Technical issues**

@@Support from IWB centre <*is cause of*> **@@Technical issues**

@Barriers affecting reaction towards teaching via IWB <*is associated with*> **@@Technical issues**

@@Value of IWBs

<*is associated with*> **Learning**

@Engage with technology <*is property of*> **@@Value of IWBs**

@Usefulness of technology <*is associated with*> **@@Value of IWBs**

@Barriers affecting reaction towards teaching via IWB

<*is associated with*> **@@Insufficient time**

<*is associated with*> **@@Technical issues**

<*is part of*> **Learning**

<*is part of*> **Reaction towards scaffolding**

@@Face2face teaching <*is part of*> **@Barriers affecting reaction towards teaching via IWB**

@@Interactivity <*is part of*> **@Barriers affecting reaction towards teaching via IWB**

@Engage with technology

<*is part of*> **@@Exciting expectation**

<*is property of*> **@@Value of IWBs**

@@Fun <*is property of*> **@Engage with technology**

@@Inclusive <*is property of*> **@Engage with technology**

@@Interactivity <*is property of*> **@Engage with technology**

Reaction towards scaffolding <*is associated with*> **@Engage with technology**

@Quality assurance

<*is part of*> **@@Insufficient time**

<*is part of*> **@@Interactivity**

@@Inclusive <*is property of*> **@Quality assurance**

Human Capital Return on Investment <*is associated with*> **@Quality assurance**

@Technophobia

<*is cause of*> **@@Face2face teaching**

<*is cause of*> **@@Scared to ask questions**

<*is associated with*> **@@Support from IWB centre**

@@Impersonal <*is property of*> **@Technophobia**

@@Photo's on screen <*is property of*> **@Technophobia**

Human Capital Return on Investment <*is associated with*> **@Technophobia**

Reaction towards scaffolding <*is associated with*> **@Technophobia**

@Usefulness of technology

<*is part of*> **@@Face2face teaching**

<*is cause of*> **@@More sessions needed**

<*is property of*> **@@Photo's on screen**

<*is associated with*> **@@Value of IWBs**

<*is cause of*> **@Value of IWB**

Human Capital Return on Investment <*is associated with*> **@Usefulness of technology**

Learning <*is associated with*> **@Usefulness of technology**

@Value of IWB
<is associated with> **@@Interactivity**
@Usefulness of technology *<is cause of>* **@Value of IWB**
Learning *<is associated with>* **@Value of IWB**
Cost
Human Capital Return on Investment
<is associated with> **@Quality assurance**
<is associated with> **@Technophobia**
<is associated with> **@Usefulness of technology**
<is associated with> **Scaffolding via Interactive Whiteboards**
Learning
<is associated with> **@Usefulness of technology**
<is associated with> **@Value of IWB**
<is associated with> **Scaffolding via Interactive Whiteboards**
@@Value of IWBs *<is associated with>* **Learning**
@Barriers affecting reaction towards teaching via IWB *<is part of>* **Learning**
Reaction towards scaffolding
<is associated with> **@Engage with technology**
<is associated with> **@Technophobia**
<is associated with> **Scaffolding via Interactive Whiteboards**
@Barriers affecting reaction towards teaching via IWB *<is part of>* **Reaction towards scaffolding**
Scaffolding via Interactive Whiteboards
Human Capital Return on Investment *<is associated with>* **Scaffolding via Interactive Whiteboards**
Learning *<is associated with>* **Scaffolding via Interactive Whiteboards**
Reaction towards scaffolding *<is associated with>* **Scaffolding via Interactive Whiteboards**

Code Hierarchy

@@@Bad sound *<is>* **Root**
@@Access to technology *<is>* **Root**
@@Technical issues *<is part of>* **@@Access to technology**
@@@Bad sound *<is part of>* **@@Technical issues**
@@Exciting expectation *<is>* **Root**
@Engage with technology *<is part of>* **@@Exciting expectation**
@@Fun *<is property of>* **@Engage with technology**
@@Face2face teaching *<is>* **Root**
@Technophobia *<is cause of>* **@@Face2face teaching**
@@Impersonal *<is property of>* **@Technophobia**
@@Fun *<is>* **Root**
@@Impersonal *<is>* **Root**
@@Inclusive *<is>* **Root**
@@Insufficient time *<is>* **Root**
@Barriers affecting reaction towards teaching via IWB *<is associated with>* **@@Insufficient time**
@@Face2face teaching *<is part of>* **@Barriers affecting reaction towards teaching via IWB**
@Technophobia *<is cause of>* **@@Face2face teaching**
@@Impersonal *<is property of>* **@Technophobia**
@@Interactivity *<is>* **Root**
@Quality assurance *<is part of>* **@@Interactivity**
@@Inclusive *<is property of>* **@Quality assurance**
@@Longer sessions *<is>* **Root**
@@Insufficient time *<is cause of>* **@@Longer sessions**
@Barriers affecting reaction towards teaching via IWB *<is associated with>* **@@Insufficient**

time
@@Face2face teaching <*is part of*> **@Barriers affecting reaction towards teaching via IWB**
@Technophobia <*is cause of*> **@@Face2face teaching**
@@Impersonal <*is property of*> **@Technophobia**
@@More sessions needed <*is*> **Root**
@@Insufficient time <*is cause of*> **@@More sessions needed**
@Barriers affecting reaction towards teaching via IWB <*is associated with*> **@@Insufficient time**
@@Face2face teaching <*is part of*> **@Barriers affecting reaction towards teaching via IWB**
@Technophobia <*is cause of*> **@@Face2face teaching**
@@Impersonal <*is property of*> **@Technophobia**
@@Photo's on screen <*is*> **Root**
@Usefulness of technology <*is property of*> **@@Photo's on screen**
Human Capital Return on Investment <*is associated with*> **@Usefulness of technology**
@@Reinforces learning <*is*> **Root**
@@Interactivity <*is part of*> **@@Reinforces learning**
@Quality assurance <*is part of*> **@@Interactivity**
@@Inclusive <*is property of*> **@Quality assurance**
@@Scared to ask questions <*is*> **Root**
@Technophobia <*is cause of*> **@@Scared to ask questions**
@@Impersonal <*is property of*> **@Technophobia**
@@Support from IWB centre <*is*> **Root**
@Technophobia <*is associated with*> **@@Support from IWB centre**
@@Impersonal <*is property of*> **@Technophobia**
@@Technical issues <*is*> **Root**
@@@Bad sound <*is part of*> **@@Technical issues**
@@Value of IWBs <*is*> **Root**
@Engage with technology <*is property of*> **@@Value of IWBs**
@@Fun <*is property of*> **@Engage with technology**
@Barriers affecting reaction towards teaching via IWB <*is*> **Root**
@@Face2face teaching <*is part of*> **@Barriers affecting reaction towards teaching via IWB**
@Technophobia <*is cause of*> **@@Face2face teaching**
@@Impersonal <*is property of*> **@Technophobia**
@Engage with technology <*is*> **Root**
@@Fun <*is property of*> **@Engage with technology**
@Quality assurance <*is*> **Root**
@@Inclusive <*is property of*> **@Quality assurance**
@Technophobia <*is*> **Root**
@@Impersonal <*is property of*> **@Technophobia**
@Usefulness of technology <*is*> **Root**
Human Capital Return on Investment <*is associated with*> **@Usefulness of technology**
@Value of IWB <*is*> **Root**
@Usefulness of technology <*is cause of*> **@Value of IWB**
Human Capital Return on Investment <*is associated with*> **@Usefulness of technology**
Cost <*is*> **Root**
Human Capital Return on Investment <*is*> **Root**
Learning <*is*> **Root**
@@Value of IWBs <*is associated with*> **Learning**
@Engage with technology <*is property of*> **@@Value of IWBs**
@@Fun <*is property of*> **@Engage with technology**
Reaction towards scaffolding <*is*> **Root**
@Barriers affecting reaction towards teaching via IWB <*is part of*> **Reaction towards scaffolding**
@@Face2face teaching <*is part of*> **@Barriers affecting reaction towards teaching via IWB**
@Technophobia <*is cause of*> **@@Face2face teaching**
@@Impersonal <*is property of*> **@Technophobia**
Scaffolding via Interactive Whiteboards <*is*> **Root**

Human Capital Return on Investment *<is associated with>* **Scaffolding via Interactive Whiteboards**

Addendum 3.7

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Questionnaire to evaluate change with respect to value and behaviour that students obtained

Please reflect on the IWB sessions on NWPK 512, then indicate your opinion on each statement.

Statement	Strongly agree	Moderately agree	Unsure / Undecided	Moderately disagree	Strongly disagree
The instruction was effective					
The IWB sessions met my expectations					
The IWB sessions addressed the issues I needed at the time					
The IWB sessions provided opportunity for my professional development					
The IWB sessions enhanced my understanding of fundamental principles of Algebra					

1. To what extent did your participation in and attendance of the IWB sessions affect you?

It affected me to the extent that.....	To a great extent	To a moderate extent	Unsure / Undecided	To a small extent	To no extent
I was better able to perform my job duties					
I was motivated to succeed in my studies					
I gained more confidence in teaching Mathematics					
My own understanding of fundamental principles of Algebra improved					
Other: (Please add here)					

2. How do you use the information and skills you learned from attending the IWB sessions?

I use the information and skills in dealing with.....	Strongly agree	Moderately agree	Unsure / Undecided	Moderately disagree	Strongly disagree
My co-teachers					
My peer Mathematics teachers					
The public					
My community					
My family					
My students					
Other: (Please add here)					

3. As a result of the IWB sessions, rate how you IMPROVED in each competency area.

Competencies	Greatly improved	Somewhat improved	Unsure / Undecided	Somewhat unimproved	Very unimproved
Understanding yourself and others					
Understanding your own understanding of fundamentals of					

Addendum 3.7

Algebra					
Communicating clearly in writing					
Listening effectively					
Solving problems					
Communicating effectively by speaking					
Motivating learners to excel in Mathematics					
Changing peoples' attitudes towards Mathematics					

4. I would recommend the IWB sessions on NWPK 512 to other students who are enrolled for the module.

Strongly agree	Moderately agree	Unsure / Undecided	Moderately disagree	Strongly disagree

5. Please complete the following generic questions.

Your current age?		Younger than 30 years	30 – 40 years	40 – 50 years	Older than 50 years	
Your sex?		Male		Female		
In what phase are you currently teaching Mathematics?		FP (Gr.R – 3)	IP (Gr.4 – 6)	SP (Gr.7 – 9)	FET (Gr.10 – 12)	
Which grades are you currently teaching or have you taught Mathematics before (for at least 1 year)?	Gr. R - 3	Gr. 4 - 6	Gr. 7	Gr. 8	Gr. 9	Gr. 10 – 12

6. If there's anything else you would like to say about the IWB sessions, please do so here.

_____
_____
_____
_____
_____

Thank you for taking the time to fill out this questionnaire

Addendum 3.8

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Questionnaire to evaluate change w.r.t value and behaviour that students obtained

1. To what extent did the participant's attendance of the IWB sessions affect him/her?

It affected the participant to the extent that.....	To a great extent	To a moderate extent	Unsure / Undecided	To a small extent	To no extent
He / She is better able to perform his/her job duties					
He / She is motivated to succeed in his/her studies					
He / She gained more confidence in teaching Mathematics					
His / Her own understanding of fundamental principles of Algebra improved					
Other: (Please add here)					

2. How does the participant use the information and skills that he/she learned from attending the IWB sessions?

The participant uses the information and skills in dealing with.....	Strongly agree	Moderately agree	Unsure / Undecided	Moderately disagree	Strongly disagree
His / Her co-teachers					
His / Her peer Mathematics teachers					
The public					
His / Her community					
His / Her family					
His / Her students					
Other: (Please add here)					

3. As a result of the IWB sessions, rate how the participant IMPROVED in each competency area.

Competencies	Greatly improved	Somewhat improved	Unsure / Undecided	Somewhat unimproved	Very unimproved
Understanding him/herself and others					
Understanding his/her own understanding of fundamentals of Algebra					
Communicating clearly in writing					
Listening effectively					
Solving problems					
Communicating effectively by speaking					
Motivating learners to excel in Mathematics					
Changing peoples' attitudes towards Mathematics					

Addendum 3.8

4. What is your relationship with the participant?

Peer	
Supervisor	

5. Please complete the following generic questions.

Your current age?		Younger than 30 years	30 – 40 years	40 – 50 years	Older than 50 years	
Your sex?		Male		Female		
In what phase are you currently teaching Mathematics?		FP (Gr.R – 3)	IP (Gr.4 – 6)	SP (Gr.7 – 9)	FET (Gr.10 – 12)	
Which grades are you currently teaching or have you taught Mathematics before (for at least 1 year)?	Gr. R - 3	Gr. 4 - 6	Gr. 7	Gr. 8	Gr. 9	Gr. 10 – 12

6. If there's anything else you would like to say about the IWB sessions, please do so here.

_____
_____
_____
_____
_____

Thank you for taking the time to fill out this questionnaire

Addendum 3.9

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Pre-test for NWPK 512 [20 minutes]

1. Complete this section first by choosing one option in each case of A, B and C:

A. Age group: **25 – 40 years** **41 – 50 years** **older than 50 years**

B. Sex: **Male** **or** **Female**

C. Teaching Maths in phase: **Foundation phase** **Intermediate phase** **Senior phase** **FET phase**

2. No names or student numbers necessary, but please write down the number the facilitator assigned to you. And remember it so that you use the same number when doing the post-test

Number: ☐

3. Answer the following questions by doing it on the test page

1. Write down the next four terms of each pattern and the functional relationship for each:

1.1 5; 8; 11; _____; _____; _____; _____;

1.2 2; 4; 8; _____; _____; _____; _____;

2.1 Write [- 3 ; 2) in set-builder notation. _____

2.2 Express [- 3 ; 2) graphically. _____

2.3 Express { - 3 ; 2 } graphically. _____

2.4 Write 

in set-builder notation.

Addendum 3.9

_____

3. Write down algebraic expressions for the following:

3.1 five times the sum of a number p and three _____

3.2 the sum of five times a number p and three _____

3.3 the product of m and the square of y _____

3.4 the number of boys in a class of 30 if there are m girls in the class _____

3.5 the sum of three consecutive natural numbers if the smallest number is n

_____

4. Simplify:

4.1 2^{-3}= _____

4.2 $(3x^4)^2 - 5(x^2)^4 + 2x^6$ = _____

4.3 $20 - 10(k - 2)$ = _____

4.4 $\frac{a}{b} - \frac{b}{a}$ = _____

4.5 $\frac{a}{b} \times \frac{b}{a}$ = _____

5. Factorise in full:

a. $2a + 4$ = _____

b. $4 - a^2$ = _____

c. $x^2 - 5x - 6$ = _____

6.1 Simplify the expression $2x^2 + 4 + 4x^2$ = _____

6.2 Factorise the expression $2x^2 + 4 + 4x^2$ = _____

6.3 Explain the difference between “simplifying” and “factorising” an expression in your own words.

_____

_____

_____

Addendum 3.9

7. Simplify: $\frac{x}{3}+\frac{5}{x}-\frac{x+1}{2}$

8. Solve for x: $\frac{x}{3}+\frac{5}{x}=\frac{x+1}{2}$

9. Explain the basic difference between “simplifying an expression” and “solving an equation” in your own words.

10. If $If\ a=-1,\ p=0\ \ and\ \ m=\frac{1}{2}\ \ evaluate\ \ a^p-\frac{1}{m}$

Thank you for completing this test

Addendum 3.10

Post-test for NWPK 512 [20 minutes]

1. Complete this section first by choosing one option in each case of A, B and C:

A. Age group: **25 – 40 years** **41 – 50 years** **older than 50 years**

B. Sex: **Male** **or** **Female**

C. Teaching Maths in phase: **Foundation phase** **Intermediate phase** **Senior phase** **FET phase**

2. No names or student numbers necessary, but please write down the number the facilitator assigned to you. And remember it so that you use the same number when doing the post-test

Number: ☐

3. Answer the following questions by doing it on the test page

1. Write down the next four terms of each pattern and the functional relationship for each:

1.1 5; 8; 11; _____; _____; _____; _____;

1.2 2; 4; 8; _____; _____; _____; _____;

2.1 Write [- 3 ; 2) in set-builder notation. _____

2.2 Express [- 3 ; 2) graphically. _____

2.3 Express { - 3 ; 2 } graphically. _____

2.4 Write 

in set-builder notation.

_____

Addendum 3.10

3. Write down algebraic expressions for the following:

3.1 five times the sum of a number p and three _____

3.2 the sum of five times a number p and three _____

3.3 the product of m and the square of y _____

3.4 the number of boys in a class of 30 if there are m girls in the class _____

3.5 the sum of three consecutive natural numbers if the smallest number is n

_____

4. Simplify:

4.1 2^{-3}= _____

4.2 $(3x^4)^2 - 5(x^2)^4 + 2x^6$ = _____

4.3 $20 - 10(k - 2)$ = _____

4.4 $\frac{a}{b} - \frac{b}{a}$ = _____

4.5 $\frac{a}{b} \times \frac{b}{a}$ = _____

5. Factorise in full:

a. $2a + 4$ = _____

b. $4 - a^2$ = _____

c. $x^2 - 5x - 6$ = _____

6.1 Simplify the expression $2x^2 + 4 + 4x^2$ = _____

6.2 Factorise the expression $2x^2 + 4 + 4x^2$ = _____

6.3 Explain the difference between “simplifying” and “factorising” an expression in your own words.

_____

_____

_____

Addendum 3.10

7. Simplify: $\frac{x}{3}+\frac{5}{x}-\frac{x+1}{2}$

8. Solve for x: $\frac{x}{3}+\frac{5}{x}=\frac{x+1}{2}$

9. Explain the basic difference between “simplifying an expression” and “solving an equation” in your own words.

10. If $If\ a=-1,\ p=0\ \ and\ \ m=\frac{1}{2}\ \ evaluate\ \ a^p-\frac{1}{m}$

Thank you for completing this test

```
GET DATA /TYPE=XLSX
  /FILE='Q:\D\Dreyer_Hermien_Jul14\Suria data 18 July 2014.xlsx'
  /SHEET=name ' Pre-Test; marks per question'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet13 WINDOW=FRONT.

SAVE OUTFILE='Q:\D\Dreyer_Hermien_Jul14\Pre-test.sav'
  /COMPRESSED.
RELIABILITY
  /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL CORR.
```

Reliability

Notes	
Output Created	
Comments	
Input	
Missing Value Handling	
Syntax	
Resources	

[DataSet13] Q:\D\Dreyer_Hermien_Jul14\Pre-test.sav

Warnings

The determinant of the covariance matrix is zero or approximately zero. Statistics based on its inverse matrix cannot be computed and they are displayed as system missing values.

Scale: ALL VARIABLES

Case Processi

Cases	

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha
.778

Inter-Item Correlations

Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10

```
GET DATA /TYPE=XLSX
  /FILE='Q:\D\Dreyer_Hermien_Jul14\Suria data 18 July 2014.xlsx'
  /SHEET=name 'Pre-and Post-tests'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
```

```
DATASET NAME DataSet14 WINDOW=FRONT.
T-TEST PAIRS=PreTest WITH PostTest (PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.

NPAR TESTS
  /WILCOXON=PreTest WITH PostTest (PAIRED)
  /MISSING ANALYSIS.

SORT CASES  BY V1.
SPLIT FILE LAYERED BY V1.
T-TEST PAIRS=PreTest WITH PostTest (PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.
```

T-Test

	Notes
Output Created	
Comments	
Input	
Missing Value Handling	
Syntax	
Resources	

V1
E
K

V1

E
K

V1
E
K

```
NPAR TESTS
  /WILCOXON=PreTest WITH PostTest (PAIRED)
  /MISSING ANALYSIS.
```

NPar Tests

Notes	
Output Created	
Comments	
Input	
Missing Value Handling	
Syntax	
Resources	

a. Based on availability of workspace memory.

Wilcoxon Signed Ranks Test

V1
E

K

a. Post-Test < Pre-Test

b. Post-Test > Pre-Test

c. Post-Test = Pre-Test

Test Statistics[a]

V1
E
K

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

```
SAVE TRANSLATE OUTFILE='Q:\D\Dreyer_Hermien_Jul14\Pre-Post.xlsx'
  /TYPE=XLS
  /VERSION=12
  /MAP
  /REPLACE
  /FIELDNAMES
  /CELLS=VALUES.

Data written to Q:\D\Dreyer_Hermien_Jul14\Pre-Post.xlsx.
3 variables and 20 cases written to range: SPSS.
Variable: V1                Type: String   Width:   1
Variable: PreTest           Type: Number   Width:  12   Dec: 1
Variable: PostTest          Type: Number   Width:  12   Dec: 1


GET DATA /TYPE=XLSX
  /FILE='Q:\D\Dreyer_Hermien_Jul14\Suria data 18 July 2014.xlsx'
  /SHEET=name ' Student Questionnaire'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet15 WINDOW=FRONT.

SAVE OUTFILE='Q:\D\Dreyer_Hermien_Jul14\Student.sav'
  /COMPRESSED.
FREQUENCIES VARIABLES=V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V1
  /ORDER=ANALYSIS.
```

Frequencies

Notes	
Output Created	
Comments	
Input	
Missing Value Handling	
Syntax	
Resources	

```
[DataSet15] Q:\D\Dreyer_Hermien_Jul14\Student.sav
```

N

Frequency Table

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

```
GET DATA /TYPE=XLSX
  /FILE='Q:\D\Dreyer_Hermien_Jul14\Suria data 18 July 2014.xlsx'
  /SHEET=name 'Supervisor Questionnaire'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet16 WINDOW=FRONT.

SAVE OUTFILE='Q:\D\Dreyer_Hermien_Jul14\Supervisor.sav'
  /COMPRESSED.
FREQUENCIES VARIABLES=V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V1
  /ORDER=ANALYSIS.
```

Frequencies

	Notes
Output Created	
Comments	
Input	
Missing Value Handling	
Syntax	
Resources	

[DataSet16] Q:\D\Dreyer_Hermien_Jul14\Supervisor.sav

N

Frequency Table

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

Valid

	21-JUL-2014 12:33:08
Data	Q:\D\Dreyer_Hermien_Jul14\Pre-test.sav
Active Dataset	DataSet13
Filter	<none>
Weight	<none>
Split File	<none>
N of Rows in Working Data File	20
Matrix Input	
Definition of Missing	User-defined missing values are treated as missing.
Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
	RELIABILITY /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /SUMMARY=TOTAL CORR.
Processor Time	00:00:00.00
Elapsed Time	00:00:00.02

ng Summary

	N	%
Valid	20	100.0
Excluded[a]	0	0.0
Total	20	100.0

Cronbach's Alpha Based on Standardized Items	N of Items
.908	10

Summary Item Statistics

Mean	Minimum	Maximum	Range
.495	.023	.943	.920

Item-Total Statistics

Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation
6.200	21.853	.562	
8.000	23.526	.704	
6.475	17.039	.525	
6.300	20.484	.253	
6.975	17.881	.644	
6.975	18.539	.760	
8.000	23.895	.825	
8.025	24.697	.790	
7.875	23.418	.649	
7.850	23.871	.578	

	21-JUL-2014 12:36:01
Active Dataset	DataSet14
Filter	<none>
Weight	<none>
Split File	V1
N of Rows in Working Data File	20
Definition of Missing	User defined missing values are treated as missing.
Cases Used	Statistics for each analysis are based on the cases with no missing or out-of-range data for any variable in the analysis.
	T-TEST PAIRS=PreTest WITH PostTest (PAIRED) /CRITERIA=CI(.9500) /MISSING=ANALYSIS.
Processor Time	00:00:00.02
Elapsed Time	00:00:00.02

Paired Samples Statistics

		Mean	N
Pair 1	Pre-Test	8.750	10
	Post-Test	11.300	10
Pair 1	Pre-Test	7.500	10
	Post-Test	7.950	10

Paired Samples Correlations

	N	Correlation

Pair 1	Pre-Test & Post-Test	10	.931
Pair 1	Pre-Test & Post-Test	10	.860

Paired Samples Test

		Mean	Std. Deviation
Pair 1	Pre-Test - Post-Test	-2.5500	2.7228
Pair 1	Pre-Test - Post-Test	-.4500	2.3028

	21-JUL-2014 12:36:11
Active Dataset	DataSet14
Filter	<none>
Weight	<none>
Split File	V1
N of Rows in Working Data File	20
Definition of Missing	User-defined missing values are treated as missing.
Cases Used	Statistics for each test are based on all cases with valid data for the variable(s) used in that test.
	NPAR TESTS /WILCOXON=PreTest WITH PostTest (PAIRED) /MISSING ANALYSIS.
Processor Time	00:00:00.00
Elapsed Time	00:00:00.00
Number of Cases Allowed[a]	112347

Ranks

		N	Mean Rank
Post-Test - Pre-Test	Negative Ranks	1[a]	4.00
	Positive Ranks	9[b]	5.67

	Ties	0[c]	
	Total	10	
Post-Test - Pre-Test	Negative Ranks	4[a]	6.63
	Positive Ranks	6[b]	4.75
	Ties	0[c]	
	Total	10	

	Post-Test - Pre-Test	Effect size
Z	-2.403	0.54
Asymp. Sig. (2-tailed)	.016	
Z	-0.103	0.02
Asymp. Sig. (2-tailed)	.918	

4 V15 V16 V17 V18 V19 V20 V21 V22 V23 V24 V25 V26 V27 V28 V29

	21-JUL-2014 12:38:59
Data	Q:\D\Dreyer_Hermien_Jul14\Student.sav
Active Dataset	DataSet15
Filter	<none>
Weight	<none>
Split File	<none>
N of Rows in Working Data File	10
Definition of Missing	User-defined missing values are treated as missing.
Cases Used	Statistics are based on all cases with valid data.
	FREQUENCIES VARIABLES=V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17 V18 V19 V20 V21 V22 V23 V24 V25 V26 V27 V28 V29 /ORDER=ANALYSIS.
Processor Time	00:00:00.00
Elapsed Time	00:00:00.05

	1.1000000000000001	1.2	1.3
Valid	10	10	10
Missing	0	0	0

1.1000000000000001

	Frequency	Percent	Valid Percent
1	8	80.0	80.0
2	2	20.0	20.0
Total	10	100.0	100.0

1.2

	Frequency	Percent	Valid Percent
1	4	40.0	40.0

2	6	60.0	60.0
Total	10	100.0	100.0

1.3

	Frequency	Percent	Valid Percent
1	3	30.0	30.0
2	7	70.0	70.0
Total	10	100.0	100.0

1.4

	Frequency	Percent	Valid Percent
1	5	50.0	50.0
2	5	50.0	50.0
Total	10	100.0	100.0

1.5

	Frequency	Percent	Valid Percent
1	3	30.0	30.0
2	7	70.0	70.0
Total	10	100.0	100.0

2.1

	Frequency	Percent	Valid Percent
	2	20.0	20.0
1	1	10.0	10.0
2	7	70.0	70.0
Total	10	100.0	100.0

2.2000000000000002

	Frequency	Percent	Valid Percent
1	6	60.0	60.0
2	3	30.0	30.0
3	1	10.0	10.0
Total	10	100.0	100.0

2.2999999999999998

	Frequency	Percent	Valid Percent
1	6	60.0	60.0
2	4	40.0	40.0
Total	10	100.0	100.0

2.4

	Frequency	Percent	Valid Percent

1	3	30.0	30.0
2	6	60.0	60.0
3	1	10.0	10.0
Total	10	100.0	100.0

3.1

	Frequency	Percent	Valid Percent
1	3	30.0	30.0
2	7	70.0	70.0
Total	10	100.0	100.0

3.2

	Frequency	Percent	Valid Percent
1	6	60.0	60.0
2	4	40.0	40.0
Total	10	100.0	100.0

3.3

	Frequency	Percent	Valid Percent
1	2	20.0	20.0
2	5	50.0	50.0
3	2	20.0	20.0
4	1	10.0	10.0
Total	10	100.0	100.0

3.4

	Frequency	Percent	Valid Percent
1	1	10.0	10.0
2	6	60.0	60.0
3	2	20.0	20.0
4	1	10.0	10.0
Total	10	100.0	100.0

3.5

	Frequency	Percent	Valid Percent
1	5	50.0	50.0
2	5	50.0	50.0
Total	10	100.0	100.0

3.6

	Frequency	Percent	Valid Percent
1	8	80.0	80.0
2	2	20.0	20.0
Total	10	100.0	100.0

4.0999999999999996

	Frequency	Percent	Valid Percent
1	6	60.0	60.0
2	3	30.0	30.0
3	1	10.0	10.0
Total	10	100.0	100.0

4.2

	Frequency	Percent	Valid Percent
1	3	30.0	30.0
2	7	70.0	70.0
Total	10	100.0	100.0

4.3

	Frequency	Percent	Valid Percent
1	4	40.0	40.0
2	6	60.0	60.0
Total	10	100.0	100.0

4.4000000000000004

	Frequency	Percent	Valid Percent
1	6	60.0	60.0
2	3	30.0	30.0
4	1	10.0	10.0
Total	10	100.0	100.0

4.5

	Frequency	Percent	Valid Percent
1	1	10.0	10.0
2	8	80.0	80.0
4	1	10.0	10.0
Total	10	100.0	100.0

4.5999999999999996

	Frequency	Percent	Valid Percent
1	5	50.0	50.0
2	3	30.0	30.0
3	2	20.0	20.0
Total	10	100.0	100.0

4.7

	Frequency	Percent	Valid Percent

1	8	80.0	80.0
2	2	20.0	20.0
Total	10	100.0	100.0

4.8

	Frequency	Percent	Valid Percent
1	7	70.0	70.0
2	3	30.0	30.0
Total	10	100.0	100.0

5.0999999999999996

	Frequency	Percent	Valid Percent
1	8	80.0	80.0
2	2	20.0	20.0
Total	10	100.0	100.0

6.1

	Frequency	Percent	Valid Percent
1	1	10.0	10.0
2	2	20.0	20.0
3	6	60.0	60.0
4	1	10.0	10.0
Total	10	100.0	100.0

6.2

	Frequency	Percent	Valid Percent
1	4	40.0	40.0
2	6	60.0	60.0
Total	10	100.0	100.0

6.3

	Frequency	Percent	Valid Percent
2	5	50.0	50.0
3	5	50.0	50.0
Total	10	100.0	100.0

6.4

	Frequency	Percent	Valid Percent
2	4	40.0	40.0
3	4	40.0	40.0
4	1	10.0	10.0
5	1	10.0	10.0
Total	10	100.0	100.0

4 V15 V16 V17 V18 V19 V20 V21 V22 V23

	21-JUL-2014 12:39:45
Data	Q:\D\Dreyer_Hermien_Jul14\Supervisor.sav
Active Dataset	DataSet16
Filter	<none>
Weight	<none>
Split File	<none>
N of Rows in Working Data File	10
Definition of Missing	User-defined missing values are treated as missing.
Cases Used	Statistics are based on all cases with valid data. FREQUENCIES VARIABLES=V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17 V18 V19 V20 V21 V22 V23 /ORDER=ANALYSIS.
Processor Time	00:00:00.02
Elapsed Time	00:00:00.02

	1.1000000000000001	1.2	1.3
Valid	10	10	10
Missing	0	0	0

1.1000000000000001

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	6	60.0	60.0
2	3	30.0	30.0
Total	10	100.0	100.0

1.2

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	7	70.0	70.0
2	2	20.0	20.0
Total	10	100.0	100.0

1.3

	Frequency	Percent	Valid Percent
1	10	100.0	100.0

1.4

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	5	50.0	50.0
2	4	40.0	40.0
Total	10	100.0	100.0

2.1

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	5	50.0	50.0
2	4	40.0	40.0
Total	10	100.0	100.0

2.2000000000000002

	Frequency	Percent	Valid Percent
1	8	80.0	80.0
2	2	20.0	20.0
Total	10	100.0	100.0

2.2999999999999998

	Frequency	Percent	Valid Percent

	1	10.0	10.0
1	3	30.0	30.0
2	5	50.0	50.0
3	1	10.0	10.0
Total	10	100.0	100.0

2.4

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	3	30.0	30.0
2	6	60.0	60.0
Total	10	100.0	100.0

2.5

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	4	40.0	40.0
2	4	40.0	40.0
3	1	10.0	10.0
Total	10	100.0	100.0

2.6

	Frequency	Percent	Valid Percent
1	10	100.0	100.0

3.1

	Frequency	Percent	Valid Percent
	2	20.0	20.0
1	5	50.0	50.0
2	3	30.0	30.0
Total	10	100.0	100.0

3.2

	Frequency	Percent	Valid Percent
1	5	50.0	50.0
2	5	50.0	50.0
Total	10	100.0	100.0

3.3

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	6	60.0	60.0
2	3	30.0	30.0
Total	10	100.0	100.0

3.4

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	9	90.0	90.0
Total	10	100.0	100.0

3.5

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	4	40.0	40.0
2	5	50.0	50.0
Total	10	100.0	100.0

3.6

	Frequency	Percent	Valid Percent
	1	10.0	10.0
1	5	50.0	50.0
2	4	40.0	40.0
Total	10	100.0	100.0

3.7

	Frequency	Percent	Valid Percent
1	9	90.0	90.0
2	1	10.0	10.0
Total	10	100.0	100.0

3.8

	Frequency	Percent	Valid Percent
1	9	90.0	90.0
2	1	10.0	10.0
Total	10	100.0	100.0

4.0999999999999996

	Frequency	Percent	Valid Percent
	1	10.0	10.0
3	7	70.0	70.0
4	2	20.0	20.0
Total	10	100.0	100.0

4.2

	Frequency	Percent	Valid Percent
1	6	60.0	60.0

2	4	40.0	40.0
Total	10	100.0	100.0

4.3

	Frequency	Percent	Valid Percent
2	5	50.0	50.0
3	4	40.0	40.0
4	1	10.0	10.0
Total	10	100.0	100.0

4.4000000000000004

	Frequency	Percent	Valid Percent
2	5	50.0	50.0
3	2	20.0	20.0
5	2	20.0	20.0
6	1	10.0	10.0
Total	10	100.0	100.0

Maximum / Minimum	Variance	N of Items
40.895	.046	10

Cronbach's Alpha if Item Deleted
.749
.759
.764
.814
.728
.712
.762
.772
.758
.764

Std. Deviation	Std. Error Mean	p	Effect size
6.5627	2.0753		
7.3907	2.3371	.016	0.39
3.4721	1.0980	.552	0.13
4.4563	1.4092		

Sig.

.000
.001

Paired Differences					
	95% Confidence Interval of the Difference				
Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
.8610	-4.4978	-.6022	-2.962	9	.016
.7282	-2.0973	1.1973	-.618	9	.552

Sum of Ranks
4.00
51.00

26.50
28.50

Statistics

1.4	1.5	2.1	2.2000000000000002	2.2999999999999998	2.4
10	10	10	10	10	10
0	0	0	0	0	0

Cumulative Percent
80.0
100.0

Cumulative Percent
40.0

100.0

Cumulative Percent
30.0
100.0

Cumulative Percent
50.0
100.0

Cumulative Percent
30.0
100.0

Cumulative Percent
20.0
30.0
100.0

Cumulative Percent
60.0
90.0
100.0

Cumulative Percent
60.0
100.0

Cumulative Percent

30.0
90.0
100.0

Cumulative Percent
30.0
100.0

Cumulative Percent
60.0
100.0

Cumulative Percent
20.0
70.0
90.0
100.0

Cumulative Percent
10.0
70.0
90.0
100.0

Cumulative Percent
50.0
100.0

Cumulative Percent
80.0
100.0

Cumulative Percent
60.0
90.0
100.0

Cumulative Percent
30.0
100.0

Cumulative Percent
40.0
100.0

Cumulative Percent
60.0
90.0
100.0

Cumulative Percent
10.0
90.0
100.0

Cumulative Percent
50.0
80.0
100.0

Cumulative Percent

80.0
100.0

Cumulative Percent
70.0
100.0

Cumulative Percent
80.0
100.0

Cumulative Percent
10.0
30.0
90.0
100.0

Cumulative Percent
40.0
100.0

Cumulative Percent
50.0
100.0

Cumulative Percent
40.0
80.0
90.0
100.0

Statistics

1.4	2.1	2.2000000000000002	2.2999999999999998	2.4	2.5
10	10	10	10	10	10
0	0	0	0	0	0

Cumulative Percent
10.0
70.0
100.0

Cumulative Percent
10.0
80.0
100.0

Cumulative Percent
100.0

Cumulative Percent
10.0
60.0
100.0

Cumulative Percent
10.0
60.0
100.0

Cumulative Percent
80.0
100.0

Cumulative Percent

10.0
40.0
90.0
100.0

Cumulative Percent
10.0
40.0
100.0

Cumulative Percent
10.0
50.0
90.0
100.0

Cumulative Percent
100.0

Cumulative Percent
20.0
70.0
100.0

Cumulative Percent
50.0
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Cumulative Percent
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Cumulative Percent
60.0

100.0

Cumulative Percent
50.0
90.0
100.0

Cumulative Percent
50.0
70.0
90.0
100.0

3.1	3.2	3.3	3.4	3.5	3.6	4.0999999999999996	4.2
10	10	10	10	10	10	10	10
0	0	0	0	0	0	0	0

2.6	3.1	3.2	3.3	3.4	3.5	3.6	3.7
10	10	10	10	10	10	10	10
0	0	0	0	0	0	0	0

4.3	4.4000000000000004	4.5	4.5999999999999996	4.7	4.8	5.0999999999999996
10	10	10	10	10	10	10
0	0	0	0	0	0	0

3.8	4.0999999999999996	4.2	4.3	4.4000000000000004
10	10	10	10	10
0	0	0	0	0

6.1	6.2	6.3	6.4
10	10	10	10
0	0	0	0

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Hierdie vorm is ook in Afrikaans beskikbaar

(Op die NWU Webblad gaan na https://intranet.nwu.ac.za/opencms/export/intranet/html/en/in-im-rs/researchethics/index.html
en selekteer dan die verlangde dokument vanuit die lys)

The latest version of this form in English

(On the NWU Website go to https://intranet.nwu.ac.za/opencms/export/intranet/html/en/in-im-rs/researchethics/index.html
and then select the required document from the list)

NWU Office for Research Support – Ethics Committee

NWU ETHICS APPLICATION FORM

Application for Approval for Scientific Projects with Human Participants, Biological Samples of Human Origin or Vertebrates

Version 1.05 (Mei 2008)

CONFIDENTIAL! / VERTROULIK!

Instructions and recommended path for the completion of your application:

1. Read/study the information guide and familiarise yourself with the terminology, principles, concepts, instructions and procedures.
2. All applicants complete § 1, 2 & 3. ***Tip:*** *Navigate from the table of contents to appropriate sections in this application form. Hold [Ctrl] + click with the mouse on the appropriate heading.*
3. Select the sub-sections from § 4, 5, 6, 7 & 9 that are applicable to your project (by utilising the table of contents) and complete.
4. Liaise with appropriate officers and colleagues mentioned in § 8, complete, print the pages and have them signed.
5. If applicable, compile a typical form for informed consent to be submitted with your ethics application form. You may use the model form on the Webpage of the Ethics Committee, or you may compile your own form (or multiple forms for e.g. sub-projects with different participant target groups) according to the guidelines.
6. Submit the completed Ethics Application Form via e-mail to ethics@nwu.ac.za *(contact person Ms Hannekie Botha)*.
7. Send the original hard copies of the signed pages to the Office of the Ethics Committee, Box 116, PUK, North-West University, Potchefstroom, 2520 *(contact person Ms Hannekie Botha)*.

NWU Ethics Number ***(for office use only)***

N	W	U	-	?	?	?	?	?	-	?	?	-	?	?
Institution				Project Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Campus	Potchefstroom	**Faculty**	Education Sciences
Project Head	Prof. A.S. Blignaut	**Research Focus Area / Unit**	5.1 Teach-learn
Project Title	Design integration of interactive whiteboards in an open distance mathematics programme		

Table of Contents

Please note! ***Document navigation***

Use this table of content to jump-link to appropriate sections (Ctrl on the keyboard + mouse-click on the page number). Use Ctrl + Home to jump back to the top of the document and scroll down to the Table of Contents again. The mouse wheel may work best for scrolling.

As you complete the application form, page numbers may change and the links in the table of contents below will not work correctly any longer. You then need to update it as follows: highlight the table of contents below, press "F9" on you keyboard and select to "update page numbers only".

Section 1: Project Classification

Complete every option of all the questions in this section and sign. This section is used to classify your project and select suitable evaluators. *(This application form is currently being developed in Web format. As soon as it has been designed and made available, this section will be used to compile your individualised electronic ethics application form, so that only those sections that apply to your project are included. This will simplify the completion of the application form for you and prevent you having to complete an unnecessarily long application form with irrelevant questions.)*

1.1 Date of application

(Fill in below the date of the first submission of this ethics application)

2	0	1	3	-	1	0	-	0	1
c	c	y	y		m	m		d	d

Date

1.2 In this project use is made of:

(Mark ALL options as "Yes" or "No" with **X** *in the appropriate box – more than one option may be "Yes".)*

Description		Yes	No
Human participants (subjects)	– humanities qualitative	☒	☐
	– humanities quantitative	☒	☒
	– biological / biomedical scientific	☐	☒
	– all other (e.g. economic, judicial, etc.)	☐	☒
Filed privileged information or stored biological samples of human origin *(e.g. medical files or samples collected for another project or medical diagnosis)*		☐	☒
Animal subjects (vertebrates)		☐	☒

1.3 Context of the Project

(Mark ALL options as "Yes" or "No" with **X** *in the appropriate box – more than one option may be "Yes".)*

Description		Yes	No
Scientific Research (experiment or study)	– Project falls within a research focus area	☒	☐
	– Project falls outside a research focus area	☐	☒
	– Project includes postgraduate study (e.g. doctorate or masters)	☒	☐
	– Project includes contract work	☐	☒
Training (education purposes) *…excluding research-based Master's & Doctoral – see "Scientific Research" above*	– For staff of the North-West University	☐	☒
	– For students (undergraduate or postgraduate learners)	☒	☐
	– For other learners (not associated with University)	☐	☒
Other context (specify below)		☐	☐

Other context (specify)

1.4 **This application:**
(Select the correct option from the dropdown box)

> ***More information***
> *An application cannot include both a pilot study and the full project. Where a pilot study is necessary for the planning of the full project (i.e. to determine the optimal conditions / number of participants / etc.), the ethics application for the pilot study must first be completed, whereupon the application is made for ethical approval of the full project based on the results of the pilot study. For a full project adequate data is available to plan the final study, or the project is only for training purposes. See also the "Information Guide for the NWU Ethics Application Form" (available on the Webpage) for further explanation.*

Description	Response
Is this an application for a ***full project*** or a ***pilot study***?	**Full project**
Has this project also been evaluated by ***another ethics committee*** (e.g. multi-institutional projects)?	**No, and will not be**
Are there any ***contractual agreements*** with any person, group or institution involved in this project (see §2.7)?	**No**

1.5 **This project encompasses experimentation with use, administration or restraint of, or other intervention with:**
(Mark ALL options as "Yes" or "No" with **X** *in the appropriate box – more than one option may be "Yes".)*

Description	Yes	No
Persons who are particularly vulnerable or incompetent to give informed consent (e.g. minors, own students, intellectually incompetent persons, defenceless communities)	☐	☒
Human stem cells, germ line cells, embryos and/or foetuses	☐	☒
Living cell and tissue cultures	☐	☒
Use of genetic material, genetic manipulation, or genetically manipulated animals, plants or other organisms / tissue / cells	☐	☒
Injections, blood samples, swabs and similar interference	☐	☒
Use of drugs / medicines	☐	☒
Use of radio-active substances	☐	☒
Use of toxic substances or dangerous substances	☐	☒
Use of food, fluids or nutrients	☐	☒
Psychometric measuring instruments and questionnaires	☐	☒
Any other aspect of potentially ethically sensitive nature (specify below)	☐	☒

Other aspects (specify)

Not applicable

1.6 **For this project the following persons were included in the project team:**
(Fill in the number concerned with ALL options.)

Description		Number	
		Local	Foreign
All projects *(everyone completes this)*	– Project Head	1	0
	– Project supervisor	3	0
Only for research projects (experiment or study)	– Co-workers (researchers of the North-West University)	0	0
	– Co-workers (researchers outside the North-West University)	0	0
	– Co-workers (postgraduate students of the North-West University)	0	0
	– Assistants / field workers	0	0
Only for training / educational projects (educational purposes)	– Co-workers (lecturers of the North-West University)	0	0
	– Co-workers (lecturers outside the North-West University	0	0
	– Students (undergraduate learners of the North-West University)	0	0
	– Students (postgraduate learners of the North-West University)	1	0
	– Other learners (not associated with the North-West University)	0	0
	– Assistants / field workers	0	0
Sponsors		0	0
Other members of the project team, *excluding professional supervisors mentioned below in §1.7 (specify below)*.		0	0

Other members of the project team (specify)

None

1.7 **The following professional supervisory persons are involved in this project (may in no way be directly involved with the research)**
(Fill in the number involved in ALL options.)

Researcher / Supervisor	Number
Supervisory Doctor	0
Supervisory Nurse	0
Supervisory Veterinary Surgeon	0

Researcher / Supervisor	Number
Supervisory Psychologist	0
Supervisory Pharmacist	0
Other Supervisory Person *(specify below)*	0

Other supervisory person (specify)

None

1.8 **I hereby declare that the above information in "Section 1: Project Classification" is complete and correct and that I did not withhold any information.**

Yes	No
☒	☐

Remember to save your document regularly as you complete it!

Section 2: Project Head, Co-workers and Supervisors

2.1 Details of Project Head

Name and details of the Project Head. **N.B!** Only NWU staff, or extraordinary professors in collaboration with staff of the North-West University, may register as Project Heads. A complete Medicines Control Council format *curriculum vitae* (MCC format CV[1]) must be attached by applicants for whom a recent CV is not available centrally to the University, as well as by all first applicants.

[1] The template for the MCC format CV is available from the Webpage of the NWU Ethics Committee.

More information

The "Project Head" accepts final, overall responsibility for the management of the total project. The Project Head is sometimes referred to in research projects as the Principle Investigator. The Project Head is a part of the project team.

The MCC format CV contains BRIEF SUMMARY of information relevant to the project under the headings "Personal Details", "Academic and Professional Qualifications", "Registrations at Professional Councils", "Current Personal Medical Malpractice Insurance Details" (if applicable), "Relevant Related Work Experience and Current Position", "Participation in Relevant Research in the Last Five Years", "Peer Reviewed Publications and Conference Presentations in the Past Five Years", "Date and Details of Last GCP/GLP Training", "Any additional Relevant Information Supporting Demonstrating Abilities to Participate in Conducting this Project"

Surname	Full Names	Title
Blignaut	Anita Seugnet	Professor

NWU Campus	Faculty	School / Subject Group / Institute
Potchefstroom	Education Sciences	Technology Enhanced Learning for Higher Education (TELHE)

Status	Rank / Designation	NWU Staff No.
Permanent Staff	Research Professor	21152276

Research Focus Area / Research Unit (if applicable)	Qualifications[2] (as applicable for project)	Professional Registration[3] (body & category)
5.1 Teach-learn	PhD	Not applicable

Telephone		NWU-box or Postal Address
Work	Home / Cell	
018 299 4566	083 469 3700	Internal Box 539

E-mail Address
Seugnet.Blignaut@nwu.ac.za

[2] Fill in all qualifications relevant to the project, e.g. Ph.D., M.Sc., M.B.Ch.B., B.Pharm., B. Cur., M.Psig., etc.

[3] Fill in your category of professional registrations with councils that are applicable to the project, e.g. HPCSA if medical doctor, SAPC if pharmacist, SANC if nurse, HPCSA if clinical psychologist, SACNASP if scientist of SA Council of Natural Science Professions, etc.

2.2 Details of Project Supervisor

2.2.1 Is the Project Head also the project supervisor?
(Please mark with **X** *in the appropriate box)*

> ***More information***
> *Where the Project Head is not physically present or consistently available and where supervision of the research activities is necessary, or where the Project Head is relatively inexperienced (e.g. junior researchers in the case of a research project, or lecturers in the case of training), a suitable researcher / lecturer may be designated as project supervisor. The project supervisor is part of the project team.*

Yes	No
☒	☐

2.2.2 If "No" (i.e. if the Project Head is not the research supervisor) details of the supervisor must also be supplied. If "Yes", this part can be left blank.

Surname	Full Names	Title

NWU Campus	Faculty	School / Subject Group / Institute
- select -	- select -	

Status	Rank / Designation	NWU Staff No.
- select -		

Research Focus Area / Research Unit (if applicable)	Qualifications[4] (as applicable for project)	Professional Registration[5] (body & category)
- select -		

Telephone		NWU-box or Postal Address
Work	Home / Cell	

E-mail Address

[4] Fill in all qualifications relevant to the project, e.g. Ph.D., M.Sc., M.B.Ch.B., B.Pharm., B. Cur., M.Psig., etc.

[5] Fill in your category of professional registrations with councils that are applicable to the project, e.g. HPCSA if medical doctor, SAPC if pharmacist, SANC if nurse, HPCSA if clinical psychologist, SACNASP if scientist of SA Council of Natural Science Professions, etc.

2.3 Other Members of the Project Team

2.3.1 Names, qualifications and associations of all other co-workers (researchers and postgraduate students in the case of a research project, or lecturers in the case of training) and assistants / field workers who form part of the project team (excluding professional supervisors who may not be directly involved in the project – see §2.4):

Name	Qualifications[6]	Professional Registration[7]	Association and/or Function
Prof Hercules Nieuwoudt	PhD	Not applicable	Co-supervisor
Dr Hennie Esterhuizen	PhD	Not applicable	Co-supervisor
Hermien Dreyer	Hons BEd	Not applicable	MEd-researcher

(Type one name per row, or type "none" if there is no other team member)

6 Fill in all qualifications that are relevant to the project to be able to act as professional supervisor, e.g. M.B.Ch.B., B.Pharm., B. Cur., M.Psig., etc.

7 Fill in all categories of professional registrations with councils that are applicable to the project to be able to act as professional supervisor, e.g. HPCSA if medical doctor, SAPC if pharmacist, SANC if nurse, HPCSA if clinical psychologist, etc.

2.4 Professional Supervisors

2.4.1 Name and qualifications of all supervisory professional persons (e.g. doctor, psychologist, nurse, pharmacist, etc.) **N.B!** The professional supervisor(s) may not be part of the project team!

> ***More information***
> *In all cases where medical emergencies may possibly arise, the physical presence of a doctor and a registered nurse is required. For the drawing of blood samples (e.g. diet manipulation and similar studies) the presence of a registered nurse is sufficient.*

Name	Qualifications[8]	Professional Registration[9]	Function
Not applicable			

(Type one name per row, or type "none" if there is no supervisory person.)

2.5 Conflict of Interests & Sponsors

2.5.1 Declare with full details any conflict of interests of any one member of the project team or professional supervisor (see § 2.1, 2.2, 2.3 & 2.4).

Name of Researcher	Complete Description and Declaration
None	Not applicable

(Type one name per row, or type "none" if there is no member of the project team or professional supervisor with a conflict of interest.)

[8] Fill in all qualifications that are relevant to the project to be able to act as professional supervisor, e.g. M.B.Ch.B., B.Pharm., B. Cur., M.Psig., etc.

[9] Fill in all categories of professional registrations with councils that are applicable to the project to be able to act as professional supervisor, e.g. HPCSA if medical doctor, SAPC if pharmacist, SANC if nurse, HPCSA if clinical psychologist, etc.

2.5.2 Give full details of all sponsors of the project (name, address, affiliation with the project and the nature and extent of each sponsor's contribution).

Name of Sponsor	Contact Details	Affiliation & Contribution
None	Not applicable	Not applicable

(Type one name per row, or type "none" if there are no sponsors.)

2.5.3 Is any participant in the project directly or indirectly involved with one or more of the sponsors? Give full details.

Name of Participant	Association with Sponsor
None	Not applicable

(Type one name per row, or type "none" if there are no such participants.)

2.5.4 Does any member of the project team receive any form of remuneration or other benefits from the sponsor(s), either directly or indirectly? Give full details.

Name of Team Member	Details
None	Not applicable

(Type one name per row, or type "none" if there are no such team members.)

2.6 ***Collaborations***

Declare with full details all collaboration agreements, e.g. with researchers or lecturers from another institution, national or international, who will be working on a defined section of the project.

> ***More information***
>
> *Your local team may collaborate with a team from a different institution in South Africa or internationally, thereby, for example, to incorporate and benefit from their expertise and/or facilities. Typically in such cases you take responsibility for a certain part of the project and the collaborator for a different part. These responsibilities and agreements must be fully described and declared here.*

Name of Collaborator	Full Description and Declaration
None	Not applicable

(Type one name per row, or type "none" if there are no contractors.)

2.7 ***Contractual Agreements***

Declare with full details all contractual agreements (e.g. with team members, collaborators or sponsors) on the project.

Please note! A copy of any contractual agreements MUST be submitted to the Office of the Ethics Committee, together with submission of this application.

> ***More information***
>
> *Sometimes there are e.g. contractual obligations with co-workers of organisations outside the University. These contractual obligations may e.g. place restrictions on certain aspects on the availability of raw data i.t.o. intellectual right of ownership. Particularly where foreign co-workers are involved, these contracts can get complex. Therefore you must indicate here what these contractual obligations encompass, whether the University approved and sanctioned it and declare and describe any other potential legal and ethical implications thereof.*

Name of Contractor	Full Description and Declaration
None	Not applicable

(Type one name per row, or type "none" if there are no contractors.)

Remember to save your document regularly as you complete it!

Section 3: General Project Background

In this section the general project information is highlighted as of scientific interest, to give the selection panel a broad overview of the project and to sketch the context. You can therefore represent and discuss it here typically as you would do it for publication in a technical magazine or for a funding application. You also don't have to highlight and defend any ethical justifiability in Section 3, since it is done in Sections 4, 5 and 6.

3.1 Full, descriptive title of the project

Design integration of interactive whiteboards in an open distance mathematics programme

3.2 Has this project been already been evaluated and approved by a scientific committee (e.g. a committee for higher degrees, research committee, educational committee, etc.)? If "Yes", provide details. If "No", provide a reason.
(Please mark with **X** *in the relevant block and provide details if "Yes")*

More information

The NWU Ethics Committee may have to rely on the expertise of a scientific committee (e.g. a committee for higher degrees, research committee, educational committee, etc.) regarding the evaluation of the scientific and/or educational merits and design of the project. Usually a project should have been evaluated and approved by such a committee before submission of an Ethics Application. If, however, this is not possible, the Ethics Committee must be notified as such and will have to evaluate the scientific and/or educational merits and design of the project, since scientific justifiability is implicit in ethical justifiability.

Yes	No	Details
☒	☐	Proposal accepted by Research Committee.

3.3 Envisaged commencement and completion date of the project

More information

Here you can indicate the expected commencement and ending dates of the project, which may be anything from a day to a few years. Projects are approved by the ethics committee for a maximum of 5 years, whereupon a new application must be submitted again. The full expected duration of the project, even if it is more than 5 years, must be filled in below. Even if the expected duration of the project is uncertain, you can still make an estimate here and report the progress with the annual report.

Commencement Date	Completion Date
2012 - 04 - 01 (cc yy - mm - dd)	2014 - 04 - 01 (cc yy - mm - dd)

3.4 Background & Motivation

More information

Describe the need for this specific project (e.g. literature background and the scientific or clinical problematic nature and observations that gave rise to the planning of this project) in order to place the proposed project in perspective and support it with relevant literature references.

Statement of the problem and motivation for the research

Worldwide, many people who are unable to study full-time on-campus at residential universities choose distance education (DE) as mode of study. These students are mostly employed adults who are subjected to the multiple responsibilities brought about by working

and studying simultaneously. With good planning and support it is possible for students to undertake professional development and further their qualifications from home in their own time via DL, while employed and supporting their families (Ferreira & Venter, 2010). They do, however, face many challenges (Mdakane, 2011).

Modern DL learning technologies bridge some of these challenges. Information and Communication Technology (ICT) can support diversity, personalise learning and provide tele-collaboration between course participants. No single ICT-based learning technology[10] (LT) can address all the learning needs of diverse South African distance students, and selecting a LT from a spectrum of LTs is an important decision during multi-modal learning (Blignaut & Esterhuizen, 2011). An example of modern LTs used at the Unit for Open Distance :Learning (NWU) is interactive whiteboards (IWBs). IWBs provide two-way ICT communication, multiple user touch screen interaction, and assist in overcoming the physical distance between the lecturer and students: "An IWB set-up involves the image generated by a computer being projected onto a touch-sensitive screen the size of a conventional whiteboard, where the touch of a pen is the equivalent to a mouse click" (Kent, 2006, p. 25). IWBs can be used in a variety of ways, and they should not merely be used as presentation tools, but also for their additional affordances in terms of interactivity (Koenraad, 2008).

The Unit for Open Distance :Learning (NWU) is committed to evaluate the use of its extensive investment in IWBs to confirm the added value of using IWBs as part of their teaching and learning cache, as well as to establish best practices for the use of IWBs in DE. The literature provides a variety of ICT learning technology implementation models. Examples of well-known models are the ADDIE model (Zimnas *et al.*, 2009), the Dick and Cary model (Akbulut, 2007), the Reeves model (Hennesy *et al.*, 2010), and the Stoner model (1996). For this study the researcher selected the Stoner Systems Life Cycle of Learning Technology (Stoner, 1996) as it explicitly involves curriculum design aspects as part of the design of integrating LT for teaching and learning (Figure 1).

[10] "Learning technology is the broad range of communication, information and related technologies that can be used to support learning, teaching, and assessment" (Association for Learning Technology, 2010).

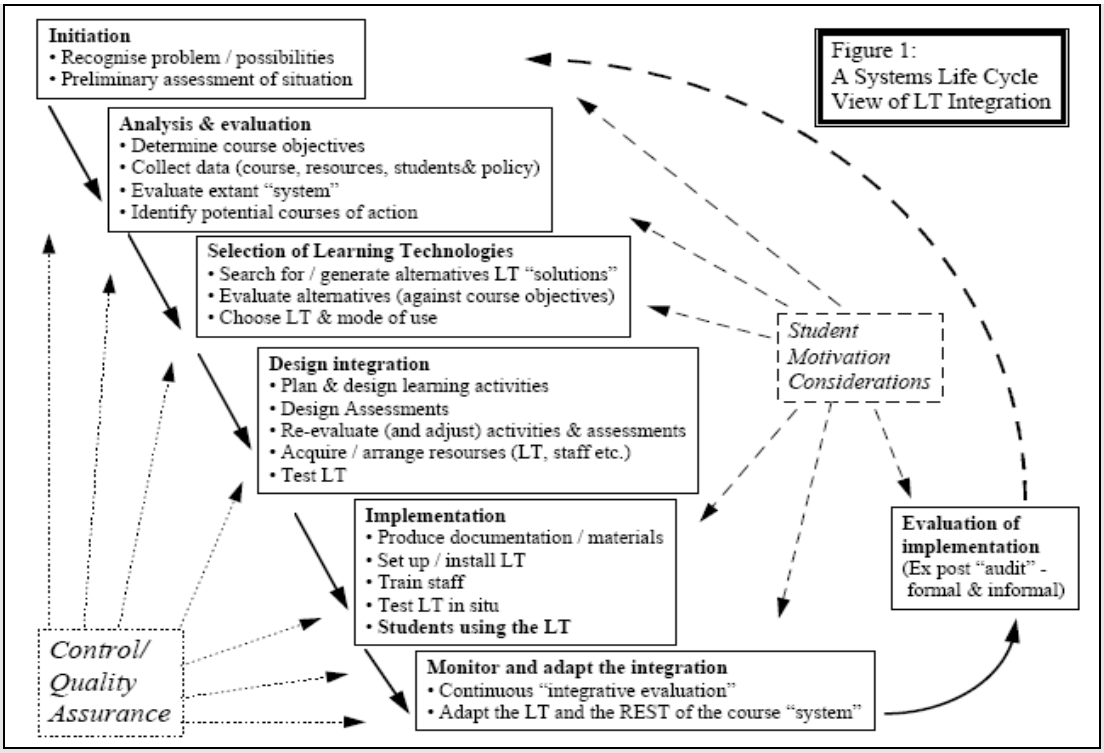

Figure 1: Stoner's (1996) model of learning technology integration

Although Stoner's model seems linear, it comprises a set of interrelated stages encompassed by the evaluation of the implementation of the learning technology, as well as quality assurance aspects, i.e. control of what is being changed and ensuring that learning objectives are met by students in an appropriate manner (Stoner, 1996) as the process unfolds. Figure 1 indicates that recognising the instructional problems or possibilities of using the LT initiates the evaluation of implementation of a learning technology. The Unit for Open Distance :Learning (NWU) extensively uses IWBs for course facilitation. Reflecting on how IWBs could be *initiated* and optimally used as scaffolding[11] of DL Mathematics programmes, e.g. the NWPK 512, an ACE Mathematics module, where almost fifty percent of the students do not pass the module at their first examination attempt, this issue presents both instructional and research problems and possibilities at the same time.

Consequential steps of Stoner's cycle of LT integration are to *analyse* why changes to design integration should be made and why the LT is needed within the teaching and learning of this module. NWPK 512 is a core Mathematics module and students have to pass the module to obtain the qualification. More importantly, teacher-students should gain a deep understanding of the fundamentals of Algebra in order to effectively teach it at their schools. The latter is one of the essential outcomes of this module. Aspects to consider during the analysis phase are

[11] Scaffolding within the theory of constructivism, is a teaching strategy, used by a facilitator, to assist a student in his process of learning in a way that he becomes more self-regulated and independent (Valkenburg, 2010).

determining course objectives, collecting data relating to the course and resources, data on the students and policy, evaluation of the extant system, and identifying a potential course of action for integrating the LT.

A *selection of LTs* is imperative as the aim of using an LT is about enhanced learning and not about the affordances of the technology. The Unit for Open Distance :Learning (NWU) has been using IWBs for some time and they have been installed at more than thirty learning centres across South Africa. If the integration of the LT is effective, the process of learning is also enhanced (Taylor, 2001). IWBs should not merely support teaching functions, such as to explain, demonstrate and present instruction, thereby promoting teacher-centred instruction (Nieuwoudt, 2006) while students remain passive receivers of knowledge. Challenging and effective education implies independent learning and (co-)construction of knowledge (Koenraad, 2008).

Design integration relates to planning and designing learning outcomes, designing assessments, re-evaluating and adjusting learning activities, acquiring learning resources, and testing the LT (Figure 1). To enhance learning, one should ensure that the LT is readily available to students and exclude technical problems for the smooth and uninterrupted use of the LT. Therefore, IWBs should be used to increase interactivity instead of merely reading documents behind glass. Re-evaluation and adjustment of teaching and learning strategies should take place on a continuous basis, taking into consideration students' learning experiences (Stoner, 1996). The teaching staff should be trained, and the LT should be tested *in situ*. The focus of this study relates to the phase of *design integration* as the Unit for Open Distance :Learning (NWU), in its process of adopting learning technologies for ODL, currently places design integration of learning technology at the centre of attention.

When the actual *implementation* of the LT takes place, lecturers should ensure that the students are motivated, and that they know how to learn with the help of LT (Stoner, 1996). *Monitoring as well as adaptation* maintains the technology integration. Continuous integrative evaluation should take place throughout the course and adaptations should be made continuously so that problems can be rectified before students' learning has been compromised (Stoner, 1996). After an initial implementation, an *evaluation of the implementation* should take place. This evaluation will provide answers to the success of the LT integration. This evaluation can be of formative or summative nature, or a combination thereof (Stoner, 1996).

A key consideration to LT integration is the establishing of *student motivation*. Motivating students to make the change, to use LT for learning, is vital to the success of the project.

Motivation of students has the potential to affect all the aspects of the LT integration life-cycle. *Control/quality assurance* and *evaluation of implementation* converge to provide evaluation of outcomes, and also ensure the quality of learning with technology (Stoner, 1996).

In summary, the research problem that arises from the description of the background and a brief unpacking of the conceptual framework is: *How can scaffolding of Mathematics concepts contribute towards the design integration of IWBs as LT in learning technology integration at the Unit for Open Distance Learning (NWU)?*

3.5 Project Objectives

More information
Describe the specific aims with the project (e.g. research aims, objectives with the study, learning outcomes, etc.). Where applicable, provide a formulated research problem for the project.

The purpose of this study is to evaluate how LT through scaffolding of Mathematics concepts via IWBs can contribute towards the success of design integration (Figure 1) at the Unit for Open Distance Learning (NWU). From the purpose of this study, the following research question: *How can IWBs enhance the scaffolding of Mathematics teaching and learning in an ODL programme?* Collectively, the following five sub-questions, in accordance with the Kirkpatrick (1998) evaluation method used during the study (§ 5.2), culminate to address the above main research question:

1. How do students react to Mathematics education facilitation via IWB scaffolding (do they like it or not)?
2. How do students perceive their learning that take place through scaffolding of Mathematics via IWBs?
3. Do the students' peers note change in their on-the-job behaviour as a result of learning Mathematics augmented with scaffolding during IWB classes?
4. Do students pass their next examination opportunity after attending Mathematics scaffolding during IWB sessions? In other words, do their marks improve as a result of them having attended the IWB sessions?
5. How does the return on investment (ROI) of the traditional contact model compare to facilitation via IWBs?

3.6 Project Design, and Procedures / Methods / Techniques

More information

Describe, as applicable, the project layout (e.g. how many human participants / animal subjects and what classification into test groups is planned), what type and how many experiments / studies / interactions / interferences are planned to achieve the project objectives and what interventions / procedures / techniques / methods / approaches / therapy will be used, how data will be collected, etc. Describe in full how the project will be carried out, also with reference to the order of all the steps.

This information lays the basis for Sections 4, 5 & 6 where aspects of ethical importance, as applicable, are discussed. There is therefore no need for you to highlight any ethical justifiability already in this section, but you can discuss it in subsequent sections where it comes up.

Research Design and Methodology

The Literature Study

Extensive literature searches will be conducted on EBSCOhost, ERIC, Academic Search Premier and Teacher Reference Centre, Google and Google Scholar databases, catalogues of South African and International university libraries, JSTOR, SABINET as well as the World Wide Web (WWW).

The following keywords will be used: constructivism, scaffolding, ICT, Mathematics, distance learning, IWB, teaching, learning, and facilitation.

Site or social network selection

The Unit for Open Distance Learning (NWU) offers continuous teacher professional development through ODL programmes. Qualifications offered include the *National Professional Diploma in Education* (NPDE), and various options for the *Advanced Certificate in Education* (ACE), the *BEd* and the *BEd Hons*. The ACE in Mathematics is one of seventeen ACE-programmes offered by the Unit for Open Distance Learning (NWU) . Many students struggle to pass the Mathematics major modules that comprise mathematical concepts at their first attempt. NWPK 512 is an example of a major module on the fundamentals of Algebra that deals with the fundamental concepts of Algebra for the Senior Phase. Forty eight percent of students who wrote examinations in this module during March 2011, had failed the module at least once before (OLG, 2011). Teacher-students require a deep understanding of concepts like algebraic reasoning, polynomials, indices, basic operations, factorisation of polynomials, algebraic fractions and solving linear and elementary quadratic equations to pass the module and to be able to teach their own learners at their respective schools. Students take the examination two or three times before they pass the module. A possible reason could be that they themselves do not have a grounded understanding of Mathematics.

Students who study through ODL often study alone. They receive their study material delivered to their door step and then they are responsible for studying by themselves (Ferreira & Venter, 2010). They often experience many challenges to succeed in their studies. Most of the teacher-students live far apart, often in distant rural areas where support is limited. Contact classes are not compulsory for these students and only about thirteen percent attend them due to the distances they have to travel (OLG, 2011). Tuition during contact classes at study centres does not cover the entire curriculum and students are left to master it on their own. Facilitators are appointed at the learning centres to support students with academic and logistical issues. Sometimes the facilitators at centres are not helpful (Mdakane, 2011). It is difficult for students to master Mathematics and to pass the Mathematics modules without additional support. From my experience as a Mathematics lecturer, my premise is that students perform better in examinations if concepts have been explained to them in person. The more understanding the teacher-students attain of the fundamental concepts of

Mathematics, the better they are able to interact with the concepts in their own classrooms and contribute towards their learners' understanding of Mathematics. The reverse may also be true.

The selected research site for this study is the Bisho Centre in the Eastern Cape as many students attend contact classes at this centre (Redelinghuys, 2012). Transport and infrastructure arrangements are adequate at the Bisho learning centre. The Bisho student population is a true representation of the general student population of the Unit for Open Distance Learning (NWU) as they range from upper-class students arriving at the centre with their own transportation, and who have ready access to resources, through middle-class students who make ends meet without too many challenges, to students who live in rural areas and experience severe challenges with respect to transport and other study needs.

Kirkpatrick (1998) states that facilities used for courses should be comfortable and convenient. Classrooms should not be too small and have comfortable furniture; the area should not be noisy, classes should not be disturbed; students should not travel long distances to the training venue; classroom should be at comfortable temperatures. Students studying through DL often do have to travel long distances to training centres and some other distracters may also be present at the centres, but the researcher will diminish these factors as far as possible when conducting the study at Bisho.

5.1 Research design according to a multi-modal approach

The proposed research will take place according to a mixed methods research design. Creswell and Plano Clark (2011:5) defines mixed methods research as: "a procedure for collecting, analysing and mixing both quantitative and qualitative data at some stage of the research process within a single study to understand a research problem more completely." This design permits researchers to explore a topic by analysing the data qualitatively before a subsequent quantitative examination (Ivankova, Creswell, & Plano Clark, 2007). When quantitative and qualitative methods are used in combination within one study, they complement each other in order to provide an elaborate approach to the research problem, resulting in a deeper understanding thereof (Ivankova *et al.*, 2007).

Kirkpatrick's (1998) evaluation for the quality assurance and engagement of LT programmes, presented as DL, has for many years been extensively used as international foundation for people already employed (Roffe, 2002). The approach consists of qualitative as well as quantitative components as it produces usable information to be used for the improvement of programmes (Phillips, 2003). A Kirkpatrick evaluation focuses on the supportive descriptions

of engagement, enhancement and execution of student learning programmes. Current quality assurance recommends the use of this approach for contexts of technology enhanced learning in distance programmes (Roffe, 2002). The Kirkpatrick (1998) methodology of programme evaluation will therefore be used in this research to evaluate how scaffolding of Mathematics concepts contributes towards the design integration of IWBs at the Unit for Open Distance Learning (NWU). The managers of teaching and training at UNIT Unit for Open Distance Learning (NWU) are concerned with quality tuition, i.e. training that is accepted, trusted, respected and needed (Kirkpatrick, 2010).

Although the Kirkpatrick evaluation model was founded more than fifty years ago, various authors have recently contributed to the model to extend the scope of its usefulness (Simonson, 2007). The model evaluates training programmes on four levels and concerns itself with the *results* rather than with the *mechanisms* of programmes (Horton, 2005). Levels 1 and 2 evaluation findings of the Kirkpatrick model relate to students' internal drivers. During the study these levels will be evaluated according to an interpretive approach. They will be attained according to qualitative measures. They will collect information on students' satisfaction with the course and their perceptions on whether they have mastered the course content. Levels 3 and 4 relate to external drivers and will provide information on the application of acquired skills, as well as on the impact on the learning results (Basarab, 2011). They will be attained according to quantitative measures.

Phillips (2003) added a fifth level to Kirkpatrick's four levels—the return on investment (ROI) (Simonson, 2007). Evaluation at this level indicates the relationship between the amount of money spent on the training and the monetary benefits of the training (Peak & Berge, 2006). Level 5 evaluation provides information on the impact that the training programme has on the financial viability of the training (Peak & Berge, 2006). The Phillips augmented model receives increased attention as the cost of programmes should be compared to the outcomes of the programmes in order to provide evidence for curriculum-related decisions (Simonson, 2007). Actual costs as well as human effort are considered (Phillips, 2003). In summary, the Phillips' augmenting determines whether:

- the students liked to be taught the proposed way
- learning took place
- the students used the knowledge that they gained through the programme at their place of work
- the results came from attending the training programme
- the investment in the LT is financially worthwhile, also in terms of consequences on human capital.

Figure 2 represents the typical cycle of evaluating a programme (Kirkpatrick, 1998).

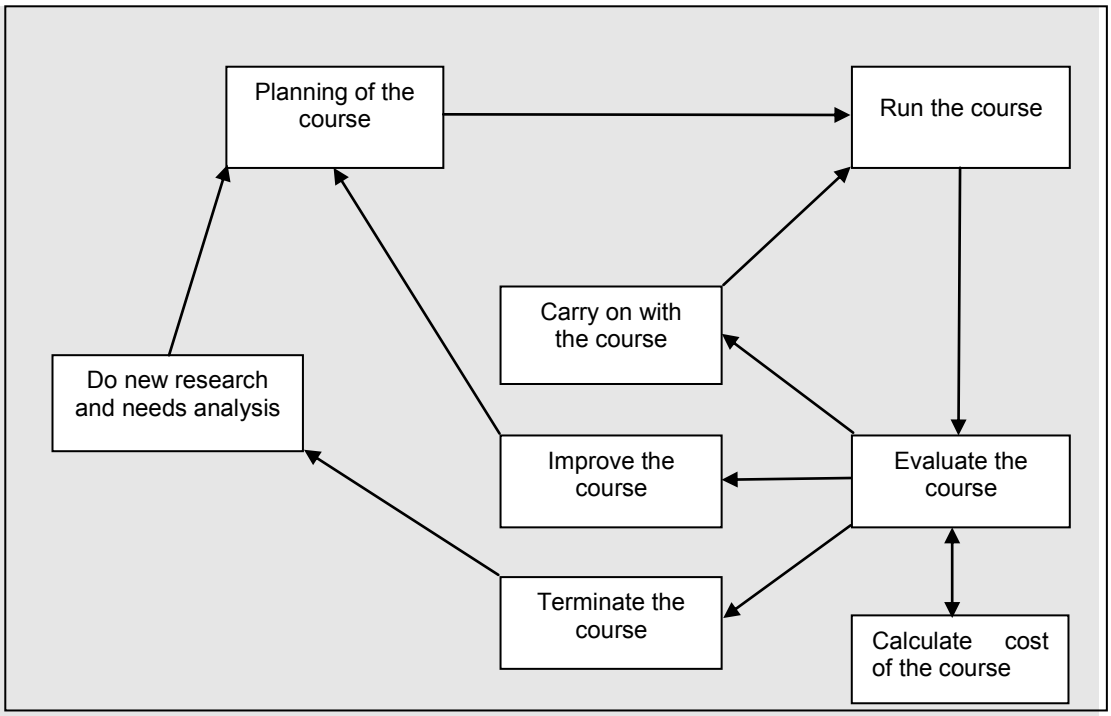

Figure 2: **The Kirkpatrick Cycle of a Course** (adapted from (Kirkpatrick, 1998))

Table 2 provides an overview of the research design components used during the augmented Kirkpatrick evaluation of this proposed study. The qualitative approaches are elucidated in § 5.4 and the quantitative approaches in § 5.5.

Table 2: **Summary of data collection instruments**

Levels of evaluation	Approach	Strategies
Level 1: Reaction	Qualitative	1. Observation schedule (Addendum D) for the learning centre coordinator to observe the reaction of students during the IWB session 2. Observation schedule (Addendum E) for the researcher relating to the captured video of IWB sessions 3. Focus group interviews (Addendum I) with students after completion of the IWB session
Level 2: Learning	Qualitative	1. Interviews with participants after IWB sessions (Addendum I)
Level 3: Behaviour	Quantitative	1. Pre-test-post-test (Addendum F) to determine the students' change with respect to their understanding of Mathematics 2. Questionnaires to evaluate the change with respect to the value that the students obtained from the module. The questionnaires will be addressed to: (i) the research participants (Addendum G) (ii) the peers of the participants at their respective schools (Addendum H) (iii) the supervisors of the participants at their respective schools (Heads of Departments or Principals) – Addendum H

Level 4: Results	Quantitative	1. Examination marks of the current examination compared to previous examinations
Level 5: ROI	Quantitative Qualitative	1. Descriptive statistical comparison of monetary costs of the two modes of delivery 2. Open-ended questionnaire to peer lecturers presenting Mathematics modules (Addendum J)

In levels 4 and 5 (See Section 3.6), data pertaining to examination marks and monetary costs will be obtained from the NWU (Unit for Open Distance Learning) data-base. Although this readily available data is quantitative in nature, only descriptive statistics (frequencies and percentage frequencies) will be reported in support the qualitative findings. To report the difference in monetary costs, only the two averages for contact vs Interactive Smart-Board, will be compared. No further quantitative statistics will be performed on this data, besides the reporting of frequencies and percentage frequencies. All other quantitative data, obtained for example via Addendum H, will only be reported in the form of descriptive statistics (frequencies and percentage frequencies). No further quantitative statistical analysis or reporting will be conducted. The Pre-Test and Post-Test scores will also be reported only in descriptive form to support the qualitative findings of this study.

Research Design: Qualitative Research Approach

The questions that arise from evaluating the first two levels of Kirkpatrick's evaluation (Table 2) constitute the qualitative component of the proposed study as an interactive design which focuses on the students' lived experiences in their natural settings. It measures participants' satisfaction with the programme, and whether changes in knowledge, skills and attitudes have taken place (Phillips, 2003).

Researcher's role

A qualitative researcher has different ways of ensuring quality research (Creswell, 2003). In qualitative studies, researcher subjectivity is accepted as something that should be managed and explained (Nieuwenhuis, 2007b). The qualitative researcher studies a phenomenon as it presents itself in the real life context. Nieuwenhuis (2007a) states that the involvement of qualitative researchers is essential as they have to capture the lived experiences of research participants. The qualitative researcher is the primary measuring instrument (Gall, Gall, & Borg, 2007; Maree, 2007). Gall *et al.* claim that the researcher is personally involved in the phenomenon under study as s/he carries out the data collection and has to interact with the participants in order to understand their experience of the phenomenon.

The researcher of the IWB-study is the Mathematics lecturer at the Unit for Open Distance Learning (NWU), responsible for NWPK 512, and she will be involved in the whole process.

She will design the research, obtain permission, identify and brief the participants, facilitate the IWB sessions, collect the data via observations and interviews, analyse the data, and finally compile a research report of findings to the NWU and the research participants. Therefore, the researcher will be playing a participative role in and during the study (Nieuwenhuis, 2007a).

Participant selection

Merriam (2009) defines purposeful sampling as being based on the assumption that the researcher primarily wants to discover, understand and gain insight in a specific phenomenon. The researcher therefore has to select a specific sample from which the maximum can be learnt (Leedy & Ormrod, 2005). The logic and power of purposeful sampling lies in the selection of information-rich participants who are studied in depth (Merriam, 2009). Participants will be selected because of their defining characteristics that make them the holders of the data needed for the study (Nieuwenhuis, 2007b). The specific type of purposive sampling for the proposed study will be convenience sampling, namely an availability sampling according to (i) their availability in terms of their first-hand experience of the IWBs by attending contact classes at Bisho centre; (ii) having failed NWPK 512 at least once. Students who adhere to these two criteria will be invited to participate in the qualitative aspects of the study. Data will be collected until data-saturation is reached.

Data collection strategies

The qualitative data collection strategies will take place according to the first two levels of Kirkpatrick's augmented five-level evaluation model (Table 2). Creswell (2003) distinguishes the following three types of data collection procedures in qualitative research: *observations (Addendums D and E), interviews (Addendum I)* and *documents*, including *audiovisual documents*. An *observation* relates to the systematic process of recording of the behavioural patterns of participants, without necessarily questioning them (Nieuwenhuis, 2007a). Creswell (2003) argues that the researcher should take field notes on the behaviour and activities of individual participants at the research site during an observation. An *interview* is a two-way conversation in which the interviewer asks the participant questions in order to collect data on the phenomenon under study (Nieuwenhuis, 2007a). Focus group interviews (Addendum I) have similar aims, but should not include more than about eight participants per group (Creswell & Plano Clark, 2011). The researcher aims to see the world through the eyes of the participants.

<u>Level 1 – Reactions: Interviews and observations</u>

The sub-question of the proposed study is whether students like to be taught via IWBs: How do they feel about sitting in a classroom, interacting through an electronic device instead of talking directly to a person? The aim of this level of evaluation is to determine the participants'

reactions to the IWB facilitation. Although learning is not guaranteed by positive reactions to a programme, the inverse is almost a certainty (Kirkpatrick, 2007). Horton (2005) claims that frequent evaluations help to reduce the number of dropouts before students reach the end of their courses. Evaluation will take place after each facilitation session, and not only at the end of the programme.

Three strategies will be used during this study to capture Level 1 data: (i) a captured video of the IWB sessions will be analysed by the researcher according to an observation schedule (Addendums E) to ascertain how the students reacted towards the use of scaffolding during the sessions. (ii) The coordinator at Bisho centre will observe the participants with the assistance of an observation schedule (Addendum D) to record aspects like: (a) do students arrive on time? (b) do students come prepared to the session? (c) do students pay attention during the presentation? (d) do students participate by asking questions and making comments? (e) what are their experiences of the session?; and (iii) at the end of each IWB session, the researcher will conduct a focus group interview with the participants who attended the session, in order to obtain feedback on their satisfaction with the session, as well as with the programme as a whole.

Level 2 – Learning: Individual interviews

The aim of evaluation at Level 2 is to determine whether learning has taken place. Learning involves the change in knowledge, skills and attitudes. The researcher will interview the students about their learning using an interview schedule (Addendum I) This will provide data on their learning of Mathematics during the NWPK 512 module. The data will be collected through individual interviews via IWBs after the sessions.

Participating students will receive an Information Letter (Addendum A), and will be asked to complete an Informed Consent Letter (Addendum B). Centre Coordinators will also receive an Information Letter (Addendum C), and will be asked to assist with the observations using an observation schedule (Addendum D). During the session, the researcher will also do observations (Addendum E). Participating students will do a Pre-test, and afterwards a Post-test, in order to measure if they gained Mathematical knowledge and skill during the Interactive Smart-Board session. Participating students, as well as their peers/supervisors will be asked to complete questionnaires (Addendums G and H respectively). Lastly, the researcher will conduct focus-group interviews, as well as individual interviews (if necessary) with participants (Addendum I)

Data analysis

Qualitative data analysis is an inductive process. Nieuwenhuis (2007a) describes qualitative

data analysis as ongoing and iterative—as a non-linear process which implies that collecting, processing, analysing and reporting data are intertwined, and not merely a number of successive steps. Themes and patterns emerge through the analyses to describe and explain the students' learning experiences. The aim is to summarise the data to capture the common words, phrases, themes or patterns that would aid the researcher's understanding and interpretation of the data (Nieuwenhuis, 2007a). Qualitative data are textual and the researcher never wants to measure but to interpret and make sense of the data.

Creswell argues that qualitative analysis involves preparing the data for analysis and conducting different analyses. To move deeper into understanding and representing the data, he suggests the following six steps for a generic process of data analysis:

Step 1: Organise and prepare the data for analysis

Step 2: Obtain a general sense of the data and reflect on the overall meaning

Step 3: Begin the detailed analysis with a coding process

Step 4: Generate a description of the setting or people as well as of categories or themes for analysis

Step 5: Give a description to convey the findings of the analysis

Step 6: Give an interpretation of the data.

An integrated hermeneutic unit will capture the data during analysis (Nieuwenhuis, 2007a). This understanding constantly takes place from the whole to the part and back to the whole. The collected data will therefore have to be textually rich in order to make sense of the bigger picture or the whole (Nieuwenhuis, 2007a). To make provision for the validity and trustworthiness of the study the researcher will make use of triangulation in order to judge whether separate pieces of information all point to the same conclusion (Leedy & Ormrod, 2005). A content analysis with Atlas.ti™ will identify data categories and themes.

Research Design: Quantitative Research Approach

The key concepts in quantitative research are objectivity, numerical data and ability to be generalised (Maree & Pietersen, 2007). Maree and Pietersen (2007) define quantitative research as: "A systematic and objective approach in its ways of using numerical data from only a selected subgroup of a population to generalise the findings to the population that is being studied." The Kirkpatrick evaluation also includes quantitative components on Levels 3, 4 and 5 (Table 2). The proposed Kirkpatrick study however comprises a specific subgroup of the population of NWPK512. The sampling strategy in this case relates to an availability/ convenient sample (Blaxter, Hughes, & Tight, 2001). Levels 3 and 4 evaluation of the Kirkpatrick model, followed by the add-on Level 5 of Phillips form the quantitative part of the

study. At Level 3 the researcher will measure the success of the training programme in terms of increased productivity and improved quality by getting feedback from the supervisors of the participants. At Level 4 the researcher is going to compare the examination results of the participants to their previous examination results for this module. Determining the ROI when doing Level 5 evaluation is an important component of the quantitative part of the proposed study. This can provide an indication of the impact that the IWBs have on the strategic aspects of ODL delivery. The outcome of the proposed study can assist management of the Unit for Open Distance Learning (Nwu) in planning for the future. The data generated at these levels will be of numeric nature and will be analysed and interpreted quantitatively.

The quantitative component of the proposed study involves evaluation at three different levels and therefore actually consists of three sub-components. The lay-out of the quantitative part of the proposal will be treated as such.

Level 3 – *Behaviour*

Evaluation at Level 3 attempts to measure the success of the training or teaching programme in terms of increased productivity and improved quality (Simonson, 2007). The aim is to determine whether participants have changed their on-the-job behaviour as a result of participating in the course. Kirkpatrick (1998) describes four criteria as part of change. Students should have a desire to change, know what to do and how to do it, work in a conducive climate, and receive rewards for changing. The first two requirements can be accomplished by creating a positive attitude towards the desired change and by scaffolding the appropriate knowledge and skills. The third requirement refers to the participants' supervisors at work. Kirkpatrick describes five environments that influence motivation: preventing, discouraging, neutral, encouraging and requiring. Rewards can be intrinsic, extrinsic, or both. Intrinsic rewards relate to feelings of satisfaction and pride, while extrinsic rewards can include praise from the lecturer, headmasters, significant others, or even monetary awards.

Kirkpatrick (2007) refers to Level 3 evaluation as the key to maximizing training and development effectiveness. He claims that training and learning do not mean anything unless they are applied. Simonson (2007) describes evaluation at Level 3 as an attempt to determine whether the skills, knowledge and attitudes that were learnt as a result of the training, are being transferred to the actual learning activities. It is, however, critical and problematic to time the evaluation at this level, since it is difficult to know when transfer actually occurs. Evaluating at this level is difficult because the changes that are measured seldom have only a single cause and they do not necessarily happen within a certain time after the training programme was attended (Horton, 2005). This is why Horton (2005) suggests that we may have to trade accuracy for credibility when evaluating at Level 3. When evaluating one has to decide what matters. Horton's advice is to determine the single most important measure of success for the

top management of the company before designing the evaluation programme. Secondly, his advice is to find ways to estimate the value of learning with technology. Best is to ask the students themselves, their peers and their supervisors because they should give a reasonably accurate picture of the value of that which has been learnt. The researcher has to estimate how much of the change is due to attending the training programme and to how confident the researcher is in this estimate.

Please note that only descriptive statistics (frequencies and percentage frequencies) will be reported for all quantitative data, in support of the qualitative component of this study.

Research Population

The population (N) of the proposed study consists of all NWPK 512 students who are registered at the Open Learning Group (OLG) and who have failed the module before. Because purposeful sampling will be used for the qualitative first phase of the study, and the quantitative second part of the study will have to involve the same students as respondents, the method of sampling for the quantitative phase will also be purposeful convenience sampling. The sample (n) for the proposed study will therefore consist of students who attend classes at Bisho and who meet the above selection criteria. The size of the population as well as the size of the sample will be known after the students have registered in 2013.

Variables

The independent variable at Level 3 in the proposed study is defined as the facilitation of NWPK 512 via IWBs. The dependent variable at this level is defined as the change in the students' on-the-job behaviour as a result of attending the IWB-facilitation.

Measuring instruments: Pre-test-Post-test and Questionnaires

Two instruments relate to the measurement of Level 3 criteria: (i) The change with respect to the learning and understanding of Mathematics will be measured by using a pre-test-post-test (Addendum I) evaluation. The students (participants) will write a pre-test (Addendum I) on the aspects that will be dealt with in the NWPK 512 module before the training programme commences. This test will be repeated after completion of the course in order to measure if change has occurred; The researcher will also let a control group write the pre-test-post-test evaluation in order to compare the results of the two groups. (ii) Questionnaires on a Likert-scale will collect data relating to the value that the participating teacher-students got from attending the IWB-facilitation (Addendum G). Questionnaires will be addressed to (a) the participating students (Addendum G), (b) their peers at their respective schools (Addendum H), and (c) their supervisors (Addendum H). The data will be collected about three months after

completion of the course. Obtaining feedback (Addendum H) on the change in behaviour of the teacher-students from their peers and supervisors also, adds to the validity and reliability of the research (Leedy & Ormrod, 2005). For all these questionnaires, only descriptive statistics will be reported in support of the qualitative component of this study.

Data Analysis

The data collected when evaluating at Level 3 will be analysed in order to only report descriptive statistics in support of the qualitative component of this study.

Level 4 – *Results*

The aim of the evaluation at this level is to determine whether the programme has adhered to the expected final results. Kirkpatrick defines results to be the final results obtained because the participants have attended the programme (Kirkpatrick, 1998). The single most important measure of success in the proposed study of IWBs acting as scaffolds for Mathematics students in ODL can be defined as the pass rate of the students repeating NWPK512. If these students pass the examination after they have attended the IWB sessions the researcher could claim that IWBs have contributed towards learning of Mathematics in ODL. The researcher will do this evaluation after the participants have received the results of their next examination opportunity in NWPK 512.

Study Population

The population (N) of the proposed study consists of all NWPK 512 students who are registered at the OLG and who have previously failed the module. The sample (n) for the proposed study will therefore consist of students (respondents) who attend classes at Bisho and meet the selection criteria. The size of the population as well as the size of the sample will be known after registration of the students.

Variables

The independent variable at Level 4 in the proposed study is defined as the facilitation of NWPK 512 via IWBs. The dependent variable at this level is defined as the examination pass rate of the repeating NWPK 512 students, i.e. the improvement in students' own understanding of Mathematics in order for them to teach Mathematics more effectively. In order to compare the learning outcomes of the IWBs, the examination results of the convenience sample will also be compared to the examination results of all students registered for NWPK 512.

Measuring instruments: Comparison of examination results with previous examination

results

Evaluation at this level has as its aim to determine whether the participants passed NWPK 512 during their next examination opportunity. This will be an indication of the success of the training programme. The examination results of the participating students will also be compared (descriptively) to the results they obtained in the previous opportunity (when they failed the module. The data will be collected from the examination section of OLG. In order to compare the learning outcomes of the IWBs, the examination results of the convenience sample will also be compared to the examination results of all students registered for NWPK 512.

Data Analysis

Examination results will be obtained from the data-base of the Unit for Open Distance Learning, and will be reportedf only descriptively (frequencies and percentage frequencies) in support of the qualitative component of this study. The relationships between IWB facilitation and examination success also be determined through the use of descriptive statistics.

Level 5 – ROI

In levels 4 and 5 (See Section 3.6), data pertaining to examination marks and monetary costs will be obtained from the NWU (Unit for Open Distance Learning) data-base. Although this readily available data is quantitative in nature, only descriptive statistics (frequencies and percentage frequencies) will be reported in support the qualitative findings. To report the difference in monetary costs, only the two averages for contact vs Interactive Smart-Board, will be compared. No further quantitative statistics will be performed on this data, besides the reporting of frequencies and percentage frequencies.

Evaluation on Level 5 relates to learning with technology activities converted into monetary values for the comparison of the use of IWBs versus the previous model where lecturers visited the learning centres. The previous model involved not only high costs of travelling and accommodation, but also implied many hours spent travelling. The researcher will also consider these human factors when calculating the average annual cost of running the training programme without IWBs. To determine the ROI the researcher will calculate the annual cost for running the programme via the IWBs. The cost in this case involves the cost for the installation and maintenance of the IWBs and also appointing specific staff members to be responsible for them. To finally calculate the ROI the researcher will compare these two sets of costs. The researcher will also capture the ROI in terms of human effort by means of open-ended questionnaire (Addendum G) to determine the experiences of lecturers in both the teaching models. This level therefore involves qualitative as well as quantitative data.

Measuring instruments: Cost analysis of delivery modes and open-ended questionnaire

Two data collection strategies relate to this level of evaluation: (i) Cost analysis of running the current mode of delivery compared to the previous mode of delivery; (ii) an open-ended questionnaire (Addendum J) will capture the experiences of lecturers involved in the delivery of the Mathematics programme in terms of their experiences of the two modes of delivery.

Data Analysis

Data analysis will relate to two aspects: (i) Financial data will be obtained from the administrative sections of the Unit for Open Distance Learning (NWU) and OLG. As IWBs have been installed at many learning centres countrywide, lecturers no longer have to travel to centres for facilitator and student training, descriptive statistics will indicate the monetary differences between the two models; (ii) Atlas.ti™ will be used to capture and analyse qualitative data from the open-ended questionnaires in terms of lecturers' experiences of the two modes of delivery. Beside descriptive statistics, no further statistical analysis will be conducted on the quantitative data obtained via Addendum J.

3.7 Expected Results

More information

Where and if applicable, describe what possible or theoretically predictable results, or spectrum of results, you expect to get. Where applicable, formulate the research hypothesis. These refer to expectations and not to real results. However, if you do not have any idea of the kind of results you may expect, state so.

No results can be speculated because of the explorative nature of this research.

Remember to save your document regularly as you complete it!

Section 4: Specific Ethical Implications of Project Design

The information contained in this part is additional to what is contained in "Section 3: General Project Background". Only answer the subsections that apply to this project.

- Sec 4a: Human participants (subjects)
- Sec 4b: Filed privileged information or stored biological samples of human origin
  (e.g. where information or samples are collected for another project or for medical diagnosis)
- Sec 4c: Animal subjects (vertebrates)

Sec 4a: Human Participants (Subjects)

You have already set out the project design and procedures / methods / techniques in detail in § 3.6 above. Now highlight only the following aspects for the evaluators.

4.1 *Probable experience of the participants (subjects):*
What will the probable experience of participants be and what measures are in place to ensure the welfare of the participants? Describe all the steps in detail and in order, so that the evaluator can form an image of the experience of the subject. (In the case of injections, blood samples, swabs, etc. that will be discussed in Sec 6e, § 6.16, you need only to refer to Sec 6e, without extensive discussion).

More information

While you place emphasis on the probable experience of the participants, refer inter alia to the following aspects, as applicable to your project:

- *Highlight what participants will be expected to do, what will be done to them, what observations will be made and how long it will take. This includes aspects such as all specific interferences, procedures, sample collections (e.g. number, quantities/volumes, frequency, routes of administration and measurements, etc.) and methods of information gathering (e.g. measurements, number, frequency, etc.) and what the probable associated experience of participants will be.*
- *What measures are in place to restrict discomfort and to see to the welfare of the participants.*
- *Provide particularly details on any step that may violate his privacy and/or may result in any form of emotional discomfort or even pain. In this way describe clearly e.g. the use or holding back of provisions / help / advice / treatments / painkillers. What measures are in place to restrict the violation of privacy and/or to minimise discomfort or pain.*

During the qualitative part of the study participants will be selected for interviews. Participants will be contacted in advance and are under no obligation to participate (Addendums A and B). All data collected will be handled confidential. The interviews will be conducted in groups or individual, as the participants prefer. Each student teacher will complete a letter of consent (Addendum B), providing the researcher with permission to continue with the research. This letter will also ensure that teacher-student participation is voluntary, that they can withdraw at any time, and that all information will be treated confidential.

4.2 *Choice of techniques / methods / procedures:*

As applicable to your project, with reference to available alternatives (if applicable), motivate your choice of the specific procedures / techniques / methods / approaches to achieve your project's aims.

More information

It must be clear to the evaluators that you have chosen a meaningful / best project design to achieve your project aims. Some disciplines will need more information than others. Note the following as applicable:

- *Particularly where alternative standard interventions / procedures / techniques / methods, approaches / therapy exist to what you used in the project, it is important to motivate your alternative choice. In some exceptional cases many options may exist, without there being a standard, and you simply selected one of many on the basis of availability. Whatever your reason, it must simply be highlighted clearly for the evaluators.*
- *Describe in detail how you will ensure that the interventions / procedures / techniques / methods / approaches / therapy are rigoristic, such as e.g. reliability / validity / trustworthiness / authenticity. (credibility / transferability / conformability / dependability / etc.)?")*

This is mainly a qualitative study, in which quantitative data will be reported only in descriptive vorm in support of the qualitative findings:

Table 2: Summary of data collection instruments

Levels of evaluation	Approach	Strategies
Level 1: Reaction	Qualitative	1. Observation schedule (Addendum C) for the learning centre coordinator to observe the reaction of students during the IWB session 2. Observation schedule (Addendum E) for the researcher relating to the captured video of IWB sessions 3. Focus group interviews (Addendum I) with students after completion of the IWB session
Level 2: Learning	Qualitative	1. Interviews with participants after IWB sessions (Addendum I)
Level 3: Behaviour	Quantitative	1. Pre-test-post-test (Addendum F to determine the students' change with respect to their understanding of Mathematics 2. Questionnaires to evaluate the change with respect to the value that the students obtained from the module. The questionnaires will be addressed to: (i) the research participants (Addendum G) (ii) the peers of the participants at their respective schools (Addendum H) (iii) the supervisors of the participants at their respective schools (Heads of Departments or Principals) – Addendum H
Level 4: Results	Quantitative	1. Examination marks of the current examination compared to previous examinations
Level 5: ROI	Quantitative Qualitative	1. Descriptive statistical comparison of monetary costs of the two modes of delivery 2. Open-ended questionnaire to peer lecturers presenting Mathematics modules (Addendum J)

4.3 *Dangers / risks and precautions:*

Name and explain in context, as applicable, all dangers and risks that are associated with the specific procedures / techniques / methods / approaches that are used in the project. Also explain the necessary precautions to ensure the welfare of participants (subjects) and to ensure the safety of the researchers / assistants / field workers, as well as the community and environment. **N.B!** Where an aspect is, however, covered fully in "Section 6: Matters that Necessitate Additional Information", you can simply refer to the specific subsection in this application form.

None

4.4 *Expertise, skills and legal competencies:*

What expertise, skills and legal competencies are needed to implement the project? Do the Project Head / research supervisor / researcher(s) / assistants / field workers have at their disposal the necessary background / expertise / qualifications / professional registrations to implement the techniques concerned? If not and as applicable, explain how the necessary training will be provided before the project commences.

The researcher is the lecturer responsible for the relevant module (NWPK 512) at the NWU and is therefore concerned about the success of the students. Everyone involved in the project do have at their disposal the necessary background and expertise to implement the techniques concerned.

4.5 *Facilities:*

Describe the place(s) and facilities in detail where the project will be implemented.
(Where the project holds more than minimal risk, all emergency care situations must be carried out within an emergency care space approved by the supervisory doctor.)

The project (i.e. the IWB sessions) will be presented from the UODL on the Potchefstroom campus of the Northwest University. The participants who will be on the receiving side will be attending in the whiteboard classes in Rustenburg. Facilities on both ends will consist of IWBs, desks and chairs in air-conditioned classrooms.

4.6 *Legal authorisation*:

As applicable, describe in detail what authoritarian bodies must grant authorisation for this project (e.g. Department of Health, Medicine Control Council, etc.). Also mention whether authorisation has already been obtained, with reference to attached proof, or how you will go about getting authorisation before the project commences.

More information

You need not duplicate information on the use of medicinal drugs in humans that will be described in full under Sec 6f, but in such cases only mention here approval by the Medicines Control Council and refer to Sec 6f.

Authorization to conduct the research will be obtained from the North West University's ethical comittee. Written concent from the participants will be obtained (Addendum B).

4.7 *Goodwill permission /consent*:

As applicable, describe in detail what interest group representatives must give permission for this project (e.g. community leaders, church leaders, tribal chiefs or other). Also mention whether permission has already been obtained, with reference to attached proof, or how you will go about getting permission before the project commences.

Not applicable.

4.8 *Participant: information & voluntary participation (recruitment, consent & assent):*

Explain how you will go about ensuring voluntary participation, informed consent and assent for all participants. Also explain in this context the way / process in which you will recruit participants (subjects).

More information

According to law all participants must be fully informed about the implications and risks associated with participation in the project and participation in any project is completely voluntary at all times, unless there are specific reasons why it is not possible (e.g. babies, persons that are intellectually incompetent, etc.) In the latter case ethical justification and precautions must be very clear and consent must be given by the legally competent person who is legally authorised to act on that person's behalf (e.g. the lawful parent / guardian and not a school principal, matron, etc.).

Recruitment of human participants must take place within a specified time frame / schedule (i.e. specified starting and ending date) and cannot continue indefinitely.

Furthermore, participants may withdraw from the project at any time without providing reasons and without accompanying discrimination. Even if there is proxy consent from parents / guardians of minors, these persons must still assent voluntarily (without which participation may not take place). In this part you can therefore explain how you:

- *INFORMATION*
  will go about explaining the project and accompanying implications to all participants (and parents / guardians) where applicable. Where research is not carried out in participants' mother tongue, explain how you will go about conveying the information in an understandable manner. Refer to an attached letter with information for informed consent that will be used, where applicable. Where participants are not literate, the information and process for obtaining informed consent (e.g. oral / tape recording, etc.) must be explained in full and the exact information and questions that will be used must be attached.
- *VOLUNTARY PARTICIPATION*
  will ensure voluntary participation by seeing to it that:
  - *recruitment takes place in such a way that the participants do not feel intimidated by the process or implicitly "bribed", but decide absolutely voluntarily to participate*
  - *assent of all participants is obtained, especially where minors and other vulnerable persons or groups are involved (e.g. sick and desperate persons, persons who are not intellectually competent, traumatised or emotionally vulnerable persons, etc.).*
  - *it is explained to participants that they may withdraw from the study at any time (without the necessity of providing reasons).*
- *CONSENT*
  will ensure that informed consent of every participant, or legally competent person who is legally authorised to act on that person's behalf, is obtained.

An Information Letter (Addendum A) and an Informed Concent Form (Addendum B) in which the purpose of the research as well as all ethical aspects are explained will be made available to each participant to sign.

4.9 *Criteria for participant selection & recruitment:*

Describe in full what inclusions and inclusion criteria will be used to select participants (subjects) and motivate.

More information

Refer to inclusion and exclusion criteria and how it is justified (reasons). Also refer to aspects such as race, gender, age limits, institutional affiliation or any other specific relevant criteria. Motivate your choice of the specific group.

The target population for the project consists of all the students who are registered for a specific module [NWPK 512] and who have already had at least one examination attempt without success. For this study, all students of a specific area that fall within the population will be selected as participants. See Section 3.6.

4.10 *Benefits for participants (subjects):*

Describe the potential benefits that the study might hold for the individual participants, a specific group or the community:

> ***More information***
>
> *It may be unacceptable to perform experiments in a community that will not be able to benefit from the results of the study (for example, drug studies performed with participation from a community where this community will not be able to afford the drug when it becomes available on the market).*

Recommendations of the study will be to design, implement and evaluate the use of IWBs in an open distance mathematics programme. Benefits for the participants are that they hopefully learn better this way and consequently succeed in the module.

4.11 *Incentive and reimbursement for participants (subjects):*

Is any form of incentive or reimbursement offered to participants? If "Yes", describe it in full in terms of what, how, where, when, how much, terms and conditions, etc.

(Please mark with **X** *in the relevant block and provide details if "Yes")*

> ***More information***
>
> *Participants may never be bribed to participate and as a general rule participants should not be remunerated for participation as such. However, in exceptional cases when human participants do receive personal financial benefits, the NWU Ethics Committee prefers that these be specified as for transport to participate and for personal sustenance (e.g. meals) during participation.*

Yes	No	Description
☐	☒	Not applicable

4.12 *Misleading of participants (subjects):*

Is use made of any form of misleading in the protocol where the participants are not told the complete truth (e.g. placebo or other)? If "Yes", motivate in full why it is necessary, how it is justified and describe how the participants will be protected against potential negative consequences of the misleading information or placebo. **N.B!** Your attention is drawn pertinently to Annexure 5 of the Ethics Committee's "Guidelines for the evaluation of the ethical aspects of experimentation with man or animal, August 2003", as available on the NWU website [Web link].

(Please mark with **X** *in the appropriate box and provide details if "Yes")*

> ***More information***
>
> *Justification*
> *In case of the treatment (e.g. drug or psychotherapeutic intervention) of a particular disease/condition, the use of a placebo can be justified only if there is no alternative treatment with proven efficacy. When such an alternative treatment exists, the test treatment must be compared with the standard treatment as control, and the use of a placebo is not acceptable.*
>
> *Protection of participants*
> *Describe, for example, how debriefing will take place and/or how the participants will be monitored.*

Yes	No	Motivation
☐	☒	Not applicable

4.13 *Announcement of results to participants (subjects):*

Is there any reason why the information obtained from participants cannot be made available to them immediately? If "Yes", motivate in full, with reference to when and how the results will in fact be announced.

(Please mark with **X** *in the appropriate box and provide details if "Yes")*

Yes	No	Motivation
☐	☒	Not applicable

4.14 *Confidentiality:*

Explain what measures you will take to ensure the confidential handling of the data (information) of participants.

Ethical principles will be applied throughout the project. These principles includes: professional competence, professional relationship with participants, privacy and trustworthiness.

4.15 *Storage and archiving of data:*

Explain how, where and how long the research data will be stored. **N.B!** All raw data remains the property of the North-West University. Only copies may leave the storage area, and then only by authorised persons. Where an outside party, e.g. a sponsor, lays claim to the original data, certified copies must be stored on the Campus and the same rules apply as above.

More information

Some legislation, rules and regulations for certain professions stipulate that data must be stored for a specified minimum period, such as e.g. a minimum of 6 years for psychology. Most government departments however store data for a minimum of 7 years and it is recommended as a general rule that data is not stored for less than 7 years. You must therefore indicate here what the requirements are that apply to your project. Furthermore, does any person have the right to request to see and study the original data of published results in order to verify the accuracy and validity thereof?

The data will be kept in the safe of the Unit for open Distance Learning (NWU Potchefstroom Campus) for at least seven years as stipulated above.

Remember to save your document regularly as you complete it!

Sec 4b: Filed Privileged Information or Stored Biological Samples of Human Origin

Fill this part in only for the use of existing, filed privileged information of humans (e.g. medical files) or existing, stored biological samples (e.g. tissue or fluids) of human origin, e.g. where samples are collected for another project or for medical diagnosis. This part is therefore not filled in if the information or samples will be obtained from a clinical trial, which has already been described in "Sec 4a: Human Participants (Subjects)".

4.16 *Material description:*

Give a full description of the privileged information or human biological samples you wish to use.

Not applicable

4.17 *Legal authorisation:*

As applicable, describe in full what authoritarian bodies must grant authorisation for this project (e.g. Department of Health, Medicine Control Council, etc.). Also mention whether authorisation has already been obtained, with reference to attached proof, or how you will go about getting authorisation before the project commences.

(Please mark with **X** *in the appropriate box and provide details / explanation, or type "not applicable")*

More information

Certain substances that are typically associated with experimental work require authorisation and approval. Examples include:

- *radio-active substances*
- *drugs with a high scheduling status*
- *certain toxic substances*

Yes	No	Details / Explanation
☐	☒	Not applicable

4.18 *Goodwill permission /consent*:

As applicable, describe in detail what interest group representatives must give permission for this project (e.g. community leaders, church leaders, tribal chiefs or other). Also mention whether permission has already been obtained, with reference to attached proof, or how you will go about getting permission before the project commences.

Not applicable

4.19 *Informed authorisation:*

Is there existing informed consent that allows the use of the available, stored samples of human origin for use in this project? If so, provide details and if not, explain how you will go about ensuring informed consent of all individuals whose biological tissue is used.

(Please mark with **X** *in the appropriate box and provide details / explanation, or type "not applicable")*

More information

According to law all individuals whose biological material is used (even if it is remains of another experiment or available in a bank) must grant informed consent that it may be used for the study concerned. The informed consent may also be wide, e.g. that consent is given that it may be used for medical research, in which case it is suitable for additional projects. There are certain exceptions, such as standard cell culture lines that are available from registered banks.

Yes	No	Details / Explanation
☐	☒	Not applicable

4.20 *Risks:*

What are the potential risks that the handling, storage, transport and/or disposal of the privileged information or biological material? Are there any contaminated disposable objects that poses a risk for man, animal and/or the environment? What measures will you have in place to manage the risks? **N.B!** Where an aspect is, however, covered fully in "Section 6: Matters that Necessitate Additional Information", you can merely refer to the specific subsection in this application form.

More information

Where original information is handled, privileged information may leak when it is not handled with the due caution.

Biological materials can spread infections or cause contamination. When certain biological fluids, especially if it contains drugs, land in drinking water or the sewerage system, it can contaminate the environment. When an experimenter inadvertently contaminates himself/herself with certain types of living tissue or cells, it can grow and sometimes even cause cancer. Genetically manipulated tissue or cells can potentially cause contamination in the environment. Contact with infected blood can typically cause infection with HIV or Hepatitis B.

Biological waste holds a potential public and environmental danger. Some biological materials must first be sterilised before disposing of it. Other biological materials, as well as contaminated needles and syringes, must be thrown away as "hazardous waste" in special containers and removed by professional disposal agents. Living tissue and cells must also be destroyed first. You must therefore indicate here what the requirements are that are applicable to your project and what measures you have in place to manage it.

Not applicable

4.21 *Expertise, skills and legal competencies:*

What expertise, skills and legal competencies are needed to implement the project? Do the Project Head / research supervisor / researcher(s) / assistants / field workers have at their disposal the necessary background / expertise / qualifications / professional registrations to handle the privileged information or implement the techniques concerned? If not and as applicable, explain how the necessary training will be provided before the project commences.

More information

Biological samples of human origin are a donation, that must be dealt with responsibly and waste must be restricted. Safe handling is also important. Indicate therefore whether enough expertise, skill and legal competence exists to prevent the wasting of biological samples of human origin (e.g. the prior acquisition of technique) and to ensure the safe, responsible use of the samples.

Type here

4.22 *Facilities:*

Describe the place(s) and facilities in detail where the project will be implemented.
(Where the project holds more than minimal risk, all emergency care situations must be carried out within an emergency care space approved by the supervisory doctor.)

Type here

4.23 *Storage and archiving of data:*

Explain how, where and how long the research data will be stored. **N.B!** All raw data remains the property of the North-West University. Only copies may leave the storage area, and then only by authorised persons. Where an outside party, e.g. a sponsor, lays claim to the original data, certified copies must be stored on the Campus and the same rules apply as above.

> ***More information***
>
> *Some legislation, rules and regulations for certain professions stipulate that data must be stored for a specified minimum period. Most government departments however store data for a minimum of 7 years and it is recommended as a general rule that data is not stored for less than 7 years. You must therefore indicate here what the requirements are that apply to your project. Furthermore, any person must have the right to request to see and study the original data of published results in order to verify the accuracy and validity thereof.*

Not applicable

Remember to save your document regularly as you complete it!

Sec 4c: Animal subjects (Vertebrates)

4.24 *Animal subject description:*

Give a full description of the animal subjects that you will use.

Animal subject species	Number	Gender	Age/Mass
Not applicable	0	- select -	Type here

4.25 *Justification:*

Provide a justification for the use of vertebrates and the choice of the species for this study. Explain briefly too what theoretical or practical value this study may have. The evaluators use this information to carry out a cost / benefit calculation.

Type here

4.26 *Alternatives:*

Are there any ethically friendlier alternatives available to achieve the project objectives meaningfully (e.g. lower order animals without consciousness / feeling, tissue cultures, computer models, etc.)?

(Please mark with **X** *in the appropriate box and provide details if "Yes")*

Yes	No	Details
☐	☐	Not applicable

4.27 *Animal subject availability:*

Is this species available from the Animal Testing Centre? If "No", motivate why this species is more suitable for your research than those that are in fact available, mention where the animals are available and what the microbiological status of these subjects is.

(Please mark with **X** *in the appropriate box and provide a motivation if "Yes")*

Yes	No	Motivation
☐	☐	Type motivation here, or type "Not applicable"

4.28 *Permits:*

Is a permit required by law for the capture, collection, transport or detention of this species of vertebrate? If "Yes", mention the name and address of the authorising authority.

(Please mark with **X** *in the appropriate box and provide details if "Yes". If the permits already exist, also mention the permit number, terms and conditions and expiry date)*

Yes	No	Motivation & Details
☐	☐	Type motivation here, or type "Not applicable"

4.29 *Probable experience of the animal subject:*

What will the probable experience of the animal subject be and what measures are in place to minimise the suffering / discomfort? Also indicate the severity or degree of discomfort/suffering to which the subjects may be exposed.

More information

List the procedures that may cause restraint, discomfort, anxiety and pain. While you emphasise the probable experience of the subjects, refer inter alia to the following aspects, as applicable to your project:

- *Provide in particular details on any step that may cause any form of discomfort or even suffering. Describe clearly e.g. the use or withholding of any painkillers, anaesthetic, surgical techniques, intra-operative and post-operative care and/or euthanasia at the end of the experiment.*
- *Describe furthermore all specific procedures and sample collections (e.g. number, frequency, routes of administration and measurements, etc.).*
- *Categorise the procedures as minimal, intermediary or high, with reference to the abbreviated scale of the "MRC Guideline Book 3: Use of Animals in Research". Give the probable duration of the suffering. Also describe the steps that will be taken to minimise/alleviate the suffering, e.g. the use of analgesics or anaesthetic, and estimate how effective it is likely to be.)*
- *Describe all the steps fully and in order, so that the evaluator can form an image of the probable experience of the subject.*

Type here

4.30 *Monitoring of subjects:*

Where the experimental interference may have specific impact on the welfare of the animal subjects, list criteria to monitor the welfare of the animals during the experiment. *(List e.g. clinical signs peculiar to the experiment that can indicate to experimenters and animal subject carers whether the subjects react as expected or when something goes wrong and animals suffer unnecessarily. Also indicate what measures the experimenters and animal subject carers can take to minimise suffering.)*

Type here

4.31 *Subject handling:*

Have all persons who will be handling the subjects completed an appropriate course in animal subject handling?

(Please mark with X in the appropriate box and provide details if "Yes")

Yes	No	Details
☐	☐	Type here

4.32 *Expertise, skills and legal competencies:*

What expertise, skills and legal competencies are needed to implement the project? Do the Project Head / research supervisor / researcher(s) / assistants / field workers have at their disposal the necessary background / expertise / qualifications / professional registrations to implement the techniques concerned? If not and as applicable, explain how the necessary training will be provided before the project commences.

Not applicable

4.33 *Facilities:*

Describe the place(s) and facilities in detail where the project will be implemented. *(Where the project holds more than minimal risk, all emergency care situations must be carried out within an emergency care space approved by the supervisory doctor.)*

Not applicable

4.34 *Storage and archiving of data:*

Explain how, where and how long the research data will be stored. **N.B!** All raw data remains the property of the North-West University. Only copies may leave the storage area, and then only by authorised persons. Where an outside party, e.g. a sponsor, lays claim to the original data, certified copies must be stored on the Campus and the same rules apply as above.

More information

Some legislation, rules and regulations for certain professions stipulate that data must be stored for a specified minimum period. Most government departments however store data for a minimum of 7 years and it is recommended as a general rule that data is not stored for less than 7 years. You must therefore indicate here what the requirements are that apply to your project. Furthermore, does any person have the right to request to see and study the original data of published results in order to verify the accuracy and validity thereof?

Not applicable

Remember to save your document regularly as you complete it!

Section 5: Statistical Justifiability

A special section is devoted to statistical justifiability of your intended project. So e.g. the most sound research problem, methodology and data processing can't make a project succeed if the project design (experimental design) did not take into account statistical justifiability. Poor statistical planning can cause a good project to fail and may render the results useless for answering the set research problems. To involve human participants or animal subjects in such a poorly planned project now would be unethical. It is therefore important to indicate in this section how you as Project Head will ensure that your project design is statistically justifiable.

Sec 5a: Human Participants (Subjects)

Only fill this part in if this project makes use of human participants.

5.1 *Approval:*

Has this project been approved by Statistical Consultation Service of the North-West University? **N.B!** Approval of the design and statistical justifiability of your project by Statistical Consultation Service before submission of the ethics application is not compulsory. However, it is certainly strongly recommended, since it may identify unnecessary shortcomings beforehand and can speed up the process of ethical approval.

(Mark "Yes" or "No" with **X** *in the appropriate box. Provide any additional comments as necessary.)*

> ***More information***
>
> *Qualitative studies do not usually require statistical processing of data. Meaningful project design is, however, still necessary to obtain meaningful results. To the contrary, quantitative studies where data must be processed, do require statistical processing of the raw data as a rule. Ensuring good, meaningful data, appropriate statistical processing and meaningful interpretation of the data begins, however, with thorough planning of the study design.*

Yes	No	Additional Comments
☒	☐	The project head is an expert in the field of qualitative data analysis (using Atlads.ti) and will oversee all qualitative data analysis. In levels 4 and 5 (See Section 3.6), data pertaining to examination marks and monetary costs will be obtained from the NWU (Unit for Open Distance Learning) data-base. Although this readily available data is quantitative in nature, only descriptive statistics (frequencies and percentage frequencies) will be reported in support the qualitative findings. To report the difference in monetary costs, only the two averages for contact vs Interactive Smart-Board, will be compared. No further quantitative statistics will be performed on this data, besides the reporting of frequencies and percentage frequencies. All other quantitative data, obtained for example via Addendum H, will only be reported in the form of descriptive statistics (frequencies and percentage frequencies). No further quantitative statistical analysis or reporting will be conducted. The Pre-Test and Post-Test scores will also be reported only in descriptive form to support the qualitative findings of this study.

If "Yes", attach the completed and signed "Sec 8e: Statistical Consultation Service". If "No", ensure that enough information is available in the application form to make it possible for evaluators to check the justifiability of the project design.

5.2 *Participant recruitment and randomness:*

Describe in full how statistical justifiability (e.g. randomness) will be handled in the recruitment of participants (subjects) and motivate.

Due to the size of the population everyone will be recruited to become a participant in the study. They will, however, be free to accept. See Section 3.6

5.3 *Design:*

Describe the study design / experimental design:

(Please mark with X in the applicable right-hand box)

Type	Description	Mark
Parallel Design	Participants divided into groups; one intervention per group	☐
Crossover Design	Two or more interventions per participant, with "washing out periods" in between	☐
Factorial Design	Participants divided into groups; each group receives a combination of 2 or more interventions or is subject to 2 or more factors that are controlled	☐
Any other design (not listed above – describe below)		☒

See Section 3.6 for a comprehensive overview of the research design and methodology.

5.4 *Exposé of project design:*

Describe the group classifications, as applicable:

(Please click in the right-hand box and type the correct number)

More information

N.B! *It is important that you calculation of the number of human participants is accurate. If you now indicate an incorrect number of human participants and/or want to amend the number later, it would mean that you would have to apply again to the Ethics Committee for the amendment. The use of a different number of human participants to that for which an application was made and approved, makes your approval invalid, it is illegal and deprives you of any protection that the ethical approval offers.*

If you cannot do an accurate forecast and calculation now of the number of human participants required, it is perhaps an indication that you should first apply for a pilot study and then apply for the full project based on the results of the pilot study.

Number of groups	0
Number of participants per group	0
Total number of participants	0

In the case of more complex group classifications, provide a clear schematic representation or other suitable exposé

See Section 3.6

5.5 *Motivation for project design:*

Motivate the design, group sizes and conditions by referring to similar published studies and/or refer to pilot studies that have already been carried out to justify the above design, number of participants, group sizes and conditions.

> ***More information***
>
> *So you must e.g. show that the design and group sizes will deliver the required precision and differentiation power to show meaningful differences (effect size). If there is no information, however, this application must be for a pilot study first and you must indicate it clearly as such in the application (see §1.4) and mention that a successive application will be submitted for the full project, in which the information obtained from the pilot study will be included.*

See Section 3.6

5.6 *Allocation to groups:*

Describe in full how participants (subjects) will be apportioned to groups randomly (as applicable).

> ***More information***
>
> *Describe the process of how random apportionment of participants will take place. As applicable, also describe then how the decision will be made as to which of the various interventions / procedures / techniques / methods / approaches / therapy will be apportioned to the various groups.*

See Section 3.6

5.7 *Disturbance variables:*

Describe the foreseeable disturbance variables (background variables) of the project and how you will manage them.

> ***More information***
>
> *What background variables (disturbance variables) are inherent that cannot be kept constant in executing the study, e.g. different researchers carrying out the study / experiment; more than one laboratory being used; different days during which the study / experiment runs, etc. What measures are in place to control / manage / monitor these variables?*

If the study is done in another area the results may be different. The study may also yield different results when other modules are concerned.

If students cannot attend specific sessions the researcher will manage this by scheduling alternative dates.

Remember to save your document regularly as you complete it!

Sec 5b: Filed Privileged Information or Stored Biological Samples of Human Origin

Fill this part in only for the use of existing, filed privileged information of humans (e.g. medical files) or existing, stored biological samples (e.g. tissue or fluids) of human origin, e.g. where samples are collected for another project or for medical diagnosis. This part is therefore not filled in if the information or samples will be obtained from a clinical trial, which has already been described in “Sec 4a: Human Participants (Subjects)”.

5.8 *Approval:*

Has this project been approved by Statistical Consultation Service of the North-West University? **N.B!** Approval of the design and statistical justifiability of your project by Statistical Consultation Service before submission of the ethics application is not compulsory. However, it is certainly strongly recommended, since it may identify unnecessary shortcomings beforehand and can speed up the process of ethical approval.

(Mark "Yes" or "No" with **X** *in the appropriate box. Provide any additional comments as necessary.)*

> ***More information***
>
> *Qualitative studies do not usually require statistical processing of data. Meaningful project design is, however, still necessary to obtain meaningful results. To the contrary, quantitative studies where data must be processed, do require statistical processing of the raw data as a rule. Ensuring good, meaningful data, appropriate statistical processing and meaningful interpretation of the data begins, however, with thorough planning of the study design.*

Yes	No	Additional Comments
☐	☐	Not applicable

If "Yes", attach the completed and signed "Sec 8e: Statistical Consultation Service". If "No", ensure that enough information is available in the application form to make it possible for evaluators to check the justifiability of the project design.

5.9 *Information/material selection:*

Describe in full how the information or biological material will be selected or obtained and motivate.

> ***More information***
>
> *Refer to availability of the appropriate information or biological material. Where applicable, also refer to aspects such as race, gender, age limits or any other specific relevant characteristics of the individuals whose information or biological material will be used. Motivate your choice of the specific group.*

Not applicable

5.10 *Exposé of project design:*

Describe the group classifications, as applicable:

(Please mark with X in the applicable right-hand box)

> ***More information***
>
> ***N.B!*** *It is important that you calculation of the number of samples is accurate. If you now indicate an incorrect number of samples and/or want to amend the number later, it would mean that you would have to apply again to the Ethics Committee for the amendment. The use of a different number of samples to that for which an application was made and approved, makes your approval invalid, it is illegal and deprives you of any protection that the ethical approval offers.*
>
> *If you cannot do an accurate forecast and calculation now of the number of samples required, it is perhaps an indication that you should first apply for a pilot study and then apply for the full project based on the results of the pilot study.*

Number of groups	0
Number of samples per group	0
Total number of samples	0

In the case of more complex group classifications, provide a clear schematic representation or other suitable exposé

Type here for more complex exposés, or type “None”

5.11 *Motivation for project design:*

Motivate the design, group sizes and conditions by referring to similar published studies and/or refer to pilot studies that have already been carried out to justify the above design, number of participants, group sizes and conditions.

More information

So you must e.g. show that the design and group sizes will deliver the required precision and differentiation power to show meaningful differences (effect size). If there is no information, however, this application must be for a pilot study first and you must indicate it clearly as such in the application (see §1.4) and mention that a successive application will be submitted for the full project, in which the information obtained from the pilot study will be included.

Type here

5.12 *Disturbance variables:*

Describe the foreseeable disturbance variables (background variables) of the project and how you will manage them.

More information

What background variables (disturbance variables) are inherent that cannot be kept constant in executing the study, e.g. different researchers carrying out the study / experiment; more than one laboratory being used; different days during which the study / experiment runs, etc. What measures are in place to control / manage / monitor these variables?

Not applicable

Remember to save your document regularly as you complete it!

Sec 5c: Animal subjects (vertebrates)

Only fill this part in if this project makes use of vertebrate subjects.

5.13 *Approval:*

Has this project been approved by Statistical Consultation Service of the North-West University? **N.B!** Approval of the design and statistical justifiability of your project by Statistical Consultation Service before submission of the ethics application is not compulsory. However, it is certainly strongly recommended, since it may identify unnecessary shortcomings beforehand and can speed up the process of ethical approval.

*(Mark "Yes" or "No" with **X** in the appropriate box. Provide any additional comments as necessary.)*

> ***More information***
> *Qualitative studies do not usually require statistical processing of data. Meaningful project design is, however, still necessary to obtain meaningful results. To the contrary, quantitative studies where data must be processed, do require statistical processing of the raw data as a rule. Ensuring good, meaningful data, appropriate statistical processing and meaningful interpretation of the data begins, however, with thorough planning of the study design.*

Yes	No	Additional Comments
☐	☐	Not applicable

If "Yes", attach the completed and signed "Sec 8e: Statistical Consultation Service". If "No", ensure that enough information is available in the application form to make it possible for evaluators to check the justifiability of the project design.

5.14 *Design:*

Describe the experimental design

*(Please mark with **X** in the applicable right-hand box)*

Type	Description	Mark
Parallel Design	Animal subjects divided into treatment groups; one treatment per group	☐
Crossover Design	Two or more treatments per animal subject, with "washing out periods" in between	☐
Factorial Design	Animal subjects divided into groups; each group receives a combination of 2 or more treatments or is subject to 2 or more factors that are controlled	☐
Any other design (not listed above – describe below)		☐

Not applicable

5.15 *Exposé of project design:*

Describe the group classifications and number of animal subjects, as applicable. Ensure that you calculate the total number of animal subjects correctly and that your calculations are clearly shown.

> ***More information***
>
> ***N.B!*** *It is important that you calculation of the number of animal subjects is accurate. If you now indicate an incorrect number of subjects and/or want to amend the number later, it would mean that you would have to apply again to the Ethics Committee for the amendment. The use of a different number of animal subjects to that for which an application was made and approved, makes your approval invalid, it is illegal and deprives you of any protection that the ethical approval offers.*
>
> *If you cannot do an accurate forecast and calculation now of the number of subjects required, it is perhaps an indication that you should first apply for a pilot study and then apply for the full project based on the results of the pilot study.*

Number of groups	0
Number of animals per group	0
Total number of animals	0

In the case of more complex group classifications, provide a clear schematic representation or other suitable exposé

The number of students that will be present during the Interactive Smart-Board session can not be determined beforehand.

5.16 *Motivation for project design:*

Motivate the design, group sizes and conditions by referring to similar published studies and/or refer to pilot studies that have already been carried out to justify the above design, number of animal subjects, group sizes and conditions.

> ***More information***
>
> *So you must e.g. show that the design and group sizes will deliver the required precision and differentiation power to show meaningful differences (effect size). If there is no information, however, this application must be for a pilot study first and you must indicate it clearly as such in the application (see §1.4) and mention that a successive application will be submitted for the full project, in which the information obtained from the pilot study will be included.*

Type here

5.17 *Allocation to groups:*

Describe in full how animal subjects will be apportioned to groups randomly (as applicable) and, where applicable, how the experimental treatments will be allocated to each group.

> ***More information***
>
> *Describe the process of how random apportionment of animal subjects will take place. As applicable, also describe then how the decision will be made as to which of the various treatments will be apportioned to the various groups.*

Type here

5.18 *Disturbance variables:*
Describe the foreseeable disturbance variables (background variables) of the project and how you will manage them.

> ***More information***
> *What background variables (disturbance variables) are inherent that cannot be kept constant in executing the study, e.g. different researchers carrying out the study / experiment; more than one laboratory being used; different days during which the study / experiment runs, etc. What measures are in place to control / manage / monitor these variables?*

Type here

Remember to save your document regularly as you complete it!

Section 6: Matters that Necessitate Additional Information

Sec 6a: Persons who are Particularly Vulnerable or Incompetent to Give Informed Consent

Please complete this section if there are any minors, students, people who are intellectually incompetent to give informed consent or otherwise vulnerable persons/communities involved in this project.

6.1 This project includes experimentation with, use, administration or restraint of, or other intervention with:
(Mark ALL options as "Yes" or "No" with **X** *in the appropriate box – more than one option may be "Yes".)*

Description	Yes	No
Minors	☐	☒
People who are intellectually incompetent to give informed consent	☐	☒
Own students (registered learners at the NWU)	☒	☐
Defenceless communities (e.g. prisoners, institutionalised patients, illiterate persons, rural communities, poverty, etc.)	☐	☒
Otherwise vulnerable persons (e.g. due to illness, desperation, emotional trauma, rape, other need, etc.)	☐	☒

6.2 *Definition:*
Define in more detail the group of people (as marked in question 6.1 above) included in the project.

> ***More information***
> *Explain the group i.t.o. aspects such as precisely who they are, where they come from and what makes them vulnerable.*

The target population for this study is a group of NWPK 512 students who are registered for the ACE in Mathematics and who have already had at least one examination attempt without success.

6.3 *Any association of participants with project team members:*

Declare any association of any of the participants with any members of the research team.

More information

Family & friends:
If any of the participants happen to be family or close friends of any member of the research team, it must be mentioned.

Students:
Students may not be recruited individually as participants (subjects). A lecturer / researcher may not allow any person at all to be involved as a participant (subject) of the project if that person is also involved in or registered for any course / module / programme / project that the lecturer / researcher presents.

Patients / clients:
If any of the participants are linked professionally to any of the members of the research team (e.g. patient-doctor relationship) it must be declared.

Not applicable

6.4 *Motivation:*

Explain the necessity for including this specific group of vulnerable people as human participants (subjects).

n.a.

6.5 *Management of justifiability:*

Explain how ethical justifiability will be ensured from beginning to end.

More information

Minors:
Explain i.a. how the persons will be recruited, how proxy consent will be obtained from the legally competent parent / guardian, how the project will be explained to them and how voluntary assent will be ensured. How will ethical justifiability be ensured from beginning to end?

Students:
Explain how you will ensure that no student is approached individually and that no one will be allowed to be involved as participant (subject) of the project if that person is also involved in, or registered for, any course / module / programme / project that the lecturer / researcher presents. How will ethical justifiability be ensured from beginning to end?

Patients / clients:
Explain how you will ensure that the professional relationship between the participants and the professional member of the project team will always be placed above the interests of the project. How will ethical justifiability be ensured from beginning to end?

Defenceless communities or otherwise vulnerable persons:
Explain how the persons will be recruited, how the project will be explained to them, how consent and voluntary assent will be obtained and how you will ensure that the persons do not feel intimidated by members of the research team or as a result of the pressure of circumstances are intimidated or "exploited". How will ethical justifiability be ensured from beginning to end?

Ethical principles will be applied throughout the project. These principles includes professional competence, professional relationship with participants, privacy and trustworthiness.

Remember to save your document regularly as you complete it!

Sec 6b: Human Stem Cells, Germ Line Cells, Embryos and/or Foetuses

Please complete this section if any human stem cells, human germ line cells and/or human embryos and/or foetuses are used in this study. If you complete this section, you would also have completed "Sec 4a: Human Participants (Subjects)" and/or "Sec 4b: Filed Privileged Information or Stored Biological Samples of Human Origin".

6.6 *Motivation:*

Provide your motivation for the use of the human biological material concerned, highlight the ethical focal points and explain how you will handle the relevant sensitive ethical problems responsibly.

Not applicable

6.7 *Expertise, legal competence & facilities:*

Do you have the necessary expertise, legal competence and facilities to work with the human stem cells, germ line cells, embryos and/or foetuses and do you have appropriate procedures to ensure safe use and disposal? Provide full details.

(Mark "Yes" or "No" with **X** *in the appropriate box. Provide additional details as necessary.)*

Yes	No	Details
☐	☐	Not applicable

Remember to save your document regularly as you complete it!

Sec 6c: Living Cell and Tissue Cultures

Please complete this section if any cell and/or tissue cultures are used in this study. If you complete this section, you would most likely also have had to complete "Sec 4b: Filed Privileged Information or Stored Biological Samples of Human Origin".

6.8 *Number:*

How many cell and tissue cultures will be used in the project?

Description	Number
Cell cultures	0
Tissue cultures	0

6.9 *Product information:*

Provide detailed product information, so that the evaluators can evaluate the ethically justifiable use of the cell and tissue cultures.

N.B! *If more than one cell line or tissue line is used, select and copy the whole table and paste as many tables underneath as is necessary.* *Tip!* *Place an empty paragraph between the tables.*

More information

Give the necessary details below.

Human origin and consent:

For standard cell and/or tissue cultures from banks such as the ATCC consent already exists for general, ethically justifiable and medically related research.

Potential dangers and risks:

Tissue banks such as the ATCC classify cell and/or tissue cultures as "bio safety level 1, 2 or 3", depending on potential for infection with pathogens which may be harmful to man, or cancerous characteristics that would make growth in a person possible after undesirable, accidental inoculation.

N.B! *These cell cultures may* ***never*** *be used in* ***people****. There are certainly studies where cells are sometimes transplanted into animal subjects.*

Cell Line or Tissue Line

Approved Name & Code	Description
Not applicable	Type here

Source / Origin / Supplier	Catalogue No.	Human Origin?	Consent for use?
Type here	Type here	Type "Yes" or "No"	Type "Yes" or "No"

Method of Storage and Maintenance	Normal Uses or Applications
Type here	Type here

Potential Dangers & Risks	Standard Precautions
Type here	Type here

Other Relevant Information & Literature References
Type here

6.10 *Expertise & facilities:*

Do you have the necessary expertise and facilities to work with the cell and/or tissue cultures and do you have appropriate procedures to ensure safe use and disposal? Provide full details.

(Mark "Yes" or "No" with **X** *in the appropriate box. Provide additional details as necessary.)*

> ***More information***
>
> *Certain cell and/or tissue cultures (e.g. bio safety levels 2 or 3) require special facilities, including class 2 laminar airflow cabinets, which also filter the outgoing air and therefore do not expose the researcher and environment to pathogens. It may also be necessary to wear gloves and jackets. Disposal includes first sterilising or destroying the cell and/or tissue cultures, as well as any disposable apparatus that is contaminated with it, with e.g. chlorine, ethanol or heat sterilisation (e.g. autoclaving).*

Yes	No	Details
☐	☐	Type here

6.11 *Measures:*

Explain the measures you have in place to protect the safety of researchers / workers / the environment against the potential detrimental effects of the cell and/or tissue cultures and waste. Also specify methods and safety measures for the disposal of cell and/or tissue cultures.

Type here

Remember to save your document regularly as you complete it!

Sec 6d: Genetic Material, Genetic Manipulation, or Genetically Manipulated Animals, Plants or other Organisms / Tissue / Cells

Please complete this section if any genetic material, genetic manipulation, or genetically manipulated organisms / tissue / cells are used or administered in this study. This also applies to dangers with abuse, whether it poses any potential danger to people, animals or the environment or not.

6.12 *Number:*

How many genetic materials, genetic manipulations or genetically manipulated organisms / tissue / cells will be used in the project?

Description	Number
Genetic materials	0
Genetic manipulations	0
Genetically manipulated organisms / tissue / cells	0

6.13 *Product information:*

Provide detailed product information, so that the evaluators can evaluate the ethically justifiable use of the genetic material, genetic manipulation, or genetically manipulated organisms / tissue / cells.

N.B! *If more than one genetic material or manipulation is used, select and copy the whole table and paste as many tables underneath as is necessary.* *Tip!* *Place an empty paragraph between the tables.*

More information

Give the necessary details such as approved name (or other description), normal uses or applications (or as in the project), potential dangers (e.g. contamination or escape of a genetically manipulated plant or animal in nature, with risk of reproduction), precautions (to manage risks) and other relevant information of the genetic materials or genetic manipulation, to assist the Ethics Committee in their evaluation of the application. It could also e.g. even include the risk of environmental contamination. Recognised textbooks or other scientific publications or registered information posters must be referred to in support of the statements.

Genetic Material or Manipulation or Genetically Manipulated Organism / Tissue / Cell

Approved Name	Source / Origin / Supplier	Method of Storage / Maintenance / Retention
Not applicable	Type here	Type here

Description	Normal Uses or Applications
Type here	Type here

Potential Dangers & Risks	Standard Precautions
Type here	Type here

Other Relevant Information & Literature References
Type here

6.14 *Expertise & facilities:*

Do you have the necessary expertise and facilities to work with the cell and/or tissue cultures and do you have appropriate procedures to ensure safe use, storage and disposal? Provide full details.

(Mark "Yes" or "No" with **X** *in the appropriate box. Provide additional details as necessary.)*

> ***More information***
>
> *Certain cell and/or tissue cultures (e.g. bio safety levels 2 or 3) require special facilities, including class 2 laminar airflow cabinets, which also filter the outgoing air and therefore do not expose the researcher and environment to pathogens. It may also be necessary to wear gloves and jackets. Disposal includes first sterilising or destroying the cell and/or tissue cultures, as well as any disposable apparatus that is contaminated with it, with e.g. chlorine, ethanol or heat sterilisation (e.g. autoclaving).*

Yes	No	Details
☐	☐	Not applicable

6.15 *Measures:*

Explain the measures that will be in place to protect the workers, participants (subjects) and the environment against the potential detrimental effects and dangers of the genetic material or genetically manipulated products/plants/animals:

Type here

Remember to save your document regularly as you complete it!

Sec 6e: Injections, Blood Samples, Swabs and Similar Interferences

Please complete this section if any intravenous infusions, injections, finger prick, blood samplings, biopsies, swabs (e.g. skin, mucous, etc.) or similar interferences are used in this project.

6.16 *Discomfort and risks:*

Where any intravenous infusions, injections, finger prick, blood samplings, biopsies, swabs or similar interferences are used, give full details thereof, including the possible discomfort for the participants / animal subjects and risks it may hold for the participants / researchers / field workers / animal subjects / environment.

> ***More information***
>
> *If disposable sharp medical objects, such as injection needles that have been in contact with biological material are thrown away, it constitutes a contamination risk and injury risk. When working with blood, the researchers / field workers who take the samples are potentially exposed to infections such as Hepatitis B and AIDS.*

Type here

6.17 *Precautions:*

Where any injections, finger prick, blood samplings, biopsies, swabs or similar interferences are used, describe fully what precautions are in place to ensure the welfare of the participants (subjects) and to restrict risks to the minimum. Also explain the facilities available where the intervention is done and what professional supervision is needed. What is done to protect the safety of the researchers / assistants / field workers? How are the disposable medical objects disposed of to protect the community and environment?

> ***More information***
>
> *If disposable sharp medical objects are used, they must be thrown away e.g. in special containers and removed by professional persons. Blood samples must e.g. be taken by a nurse or medical doctor. Precautions could also include the wearing of gloves, vaccinations against Hepatitis B, etc.*

Not applicable

Remember to save your document regularly as you complete it!

Sec 6f: Use of Drugs / Medicines

Please complete this section if any drug or medicines are used or administered in this study.

6.18 *Number:*

How many drugs / medicines will be used in the project?

> ***More information***
>
> *If more than one dosage form or brand name of the same drug (active ingredient) is used, it must be counted and mentioned separately. Where applicable, placebos must also be mentioned and calculated.*

Description	Number
Drugs / medication	0

6.19 *Product information:*

Provide detailed product information, so that the evaluators can evaluate the ethically justifiable use of the drugs / medicine.

N.B! *If more than one drug / medicine is used, select and copy the whole table and paste as many tables underneath as is necessary.* *Tip!* *Place an empty paragraph between the tables.*

> ***More information***
>
> *Give the necessary details, such as approved name, accepted dosage, pharmacological action, side-effects, precautions, contra-indications and other relevant information of the medication(s), to assist the Ethics Committee in their evaluation of the application. Recognised textbooks or other scientific publications or registered information posters must be referred to in support of the statements.*
>
> *For use in animals, you may also provide information about the use of the drug in humans, but must specifically refer to the known / expected pharmacology (effects, mechanisms, indications, etc.) in the experimental animals, as well as the appropriateness of the selected doses for the animals and experimental aims (e.g. as used before).*

Drug 1

Approved Pharmacological (Generic) Name	Brand Name(s) (if applicable)
Type here	Type here

Registered at the MCC-SA?[12]	If "Yes", MCC-SA Registration Number[13]	If registered at the MCC-SA[12], is this for the indications, dosages and administrations as used in this project? Provide details where necessary.
- select -	Type here	Type here

Accepted Dosage(s)	Accepted Administration Route(s)
Type here	Type here

Pharmacological Action, Therapeutic Effects & Indications	Side-effects, Precautions & Contra-indications
Type here	Type here

Other Relevant Information & Literature References
Type here

[12] MCC-SA = Medicine Control Council of South Africa.

[13] The MCC-SA registration number can be found on medicine product leaflets.

6.20 *Professional supervision:*

Is there a professional person (e.g. doctor, pharmacist, nurse or veterinary surgeon) who has the necessary competence to exercise control over the drug / medicine?

*(Please mark with **X** in the appropriate box and provide details if "Yes")*

Yes	No	Details
☐	☐	Type here

6.21 *Special authorisation for use in humans (not applicable to animal studies):*

If any of the medication is not registered with the Medicine Control Council or, if it is registered but the study deals with indications for which it is not specifically registered, or if other doses, dosages, dosage forms or administration routes are used than what is registered, special approval must be obtained for the clinical test from the Medicine Control Council. Has such special authorisation been obtained?

*(Please mark with **X** in the appropriate box and complete further as applicable)*

Yes	No	Authorisation Number	Date of Authorisation
☐	☐	Type no. here or type "Not applicable"	2 0 _ _ - _ _ - _ _ (c c y y - m m - d d)

Indien **"Ja"**, heg 'n afskrif van die goedkeuringsbrief aan. Indien **"Nee"**, verduidelik hieronder watter hoe u te werk sal gaan om magtiging te verkry alvorens die projek aanvang neem.

***(Let wel:** Finale goedkeuring van die aansoek deur die Etiekkomitee is onderhewig aan goedkeuring van die projek deur die Medisynebeheerraad. Geen projek mag 'n aanvang neem alvorens skriftelike goedkeuring bekom is nie.)*

If "No", type explanation here, or type "Not applicable"

6.22 Explain the measures that will be in place to protect the workers, participants (subjects) and the environment against the potential side-effects of the medicinal substances and waste (disposal):

Type here

Remember to save your document regularly as you complete it!

Sec 6g: Use of Radio-Active Substances

6.23 *Description:*
Where any radio-active substances are used in experiments or administered to participants (subjects), give full details thereof, including the isotopes and possible risks it may hold for the participants / researchers / workers / animal subjects / environment.

Type here

6.24 *Competence, licensing & facilities:*
Do you have the necessary competence, licensing and facilities at your disposal to work with radio-active substances, do you have appropriate procedures to ensure safe use and disposal and do you have the necessary licensing from the Department of Health?
(Mark "Yes" or "No" with **X** *in the appropriate box. Provide the authorisation number if "Yes".)*

Yes	No	Authorisation number
☐	☐	Type here

Attach a copy of the approval certificate from the Radiation Control Officer.

6.25 *Measures:*
Explain the measures you have in place to protect the safety of participants (subjects) / researchers / workers / animal subjects / environment against the potential detrimental effects of the radio-active substances and waste. If applicable, also specify methods and safety measures for the disposal of radio-active contaminated body fluids and tissue.

Type here

Remember to save your document regularly as you complete it!

Sec 6h: Use of Toxic Substances or Dangerous Substances

Please complete this section if any toxic or dangerous substances are used or administered in this study (also drugs used in toxic doses in animal subjects, not discussed as drugs in "Sec 6f: Use of Drugs / Medicines"). This also applies to dangers with abuse, whether or not it holds any potential danger for people, animals or the environment.

6.26 *Number:*
How many toxic substances / dangerous substances will be used in the project?

Description	Number
Toxic substances	0
Other dangerous substances	0

6.27 *Product information:*
Provide detailed product information, so that the evaluators can evaluate the ethically justifiable use of the toxic and dangerous substances.
N.B! *If more than one such substance is used, select and copy the whole table and paste as many tables underneath as is necessary. Tip! Place an empty paragraph between the tables.*

> ***More information***
> *Give the necessary details such as approved name, normal uses and dosages, action, toxic effects, dangers, precautions, contra-indications and other relevant information of the toxic or dangerous substances (e.g. toxic products, carcinogenics, mutagens, pathogenic organisms, etc.), to assist the Ethics Committee in their evaluation of the application. Recognised textbooks or other scientific publications or registered information posters must be referred to in support of the statements.*

Substance 1	
Approved Name	**Normal Uses & Dosages**
Type here	Type here

Action & Toxic Effects/Dangers	**Precautions & Contra-indications**
Type here	Type here

Other Relevant Information & Literature References
Type here

6.28 Explain the measures that will be in place to protect the workers, participants (subjects) and the environment against the potential detrimental effects of the toxic or dangerous substances and waste:

Type here

Remember to save your document regularly as you complete it!

Sec 6i: Use of Food, Fluids or Nutrients

Please complete this section if any food, fluids or nutrients (alone or in combination) are used or administered in this study. This also applies to dangers with abuse, whether or not it holds any potential danger for people, animals or the environment. **N.B!** This does not include the provision of a regular plate of food for maintenance during residence.

6.29 *Number:*
How many kinds of food, fluids or nutrients will be used in the project?

> ***More information***
> *If more than one dosage form or brand name of the same drug (active ingredient) is used, it must be counted and mentioned separately. Placebos are only included, except if placebo includes no administration.*

Description	Number
Food	0
Fluids	0
Nutrients / nutrient combinations	0

6.30 *Product information:*
Provide detailed product information, so that the evaluators can evaluate the ethically justifiable use of the food, fluids and nutrients.
N.B! *If more than one food, liquid or nutrient is used, select and copy the whole table and paste as many tables underneath as is necessary.* *Tip!* *Place an empty paragraph between the tables.*

> ***More information***
> *Give the necessary details such as ingredients, approved name, normal quantities and uses, potential dangers (e.g. allergies or poisoning), abuse, precautions, contra-indications and other relevant information of the food, fluids or nutrients to assist the Ethics Committee in their evaluation of the application. It could e.g. even include the risk of allergic reaction with the use of e.g. peanuts. Recognised textbooks or other scientific publications or registered information posters must be referred to in support of the statements.*

Food, Fluid or Nutrient

Approved Name	Normal Quantities & Uses
Type here	Type here

Potential Dangers with Abuse	Precautions & Contra-indications
Type here	Type here

Other Relevant Information & Literature References
Type here

6.31 Explain the measures that will be in place to protect the workers, participants (subjects) and the environment against the potential detrimental effects of the food, fluids or nutrients and waste:

Type here

Remember to save your document regularly as you complete it!

Sec 6j: Psychometric Measuring Instruments and Questionnaires

Please complete this section if any psychometric measuring instruments or validated questionnaires are used in this project.

6.32 *Number:*

How many psychometric measuring instruments and validated questionnaires will be used in the project?

Description	Number
Psychometric measuring instrument	0
Validated questionnaires	0

6.33 *Information about the measuring instrument:*

Provide detailed information on the psychometric measuring instrument, so that the evaluators can evaluate the ethically justifiable use thereof.

N.B! *If more than one psychometric measuring instrument and/or questionnaire is used, select and copy the whole table and paste as many tables underneath as is necessary. Tip! Place an empty paragraph between the tables.*

> ***More information***
>
> *Give the necessary details about the psychometric measuring instrument to ensure meaningful use. Recognised textbooks or other scientific publications or registered information posters must be referred to in support of the statements.*

Psychometric Measuring Instrument

Approved Name	Normal Application
Type here	Type here

Reliability	Validity
Type here	Type here

Other Relevant Information & Literature References
Type here

6.34 *Validation for target group:*

Is the measuring instrument validated for the target group (e.g. for South African circumstances)? Provide full details.

(Please mark with **X** *in the appropriate box and provide details)*

Yes	No	Details
☐	☒	Type here

6.35 *Precautions:*

If applicable, explain the measures that will be in place to protect the participants against the potential detrimental effects of the use of the psychometric measuring instruments:

n.a

Remember to save your document regularly as you complete it!

Sec 6k: Any Other Aspect of Potentially Ethically Sensitive Nature

Please complete this section if there is any aspect of potentially ethically sensitive nature that is not addressed elsewhere in the application.

6.36 Please describe in full any other aspect that may potentially be of an ethically sensitive nature and which must be brought to the attention of the ethics committee:

n.a.

6.37 Explain the measures, as applicable, that will be in place to protect the workers, subjects and the environment against the potential detrimental effects of the above-mentioned interference:

n.a.

Remember to save your document regularly as you complete it!

Section 7: Other Ethics Evaluations & Risk Insurance

Sec 7a: Evaluation by other Ethics Committees

Please complete this section if this project has been or will be evaluated by any other ethics committees, for example with multi-institutional projects.

7.1 *Number:*
How many ethics committees (including the NWU Ethics Committee) have evaluated / will be evaluating this project?

Description	Number
Total number of ethics committees involved	1

7.2 Provide information about all ethics committees involved in the evaluation and approval of this project.

Name of Ethics Committee	Contact Number or E-mail address	Role
NWU Ethics Committee	ethics@nwu.ac.za	**Primary evaluator**
		- select -
		- select -

(Type one name per row, or type "None" if there are no other ethics committees involved.)

7.3 Provide information about the ethics authorisations of the ethics committees mentioned above (§ 7.2).

Name of Ethics Committee	Authorisation Status	Authorisation Details (conditions, start & end dates)	Authorisation No.
NWU Ethics Committee	Evaluation in process	Not applicable	Not applicable
	- select -		
	- select -		

(Type one name per row, or type "None" if there are no other ethics committees involved.)

Remember to save your document regularly as you complete it!

Sec 7b: Risk Insurance

The North-West University has insurance at its disposal to cover the risk of claims against the University in case of damage to subjects/participants due to professional negligence – the maximum cover is currently R30 million per annum (all projects included). However, this is only available if projects are ethically approved and researchers have kept to the protocol.

7.4 Describe the potential risks to which the participants (subjects) / researchers / assistants / field workers / animal subjects are going to be subject in so far as complications may lead to summonses.

No potential risks are being foreseen.

7.5 By which insurance are the risks associated with the project covered (e.g. NWU or other)?

NWU (the respondents will under no circumstances be harmed – particpation is voluntary)

7.6 Is this insurance adequate (measured against the probable risks)?
(Please mark with **X** *in the appropriate box)*

Yes	No
☒	☐

Remember to save your document regularly as you complete it!

Section 8: Declarations

Applications and declaration are filled in and signed by:

- Sec 8a: Project Head
- Sec 8b: Professional Supervisor(s)
- Sec 8c: Bio-Safety Officer
- Sec 8d: Terrain / Facility Manager(s)
- Sec 8e: Statistical Consultation Service
- Sec 8f: Director of School/Institute & Director of Research

The pages with declarations and signatures must be printed out and signed and sent on by internal post to the Office of the Director: Research Support, Box 116, PUK, North-West University, Potchefstroom, 2520. *As soon as this form is made available shortly in Web format and electronic verification is possible, printouts and signatures will be eliminated.*

Please fill this page in where applicable, print it (where information covers more than one page, print double-sided), have it signed and send the original signed hard copy on to the Office of the Director: Research Support (Box 116, PUK, North-West University, Potchefstroom, 2520) by ordinary / internal post.

NWU Ethics Application

Project Head (Title, Initials & Surname)	**Project Title** (see § 3.1)
Seugnet Blignaut	Design integration of interactive whiteboards in an open distance mathematics programme

NWU Ethics Number ***(for office use only)***

N	W	U	-						-			-		
Institution				Project Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Sec 8a: Project Head

Application and Declarations by Project Head

I, the undersigned, hereby apply for approval for the implementation of the experiment as described in the preceding protocol and declare that:

8.1 I have satisfied myself thoroughly as to the content of the Ethics Committee's "Guidelines for the evaluation of the ethical aspects of experimentation with man or animal" [Web link] and I will keep to the guidelines as contained in this document;

8.2 The information in this application is, to the best of my knowledge, correct and that no ethical codes will be violated with the project;

8.3 I will make sure that the project is managed ethically justifiably from start to finish;

8.4 in the case of human participants (subjects);

8.4.1 the project objectives cannot be achieved meaningfully through replacement of human participants with alternatives;

8.4.2 I will put it clearly to all participants (subjects) and am satisfied with the principle that participation (including assent) in any research project is absolutely voluntary and that no pressure, of whatever nature, will be placed on any potential participant to take part;

8.4.3 I will put it clearly to all participants (subjects) and am satisfied with the principle that any participant may withdraw from the study at any time and may ask that his/her data no longer be used in the study, without stating reasons and without fear of any form of prejudice;

8.4.4 every participant who takes part in the experiment will receive the accompanying form for informed consent and it will be ensured that every participant understands the information (including the process and risks) fully;

8.4.5 every participant will sign the informed consent in writing before the study commences, or give recorded oral consent when the former is not possible;

8.4.6 the written proxy consent of the parents or legal guardians of all minor subjects will be obtained before the experiment commences;

8.4.7 any foreseeable risk is restricted to the minimum, any permanent damage is avoided as far as possible and that appropriate precautions and safety measures are in place;

8.4.8 confidentiality of all the information of all participants will be respected and ensured;

8.5 in the case of animal subjects,

the project objectives cannot be achieved meaningfully through replacement of animal subjects (e.g. lower order animals without consciousness / feeling or tissue or other models);

8.5.1 the experimental design is such that the minimum number of animal subjects is used, no animals are wasted unnecessarily and the optimal quantity of data is obtained from the studies with the number of animals used;

8.5.2 any discomfort/suffering for animal subjects is kept to the minimum and no unnecessary suffering is caused;

8.5.3 the potential predominant advantages arising from the project exceed the risks and disadvantages for the animal subjects;

8.6 I and all co-workers / assistants / field workers are appropriately qualified, capable and legally competent to implement the proposed studies / procedures / interventions;

8.7 I will not deviate from the approved protocol and that I understand approval for the project will be cancelled if I deviate from the protocol without the approval of the Ethics Committee;

8.8 in the case of a full project (not pilot study),

8.8.1 All pre-research for the implementation of the project (pilot studies) have been finalised completely;

8.9 the experimental design is such that it is scientifically justifiable;

8.10 where necessary, I have the necessary permits at my disposal or will obtain them before the relevant actions are carried out;

8.11 I will ensure that all raw data is stored safely and remains in the possession of the North-West University;

8.12 I will report in writing any problems or complications experienced during the project without delay to the Ethics Committee;

8.13 I undertake to respect intellectual property rights throughout and to avoid any form of plagiarism;

8.14 I will report annually to the Ethics Committee (or as determined by the Ethics Committee) on the prescribed form concerning ethical aspects of the project;

8.15 I will report to the Ethics Committee on the prescribed form concerning ethical aspects of the project when the project is terminated.

Name (Title, Full Names & Surname)	**Qualifications**
Prof. Seugnet Blignaut	PhD

	2 0 _ _ - _ _ - _ _ (cc yy mm dd)
Signature	**Date**

Remember to save your document regularly as you complete it!

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NWU Ethics Application

Project Head (Title, Initials & Surname)	**Project Title** (see § 3.1)
Seugnet Blignaut	Design integration of interactive whiteboards in an open distance mathematics programme

NWU Ethics Number ***(for office use only)***

N	W	U	-						-			-		
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Sec 8b: Professional Supervisor(s)

The supervisory professional person fills this section in (where applicable)
As supervisory professional person you must note that the risk insurance from the university does not cover you and you will therefore be dependent on your own insurance. The Ethics Committee relies completely on the professional judgement of the supervisory professional person with regard to the nature and extent of the supervision, as well as the degree of risk linked to the project.

8.16 In your opinion, what should the nature and extent of supervision during the project be?

Study guidance and research support

8.17 Will you ascertain the state of health of every participant (subject) before the commencement of any participation?
(Please mark with **X** *in the appropriate box and provide details)*

Yes	**No**	**Remarks** ***(optional)***
☐	☒	Not applicable

8.18 In your opinion, what is the degree of risk for the subjects involved in the project? *Take note: Arrangements to meet the supervision requirements must be made mutually between the doctor and the Project Head.*

None

Name (Title, Full Names & Surname)	**Qualifications**
Prof. A.S. Blignaut	PhD

	2 0 _ _ - _ _ - _ _ (cc yy - mm - dd)
Signature	**Date**

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NWU Ethics Application

Project Head (Title, Initials & Surname)	**Project Title** (see § 3.1)
Seugnet Blignaut	Design integration of interactive whiteboards in an open distance mathematics programme

NWU Ethics Number ***(for office use only)***

N	W	U	-						-			-		
Institution				Project Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Sec 8c: Bio-Safety Officer

The bio-safety officer (usually an appointment at an institution, such as at the North-West University) completes this section (where applicable)

The Ethics Committee relies completely on the professional judgement of the bio-safety officer with regard to the safety risks linked to the project, as well as whether adequate safety measures are in place to be able to manage these risks responsibly.

8.19 Are the safety risks for man and environment, as described in this application, correct according to your professional judgement?
(Please mark "Yes" or "No" with **X** *in the appropriate box)*

Yes	**No**	**Remarks** ***(optional)***
☐	☐	

8.20 According to your professional judgement, are there adequate precautions and expertise in place to manage these risks responsibly?
(Please mark "Yes" or "No" with **X** *in the appropriate box)*

Yes	**No**	**Remarks** ***(optional)***
☐	☐	

Name (Title, Full Names & Surname)	**Qualifications**
Type here	Type here

	2 0 _ _ - _ _ - _ _ (c c y y - m m - d d)
Signature	**Date**

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Please fill this page in where applicable, print it (where information covers more than one page, print double-sided), have it signed and send the original signed hard copy on to the Office of the Director: Research Support (Box 116, PUK, North-West University, Potchefstroom, 2520) by ordinary / internal post.

NWU Ethics Application

Project Head (Title, Initials & Surname)	**Project Title** (see § 3.1)
Seugnet Blignaut	Design integration of interactive whiteboards in an open distance mathematics programme

NWU Ethics Number ***(for office use only)***

N	W	U	-						-			-		
Institution				Project Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Sec 8d: Terrain / Facility Manager(s)

The terrain/facility manager(s) (e.g. the manager or overseer of the offices, school, clinic, centre, laboratory or animal subject centre where the project or research activities will be carried out) completes this section (where applicable)

The Ethics Committee relies completely on you with regard to the suitability and availability of the terrain or facilities to be able to carry out the project.

8.21 Is the terrain / are the facilities available to carry out the project, as described in this application?
(Please mark "Yes" or "No" with **X** *in the appropriate box)*

Yes	**No**	**Remarks** ***(optional)***
☐	☐	

8.22 Is the terrain / are the facilities suitable for carrying out the project, as described in this application?
(Please mark "Yes" or "No" with **X** *in the appropriate box)*

Yes	**No**	**Remarks** ***(optional)***
☐	☐	

Name (Title, Full Names & Surname)	**Qualifications**

	2 0 _ _ - _ _ - _ _
Signature	**Date** (c c y y - m m - d d)

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NWU Ethics Application

Project Head (Title, Initials & Surname)	**Project Title** (see § 3.1)
Seugnet Blignaut	Design integration of interactive whiteboards in an open distance mathematics programme

NWU Ethics Number ***(for office use only)***

N	W	U	-						-			-		
Institution				Project Number						Year			Status	

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Sec 8e: Statistical Consultation Service

The statistician of the Statistical Consultation Service of the North-West University completes this section (where applicable).

More information

Prior consultation with Statistical Consultation Service can eliminate many problems, simplify and expedite the evaluation and also prevent applications from being returned due to poor project planning and/or statistical justifiability. Where the Project Head has sufficient statistical expertise at his disposal, this is, however, not compulsory.

The Ethics Committee relies completely on the professional judgement of the statistician.

Have you ascertained the experimental design of the study and is it statistically justifiable according to your judgement?
(Please mark with **X** *in the appropriate box and provide details)*

Yes	**No**	**Remarks**
☒	☐	Project Head is a research professor with advanced skill and experience in both qualitative and quantitative research. Questionnaires were designed under supervision of Statistical Consultation Services.

Name (Title, Full Names & Surname)	**Qualifications**

	2 0 _ _ - _ _ - _ _ (c c y y - m m - d d)
Signature	**Date**

Remember to save your document regularly as you complete it!

NWU Ethics Application

Project Head (Title, Initials & Surname)	Project Title (see § 3.1)
Seugnet Blignaut	Design integration of interactive whiteboards in an open distance mathematics programme

NWU Ethics Number ***(for office use only)***

N	W	U	-						-			-		

Institution — Project Number — Year — Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Sec 8f: Director of School/Institute & Director of Research

I, the undersigned, hereby declare that the above project is scientifically justified, that experimentation may proceed if it is approved by the Ethics Committee and that the Project Head/researcher has enough physical facilities, equipment and money at his disposal to implement and complete the project.

School Director / Institute Director:

Name (Title, Full Names & Surname)	**Capacity**
Prof. E.J. Spamer	Director of the Unit for Open Distance Learning (NWU)

	2 0 _ _ - _ _ - _ _ (c c y y - m m - d d)
Signature	**Date**

Research Director:

The director of the research focus area or of the research unit signs here.

Name (Title, Full Names & Surname)	**Capacity**
Prof. C. Roux	Director of Research

	2 0 _ _ - _ _ - _ _ (c c y y - m m - d d)
Signature	**Date**

Remember to save your document regularly as you complete it!

Credits

Compiled on request of the NWU Ethics Committee by Prof Christiaan B Brink (PhD)

Advisory panel: Prof Hester Klopper, Dr Alan MacLeod, Prof Nico Malan, Dr Douw van der Nest, Dr Francois van der Westhuizen, Mev. Michelle Viljoen, Prof Marié Wissing

Other credits: Many individuals contributed in various ways to formulate, develop and compile previous ethics application forms of the University, of which excerpts were used to formulate some of the contents of the current ethics application form.

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Box 60133

Vaalpark

1948

Dear Student

I am a registered student for the Masters in Education (MEd) at the North-West University. As part of my studies I have to do and complete a research project.

The title of my study is "Design integration of interactive whiteboards in an open distance mathematics programme" and the Mathematics module concerned is NWPK 512. The aim of the study is to research whether the IWB and its resources act as scaffolds in the teaching and learning of mathematics and more specific of the understanding of the fundamental principles of mathematics within this module. For the study I need registered NWPK 512 students who have already failed at least one examination opportunity in the module. The participants will have to attend five IWB sessions during which the researcher—who is also the lecturer responsible for NWPK 512—will present the big ideas of the module by using appropriate resources as scaffolds. A video of the participants will be captured during the sessions and at the end of each session focus group interviews will be conducted with the participants. To measure whether better understanding had taken place participants will do a pre-test-post-test on the fundamental principles. Open-ended questionnaires will be given to the participants, their peers and supervisors, to determine whether the participants gained any value from taking part in the scaffolding IWB sessions.

I would thus appreciate your participation due to the limited size of the population. Participation is voluntary and every participant has the right to withdraw from the research at any time—without being penalised in any way. I would, however, appreciate it that participants attend all the sessions because that will add to the success and value of the study. The outcomes of the study will determine the future teaching and learning of the module. It should also have an effect on the teaching of the participants in their own classes and therefore on the learning of their students.

I pledge to maintain the professional and research ethical codes. This signifies that:

- Your participation in this research remains voluntary and you may, at any time, withdraw from the research
- Your personal information will at all times be treated as confidential

The IWB sessions will be broadcasted during July 2013 according to the following timetable:

Date	Time
Friday 5 July 2013	17:00 – 18:00
Friday 12 July 2013	Probably two sessions of 2 hours each—time slots will be confirmed by email or fax and during session on 5th July
Saturday 13 July 2013	Probably two sessions of 2 hours each—time slots will be confirmed by email or fax and during session on 5th July

Yours sincerely

_____

Hermien Dreyer

Student number: 21168040

MEd Candidate, North-West University

Mobile number: 084 205 6609

Email: Hermien.Dreyer@nwu.ac.za

Scaffolds for:

NWPK 512
Fundamentals of Algebra

H. Dreyer
018 299 4585
Hermien.Dreyer@nwu.ac.za

Big Idea: "Patterns and Numbers"

Topics:

- Patterns
- Numbers and Number Systems
- Operations with Numbers
- Algebraic Expressions
- Exponents
- Algebraic Fractions
- Equations

Patterns

Repeating Patterns

hp://www.learnalberta.ca/content/mejhm/index.html?l=0&ID1=AB.MATH.JR.PATT&ID2=AB.MATH.JR.PATT.PATT&lesson=html/video_interacves/paerns/paernsSmall.html

- Shapes
- Numbers

Growing Patterns

- Shapes
- Numbers

http://e-learningforkids.org/Courses/EN/M1107/index.html

http://www.learnalberta.ca/content/mejhm/index.html?l=0&ID1=AB.MATH.JR.PATT&ID2=AB.MATH.JR.PATT.PATT&lesson=html/object_interactives/patterns/

http://pbskids.org/cyberchase/math-games/crack-hackers-safe/

Functional Relationship?

[to find n-th term or formula]

http://www.subtangent.com/maths/flash/ty-fn-machines.swf

http://www.learningtoday.com/corporate/files/games/Algebra_Functions_L3_V1_T4a.swf

http://hotmath.com/util/hm_flash_movie.html?movie=/learning_activities/interactivities/function_machine.swf&return_to=Algebra%20Activities%20-%20Hotmath&title=The%20Function%20Machine

Numbers and Number Systems

- Number Lines

http://mathstar.lacoe.edu/newmedia/integers/intro/activities/intro_numberline.html

- Ordering Numbers

http://www.topmarks.co.uk/Flash.aspx?f=NumberLinev5

http://www.mathplayground.com/numberballs.html

- Primes ,Odds and Evens

http://www.adaptedmind.com/v.php?vId=155

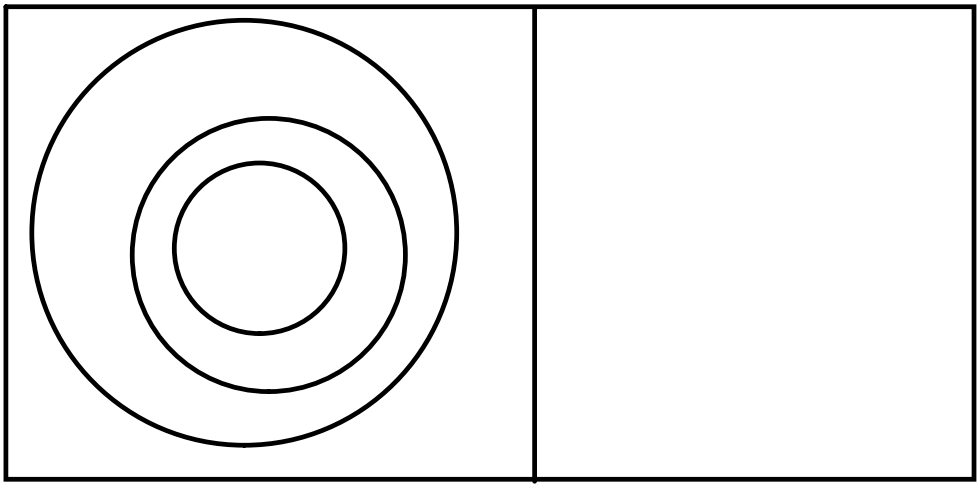
http://www.mathplayground.com/howto_primenumbers.html

- Factors and Multiples

http://www.emaths.co.uk/tutorials/MultiplesFactorsPrimes/Multiples/Presentation_Files/index.html

Number Systems

N N_0 Z Q Q^I R



Integers

http://studyjams.scholastic.com/studyjams/jams/math/numbers/integers.htm

http://mathstar.lacoe.edu/newmedia/integers/intro/activities/intro_numberline.html

http://pbskids.org/cyberchase/math-games/space-coupe-rescue/

Extra on Fractions

- Equivalent Fractions

http://www.adaptedmind.com/v.php?vId=55

http://www.matematicasdivertidas.com/Zonaflash/juegosflash/fractionpercentage.swf

- Ordering Fractions

- Decimals and Percentages

http://www.adaptedmind.com/v.php?vId=79

http://www.adaptedmind.com/v.php?vId=80

http://www.mathplayground.com/howto_perfracdec.html

Operations with Numbers

- Addition and Subtraction

hp://www.craziness.com/games/play-add-like-mad/

hp://www.craziness.com/games/play-subtracon-acon/

- Multiplication

hp://www.crickweb.co.uk/ks2numeracy-calculaon.html#alg

- Division

http://www.mathplayground.com/howto_quotients.html

- Order of Operations

http://www.mathplayground.com/howto_pemdas.html

http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMorderofoperations.html

http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMorderofoperations2.html

http://www.mathplayground.com/mv_order_of_operations.html

Algebraic Expressions

- Converting words to Algebra
  - http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMalgebraexpressionsvariableequations.html
  - http://www.mathplayground.com/olympic_math1.html
- Exponents
  - > Properties [Definitions and Laws]
    - http://www.learnalberta.ca/content/mejhm/index.html?l=0&ID1=AB.MATH.JR.NUMB&ID2=AB.MATH.JR.NUMB.EXPO&lesson=html/object_interactives/exponent_laws/use_it.html
    - http://www.brightstorm.com/math/algebra/exponents/introduction-to-exponents/
    - http://www.brightstorm.com/math/algebra/exponents/multiplication-and-division-pro
    - http://www.brightstorm.com/math/algebra/exponents/zero-and-negative-expone
  - > Powers of 10
    - http://www.learnalberta.ca/content/mejhm/index.html?l=0&ID1=AB.MATH.JR.NUMB&ID2=AB.MATH.JR.NUMB.EXPO&lesson=html/object_interactives/patterning_the_powers_of_10/use_it.html
- Simplification of expressions
  - http://www.emaths.co.uk/tutorials/Brackets/Multiplying%20out%20a%20Bracket/Presentation_Files/index.html
  - http://www.emaths.co.uk/tutorials/Brackets2/Multiplying%20out%20two%20Brackets/Presentation_Files/index.html
  - http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMalgebraexpressionsvariableequations.html
  - http://www.mathplayground.com/mv_simplifying_combining_like_terms.html
- Factorizing polynomials
  - http://lincs.skoool.co.uk/content/keystage4/maths/pc/lessons/uk_ks4_factors_1/interface.html?id=f1
- Taking out the HCF and Grouping
  - http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMalgebrafactoringbygrouping1.html
  - http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMalgebrafactoringbygrouping2.html
- Difference between two squares
  - http://www.brightstorm.com/math/algebra/factoring-2/difference-of-perfect-squares/
  - http://www.brightstorm.com/math/algebra/factoring-2/difference-of-perfect-squares-problem-1/
  - http://www.brightstorm.com/math/algebra/factoring-2/difference-of-perfect-squares-problem-2/
  - http://www.brightstorm.com/math/algebra/factoring-2/difference-of-perfect-squares-problem-3/
- Quadratic Trinomials
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-equals-1/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-equals-1-problem-1/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-equals-1-problem-2/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-equals-1-problem-3/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-equals-1-problem-4/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-is-not-1/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-is-not-1-problem-1/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-is-not-1-problem-2/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-is-not-1-problem-3/
  - http://www.brightstorm.com/math/algebra/factoring-2/factoring-trinomials-a-is-not-1-problem-4/

Equations

- Balancing Scale
- Linear Equations and Inequalities
  - http://www.learnalberta.ca/content/mejhm/index.html?l=0&ID1=AB.MATH.JR.PATT&ID2=AB.MATH.JR.PATT.ALG&lesson=html/object_interactives/algebra/use_it.html
  - http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvMMmoresolvingequations.html
  - http://www.mathplayground.com/howto_InequalitiesA.html
  - http://www.mathplayground.com/howto_algebraeq1.html
- Quadratic Equations
  - http://jmathpage.com/middleschoolmath/middleschoolmathvideos/msmvakintrotoquadraticexpressions.html
- Word Problems
  - http://www.mathplayground.com/ThinkingBlocks/thinking_blocks_modeling%20_tool.html
  - http://www.mathplayground.com/WordProblemsWithKatie1.html
  - http://www.mathplayground.com/WordProblemsWithKatie2.html

GOOD LUCK!!