A Case Study: Exploring a DVD driven approach for teaching and learning mathematics, at secondary school level, with a framework of blended learning.

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A THESIS

Submitted in fulfilment of the requirements for the degree of Philosophiae Doctor

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Co Promoters: Professor A. Harding, Dr H. Johannes

DECLARATION BY STUDENT

I, Pragashni Padayachee (209202648), hereby declare that this thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE:

DATE: 31 December 2010

The undersigned certify that they have read, and recommended to the Faculty of Science for acceptance a thesis entitled "A Case Study: Exploring a DVD driven approach for teaching and learning mathematics, at secondary school level, with a framework of blended learning" submitted by Pragashni Padayachee in fulfilment of the requirements of the degree of Philosophiae Doctor in the Faculty of Science at the Nelson Mandela Metropolitan University.

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ABSTRACT

Post-apartheid South Africa is witnessing an education crisis of significant proportions. The new outcomes-based education system has failed to deliver and universities are suffering the consequences of under-preparation of learners for tertiary studies especially in mathematics. The educator corps is lacking and it has become common practice for universities to deploy augmented programmes in mathematics for secondary school learners in the surrounding areas. This thesis describes a particular approach of blended learning, devised for the Incubator School Project (ISP), an initiative of the Nelson Mandela Metropolitan University (NMMU) in the Eastern Cape of South Africa. The defining feature of this blended approach is that it incorporates DVD technology, which offers an affordable and accessible option for the particular group of learners and the schools they attend. The thesis poses the research question: How did the use of the DVD approach within a blended learning environment support the learning of mathematics?

This case study explores the particular blended approach and reports six fold on the approach – qualitatively based firstly on a questionnaire completed by learners and secondly on interviews of learners, thirdly on the facilitators reports, fourthly quantitatively on learner performance before and after the intervention. Fifthly six schools are used as a case study where the mathematics performance of the learners who participated in the ISP is compared to those who did not participate in the ISP. Finally the scope of blending of this model is evaluated by means of a radar chart, adapted from an existing radar measure.

This research revealed that using the DVD approach within a blended learning environment did lead to an improvement in learners perceptions about mathematics, an improvement in the manner in which they learned mathematics, an extension in their mathematics knowledge and provided learners with a supportive environment in which to learn mathematics. The elements which supported learning in this approach are presented. The findings of the study suggest that this approach impacted favourably on the mathematics learning and enhanced the mathematics learning and performance of these learners. Recommendations are offered for practice, teachers and schools and for further research possibilities.

Dedicated to:

My mother for her unconditional love, belief in me and support throughout my life, my husband and children for their love, tolerance, patience and understanding and to my spiritual guide for giving me the guidance, courage and strength to complete this journey

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LIST OF ACRONYMS AND ABBREVIATIONS

ANC	African National Congress
C2005	Curriculum 2005
CDE	Centre for Development and Enterprise
CEM	Council of Education Ministers
CHE	Council on Higher Education
DET	Department of Education and Training
DoE	Department of Education
DVD	Digital Versatile Disc
FET	Further Education and Training
f2f	face to face
GMMDU	Govan Mbeki Mathematics Development Unit
HEDCOM	Heads of Education Departments Committee
HSRC	Human Sciences Research Council
ICT	Information and Communication Technology
ISP	Incubator School Project
MEC	Member of Executive Council
MSEP	Mathematics and Science Education Project
NCS	National Curriculum Statement
NEPA	National Education Policy Act
NMMU	Nelson Mandela Metropolitan University
NQF	National Qualifications Framework
OBE	Outcomes Based Education
RUMEP	Rhodes University Mathematics Education project
SACE	South African Council of Educators
SAQA	South African Qualifications Authority

SASA	South African Schools Act
TIMSS	Third International Mathematics and Science Study
UCT	University of Cape Town
WCED	Western Cape Education Department

CHAPTER ONE : INTRODUCTION TO THE STUDY

1.1. INTRODUCTION

In this chapter the research study is charted starting with the background and rationale. The research problem is outlined and the significance and context of the research, and the research participants are described. The research aims, research questions and an overview of the research methodology is sketched. Terms significant to this research study are defined. Finally the structure of the thesis is presented.

1.2. BACKGROUND AND RATIONALE

Education in South Africa during the apartheid era (before 1995) was differentiated with the existence of racially determined education departments. The Bantu Education Act (Act No. 47 of 1953) intended to separate black South Africans from the main, comparatively very well-resourced education system for whites. According to Dr Hendrik Verwoerd, then Prime Minister of the South African National Party in the National Government and one of the architects of Bantu education, black Africans had to be educated in accordance with their limited opportunities to take up menial jobs. The quality of education offered to the black learners was according to Botha (2002) of an inferior quality and lacked effectiveness, and black schools had inferior facilities, teachers and textbooks (Wikipedia, Education in SA). Mathematics was not a part of this curriculum as Dr Verwoerd in 1953 was quoted as saying, “What is the use of teaching a Bantu child mathematics when it cannot use it in practice”. Thus Bantu Education was introduced in 1954, deliberately overlooking the teaching of mathematics and science (Maths 4 stats).

Apartheid affected the education of the majority of people in South Africa, and deprived and disadvantaged them for decades. Its effects on many facets of South African society continue to be felt. This resulted in the denial of a generation of scientists, mathematicians and engineers in South Africa. The challenge South Africa now faces is to build up its capacity in mathematics and science.

With the demise of apartheid there were great expectations of a transformed education system that would deliver a quality education for all South African citizens. The newly elected democratic ANC government, with a view to addressing the crisis caused by apartheid education and to empower its citizens, chose outcomes based education (OBE) as a platform. OBE came with an agenda to empower the learners and to create citizens who could think critically and solve problems. The transition from one education system to another is always a serious step. In South Africa, the transition created great concern

especially since it happened shortly after the 1994 election, which gave the transition to the new curriculum a political context. Furthermore, the OBE system was criticised because it had already failed in a number of other countries, since it is a system that requires many resources (well trained teachers in particular) in a country where educational resources were already under pressure. Jansen (1998) predicted that it would be widening instead of narrowing the gap between the rich and the poor students.

In 1996 a national education department and nine provincially led education departments were established. All grade 12 learners sat for the same national grade 12 examinations. These resulted in a significant decline in the pass rates. Crouch and Vinjevold (2006) suggest that this was because of the changed cognitive level of the examinations written by the African learners. Not only did the pass rate decline but the number of learners passing higher grade mathematics also declined from 29 000 to 19 000, a matter of great concern (Crouch and Vinjevold, 2006).

Sixteen years after the end of apartheid and contrary to the expectations of a quality education for all, there is now a national education crisis in South Africa, bigger than ever before, especially with regard to the teaching and learning of mathematics (Daniels, 2007; Nicholson, 2009). The change of curriculum has created many challenges for learners, teachers and universities and instead of improving the situation has worsened it (Mail and Guardian online, 2009). As a result fewer learners have the necessary skills for successfully completing mathematics and science based courses at university (Reddy, van der Berg, Lebani & Berkowitz, 2006). With regard to this crisis it seems that the previously disadvantaged communities are still the most affected in post apartheid South Africa (Ocampo, 2004). Many interventions have been initiated in an attempt to improve the mathematics education system (DoE, 2000; DST, 2002; DoE, 2001; GDE 2003). However South Africa is still struggling with poor performance in mathematics and with ways to change this situation (Reddy, van der Berg, Lebani & Berkowitz, 2006, p139).

South Africa was ranked 120th (last of the sub Saharan countries that participated) for Mathematics and Science education by The World Economic Forum (Dutta & Mia, 2009/2010). The centre for Development and Enterprise (CDE) report says that in 2004, more than half of South Africa's secondary schools failed to produce even a single higher grade Mathematics pass (CDE, 2007). In the previous dispensation one could either take higher or standard grade mathematics and for about 80 % of schools, the average number of higher grade Mathematics passes was more or less one per school. In 2006, there were fewer higher grade Mathematics and Science passes than in the previous year.

Approximately 4.8 % of all matriculation candidates passed higher grade Mathematics and approximately 21 % passed standard grade (CDE, 2007). In 2007, although there were more passes in higher grade Mathematics, the actual pass rate dropped to 4.5 % because more candidates entered for the examinations than the previous year (CDE, 2007). In 2008 the first cohort of OBE trained matriculants sat for the new National Curriculum Statement (NCS) examination which saw all learners taking either mathematics or mathematics literacy. The results of this examination indicated that the crisis in mathematics education is still increasing in South African schools.

This crisis is highlighted in the Eastern Cape, one of the poorest of the nine provinces of South Africa (Ajam & Janine, 2007; Peter, 2009). The grade 12 results have consistently placed the Eastern Cape in the lower three of the provinces for the past years. A lack of qualified teachers and resources has featured as reasons for this poor performance (Mgwebi, 2009). The Eastern Cape Education member of executive council (MEC) Mahlubandile Qwase highlighted the challenges particularly faced by the province in trying to transform education. These include:

- The capacity of teachers to translate the policy and methodology to make an impact and succeed
- The considerable lack of resources (human, financial and material) needed to maintain and transform the education sector
- A neglected education infrastructure
- A lack of service delivery in schools (schools without sanitation and water)
- High levels of poverty in the communities (hungry children cannot concentrate, learn and compete with better nourished children)
- A lack of adequate dietary provision
- Prevalent historic structural weaknesses
- An inadequate culture of learning and teaching in schools

(Mgwebi, 2009)

From a Higher Education perspective there is governmental pressure to ensure that there is increased access to higher education for a diverse group of learners and to increase the quality of mathematics learners. This is in line with governmental policies to ensure social reform and to adequately skill a necessary workforce for a future South Africa. The National

Plan for Higher Education (DoE, 2001) outlines five goals for the transformation of Higher Education. These goals are intended to increase access to higher education, promote equity to redress past demographic inequalities, to ensure diversity to meet national and regional skills and knowledge needs, to build research capacity and to reorganize the institutional landscape to establish new forms and identities.

1.3. PROBLEM DESCRIPTION

The researchers work as a mathematics lecturer at the NMMU (Nelson Mandela Metropolitan University) in the Eastern Cape has shown that many first year students are under prepared with respect to mathematics. Quoting Kader Asmal, a previous minister of education (Asmal, 2000), "Mathematical illiteracy is rife in our society". This statement has implications for our higher education students in science and information based professions, in which numbers are declining.

Teachers in many South African schools especially in the fields of mathematics and science are under qualified (Simkins, Rule & Bernstein, 2007). In their submission to the Council of Education Ministers (CEM) the Mathematics Education Community highlighted the under preparedness and inadequacies of mathematics school teachers in South Africa (Adler, Brombacher & Shan, 2000). This crisis has further intensified since there are large numbers of mathematics teachers leaving the country or entering industry (Mphalala & Tshishonge, 2008). South African schools are struggling to fill 62000 vacant posts in an effort to close the maths and science teacher gap (Kgosana, 2008). The present education system has disadvantaged many students by failing to meet their educational needs. As a result those that pursue degree studies in the natural sciences face enormous odds in completing their studies successfully (Stumpf & Foxcroft, 2005). The level of mathematics teaching at schools attended by the vast majority of the population needs to be upgraded (Umalusi, 2008).

It has become common practice over the last few years for universities to initiate outreach programmes in order to develop secondary school learners especially with regard to Mathematics. Through this practice, it was hoped that, to some degree the question of learners' under preparedness with regard to mathematics could be successfully addressed. In so doing learners could obtain access to mathematics and science based courses and could then qualify as mathematics teachers.

The above notions certainly motivate a need for appropriate interventions in the teaching and learning of mathematics. Such interventions need to be designed, developed or

adapted to include different delivery modes to successfully empower educators and learners.

1.4. THE CONTEXT

The need for such an intervention was realised by the Govan Mbeki Mathematics Development Unit (GMMDU) situated in the Mathematics and Applied Mathematics Department of the NMMU. In 2002 a grade 12 learner project was initiated to address the mathematics crisis. The initiative was launched under the title of Incubator School Project (ISP) and the format was that grade 12 learners from schools in the surrounding areas of Port Elizabeth in the Eastern Cape would be presented with mathematics sessions on Saturday mornings. The ISP targeted those grade 12 learners with the potential in Mathematics who wished to pursue careers in Science, Engineering and Technology as well as Mathematics and Science teaching. In particular most of the learners who formed part of this project were from the previous Department of Education and Training (DET) schools. Before 1996 these schools were designated for attendance by the Black community and were situated in the so called black townships. In most cases the schools that these learners attended had limited resources.

In 2006 a decision was taken to explore the use of technology in the teaching of mathematics and the DVD technology was decided on as the most appropriate technology (GMMDU, 2006). As part of the ISP, in 2006 a series of twenty grade 12 mathematics DVDs covering the various mathematics topics in the then grade 12 mathematics syllabus was developed. These were used in the 2007 ISP presentations within the Nelson Mandela Metropolis. Decisions were taken on the basis of the feedback from questionnaires given to learners, reports of facilitators as well as discussions of the management team of the GMMDP. The DVD technology was implemented in the teaching and learning of mathematics in the ISP in 2007 and 2008. This series of DVDs was redesigned in 2007 to encompass the new national curriculum changes and it was used in the 2008 ISP. Upon reflection on the 2007 and 2008 implementation it was decided that technology alone was not optimally effective in the teaching and learning of mathematics and a decision was taken to use this technology within a blended learning environment (GMMDU, 2008). In 2009 a blended learning approach was used in conjunction with the DVD approach.

The decision taken to use technology within a blended learning approach ties in with the views of Dhanarajan (2001, p.2) that innovative approaches using technology are needed to mend the crisis we are faced with in mathematics teaching and learning in South Africa. This notion as Dhanarajan explains is required for the following reasons:

- A large part of the South African population and the rest of Sub Saharan Africa still live in educationally deprived situations and unless educators and their policy-makers change their ways of delivering education, the situation will not improve, despite the rising levels of investment in the sector.

- Unless these tools are used to take learning and training to disadvantaged communities, their deprivations cannot be overcome. Those who work in the field of distance education can and must provide the direction and leadership needed to bring about such change.

1.5. SIGNIFICANCE OF THE STUDY

There are many interventions in South Africa designed to address the crisis in mathematics. These will be sketched and elaborated on further in Chapter Two. The need to explore the different approaches in the teaching and learning of mathematics is urgent due to the ever worsening crisis in mathematics education. Employers trying to comply with the Employment Equity Act face a daunting task in changing employee profiles, as there is a serious lack of black graduates in fields such as science and mathematics (HSRC, 1999).

It is intended through the exploration of a DVD approach within a blended learning context to highlight an intervention which could be used more widely and thus have the potential to allow larger numbers of matriculants to graduate and with higher grades and with a better understanding in mathematics. In so doing an opportunity could be provided to prepare them more adequately for higher learning by providing learners with an opportunity to enhance their mathematics learning and increase their mathematical capacity. The outcome of this research could benefit the socio-economic dispensation of the country by contributing to an increase in the number of black students entering into science and mathematics based courses at university level and subsequently an increase in the number of black graduates in mathematics and science fields, as well as an increase in the number and quality of mathematics teachers. The outcome of this research has the possibility of contributing to the upliftment of the overall standard of mathematics in this country but especially in the Eastern Cape.

Knowledge gained from this study may contribute to alleviating the mathematics crisis experienced in the country. It could do so by describing an implemented blended learning model and presenting the pitfalls and successes. The study should be of value to anyone who is involved in or considers similar programmes.

1.6. RESEARCH AIMS

The primary aim of the research was to explore the use of DVD technology within a blended learning environment in teaching and learning mathematics in terms of the elements that support learning, learner experiences and the impact on learners' mastery of mathematics. The long term aim is to provide a feasible solution to the education crisis in South Africa.

1.7. RESEARCH QUESTIONS

The purpose of this research study was to explore the blended learning approach supported by DVD technology to identify elements that provide a supportive learning environment in order to answer the research question:

> ***How did the use of DVD technology within a blended learning environment support the learning of mathematics?***

1.8. RESEARCH SUB QUESTIONS

In order to direct the exploration of the research question the following sub questions needed to be posed.

1. **How did the elements present in the DVD driven approach support the teaching and learning of mathematics?**
2. **How do learners experience this blended learning approach?**
3. **What impact on learners' mastery of mathematics has the approach made?**

1.9. OVERVIEW OF THE RESEARCH METHODOLOGY

This research study reports on the use of DVD technology within the context described in section 1.4. The timeframe for the study is from January 2009 to December 2009 and focuses on the use of DVD technology to teach and learn mathematics within a blended learning approach.

The focus of this research study was the 2009 ISP which forms part of a larger project. The 2002 – 2008 ISP will be taken as earlier cycles of the larger action research project. The evaluation of each cycle in this action research informed the next cycle in the project. This larger project will be outlined in Chapter Four. In 2007 the use of DVD technology was introduced in the ISP. This research study focused on the use of DVD technology within a blended learning environment in the 2009 ISP.

A case study research design was used since the study was bounded by time, place and subject, served as an exploration of a particular case of teaching and learning mathematics, was a study in a natural context, and was a study on the perspectives of the participants. A mixed methods approach to collecting and analysing the data was employed. A mixed method approach may be defined as "the type of research in which a researcher or team of researchers combine elements of qualitative and quantitative research approaches (e.g., the use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration" (Johnson, Onwuegbuzie & Turner, 2007, p124).

The research participants comprised 194 grade 12 mathematics learners, from local schools in the Nelson Mandela Metropole who had made application to participate in the 2009 project and were selected to be part of this project. In addition the facilitators who were involved in the 2009 ISP project were research participants.

This study reports six fold on the approach – qualitatively based, firstly, on a questionnaire completed by learners; and secondly, on group interviews with learners; thirdly, on the facilitators' reports; fourthly, quantitatively on learner performance before and after the intervention. Fifthly six schools were used as a case study where the mathematics performance of the learners who participated in the ISP was compared with those who did not participate in the ISP. Finally the scope of blending of this model is evaluated by means of a radar chart, adapted from an existing radar measure developed by Harding, Kaczynski and Wood (2005).

Qualitative analysis of the data was performed to show the patterns and trends. Quantitative analysis was done on the pre test and post test, the grade 11 results and grade 12 results and the closed questions in the questionnaire. Grade 12 Mathematics results of the participants were compared with the grade 12 results of the non participants from the participating schools. Statistical tests were used on these data in order to show trends.

1.10. DEFINITION OF TERMS

The key terms that are used in this study are technology, blended learning and supportive learning environment. In addition 'matriculation' and the 'National Curriculum Statement' will be defined.

Bates and Poole (2003) view **technologies** as "physical things" and as such they cannot communicate whilst media represent the avenue of communication, requiring a source of information, a means of transferring information and someone to access and interpret this communication. The technologies that were used in this study were the DVDs and resources (hard copies of all lectures, tutorials, slides, and solutions to all exercises and tests), both one way technologies and facilitations of lessons, discussions and tutorials using tablet PC (two way technologies). The media used consisted of face to face learning, text and DVD.

A **blended learning** approach was adopted in these deliveries. Blended learning combines different delivery models to provide the most efficient and effective instruction experience. "Blended learning is a mix of appropriate delivery techniques and technologies combined to enhance the ability of the learner to learn and to achieve the desired outcome of the learning experience" (Maguire & Zhang, 2006, p2). Blended learning is normally defined as a combination of face-to-face and online learning. We expand on this definition to include any computer-based learning and especially DVD technology. Furthermore blended learning as described by Driscoll (2002) includes mixed modes of web-based technology to accomplish educational goals, combined various pedagogical / andragogical approaches aiming at an optimal learning outcome, combined forms of instructional technologies with face-to-face lecturing and combined instructional technologies with job tasks to create a harmonious effect of learning and working.

There are many possibilities which constitute a blended learning approach. In particular the live face to face: formal (instructor-led classroom), live face to face: informal (mentoring) and the self paced learning (DVDs) were used in all the ISP deliveries. The skills driven learning model was used in the ISP deliveries. This approach combined self-paced learning with instructor or facilitator support to develop specific knowledge and skills.

A blended model is an integrated strategy used to enhance teaching and learning. Pratt (2005) says that the challenge is to blend resources and activities that have the potential to enhance learning. In the South African context the availability and accessibility of

technology is very limited especially in poorer schools where it is often nonexistent. The DVD technology in this context presents a financially feasible opportunity in the teaching and learning of mathematics. Although the learners of this study did not have access to internet they all had access to a DVD machine.

A **supportive learning environment** is defined in this research study as a safe, non threatening environment where learners feel comfortable and are encouraged to learn. In addition it is an environment within which the use of technology is explored in enhancing both teaching and learning. A supportive learning environment is learner centred and interactive; it encourages participation; it engages learners collaboratively; it acknowledges learners different styles of learning; it challenges learners to set goals; it instils self confidence and provides resources and mentoring, in order for learners to succeed.

Other terms that require defining include the **matriculation** examination and the **National Curriculum statement** (NCS).

Examinations taken by learners at the end of their final year, grade 12 (**matric**), at South African schools are called **matriculation** examinations. These learners are referred to as **matriculants**.

The **National Curriculum Statement (NCS)** replaces the Senior Certificate at South African schools for grades 10 to 12. The NSC was phased in from 2006, when it was introduced to learners in grade 10. The first cohort of matriculants completed the NCS at the end of 2008.

1.11. FRAMEWORK OF THE THESIS

This thesis consists of seven chapters. In this section the structure of the rest of the thesis is outlined giving an account of what is covered in each chapter.

Chapter Two focuses on the crisis in mathematics education and presents some of the interventions to improve mathematics education in South Africa.

Chapter Three reviews the literature relevant to this study. Firstly constructivism as the paradigm underlying this intervention is outlined. Next the literature relevant to the context

of this research on supportive learning environments is reviewed. The definitions and dimensions of blended learning are presented and some of the benefits and challenges of blended leaning are discussed. The Blossom Initiative using videos is presented in this chapter. The chapter ends with the two approaches used in this intervention that of learning cycles and the community of inquiry.

Chapter Four reviews the development of the ISP between 2007 and 2009 and presents the structure of the ISP of 2009. In addition, this chapter focuses on instructional design theories and their implications for the ISP.

Chapter Five describes the research methodology and the methods applied in this study. A qualitative approach to research was decided on and a case study design was implemented for this research study. A mixed methods approach to data collection and data analysis was employed. A variety of methods were used. The chapter discusses these methods, and the ways in which they were applied in the context of this study.

Chapter Six reports on the analysis of the qualitative and quantitative data obtained in this study and it also presents the major research findings as they relate to the research sub questions. The qualitative and quantitative analysis of the following data will be presented:

- Pre tests
- Post tests
- Learners' attendance register
- Learners weekly tests
- Questionnaires
- Group interviews
- Facilitators reports
- Grade 11 and grade 12 final mathematics marks
- Comparison of six schools (grade 11 versus grade 12 performance comparing participants and non participants of the ISP)

Chapter Seven concludes the study by interpreting the findings and summarising the discussion and conclusions of all previous chapters. In this chapter the thesis' central research question "***How did the use of DVD technology within a blended learning environment support the learning of mathematics?"*** will be addressed. The chapter ends by offering recommendations for practice, for teachers and learners and making suggestions for possible further research.

CHAPTER TWO : SCHOOLING IN SOUTH AFRICA

2.1. INTRODUCTION

In Chapter One the research study was sketched and the research question that directed this research study was formulated. In this chapter the reform of the South African education system, mathematics education and mathematics interventions at secondary school level in South Africa are presented. The researcher found it relevant to review this literature since it forms a backdrop against which this research study was conducted and provides a rationale for such research studies.

2.2. SOUTH AFRICA EDUCATION SYSTEM AND THE REFORM THEREOF

South Africa before 1994 was cloaked in a policy of apartheid. The main idea of this policy was to segregate South Africa's people on the basis of race. This policy affected all aspects of life and education was no exception. Subsequent to the first democratic elections in 1994 the government of the African National Congress (ANC) was elected into power. The major task was to take down the apartheid structures. As Asmal (2001, p6) said of the demise of apartheid, "It offered unique opportunities – and responsibilities – to reconstruct a fragmented and deeply discriminatory education system, and establish a unified national system underpinned by democracy, equity, redress, transparency and participation".

After 1994 the Ministry of Education focused on developing a policy framework for educational transformation. The key policies and legislation (DoE, 2001a) included:

- The SA Constitution (1996) required that education be transformed and democratised in accordance with the values of human dignity, equality, human rights and freedom, non-racism and non-sexism. It guaranteed access to a basic education for all through the stipulation that 'everyone has the right to basic education, including adult basic education'. The fundamental policy framework of the Ministry of Education, was set out in the Ministry's first White Paper on Education and Training in a Democratic South Africa: First Steps to Develop a New System (February, 1995). This document used as its point of departure the 1994 education policy framework of the African National Congress. After extensive consultation, negotiation and revision, it was approved by the Cabinet and has since served as the principal frame of reference for subsequent policy and legislative development.

- The National Education Policy Act (NEPA) (1996), designed to write in law the policy, legislative and monitoring responsibilities of the Minister of Education and to formalise the relations between national and provincial authorities. It

established the Council of Education Ministers (CEM) and Heads of Education Departments Committee (HEDCOM) as inter-governmental forums to collaborate in building the new system, and provides for the determination of national policies in general and to further education and training for among others, curriculum, assessment, language policy and quality assurance. The NEPA embodies the principle of co-operative governance, elaborated in Schedule Three of the Constitution.

- The South African Schools Act (SASA) (1996) was established to promote access, quality and democratic governance in the schooling system. It ensures that all learners have the right of access to quality education without discrimination, and it makes schooling compulsory for children aged 7 to 14. It provides for two types of schools – independent schools and public schools. The Act's provision for democratic school governance through school governing bodies is now in place in public schools countrywide. The school funding norms outlined in SASA prioritise redress and target poverty in funding allocations to the public schooling system.

- The Further Education and Training Act (1998), Education White Paper 4 on Further Education and Training (1998) and the National Strategy for Further Education and Training (1999-2001), which provides the basis for developing a nationally co-ordinated further education and training system, comprising of the senior secondary component of schooling and technical colleges. It requires that further education and training institutions, created in terms of the new legislation, develop institutional plans, and provides for programmes-based funding and a national curriculum for learning and teaching.

- The Higher Education Act (1997), which makes provision for a unified and nationally planned system of higher education and creates a statutory Council on Higher Education (CHE) which provides advice to the Minister and is responsible for quality assurance and promotion. The Higher Education Act and Education White Paper 3 on Higher Education (1999) formed the basis for the transformation of the higher education sector through an institutional planning and budgeting framework. This culminated in the National Plan for Higher Education in 2001.

- A range of legislation, including the Employment of Educators Act (1998), to regulate the professional, moral and ethical responsibilities and competencies of teachers. The historically divided teaching force is now governed by one Act of Parliament and one professional council – the South African Council of Educators (SACE).

- The Adult Basic Education and Training Act (2000), which provides for the establishment of public and private adult learning centres, funding for ABET provisioning, the governance of public centres, and quality assurance mechanisms for the sector.

- The South African Qualifications Authority (SAQA) Act (1995) that provides for the creation of the National Qualifications Framework (NQF), establishes the scaffolding of a national learning system that integrates education and training at all levels. The NQF was an essential expression and guarantor of a national learning system where education and training are equally important and complementary facets of human competence. The joint launch on 23 April, 2001, by the Minister of Labour and the Minister of Education of the Human Resource Development Strategy reinforces the resolve to establish an integrated education, training and development strategy that will harness the potential of our young and adult learners.

- Curriculum 2005 (C2005), which envisaged for general education a move away from a racist, apartheid, rote learning model of learning and teaching to a liberating, nation-building and learner centred outcomes-based one. In line with training strategies, the re-formulation is intended to allow greater mobility between different levels and institutional sites, and the integration of knowledge and skills through ”learning pathways”. Its assessment, qualifications, competency, and skills-based framework encourage the development of curriculum models aligned to the NQF in theory and practice.

(DoE, 2001a)

In 1995 nineteen different education departments merged. Currently nine provincial departments of education manage the schools in their respective provinces. The National Curriculum Statement (NCS) was implemented in grades R to 9, in the Foundation Phase (grades R to 3) since 2004, the Intermediate Phase (grades 4 to 6) since 2005, and in grades 7 and 10 since 2006. Grades 8, 9 and 11 were implemented in 2007 and grade 12 in 2008. The NCS aims to “develop the full potential of all learners as citizens of a democratic South Africa. It seeks to create a lifelong learner who is confident and independent; literate, numerate and multiskilled; compassionate, with respect for the environment; and the ability to participate in society as a critical and active citizen” (Burger, 2009/2010, p170).

The NCS principles (Burger, 2009/2010) include social justice, a healthy environment; human rights and inclusivity, outcomes-based education, a high level of skills and knowledge for all, clarity and accessibility and as well as progression and integration. However “educational quality in historically black schools-constituting 80% of enrolment – has not improved since the political transition, despite large resource transfers to such schools” (van der Berg, 2008, p145). The large differences in achievement tests and examinations indicate that the South African educational quality leaves much to be desired (van der Berg, 2008). The issue of under qualified teachers is of much concern especially in subjects such as science and mathematics.

2.3. MATHEMATICS EDUCATION

There is a national crisis in mathematics education in South Africa. In 1998-9, South Africa performed the worst of all the 38 participating countries in the Third International Mathematics and Science Study (TIMSS). This crisis has severe implications for South Africa. "Poor maths and science education is probably the single biggest obstacle to African advancement in South Africa today" (Bernstein (a), 2004).

The shortage of teachers in mathematics and science is indeed a contributing factor to this crisis and needs to be addressed. This is confirmed by Mji and Makgato (2006, p254) who say that "...outdated teaching practices and teachers' lack of basic content knowledge" are contributing to the poor teaching of mathematics. This is further intensified by the under qualified teachers, lack of resources and overcrowded classrooms (Mji & Makgato, 2006). The 2007 CDE report states that only 14,7% of teachers in South Africa have the minimum qualifications to teach mathematics and science. These factors have contributed to a new breed of mathematics teacher who is maintaining this cycle of mediocrity (DoE, 2001a).The report further states that the many initiatives funded by the private sector and government to address this crisis had little or no effect on the system. "The maths and science education system is failing to deliver enough school-leavers equipped with HG maths and science to meet the needs of the education system, let alone the needs of the economy" (CDE, 2007).

According to this report (CDE, 2007) South Africa is allocating resources to large numbers of learners who have little or no chance of passing Senior Certificate mathematics and science whilst a large number of learners with the potential to succeed in mathematics and science are not getting the opportunity to study these subjects. Their suggestion is that good learners, good educators and effective schools need to be matched for the effective use of resources.

It is South Africa's aim over the next five years to double the number of mathematics and science passes and double the number of qualified teachers in the school system. To this end South Africans need to do the following (Bernstein (b), 2004, pp31-37).

- Mobilise for a national effort: Pull together the energy of leaders in public and private sectors to achieve a dramatic increase in performance through a common strategic framework for intervention.
- Increase the supply of qualified mathematics and science educators: Identify those we have and how we can keep them in the teaching profession. Provide incentives to encourage more people to teach mathematics and science. Institute a systematic

approach to the professional development of mathematics and science educators - there are successful models overseas. If necessary bring in educators with excellent language skills from abroad.

- Build on the potential in our school system: Support all high-performing schools and investigate ways in which they could play a bigger role. Can they deal with larger classes? Can they expand their mathematics and science departments? Can they share their expertise with other schools? Identify the next band of schools that could perform better and assist them in different ways. Link incentives to specific goals so that we are incrementally improving and expanding access to effective teaching.

- Identify all learners with potential in mathematics and science so that "no child is left behind" simply because they do not have an effective school nearby. Introduce a nationwide aptitude test (grade 9) to identify learners with talent who are then provided with financial support to attend an effective school. This could be a neighbouring school or a boarding school, public or private. Money should follow learners, thus benefiting their new school and introducing healthy competition between schools.

- Mathematics and science education initiatives should include appropriate language components. All the research indicates that learners' proficiency in the language of instruction and examination plays a very significant role in their performance in mathematics and science.

- The government's Dinaledi programme (reviewed later in this chapter) - specialist schools for mathematics and science - should be supported but needs to be re-thought and then expanded.

- Review all other educational policies for their effect on mathematics and science. This is the country's top educational priority and we must make sure that other educational reforms do not undermine our ability to achieve the doubling of HG passes that we desperately need.

- The private sector, NGOs and international donors should review the support they are giving to mathematics and science with a view to aligning with this new national thrust.

- The cabinet should establish a task force, a national partnership between public and private sectors to change the future of mathematics and science schooling in South Africa. The task force should have co-chairs from cabinet and private sector leadership and should be accountable for results, reporting annually to parliament. South Africa will not succeed unless there is a dedicated, accountable body to direct this new effort on mathematics and science.

  (Bernstein (b), 2004, pp31-37).

In 2008, pupils started writing the National Senior Certificate examination, offering seven subjects from a choice of a possible twenty nine. Examination papers were set nationally and benchmarked against international papers. Mathematics became compulsory for the first time in 2006. Learners could either take mathematics or mathematics literacy. The differences between mathematics and mathematics literacy are listed in Table 2.1.

Table 2.1 Difference between Mathematics and Mathematics Literacy

(DoE: 2003 National Curriculum statement: Mathematics, Grades 10-12, p10)

(DoE: 2003 National Curriculum statement: Mathematical literacy, Grades 10-12, p10-11)

Mathematics	**Mathematics literacy**
This curriculum is designed for those who intend to follow a career path requiring mathematics, or those who are interested in the subject. Required for tertiary studies in a science related field.	Mathematics literacy is driven by the life-related applications of mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyse everyday situations, and solve problems.
The competencies to be achieved include: • mathematical process skills, such as making conjectures, proving assertions, and modelling situations; • confident calculation, with and without calculators; • manipulation of algebraic expressions; • financial calculations; • patterns and transformation of functions; • two- and three-dimensional geometry and trigonometry; • basic statistics and probability; • differential calculus; • sequences and series; • solution of unseen mathematical problems; • historical development of mathematics in various cultures; and • use of technology in calculations, and the development of models.	The competencies to be achieved include: • use of numbers to solve real-life problems; • modelling of situations using suitable functions and graphic representation; • description, representation, and analysis of shape in two and three dimensions using geometrical skills; • critical engagement with the handling of data (statistics and probability), especially the • manner in which these are encountered in the media; and • use of technology in calculations.

The NCS policy changes have had significant implications. In 2006, 63% (or 330 513) of senior certificate matriculation candidates chose to take mathematics (CDE, 2007), whereas every learner was compelled to study mathematics or mathematical literacy for the NSC examination in 2008, amounting to more than half a million learners. The change in curriculum added approximately sixty per cent to the mathematical instructional burden at senior secondary level and the demand for mathematics teachers increased sharply.

The CDE report of 2007 reported on this curriculum change that

- Teachers at the schools that perform the best at mathematics doubted that they had the capacity to complete the new mathematics syllabus.
- Many schools chose only two of the three new papers. The third paper containing the geometry syllabus is optional and, this will result in no geometry being taught to grade 10–12 learners.
- Highly qualified experienced teachers reported that they were being burnt out by their high workload and were becoming increasingly discouraged by administrative burdens, discontentment with the education authorities, learners' poor discipline, and a lack of value for teachers.
- Teachers were concerned with the deteriorating level of education in feeder schools (CDE, 2007).

In 2008, approximately 260 000 grade 12 learners from all over South Africa wrote the first National Senior Certificate (NSC) examinations in Mathematical Literacy or Mathematics. The pass rate was 78,7% for mathematics literacy and a pass rate of 45,7% for Mathematics (North, 2008, p216). In South Africa, the emphasis is placed on the final school leaving examination as the NSC examinations mark the main exit point from the Further Education and Training band (grades 10 to 12) and is used to determine entrance into higher education (North, 2008).

Mathematics is critical to the future of South Africa since the economic development of South Africa is dependent on our students' proficiency in mathematics. However South African learners are doing disturbingly poorly at mathematics. Referring to Figure 2.1 it is

clear that of the number of learners who sit for the final matriculation examination every year only a small percentage pass mathematics (Hofmeyr, 2008).

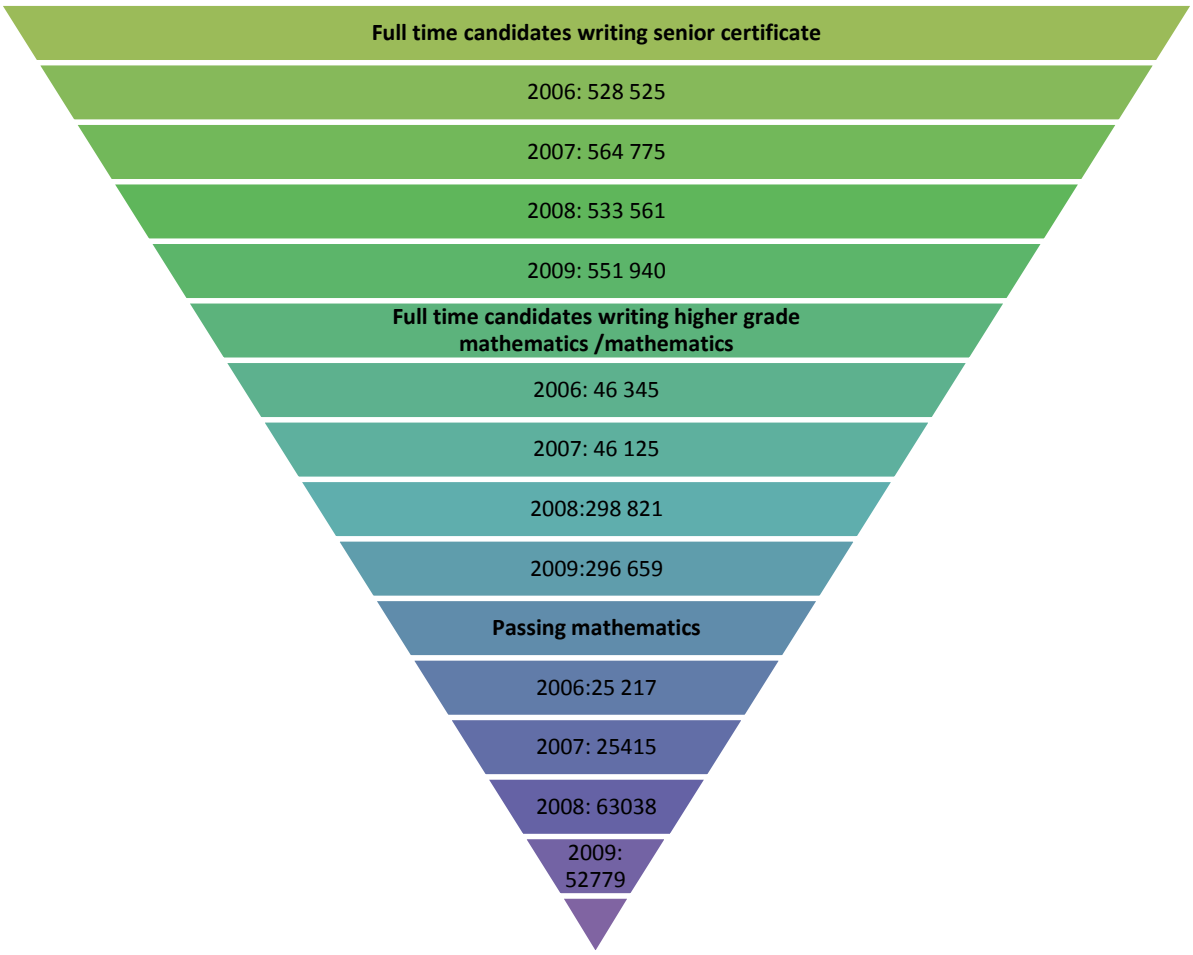


Figure 2.1 Number of Matriculation Candidates for years 2006-2009 writing and passing mathematics

(Adapted from Hofmeyr, 2008)

There is a serious skills shortage in South Africa. Not many school leavers have the necessary mathematics skills to qualify as artisans; technicians; engineers; computer scientists and actuaries that South Africa desperately needs (Hofmeyr, 2008) in order to satisfy the country's economic requirements. This poor result is attributed to a shortage of teachers (Hofmeyr, 2008). Less than fifteen percent of the current mathematics teachers have the required qualifications to teach mathematics (Hofmeyr, 2008) and only half of the secondary schools in South Africa are able to offer mathematics at a higher grade level. Yet the new NCS makes mathematics or mathematics literacy compulsory in the FET phase. This is an issue that will certainly impact negatively on the mathematics results of school leavers.

2.4. INTERVENTIONS AIMED AT IMPROVING SECONDARY SCHOOL MATHEMATICS IN SOUTH AFRICA

There is an urgent need to address the education crisis. The need to improve the quality of mathematics education is evident. At first many initiatives involved teacher development (Reddy, Lebanie and Davidson, 2003). The South African business sector in partnership with the government has focused on a number of initiatives to improve the quality of mathematics education in South Africa (Clynick & Lee, 2004). Many interventions targeting learners as well as teachers have been initiated to improve mathematics education in South Africa.

According to Clynick and Lee (2004) such interventions may be divided into four basic categories, educator support and development, learner support and development, materials support and development and other initiatives. Educator support and development include formal programmes that lead to formal qualifications and informal programmes where certificates are issued for attendance whilst learner support and development only support those learners who are preparing to write their matriculation examination. Other initiatives include resource centres, in school teacher training, talented student programmes and media projects and programmes.

This research study's focus is a learner project and therefore the literature review focuses on other such learner projects. Reddy et al (2003, p30-31) describe supplementary tuition as tuition that exists side by side with formal public schooling. They further classify the service providers for such out of school programmes as follows:

- Non Governmental Organizations, e.g. Protec and SAESA.
- Community Based Organisations: organisations, especially in small towns whose concern for mathematics and science results has started localized initiatives.
- Individuals that have started up organisations offering tuition to a localised community.
- Private sector organisations that offer tuition on a profit basis.
- Franchises that offer tuition on a large scale usually initiatives operating at national level e.g. Kumon Math, Master Math.
- Online instruction available to learners who can access internet facilities.

- Instruction on learning channels on the television, e.g. Liberty Life learning channel programmes on SABC and MINDSET on DStv.
- Supplementary tuition initiated by provincial education departments in partnership with service providers.
- Tertiary institutions that offer enrichment (outreach programmes) for the top learners to prepare them for a university programme.
- Programmes that offer second chances to matriculants to improve their symbols in mathematics and science to enable them to enter tertiary studies.
- One-on-one tutorship. These range from retired or practicing teachers who offer tuition for a fee to organizations with a database of tutors and who link learners with tutors.

Reddy et al (2003, p30-31)

There are mostly mathematics supplementary programmes and the majority of the initiatives focus on grade 12 learners. These programmes have a strong link to the school curriculum and measure their success by their ability to assist learners in passing the matriculation examination (Reddy et al, 2003, p31). In addition, some of the programmes include techniques for working through past examination question papers and they may also include aspects of career guidance or links with industry. Other programmes operate as a "helpdesk" helping learners with homework exercises or questions with which they are experiencing difficulty. Most programmes offer tuition as Saturday classes, while only a few offer tuition after school. The tutors on most of the programmes are practising schoolteachers, science graduates, university students or tertiary institution lecturers. Teacher recommendation, school performance in mathematics and science or enthusiasm for math/science is the criteria used to select learners in some programmes. Other programmes like university preparatory or outreach programmes select the best performing learners. Yet other programmes have no admission criteria allowing anybody who can pay to attend (Reddy et al, 2003).

In the next section mathematics interventions will be reviewed. Of the myriad of mathematics interventions targeting grade 12 learners these were selected since they all in some way involve technology in the teaching and learning of mathematics since this research study involves the use of technology in the teaching and learning of mathematics with a blended learning framework.

2.4.1. EXAMPLES OF MATHEMATICS INTERVENTIONS

The mathematics interventions reviewed in this section are the Dinaledi School Project, the Khanya Technology in Education Project, the Mathematics and Science Education Project (MSEP), the Zenex Foundation Project, Mindset Learn and Dr Math.

2.4.1.1. The Dinaledi School Project

The Dinaledi School Project is a Department of Education leading initiative to address the falling mathematics and science results (Simkins, Rule and Bernstein, 2007). The Dinaledi projects' main focus is on providing schools with additional resources for the teaching and learning of mathematics and science; to increase the participation of disadvantaged learners in mathematics and science; and, to introduce innovations in teaching and learning.

There are 500 schools across South Africa that participate in the project. The Dinaledi schools project is aimed at increasing access to and participation in mathematics and science in underprivileged schools (DoE (FET), 2009/2010). In response to the mathematics crisis the government has established the National Strategy for Mathematics, Science and Technology Education (NSMSTE) whose goal it is to double the number of South African learners passing mathematics. The Dinaledi schools are an important part of the NSMSTE's drive to increase the number of learners taking mathematics and science.

The Department of Education has supplied the Dinaledi schools with 251 000 copies of English, mathematics, physical science and life orientation textbooks, 500 000 copies of mathematics 911 workbooks for grade 11 and grade 12, a total of 235 000 scientific calculators for grade 11 and grade 12 learners and 20 000 mathematics and physical science exemplar papers (Cameron, 2009). In addition a number of schools in the Dinaledi Project have been selected to receive connectivity and ICT infrastructure. These schools will receive software packages aimed at the teaching of mathematics (DoE (FET), 2009/2010).

2.4.1.2. Khanya: Technology in Education Project

Khanya: Technology in Education Project is an intervention driven by the Western Cape Education Department (WCED) and which was established in 2001 to determine the part technology can play in addressing shortage of educator capacity. The idea of the Khanya project in not to replace the educator but to increase their capacity through the use of technology. It is a collaborate effort between the project, private businesses, non-profit organisations and other governmental departments and projects. This project integrates information, communication and audiovisual technology in order to improve teaching and

learning in schools. This is to be achieved by the use of appropriate, available and affordable technology (Khanya Educational Technology project, 2010).

Some of the projects' objectives include the use of technology to assist educators, using technology to provide an opportunity for learners with different learning styles, create a technology rich province, provide all educators and learners with an email address and to narrow the digital divide. In addition the project aims to increase the number of learners who take higher grade mathematics and to ensure that they are successful, to increase the number of learners qualifying to enter tertiary education and to use technology to assist disabled learners (Khanya Educational Technology project, 2010).

The aim of this project is that every teacher in the Western Cape should use technology to teach and therefore help to alleviate the shortage of qualified teachers. The project supplies schools with computers and software and well managed schools in poor areas with good academic results are targeted by the project first. It is the projects' belief that it is where the most difference will be made to teachers and learners. Eventually implementation of technology will take place at all schools. It is the projects' goal that by the start of 2012 that every educator will have the capacity to use appropriate and available technology to deliver lessons to all learners in all the schools the Western Cape (Khanya Educational Technology project, 2010).

It has also become common practice for universities to deploy augmented programmes in mathematics for secondary school learners in the surrounding areas. Examples of such programmes include the Rhodes University Mathematics Education Project (RUMEP), the University of Pretoria's the MOBI project, and the Mathematics and Science Education Project (MSEP) at the University of Cape Town (UCT).

2.4.1.3. Mathematics and Science Education Project (MSEP)

The Mathematics and Science Education Project (MSEP) is a collaborative endeavour between the WCED and University of Cape Town (UCT) and it is funded by the Embassy of the Kingdom of Netherlands. The project involves learners from five schools from disadvantaged communities and these schools are also part of the Dinaledi School Project. The aim of the project is to ensure a larger number of learners from disadvantaged communities will be able to succeed at science and technology based courses at university.

UCT provides expertise from many of their faculties. The main focus areas of the project in these disadvantaged communities are:

- Supporting quality mathematics and science education
- Improving participation and performance in mathematics and science
- Developing in service teachers with regard to mathematics, science and life skills
- Motivating confident and innovative teachers
- Promoting a passion for mathematics and science in learners
- Furnishing learners with the necessary mathematics and science skills to enable their participation in the knowledge economy
- Encouraging mathematics, science, technology and engineering awareness amongst learners

(University of Cape Town Schools Development Unit, 2010)

The project follows a three-tiered approach addressing the needs of the learners, teachers and school management. Teacher support is a priority. Teachers' needs are determined through interviews, observation and the analysis of matriculation results. Support for these teachers is provided according to their individual needs and takes the form of mentorship, co teaching, materials and resources support and additional training. The learner programme supports approximately 550 participants. Their support takes the form of additional mathematics and science classes, residential holiday camps, Saturday workshops, practicals and theme camps. The last tier of the support system is the management support which is provided by MSEP staff to principals and school managers to assist them with curriculum management (University of Cape Town Schools Development Unit, 2010).

The project is currently working with school management and teachers to improve teaching and learning by using ICT. The literature does not document how this is to take place.

2.4.1.4. Zenex Foundation

Zenex Foundation is a nonprofit independent donor organization that focuses on mathematics, science and language education in schools. The foundation has formed partnerships with government, donors and services providers in its efforts to react to education and development needs. Zenex Foundation's mission is to empower learners from disadvantaged communities to enable them to take benefit from new opportunities.

Their vision is that of skilled and empowered communities which will contribute to growth, development and the democratization of South Africa (Zenex Foundation, 2010).

The foundation has a ten year strategy (2006-2015) that involves mathematics, science and language education in South Africa; it is aligned with the objectives of the Accelerated and Shared Growth initiative of South Africa (AsgiSA) which was launched by the government in 2006. This strategy will focus on developing long term programmes to support mathematics, science and English education through the coaching and mentoring of teachers, working with learners with potential in mathematics and science, providing school management support and providing educational materials. The foundation service providers, in keeping with the Zenex Foundations holistic approach to education and development, are encouraged to engage in face to face mentorship and hands on engagement in the realities of the classroom and school (Zenex Foundation, 2010).

In only the late 1990's the foundation began to invest in projects focused on the support of secondary schools because not many initiatives at that time focused on secondary schools. In addition many of these interventions focused on improving learners' matriculation results and not on teacher training. Therefore at secondary school level the foundation has two approaches, one that focuses on teacher training while the other supports learners with potential at FET level (Zenex Foundation, 2010).

Part of the foundations' plan in the implementation of its programmes (2006-2015) will be to support 1000 black learners to achieve in mathematics science and English. This should enable them to enter tertiary education courses in those fields. It further intends to support 400 teachers to receive certificated competence in the teaching of mathematics, science and English, to support 60 secondary schools to achieve 'centre of excellence' status following set upon criteria in matric level mathematics, science and English and to support 10 school districts to implement models encouraging schools to strive for excellence in Mathematics, Science and English (Zenex Foundation, 2010).

The Zenex Foundation partnered with the Independent Schools Association of Southern Africa in 2007. It currently funds 208 of the 332 learners in the maths and English programme. One of the key components of this foundation is the upgrading of computer labs and the purchase of Smart Boards for various schools (Zenex Foundation, 2010).

2.4.1.5. Mindset Learn

Mindset Learn is an example of tutoring through the medium of television. Mindset is an educational programme offered via satellite television, using additional multimedia support. The programme is broadcast on DStv's channel 82 from Monday to Friday from 08:00 until 17:30. The focus of the programme is on Mathematics, Science and English at grade 10 to grade 12 level. Mmekoa (2005) reported on an evaluation of Mindset Learn where ten schools making use of Mindset resources were selected and then participated in the study. Principals and teachers at these schools were interviewed and observations of lessons where teachers were using Mindset resources such as live broadcasts, recorded broadcasts and lesson notes were made with regard to use of Mindset equipment (VCR and TV). All schools were medium resourced schools and these schools were provided with a satellite dish, TV, VCR or DVD and free access to DStv channel 82.

A number of observations following the evaluation were made (Mmekoa, 2005). Teachers used the resources for different purposes such as personal development, to teach those sections of the syllabus that the teachers found difficult to teach or explain and for revision with learners. They felt that textbooks were easily accessible, directly aligned to the syllabus and more important than the broadcasts. Teachers preferred the recorded lessons since the pace could be adjusted to involve explanations and discussions. Some of the constraints of Mindset included poor internet connectivity, timetabling issues at schools, teachers being unable to access broadcast schedules and the lack of accessibility of computers as well as teachers being unable to integrate the broadcast resources into their lessons (Mmekoa, 2005).

Mmekoa (2008) suggested the following lessons that should be heeded when planning or implementing a broadcast educational intervention: the programme's objectives and the support it can provide should be clarified for the sake of the key participants in the intervention; all resources should be easily and readily be available to the needs of the participants; training of the participants is needed and monitoring should be ongoing for a successful intervention.

2.4.1.6. Dr Math

Dr Math is a mobile mathematics tutoring system that runs on MXit, an instant messaging service available on all cell phones. This was initiated in 2007 and was lead by Meryl Ford. MXit is affordable and most learners have some access to a cell phone with cell phone distribution currently sitting at 84% in Africa. MXit sent messages cost approximately one or two cents and 45% of MXit users are in the 12-18 age groups (Butgereit, 2008). Six thousand learners are currently subscribed to the service and are able to access a tutor to discuss

their homework problems after school when their own teachers are not available (Butgereit, 2008). Tutors are volunteers from the University of Pretoria. Tutors work from full sized computers connected to the Internet while the learners use MXit on their cell phones (Butgereit, 2007). Real time mathematics support is given. The project has received support from the DOE and will eventually benefit more than 25 000 schools.

The interventions outlined above all use some form of technology to achieve their goals. A number of schools in the Dinaledi School Project received ICT and internet connectivity and teachers will receive software packages for the teaching of mathematics. The Khanya Technology in Education Project supplies schools with software and computers enabling teachers to deliver lessons using technology. The MSEP Project is currently working on using ICT to change teaching and learning at those schools which participate in this project. Mindset Learn offers lessons via satellite television using additional multimedia support, while Dr Math uses an instant messaging service (MXit) which is available on cell phones as a tutoring system for mathematics learners.

2.5. SUMMARY OF THE CHAPTER

This chapter has outlined the ever increasing crisis in mathematics education in South Africa and highlights the need for interventions to be initiated in order to improve this situation. Examples of interventions aimed at improving mathematics education at secondary school such as the Dinaledi School Project, the Khanya Technology in Education Project, the Mathematics and Science Education Project (MSEP), the Zenex Foundation, Mindset Learn and Dr Math have been presented and briefly discussed.

CHAPTER THREE : THEORETICAL FRAMEWORK

3.1. INTRODUCTION

Within the South African context with the unique challenges identified in the previous chapters, it is clear that some form of intervention is necessary. In this chapter theoretical perspectives are explored. Constructivism is the paradigm underlying an intervention of this nature and the philosophy thereof will be discussed. The environment and context of the intervention needs to be considered, as these will help determine the methods to be employed in the intervention. The methods of blended learning must be explored and the approach to learning will be discussed with reference to learning cycles and communities of inquiry.

3.2. CONSTRUCTIVISM

Constructivism is the paradigm underlying the Incubator School Project. Constructivism is a theory that describes how learning happens. It suggests that learners actively construct knowledge from their experiences. When constructivism is discussed, the nature of the learner, the role of the instructor, the nature of the learning process, collaboration among learners and the selection as well as the scope and sequencing of the subject matter are all important issues on which to focus (Wikipedia: Constructivism).

Constructivists hold the view that "learners construct their own reality or at least interpret it based upon their perceptions of experiences, so an individual's knowledge is a function of prior experiences, mental structures, and beliefs used to interpret objects and events. “What someone knows is grounded in a perception of the physical and social experiences which are comprehended by the mind" (Jonasson, 1991, p10). This view is in contrast with the view that sees learning as the passive transmission of information from one individual to another.

The assumptions of constructivism according to Merrill (1991) are that knowledge is constructed from experience, that learning is a personal interpretation of the world and an active ongoing process, in which meaning is developed on the basis of experience. Conceptual growth comes from the negotiation of meaning, the sharing of multiple perspectives and the changing of our internal representations through collaborative learning. The last assumption is that learning should be situated in realistic settings where testing should be integrated with the task and should not be undertaken as a separate activity.

Constructivism acknowledges that each learner has a unique background and needs, and as such is a unique individual. In this paradigm, the responsibility for learning lies with the learner (Glasersfeld, 1989). Emphasis then is placed on the learner being actively involved in the learning process. The level and source of motivation for learning is an important issue in the learning process. Sustaining this motivation for learning in learners is dependent on the learners' confidence. Glasersfeld (1989) believes that a learner's motivation to learn is strongly dependent on the learner's confidence in his/her potential for learning. The belief in one's ability to solve new problems comes from having successfully solved problems in the past (Prawat & Floden 1994). Learners gain confidence and motivation to embark on more difficult challenges by virtue of their successful completion of prior challenging tasks.

The constructivist approach views the instructors' in the role of facilitators' rather than teachers' (Bauersfeld, 1995). The facilitator assists the learners in their understanding of the content, as opposed to the teacher, who lectures the content to be covered. A facilitator provides guidance and creates the environment necessary for the learners to question and reach their own conclusions. The facilitator encourages the learner to be an active not a passive learner in the learning process supporting and challenging the learner to become an effective thinker. This requires the facilitator to wear many hats that of teacher coach and mentor. The emphasis is shifted from the instructor and the content, and towards the learner (Gamoran, Secada, & Marrett, 1998). Therefore a facilitator ought to display a different set of skills from those of the conventional teacher (Brownstein, 2001). A facilitator should be able to adapt the learning experience in order to create a worthwhile learning experience for the learner.

The learners' needs and interests are the central focus of learner centred learning. This change from teacher centredness to learner centredness may be attributed to the introduction of technologies which encourage a constructivist approach to learning (Norman & Spohrer, 1996). These authors consider the dimensions of learner centred instruction as being engagement, effectiveness and viability. Engagement refers to the capacity to provide prompt and convincing interaction and feedback to learners and is that which motivates learners. Effectiveness requires one to question how much learners actually learn and do tests necessarily indicate the depth of their understanding or the skills they have acquired. Viability refers to the feasibility of using tools, software improved distribution and the possibility of integration into classroom activities. All these aspects of the learning process are critical.

Constructivism encourages, acknowledges and accepts the fact that learners are independent. "Constructivism's central idea is that human learning is constructed, that learners build new knowledge upon the foundation of previous learning. Such a view of learning sharply contrasts with one in which learning is the passive transmission of information from one individual to another, a view in which reception, not construction, is the key" (Hoover, 1996, p1). Glasersfeld (1989) emphasises that learners construct their own understanding and that they do not simply mirror and reflect what they read. It is of importance for educators to understand constructivism and its implications in learning and teaching. Constructivism views learning not as a transfer of knowledge from teacher to learner. Rather the role of the teacher should be redefined as a facilitator who provides learners with opportunities to investigate the adequacy of their present understandings.

Teachers need to recognize the prior learning that learners have and to provide the learning environment to match this knowledge to the present experiences with which they are faced. Teachers need to focus on problems of importance to the learner rather than on themselves and to encourage peer interaction so that learners may compare their understanding with those of other learners. Time is necessary for the new knowledge to be built. Assessment is seen as a continuous and interactive process measuring the achievement of the learner, the quality of the learning experience and the nature of the courseware. The feedback from the assessment serves to inform further development.

According to constructivists, it is through collaboration that learners with different skills and from different backgrounds can construct understanding together; understanding that they would not have reached alone. Constructivist scholars (Brown, Collins & Duguid, 1989; Ackerman, 1996) see learning as “an active process where learners should learn to discover principles, concepts and facts for themselves, hence the importance of encouraging guesswork and intuitive thinking in learners” (Wikipedia: Constructivism).

The main idea of constructivism is that learners are engaged in active learning, making their own meaning and constructing their own knowledge in this process. Constructivist learning is currently an important approach in recent teaching. Gagnon and Collay (2001) suggest six main elements in the constructive learning paradigm as (1) Situation, where teachers develop a situation for learners to explain, solve and draw conclusions; (2) Groupings, referring to how to group learners and materials ; (3) Bridge, seen as an initial activity intended to build a bridge between learners prior knowledge; (4) Questions, in the form of guiding questions, to keep active learning going, to encourage reflection, anticipate questions from learners and frame other questions to encourage them to explain and

support them in thinking for themselves ; (5) Exhibit, where learners construct a physical representation of their thinking and (6) Reflections of learners about their learning.

Constructivists are of the belief that learners need to be challenged with tasks that lie just beyond their level of mastery. This increases motivation and builds on their previous successes (Brownstein, 2001). Constructivism says that in terms of the sequencing of subject matter, the basic ideas of a topic should first be introduced before being built on further (Wikipedia: Constructivism).

In the light of the ISP consideration needs to be given to what synergy exists between technology and constructivism. Perkins (1992, p45) says of constructivism and technology that independently of one another they have much to offer contemporary approaches to instruction. He asks and confirms the question whether there is a partnership between the two that is particularly advantageous in instructional design. Firstly the constructivist perspective places demands on the educational setting that cannot be easily met, because of a shortage of resources. Secondly "coaching-like" interactions are favoured by the constructivist agenda but with the present teacher: learner ratios this is hardly a reality. Therefore technologies offer particular help in ensuring the building of "more intimate supportive environments called for by the constructivist perspective" (Perkins, 1992, p53). In synergy, technology and constructivism focus on understanding and the active use of knowledge and skills.

Thus an intervention based on constructivism should present activities through which learners are provided with opportunities to discover and collaboratively construct meaning, learners are respected as unique individuals and are supported through the learning process. Instructors act as facilitators and dialogue and interaction between learners and facilitators should be encouraged.

3.3. LEARNING ENVIRONMENT

Within the paradigm of constructivism it is imperative to consider the learning environment and context of the intervention. It is with this in mind and directed by the research question on the use of a DVD approach that a discussion of supportive learning environments is presented.

Ludtke, Robitzsch, Trautweun and Kunter (2008) state that the main underlying assumption of most educational research is that features of the learning environment, such as learning climate, classroom goal structures and instructional quality shape cognitive, motivational, emotional and behavioural learning outcomes. Learning environments may be seen to consist of the entire learning setting and to include the instructional processes, teacher-learner interaction, learner-learner interaction and learner attitudes (Frenzel, Pekrun & Goetze, 2007). It is necessary to create a learning environment which effectively supports learning.

A supportive learning environment may be defined as "the creation of a caring, rigorous and relevant learning community that provides support to all learners in aiding them to achieve their highest potential" (Holtz, 2004, pp1-2). For the purposes of this research the learning environment consists of Saturday sessions that the learners attend as well as the DVD support that learners are able to access outside this setting. A supportive learning environment acknowledges the individual and encourages participation and involvement (CELT, 2008).

3.3.1. SUPPORTIVE LEARNING ENVIRONMENT

When supportive learning environments are discussed, the elements that support learning, the role of the teacher, and critical success factors are all important aspects to note.

Currently educational theories view learning as an active, constructive, social and self reflective process (CELT, 2008). To establish a supportive learning environment focused on learners' needs, the set up, learner centredness and the teacher as role model are important elements to be considered. For the set up, it is important to clarify the learning objectives and to gain an overview of the learning tasks. Ground rules need to be established and the context of the learning environment explained. The learner also needs to be introduced to the context of the learning environment. Learner centredness includes aspects such as knowing the learner and engaging learners in activities to promote lifelong learning (independent learning, self reflection and assessment, identification of his/her own needs). The learner should be allowed to practice skills and share knowledge honestly without feeling threatened or belittled. Any uncertainties or mistakes should be welcomed as opportunities to promote learning. Peer feedback should be promoted. The teacher as role model includes showing enthusiasm for the profession, promoting dialogue and listening, taking the learners' perspective into account, encouraging questions, opinions and thoughts. Judgment should be avoided and constructive feedback offered. Teachers should acknowledge their limitations and demonstrate commitment to lifelong learning (CELT, 2008).

According to Holtz (2004, p2) there are seven important elements of supportive learning environments. These are, (1) safety that involves an inclusive team of parents, students, and diverse school faculties in comprehensive planning to address the components of a safe environment. (2) shared leadership practices that involves intentional practices which distribute the responsibility and accountability for student success throughout the school community; (3) structured personalized learning communities which build in structural supports such as advisory, mentoring, transition, looping, small class and school size to provide a more individualized approach to the school environment; (4) student centered learning practices which employ techniques of cooperative learning; relating learning to real life; (5) opportunities for students to assess their own progress and set goals; (6) opportunities for students to receive guided feedback; and (7) multicultural competence need to be considered.

Caring relationships and a sense of community which emphasizes high expectations for all students, a positive school climate, students' sense of support from adults, and faculty's sense of community are issues that need to be established. School wide positive discipline and self-management practices that provide daily positive reinforcement and explicit teaching of behavioural expectations; self management practices and social skills along with systematic support for consistent and equitable enforcement of rules should be developed. Lastly active student, staff, family, and community involvement that involves an inclusive sense of a learning community with meaningful opportunities for participation from all sectors of the community should be encouraged (Holtz, 2004, p2).

In addition to Holtz the following elements are suggested added further elements. Pontius and Harper (2006, p51) suggest elements which serve as guidelines for good practice in undergraduate education. These include (1) engaging learners in active learning and (2) helping them develop coherent values and ethical standards. In addition, (3) high expectations for learning needs to be communicated and (4) systematic inquiry should be used to improve learner and institutional performances. Further, (5) resources need to be used effectively to achieve institutional missions and goals, (6) educational partnerships that advance learning should be forged and (7) supportive and inclusive communities should be built.

Similarly the "Purposeful Teaching" (Spencer, 1998) approach focuses on learning, not just covering material. The "Purposeful Teaching" approach (Spencer, 1998) is composed of six essential elements. The first element refers to the creation of an environment supportive of

and conducive to learning; the major factor is a high-intensity, but relatively safe, learning environment where the instruction builds on successful experiences, not coercive or demeaning activities. The next element refers to clearly stated outcomes expressed in terms of how learners will demonstrate their acquisition of knowledge and skills. Activities structured for the needs of the learners, such as the use of their experience, teaching to multiple learning styles, and their inclusion in defining how they will be taught comprise the third element. Learners' active physical and mental engagement in the learning process, rather than reliance on passive listening, watching, and reading activities constitute the fourth element to be considered. The fifth element refers to interactive teaching techniques that will enable a continuous checking for participant learning so that instruction can be modified for optimal learning. Lastly activities structured to precipitate critical thinking and problem solving; these skills are not subjects to be taught, but processes to be involved in and reflected upon.

Martin (2002) suggests that teachers need to apply their professional knowledge and understanding of learners, the curriculum and teaching and learning in order to create respectful, positive and safe learning environments and to create constructive relationships that are based on trust, provide social support for all students and foster positive attitudes to learning, participation and achievement. The author suggests that teachers should establish, communicate and maintain clear expectations for student learning and behaviour and provide explicit feedback on appropriate behaviour. Behaviour management strategies ought to be applied in a fair, sensitive and consistent manner and teachers should know when to seek advice on matters related to student learning and behaviour. Teachers need to undertake explicit teaching of skills to assist students to assume responsibility for themselves and to behave responsibly towards others, participate in decision making, work collaboratively and independently and feel safe to risk full participation in learning. Managing teaching time, resources and physical space is important in order to create and maintain a challenging, engaging, safe and supportive environment for learning. Monitoring independent and group work and applying effective teaching, motivational and classroom management strategies will help to maximise the full and varied participation of all the students in a classroom.

In order to create a supportive learning environment, Ward, St Leger, Beckett, and Harper (1998) identified the following critical success factors for programmes designed for at risk young people. They are outlined here as a checklist that teachers might use to reflect on the strategies they intend to implement. While some of the factors relate to students that are at risk, most critical success factors have relevance for any programme design. Their checklist includes

- Give attention to all aspects of the student by providing for their social, personal and academic development and raising their self esteem and self confidence.
- Develop students' responsibility and accountability by making negotiation, inclusive decision making and personal responsibility features of the programme.
- Develop cooperative team work by providing opportunities for students to work cooperatively with others, both inside and outside the classroom.
- Set high expectations and continually convey the message that students are expected to succeed and to accept challenges, and support them in doing so.
- Individualise and personalise learning and support students to work at their own pace on tasks that meet their particular instructional needs.
- Provide positive reinforcement by encouraging students and building on their strengths.
- Provide a caring and supportive environment where students can feel secure, attached to the programme and supported by their teachers and peers.
- Provide programme flexibility so that one is able to respond to individual needs and to needs as they change over time.
- Sustain concern for the students, and this concern should extend beyond the programme to follow-up and monitoring.
- Undertake appropriate assessment and evaluation so that programme success can be reviewed and student's level of attainment can be measured.
- Engage capable and empathetic staff by selecting staff for their capacity to relate to and assist young people at risk, and their ability to work with students to identify and address their learning and other needs.
- Secure parent and community involvement by developing links with parents and community agencies and assisting them to understand how they can contribute to and support the programme.

A supportive learning environment acknowledges the needs of the learner in the teaching and learning context. It has to be noted that a supportive learning environment encourages dialogue, the engagement of learners, promotes critical thinking and problem solving skills and assesses whether any learning has occurred. Many of the tenets of constructivism are stressed in the establishment of a supportive learning environment.

The elements discussed thus far are generic to any supportive learning environment. In a blended learning environment in affirmation of and in addition to these elements the following elements need to be considered and highlighted. Classrooms are not the only form of learning space since the majority of learning takes place outside the classroom settings. Social interaction is a part of learning where learners are motivated by social interaction with their peers and collaborative learning is emphasised. Technology is natural as learners see this as a normal part of their lives. Learning can occur out of sequence because activities may cover different forms of media, devices and communities. Learners construct content rather than consuming it, seeing that learners create and shape their own content and meanings. (Milne, 2006).

Having discussed the elements that need to be considered in a blended learning environment it seems natural to progress to a discussion of the elements that supported learning in the DVD driven approach that is embedded in a blended learning environment.

3.3.2. ELEMENTS SUPPORTING LEARNING OF MATHEMATICS IN A DVD DRIVEN APPROACH IN A BLENDED LEARNING ENVIRONMENT

The focus of this study is to explore how the DVD approach within a blended learning environment can support the learning of mathematics. Therefore, the elements present in the DVD approach, that provided a supportive environment in the blended learning environment of the ISP, needed to be explored. A synthesis of the elements as a result of the literature review done by the researcher in response to the first research sub question: '*How did the elements present in the DVD approach support the teaching and learning of mathematics?'* is highlighted.

Following a review of the literature on a supportive learning environment the researcher added to, adapted and established a list of elements that support learning. An analysis of the available literature from the most relevant articles discussed previously in Chapter Three indicated that the following main themes / clusters are regarded as important in a supportive learning environment. These themes and elements are summarised in the Table 3.1. (Adapted from Thompson & Wheeler, 2008; CELT, 2008; Holtz, 2004; Pontius and Harper , 2006; Spencer, 1998; Martin ,2002; Ward, St Leger, Beckett, and Harper, 1998).

Table 3.1 Categories and Elements of a Supportive Learning Environment

(Adapted from Thompson & Wheeler, 2008; CELT, 2008; Holtz, 2004; Pontius and Harper, 2006; Spencer, 1998; Martin, 2002; Ward, St Leger, Beckett, and Harper, 1998)

Categories/Themes	**Elements**
Physical Learning Environment	
Learning setting	1. Classroom design that supports collaborative learning 2. Elements of light, space, temperature and noise 3. Addresses the physical needs of all learners 4. Enables the use of physical resources 5. Safety of the learning environment 6. Conveys expectations with regard to the use of resources 7. Orientates the learner to the learning environment 8. Considers the class size 9. Awareness of the fact that learning can take place outside the classroom setting 10. Engages capable and appropriately qualified staff who have the capacity to relate to young people and the ability to work with a and address their learning needs and other needs 11. Supports the use of technology
Intellectual learning environment	
Stimulating learning environment	1. Establishes a culture of learning 2. Clarifies outcomes 3. Encourages questioning 4. Involves problem solving 5. Incorporates discussions 6. Communicates expectations 7. Fosters positive attitudes to learning, participation and achievement

Teaching strategies	1. Are learner centred - involves active learning, problem solving, critical thinking, and presents opportunities to receive guided support 2. Make allowances such that the individual is respected and addressed - allows learners to work at their own pace 3. In cooperates various strategies 4. Encourages collaborative learning 5. Welcomes uncertainty and uses mistakes to promote learning 6. Encourages group work 7. Engages the learner in activities to promote lifelong learning (independent learning, self reflection and assessment, identification of his or her own needs) 8. Introduces the learner to the context of the learning environment and explains the context of the learning environment 9. Allows for the management of teaching time, resources and physical space to maintain a challenging, engaging, safe and supportive environment 10. Maximises participation of all the learners 11. Promotes peer feedback 12. Integrates the use of technology in a blended learning environment 13. Are based on the notion that learners construct content rather than consume it –learners create and shape content
Instructional processes	1. Involve the tasks and activities learners perform 2. Involve the content and resources learners interact with 3. Facilitate support mechanisms – collaboration, tutorials, mentors, student facilitators 4. Uses resources effectively 5. Clarifies learning objectives and gives an overview of the learning tasks 6. Allows for programme flexibility according to the needs of the learners 7. Fosters higher order learning 8. Technology is natural - learners see this as a normal part of their lives- involve the use of technology in enabling them to achieve outcomes (ISP 2009) 9. Recognises that learning can occur out of sequence-activities that may cover different forms of media, devices and communities.

Interaction	1. Teacher-learner-show enthusiasm, promote dialogue, avoid judgement, encourage questions, opinions and thoughts, offer constructive feedback, admit limitations and demonstrate commitment 2. Learner- learner-promote peer feedback 3. Social interaction between learners is part of learning
Assessment	1. Tests 2. Tutorials 3. Questions
Emotional Learning Environment	
Safety	1. Clear expectations and rules 2. Trust 3. No fear of being belittled
Personal emotional support	1. Mentors 2. Advisors 3. Positive reinforcement 4. Sustained concern 5. Set and communicate high expectations for learning
Positive discipline and self management	1. Respect 2. Responsibility 3. Attitude to learning 4. Establish ground rules 5. Positive reinforcement 6. Apply management strategies in a fair, sensitive and consistent manner
Sense of community	1. Non threatening 2. Trust 3. Individual differences are respected 4. Support from adults by adults and peers
Personalised learning communities	1. Mentoring 2. Advisory 3. Small classes 4. Secure parent and community involvement

The focus of this study was on how the use of DVD approach within a blended learning environment could support the learning of mathematics of the 2009 ISP. The researcher has presented the elements that were indicative of the 2009 ISP blended learning environment.

To enhance a supportive learning environment interactive teaching methodologies must be employed. It has become evident that the use of technology in the learning environment today has become popular and is being embraced by more and more educators (Holtz, 2004). Next a discussion of technology will be undertaken.

3.4. USE OF TECHNOLOGY

The use of technology has revolutionalised many aspects of our lives and the field of education is no exception. With the advances in technology we now have opportunities to design learning environments that are "realistic, authentic, engaging and extremely fun". (Kirkley & Kirkley, 2005, p42). The issue though is to create a learning environment that meets the learning objectives but at the same time is fun and engaging. It has become increasing evident that the use of technologies can facilitate and enhance learning (Gribbins, Hadidi, Urbaczewski & Vician, 2007).

However many researchers are quick to point out that technology alone is not effective (Singh, 2003, Garrison & Vaughan, 2008). There needs to be a blending of different modes of delivery in order to enhance the learning process. The notion of this blended learning will be expanded on later in this chapter. Seeing that technology is often an important ingredient of blended learning it has become necessary to define the term e-learning, clarify the distinction between media and technology, to discuss the terms synchronous and asynchronous and to discuss the interactivity of technologies.

3.4.1. DEFINITIONS

The rapid development of ICT has given rise to a glossary of terms commonly used by practitioners. It is important for those involved in blended learning design to be familiar with the more commonly used terms.

e- learning

E-learning is an encompassing term that covers all learning that takes place through the use of electronic means, such as the computer, which uses the Internet or storage devices such as CD-ROMS, DVDs, or multimedia. E-learning facilitates and enhances both formal and informal learning and knowledge sharing at any time, at any place, and at any pace and is considered a current and important form of distance learning (Maguire & Zhang, 2007).

Urdan and Weggen's (2000, p8) define e-learning as "the delivery of learning materials, packages or opportunities (i.e. content) through various forms of electronic media, including the internet, intranets, extranets, satellite broadcasts, audio-video tape, interactive TV and CD-ROM".

Blended learning

The basic characteristic of blended learning is the mixture of many ingredients to enable learning to occur. Blended learning is a mixing of appropriate delivery techniques and technologies to enhance the ability of the learner to learn achieving thereby the desired outcome of the learning experience (Maguire & Zhang, 2007). Maguire and Zhang (2007) place traditional face- to-face (f2f) classroom teaching at one end of the spectrum of the learning delivery and pure e-learning at the other end. Blended learning always involves an e-learning component.

Synchronous, asynchronous and the interactivity of technology

Garrison and Anderson (2003, p34) define education as "those tools used in formal educational practice to disseminate, illustrate, communicate or immerse learners and teachers in activities purposively designed to induce learning". In the discussion of learning technology the terms synchronous and asynchronous are important. Synchronous means that the teaching and learning activities are happening at the same time, that is in real time. In a traditional classroom, for example, a teacher delivers a mathematics lesson to a class of pupils. The interaction is taking place in real time. To simulate the classroom situation in distance learning, the technology should be synchronous. Examples of synchronous communication technology include video conferencing, internet chats and online instant messages. Interaction that is not live or in real time is called asynchronous. Examples of asynchronous communication are online discussion forums.

Interactivity in terms of technology is described as being either one-way or two-way communication. One-way technology is the case of radio or television broadcasting whilst by integrating telephone and e-mail with live audio or TV broadcasting, two-way communication may be achieved.

Educational Media and Technology

So far, the terms media and technology have been used without being clearly defined. Bates and Poole (2003) argue that, to achieve effective teaching in education, it is important and necessary to differentiate and define the two concepts of media and technology. According to them, "technologies are physical things that do not communicate whilst media are the means of communication". Table 3.2 summarises the major technologies (Source: Adapted from Bates & Poole, 2003, p55) and media that can be used in blended learning in synchronous or asynchronous situations.

Table 3.2 Technologies

(Adapted from Bates & Poole, 2003, p55)

		Technologies		
		One way Broadcast		**Two way Communication**
		Synchronous	Asynchronous	Synchronous
Media	**Face to face**	Lecture	Lecture notes	Discussion, Q&A
	Text		Books	Mail
	Audio	Radio	Audio cassette	Telephone, audio conference
	Video/DVD	TV	Video cassette/DVDs	Video conference
	Digital multimedia	Webcasting ,audio, video streaming	Website, CD-rom, DVDs	Online chat, instant message

Bates and Poole (2003) defined five primary educational media. These represent ways of mediating and interpreting knowledge. These are direct f2f contact, analog audio, text (including still graphics), analog video and digital multimedia.

Technologies, in contrast, are physical, mechanical, or electronic capabilities that are used for symbol transmission and communication. Books, radio, television, cassettes, CDs, and Web sites are examples of one-way broadcasting or one-to-many technologies (that is, technologies in which a single source is disseminated to many individuals). They are good for information dissemination. Postal mail, telephone, videoconferencing, e-mail, and e-discussion forums are all examples of two-way technologies. These allow interactions such as question and answer, discussion and debate, feedback, and collective work.

The advantages of e-learning are accessibility, flexibility, and cost savings yet direct human contact especially the physical f2f interaction is missed in the learning process. By placing

learning materials online one cannot ensure that learning will occur automatically and development of good e-learning courses and the relevant learning skills and culture remains a challenge. This dilemma may be resolved by using blended learning.

3.5. BLENDED LEARNING

A discussion on blended learning is now appropriate since the method of blended learning was explored in this intervention. In this section the researcher explores the definition of blended learning, the reasons for choosing blended learning, the ingredients of blended learning, the future of blended learning and the disadvantages of blended learning. Blended learning has become increasingly popular and is quite the buzzword in learning and training settings (Graham, 2005). Blended learning is not a new concept but what is new are the ingredients of the blend. Limited to physical classroom formats (lectures, labs, etc), books or handouts in the past, today information technology (IT) provides a kaleidoscope of opportunities (Hassana & Woodcock, no date).

3.5.1. WHAT IS BLENDED LEARNING?

There are various definitions of the term blended learning. The different definitions of blended learning serve to indicate to us the complexity, adaptability, and richness of this form of learning. Blended learning means different things to different people and therein lies its widely untapped potential (Driscoll, 2002). The researcher will present a few definitions of blended learning by leading authors on blended learning in the discussion on blended learning.

There is a shift in the educational paradigm from the rigid teacher centred approach to a learner centred approach as innovations in new technologies offer “new ways to think of producing, distributing and consuming academic material” (Seely Brown & Duguid, 2000, p210). As technology becomes more advanced there are more opportunities for a learning centred approach. Kim (2007) asserts that the most natural form of learning is blended learning, as both traditional classroom learning and e-learning have strengths and weaknesses, and so to combine the strengths of both seems natural. Technology alone will not create the ideal learning environment (Luca, 2006). As indicated by Driscoll (2002) the importance of the blended learning arises from the failure of purely online learning to meet the training needs of organizations. This idea is supported by Singh and Reed (2001) who cite research from Stanford University and the University of Tennessee when they suggest that blended learning is better than both traditional methods and technology alone. Blended learning incorporates different modes of delivery to enhance the learning experience and to provide the most efficient and effective instruction experience.

Carman (2002, p1) quotes the e-learning guru Elliott Masie who says "People are not single-method learners!". Masie puts it simply: “We are, as a species, blended learners.” If this is true then people perform better when they have a mix of modalities and methods of learning. Blended learning is the combination of multiple approaches to pedagogy or teaching. For example: self-paced, collaborative or inquiry-based study. Blended learning can be accomplished through the use of 'blended' virtual and physical resources. Examples include combinations of technology-based materials and traditional print materials (Wikipedia). While there is a wide variety of responses to the question of what is being blended (Driscoll, 2002), most of the definitions are just variations of a few common themes. The three most commonly mentioned definitions as documented by Graham, Allen, and Ure (2003) are that blended learning is the combining of instructional modalities (or delivery media), the combining of instructional methods and the combining of online and face-to-face instruction.

Rossett, Douglis and Frazee (2003) say that a blend is an “integrated strategy for delivering on promises on learning and performance.” Blending involves “a planned combination of approaches, such as the coaching by a supervisor; participation in an online class; breakfast with colleagues; competency descriptions; reading on the beach; reference to a manual; collegial relationships; and participation in seminars, workshops, and online communities".

Osguthorpe and Graham (2003) identify blended learning as the combination of face to face learning with distance education delivery systems. Further Kerres and de Wit (2003) define blended learning as a combination of technology based learning with face to face learning. Additionally Graham (2005) portrays blended learning as a mix of the best of two worlds and describes blended learning as a junction of traditional face to face learning which have been around for many years and distributed learning environments which have began to grow as new technologies expand (Graham, 2005, p5).

Blended learning incorporates different modes of delivery to enhance the learning experience and to provide the most efficient and effective instruction experience. Singh and Reed (2001, p2) suggest that in developing an efficient and effective blended learning model consideration should be given to the achievement of the learning outcomes when using the ‘right technology’ to match the learning styles of the learner. Therefore, blended learning involves the use of an appropriate mix of delivery techniques and technologies, to enrich the learning experience and to achieved the outcomes of this learning (Maguire and Zhang, 2006).

The blended learning approach can consist of a number of possibilities. These can be "formal and informal, technology and people based, independent and convivial, directive and discovery orientated" (Rossett, Douglis & Frazee, 2003). Driscoll (2002) states that blended learning refers to four different concepts, combining web based technology to accomplish an educational goal, combing various pedagogical approaches to produce an optimal learning outcome, combining any form of instructional technology with face to face learning and combining any form of instructional technology with actual tasks to create effective learning.

Furthermore Heinze and Procter (2004, p12) have developed the following definition for blended learning in higher education: "Blended learning is learning that is facilitated by the effective combination of different modes of delivery, models of teaching and styles of learning, and is based on transparent communication amongst all parties involved with a course."

Kim (2007) identifies three key dimensions in classifying learning in order to define blended learning. The first dimension is physical and class based or virtual where physical learning is the traditional classroom learning situation and virtual learning refers to e learning with no instructor present, formal or informal learning where formal learning is associated with learning for a qualification and informal not, and scheduled or self paced where scheduled learning proceeds on a fixed schedule and self paced does not.

Another conceptualization is provide by Valiathan (2002, p1) who defines blended learning as a learning solution implying by this definition that there is varied delivery media (non technology based on site and technology based online), varied learning events (self paced-individual and collaborative- group based) and electronic performance support(instruction) and knowledge management (information). She explains blends in terms of different approaches to learning: Skill-driven learning, which combines self-paced learning with instructor or facilitator supported learning to develop specific knowledge and skills; Attitude-driven learning, which mixes various events and delivery media to develop specific behaviors; and Competency-driven learning, which blends performance support tools with knowledge management resources and mentoring to develop workplace competencies. Here, Valiathan links purposes (intended learning outcomes) to the delivery mechanism and the various approaches to teaching.

Blended learning is multifaceted and different authors have their own interpretations (Hassana & Woodcock, no date). All the definitions agree firstly that there is a blend of different delivery modes and secondly that there is some use of technology.

The researcher believes that the definition of blended learning that best reflects the blended learning of the ISP is that proposed by Singh and Reed (2001, p2): Blended learning focuses on optimizing the achievement of learning objectives by applying the "right" learning technologies to match the "right" personal learning style to transfer the "right" skills to the "right" person at the "right" time. The principles established by this definition are, focus on matching the appropriate technology to achieve the learning objective, the acknowledgment of individual learning styles and the level of knowledge varies according to the individual. Although technology has changed considerably, DVD still appeared to be the most appropriate technology for the 2009 ISP since it was easily available and accessible to the majority of learners and to the schools they attended. DVD was used as an ingredient in the blended learning approach reported in this research project. Blended learning in the context of this study is defined as employing a variety of appropriate methods of delivery to enhance the teaching and learning process. These methods will be illustrated further on in Chapter Three and Chapter Four.

Blended learning is gaining ever increasing popularity in the teaching and learning scenarios around the world. In the next section the researcher will explore reasons for choosing blended learning.

3.5.2. WHY BLEND?

Many authors (Garrison & Vaughn, 2008; Graham & Ure, 2005; Bonk, Kim & Zheng, 2005; Singh & Reed, 2001) advocate blended learning and many practitioners have chosen blended learning because of its many benefits. These choices need to be explored and the researcher provides reasons why blended learning is advocated.

Osguthorpe and Graham (2003) detail the six reasons why instructors, learners or designers of learning programmes chose blended learning as pedagogical richness, access to knowledge, social interaction, personal agency, cost effectiveness and ease of revision. There are a number of reasons for choosing blended learning. People mainly choose blended learning for improved pedagogy, increased access and flexibility and increased cost effectiveness (Graham, Allen & Ure, 2003; 2005).

The choice of blended learning promotes a more learning centred approach moving away from the traditional passive dissemination of information by the teacher or instructor. The use of exploratory activities in collaboration with peers, more interaction between learners and facilitators and learners themselves promote this learner-centredness. Blended learning also offers the opportunity to improve learning in large classes through the use of various instructional strategies. Collaboration with peers, together with immediate testing and feedback of their learning are also cited in research as being some of the benefits of blended learning (Rovai & Jordan, 2004).

Equally important with regard to blended learning is the idea that learning is a “continuous process not a onetime event” (Singh, 2003, pp53). The variety of resources and opportunities for learning allow learners to engage both in the classroom and out of the classroom. Voos (2003) sees blended learning as a combination of face-to-face and online media, with "seat time" being significantly reduced. In addition blended learning allows learners who cannot be present for classes at that time or place the convenience to access this learning. Blended learning extends the reach of a learning programme, thereby allowing access to those that may not ordinarily have been able to participate at a fixed time and in a fixed location.

It is important to note that blended learning accommodates learners with different learning styles. Learners are allowed to learn in their own way at their own pace. Learners like choices. They can participate in communities and enjoy interaction, guidance and encouragement from peers and instructors. However if they are reluctant to participate exclusively in independent learning blended learning in the classroom remains an alternative for them (Rossett & Frazee, 2005). Instructors need to be aware of the diversity among learners and use a variety of teaching and learning material and environments suited to more than one style. This has the “advantage of reducing a student’s dependency on one learning style”. There is a need to adopt a blended approach which can combine different delivery mechanisms that complement each other (Hassana, & Woodcock, no date).

The variety of the methods in the blended programme adds to the richness of the blended programme and allows many opportunities for learning to take place. This improves levels of learner achievement by practice, trial and error and repetition which the various learning resources provide. There are more opportunities for learners to interact with each other and their instructor in a combination of face to face and online learning environment. This serves to increase presentation and social skills and to strengthen knowledge construction. The Variation Theory as the variation theory of learning states that for learning to occur,

variation must be experienced by the learner Hassana and Woodcock, (no date). Hassana and Woodcock, (no date) also assert that discernment is at the core of our ways of experiencing the world around us and this concerns the experience of difference. It is through discernment that learning occurs. Learning occurs when critical aspects of variation in the objects of learning are discerned

Gardiner (1994) endorsed the need for classroom change to allow students to acquire more significant kinds of cognitive learning, particularly critical thinking skills. Since there are many theories of learning, there is a need for a blend. Thus, blended learning provides a better match between a learners preferred style of learning and the learning programme that is offered, and in so doing it improves the learning outcomes

There are several benefits that favour the need for blended learning in comparison with e-learning. Blended learning presents many opportunities when compared with traditional and e-learning, individually. The issue of what dimensions should be considered to create the best blend remains, however.

3.5.3. PREREQUISITES AND INGREDIENTS

Several ingredients may be combined together in a blended learning environment. The decision of which ingredients to blend should be the result of careful consideration and analysis of the learning situation. Therefore the prerequisites to blended learning programmes inform the ingredients that should be blended.

In making the decision as to which ingredients should be combined the audience should be considered (Hassana & Woodcock, no date). According to Throne, (2003, p86) the biggest danger of a blended learning project is in being focused on technology and creativity, and not the audience. Therefore it is imperative that the characteristics of the target learner be understood in order to design the most effective delivery options in achieving the learning objective.

Singh and Reed (2001) note that such a blended learning intervention needs to take into consideration a number of factors. They suggest that in designing such a blend designers need to consider learners base knowledge determining how consistent the learners' knowledge is at the outset and ascertaining preferred learning styles, whether they are individual or group learning styles. It is also important to note the location, in terms of whether the audience is localized or distributed and to determine the learners' level of

motivation, meaning how willing the learners are to obtain this learning. They also suggest that the content is as important as the method of presentation and different content may be optimally presented using different delivery methods. Also important is the consideration of the learning outcomes. These must be clearly defined and show how the learning method can support the achievement of the outcomes. The context where unique circumstances and conditions involving the learning process need to be specified together with the financial decision of the delivery option which will rest on an analysis of the development and delivery costs. Lastly, the infrastructure in terms of the availability of technology needs also to be analysed.

Hassana and Woodcock (no date) suggest the possible ingredients that may be blended, as mixing online learning with face-to-face teaching, the most popular meaning of blended learning. Mixing media refers to the several types of media that are mixed such as video, TV, and animations to achieve the learning outcomes. Mixed contexts and here Hassana and Woodcock say that "Implicit in some of the definitions is the idea that what may need to be blended are the different physical contexts within which learning takes place." Mixed pedagogies or theories of learning where blended learning would involve students learning through experiencing variation in the aspects of what it is they are studying. Mixed pedagogies consists in this context of 'pedagogical approaches' such as constructivism, behaviourism, and cognitivism. Mixed learning objectives point to a definition of blended learning that involves blending different kinds of intended learning outcomes, such as blending skill-driven, attitude-driven and competency-driven learning types. There may be a blending of self-paced and live, collaborative learning where collaborative learning involves working in groups to solving problems, sharing and clarifying ideas as well as individual effort. In addition there may be a blending of structured and unstructured learning, a blending of custom content with off-the-shelf content and a blending of learning practice and performance support.

Blended learning has progressed to include many dimensions with overlapping aspects; the question is: *"What are the "Right" ingredients for creating the most effective blended programme?"* The challenge lies in how to construct the most effective learning programme. To this effect it is useful to focus on the Khan octagonal framework.

According to Khan (Singh, 2003) there are a number of interrelated and interdependent factors that contribute to a successful learning environment. Khan's octagonal Framework, which comprises eight dimensions, allows designers of blended learning programmes to select relevant ingredients to ensure a successful learning experience (Singh, 2003).

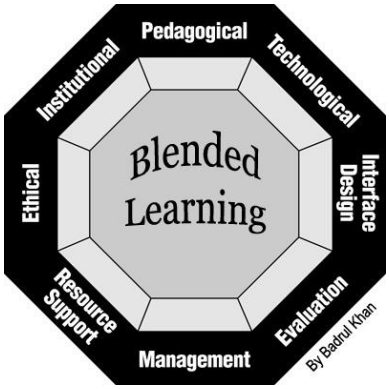


Figure 3.1 Khans-Octagonal Framework

(Singh, 2003, p52)

The eight dimensions are institutional (preparedness of organisation, availability of content and learner needs), pedagogical (content analysis, learner needs, learning objectives), technological (technical requirements), interface design , evaluation (capacity to evaluate effectiveness of the programme, the performance of the learner) , management (infrastructure and logistics), resource support (availability of different types of resources) and ethical (cultural diversity, equal opportunity and nationality) .

The issues pertaining to these dimensions will need to be addressed in order to guarantee a successful learning experience.

3.5.4. FUTURE OF BLENDED LEARNING

Blended learning today mainly acts as a replacement for or an extension of f2f learning. It is used to foster learning communities, to extend training events, to offer follow-up resources in a community of practice, to access guest experts, to provide timely mentoring or coaching, to present online lab or simulation activities, and to deliver pre-work or supplemental course materials. Bonk, Kim, and Zeng (2005) predict 10 trends linked to blended learning. The researcher summarises these below:

Trend 1. Mobile Blended Learning

Blended learning will increasingly involve handheld devices; especially cell phones where one can call up the learning that is needed or demanded (see Dr Math, as discussed previously in Chapter Two). The use of mobile and wireless technologies will result in the time and the place for learning, working, and socializing fusing, making learning more easily accessible for a wider range of individuals, thereby creating greater opportunities for lifelong learning (Ahonen, 2003; Keegan, 2002).

Trend 2. Greater Visualization, Individualization, and Hands-on Learning

Because of this added mobility, learning will also be increasingly individualized, visual, and hands-on. This prediction refers to blended environments that will bring pictures, charts, graphs, animations, simulations, and video clips which the learner can call up and manipulate. The blending of delivery mechanisms, instructional approaches, technologies, and learning situations, will evolve to support learning which is individualized yet collaborative and interactive.

Trend 3. Self-Determined Blended Learning

Blended learning will increasingly address individual needs and will increasingly be the responsibility of the learner. Greater use of exploratory and self-paced learning will demand that the learner self-regulate his or her own learning. As the need for the blending of learning becomes a decision made by learners themselves, they will assume greater control over the choice and labelling of their courses and degree programmes.

Trend 4. Increased Connectedness, Community, and Collaboration

Blended learning will foster increased connectedness, collaboration, and global awareness, connecting people, activities, and events. It will soon be a key tool for building shared cultural understanding on a global basis. If there is a need for an expert opinion or knowledgeable guest to evaluate or respond to a student's work, one can be called up on demand. If you want to incorporate peer evaluation or exchanges of student work in a class or programme, you might apply at the appropriate student exchange or mentoring sites. No longer are classes one dimensional.

Trend 5. Increased Authenticity and On-Demand Learning

Authentic and hands-on learning is needed when demanded. Increased authenticity during blended learning will occur through real world scenarios and cases. In effect, the web will be called upon to provide access to timely information that can help solve case problems as well as situate problems in the real life events and places. As this occurs, blended learning will add fuel to the present trend toward online case-learning, scenario learning, simulations and role play, and problem-based learning. It is the pedagogy employed and the learning results that ultimately matter, not the form of technology actually employed.

Trend 6. Linking Work and Learning

A sixth prediction related to blended learning environments is that as these pedagogical innovations are deployed, the differences between workplace training and formalized learning environments will undoubtedly continue to shrink.. In business, for instance, it will be common for students to be situated in a company or other type of work setting and then report back daily or weekly through web cams, asynchronous discussions, desktop videoconferencing, instant messaging, and wearable computing devices

Trend 7. Changed Calendaring

Learners will be less tied to traditional calendars for learning. Such movements from normal semester constraints and calendars will occur, in part, for learners to take advantage of unique learning blends when they become available, and, in part, for them to complete courses, degrees, and learning experiences when their schedules permit. Given the multiple versions of learning available, there will fewer prescriptions for learning. Learning will occur when the learner feels the need and has the time, not when the institution or organization has pre-arranged it.

Trend 8. Blended Learning Course Designations

Courses with reduced classroom meetings or seat time will grow as universities find that blended learning not only reduces brick and mortar needs but can simultaneously increase learning outcomes. Courses may be designated as either traditional, reduced seat time, or fully online.

Trend 9. Changed Instructor Roles

The role of the instructor will definitely continue to shift and change in these rich online learning environments. Blended learning highlights the need for instructional skills in multiple teaching and learning environments. Instead of reducing the importance of the instructor, access to an instructor becomes more essential. In effect, as blended learning nurtures greater choices and learning opportunities, various instructional skills will become more prominent including coaching, mentoring, and counselling. Such skills are increasingly vital as learners seek someone to turn to for support and guidance in their various learning quests and problems.

Trend 10. The Emergence of Blended Learning Specialists

Finally, blended learning is typically more complicated and multifaceted than either fully online or face-to-face learning. For example, blended learning instructors must know when to shift gears and add new tasks or resources and when to let the learners wander off and explore their own interests. Such instructors will be sought out since they will have skills for both traditional classroom instruction as well as for virtual environments.

3.5.5. DISADVANTAGES OF BLENDED LEARNING

The researcher has defined blended learning and presented its advantages as advocated by blended learning practitioners, authors and specialists. There are some of disadvantages to blended learning. One disadvantage of blended learning can most likely become technology dependent. This increases divisions between the technologically rich and poor. Another drawback of blended learning relates to the online aspect of isolation. Hara and Kling (2001) conducted a study of online courses, finding that feelings of isolation were an important stress factor for online students. Students perceived lack of prompt and clear feedback from the instructor as a source of confusion, anxiety and frustrations.

These indicate that the problems exhibited by some online courses may be less related to the course delivery mechanism and more related to failure in anticipating how technology can be used to support course design, facilitate learning and nurture a sense of community. Since both traditional learning and e-learning have strengths and weaknesses, there is a general agreement that traditional learning can be used to enhance e-learning (Fallon & Brown, 2003; e-learnity, 2000; Festa, 2000).

3.6. BLENDED LEARNING PROGRAMMES

There are many examples in the literature of the integration of technology within a blended learning environment to enhance teaching and learning. Of these there is a subset that uses community of inquiry as the theoretical framework; however many of these are examples of online learning. The only example of blended learning, which uses Videos/DVDs was found by the researcher, in the literature is the Blossoms project (Larson & Murray, 2008). The researcher believes that its philosophies, pedagogies and approach to blended learning overlap considerably with those of the ISP and therefore it is important to highlight this initiative here.

3.6.1. THE BLENDED LEARNING OPEN SOURCE SCIENCE OR MATHEMATICS STUDIES INITIATIVE (BLOSSOMS) PROJECT

This project is sponsored by an association of educators from around the world, who want to ensure that their countries are exposed to quality education using distance and e-

Learning technologies (Larson & Murray, 2008). The vision of BLOSSOMS is to begin to develop "a large, free repository of video modules created by gifted volunteer teachers from around the world, and via an appropriate technology for each high school using them, these blended learning modules will bring into the classroom a world-class expert in pedagogy and in the area of math or science knowledge being studied by the students" (Larson & Murray, 2008, p3). Each module covering a specific area of mathematics or physical science is designed pedagogically to run in accord with the class teacher. Each module builds on the prerequisite material studied and the presentation of the concepts is in a mind-expanding and exciting form. The rationale is to develop deeper and richer skills in the students and to enhance their critical-thinking skills, whilst, encouraging learners to pursue a science, maths or engineering career.

The following major considerations guide the Blossoms initiative (Larson & Murray, 2008, pp87-88)

- Technology is changing education, allowing richer learning opportunities.
- The Open Source movement is creating learning materials free of copyright restrictions.
- The World is co-inventing major environments on the web (e.g., Wikipedia).
- Many high school students are not interested in studying math and science, seeing them as hard work with little relevance in their lives.
- Teachers in high schools need appropriate technology-enabled means to leverage their skills in order to further engage and excite their students.
- For many teachers, a blended model that combines traditional face-to-face with technology-enhanced teaching will be a less threatening way to influence their effectiveness through technology.
- Much teaching of mathematics in high schools is done formally, often in theorem and proof mode, and the style of student learning is too often rote memorization for an examination, and then forgetting what was learnt.
- New ways need to be developed to help students engage in creative critical thinking, often assembling in unusual ways concepts and facts learned in more traditional modes.
- Students need to be shown that mathematics and science can apply in exciting and useful ways in their lives, thereby increasing the numbers who will select engineering, science and mathematics as career goals.

Those involved in the Blossoms Project have extended their definition of open educational resources beyond Internet access, to CDs, DVDs and videotape. Most high school classrooms worldwide do not have access to broadband Internet connections, necessary for viewing streaming video, but almost all can support at least videotape presentations of the materials. And videotape, iteratively started and stopped, is all that is required for this implementation of blended learning in these classrooms.

"The end goal of the BLOSSOMS project is to attract more students to math and the sciences, leading to excellent careers in the increasingly dominating 'knowledge economy' of the world. Via an appropriate technology for each high school using them, these blended learning modules aims to bring into the classroom a world-class expert in pedagogy and in the area of maths or science knowledge being studied by the students". The first 50 BLOSSOMS modules will be created by "star" teachers in Jordan, Pakistan, and at the Massachusetts Institute of Technology (MIT) and eventually by educators from around the world. Once the store is established with high standards of content and pedagogy during the pilot phase, then "the world'' will create additional BLOSSOMS video modules, with MIT providing quality assurance (Larson & Murray, 2008, p89).

It is often said that the reason for poor performance on tasks that require critical thinking and problem solving is that the school curriculum emphasizes memorization. A solution to this problem is to focus learning on constructivist principles. Learning cycles are used as models for instructional design. A framework for constructivist learning theories is presented by the 5e learning cycle (Needham, Powell, & Bentley, 1994).

3.7. LEARNING CYCLES

A learning cycle is an established planning method in education and it is consistent with contemporary theories about on how individuals learn (Lorsbach, no date). The 5e learning cycle is an instructional design model that defines a learning sequence based on the on the experiential learning philosophy of John Dewey and the experiential learning cycle proposed by David Kolb. The model presents a framework for constructivist learning theories and can be effectively used in teaching. The 5e learning cycle requires instruction to include the following elements: engage, explore, explain, extend and evaluate (Needham, Powell, & Bentley, 1994). Each of these elements is explicated with regard to the learners' role and teachers' roles in table 3.3 to table 3.7.

Engage*:* The learner has a need to know, and therefore, defines questions, issues or problems that relate to his/her world.

Table 3.3 The 5e Learning Cycle Elements: Engage

Learner	Teacher
Calls up prior knowledge	Poses problems
Has an interest	Asks questions
Experiences doubt or disequilibrium	Reveals discrepancies
Has a question(s)	Causes disequilibrium or doubt
Identifies problems to solve, decisions to be made, conflicts to be resolved	Assesses prior knowledge
Writes questions, problems, etc.	
Develops a need to know	
Self reflects and evaluates	

Explore/ Investigate: The learner gathers, organizes, interprets, analyzes, and evaluates data.

Table 3.4 The 5e Learning Cycle Elements: Explore/Investigate

Learner	Teacher
Hypothesizes and predicts	Questions and probes
Explores resources and materials	Models when needed
Designs and plans	Makes open suggestions
Collects data	Provides resources
Builds models	Provides feedback
Seeks possibilities	Assesses understandings and processes
Self reflects and evaluates	

Explain and Clarify: The learner clarifies understandings discovered, reaches conclusions or generalizations and communicates in varying modes and forms.

Table 3.5 The 5e Learning Cycle Elements: Explain and Clarify

Learner	Teacher
Clarifies understandings	Provides feedback
Shares understandings for feedback	Asks questions, poses new problems and issues
Forms generalizations	Models or suggests possible modes
Reflects on plausibility	Offers alternative explanations
Seeks new explanations	Enhances or clarifies explanations
Employs various modes for explanation (writing, art, etc)	Evaluates explanations

Expand: The learner applies these conclusions or generalizations to solve problems, make decisions, perform tasks, resolve conflicts or make meaning.

Table 3.6 The 5e Learning Cycle Elements: Expand

Learner	Teacher
Applies new knowledge	Asks questions
Solves problems	Provides feedback
Makes decisions	Provides resources
Performs new related tasks	Makes open suggestions
Resolves conflicts	Models when necessary
Plans and carries out new project	Evaluates
Asks new questions	
Seeks further clarification	

Evaluate: The learner evaluates his/her understanding of concepts and skills and his/her own learning.

Table 3.7 The 5e Learning Cycle Elements: Evaluate

Learner	Teacher
Tests	Conducts interviews
Journals	Diagnoses understanding
Performance tasks	Assesses understanding
Projects	Observes performance and understanding
Portfolio	Asks questions
Experiments	
Questions	

Table 3.3 to Table 3.6 (Needham, Powell & Bentley, 1994, pp2-3).

At the centre of the 5e learning cycle based on the constructivist theories of learning is the notion that the achievement of higher order learning outcomes can be fostered. Garrison and Anderson (2003) say of e- learning that it is a “collaborative constructive transaction”. The challenge they maintain is to create a community of inquiry harmonious with the content which will strengthen educational goals and the achievement of higher order thinking.

3.8. COMMUNITY OF INQUIRY

McMillan and Chavis (1986, p10) defined a sense of community as "a feeling that members have of belonging, a feeling that members matter to one another and to the group and a shared faith that members' need will be met through their commitment to be together". Garrison and Anderson (2003:p23) elaborate further that "a critical community of learners, from an educational perspective, is composed of teachers and students transacting with the specific purposes of facilitating, constructing, and validating understanding, and of developing capabilities that will lead to further learning.

Such a community encourages cognitive independence and social interdependence simultaneously. The community of inquiry was originally proposed by Garrison, Anderson and Archer (2000). A community of inquiry framework is based on two ideas, community and inquiry where community distinguishes the social nature of education and the function that ‘interaction, collaboration and discourse play in constructing knowledge’ while inquiry reveals the “process of constructing meaning through personal responsibility and choice”(Garrison & Vaughn, 2008, p9).

Garrison and Vaughn (2008,p29) say that "Blended learning offers the opportunity for all students to be cognitively engaged and to feel that they are learning individually by participating in, and contributing to, a community of inquiry". Garrison and Vaughn (2008, p9) define a community of inquiry as "a cohesive and interactive community of learners whose purpose is to critically analyse, construct, and confirm worthwhile knowledge". The three core elements of the community of inquiry are social presence, cognitive presence and teaching presence. There is interdependence across and within the presences as shown in Figure 3.3.

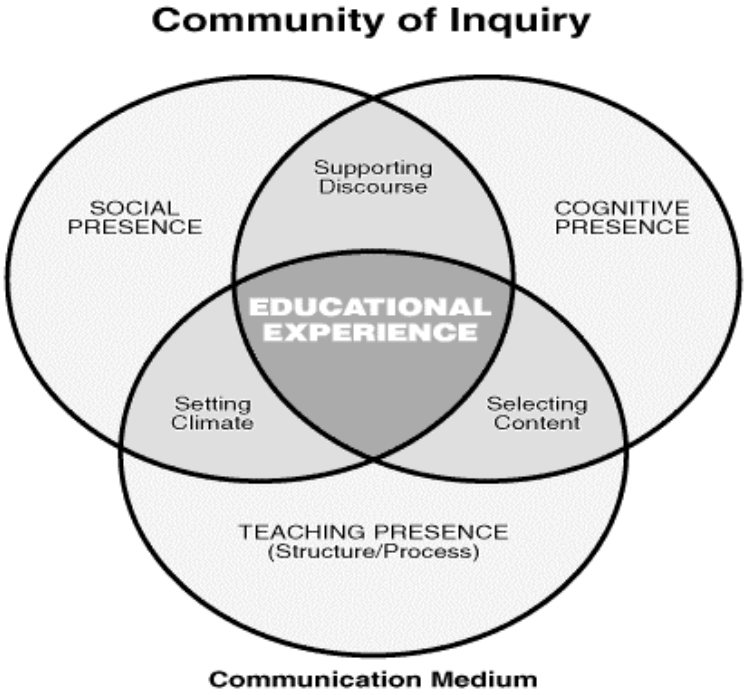


Figure 3.2 Community of Inquiry Framework

(Copyright 2008 Garrison, Anderson, Archer & Rourke, p 18, University of Calgary)

According to Garrison and Vaughn (2008) trust must be created amongst learners in a community of inquiry to ensure open communication. This, they add leads to meaningful communication. Such a community of inquiry should support interaction, encourage questioning, interaction with peers and small group discussions. And in turn, this will lead to camaraderie being created, and a sense of belonging to a group being fostered.

Garrison and Vaughn (2008) define cognitive presence as "... the process of collaboratively constructing meaning and confirming understanding in a sustainable community of inquiry" (p40). They assert that cognitive presence is fundamental to the inquiry process and explain further that since inquiry is the integration of reflective and interactive processes, the cognitive presence plots the cyclical pattern of learning from experience through reflection and conceptualisation to action and then to further experience. This is shown in Figure 3.4.

There are four phases, a triggering event, where some issue or problem is identified for further inquiry; exploration, where students explore the issue both individually and corporately through critical reflection and discourse; integration, where learners construct meaning from the ideas developed during exploration; and then resolution, where learners apply the newly gained knowledge to educational contexts or workplace settings (Garrison, Anderson, & Archer, 2001).

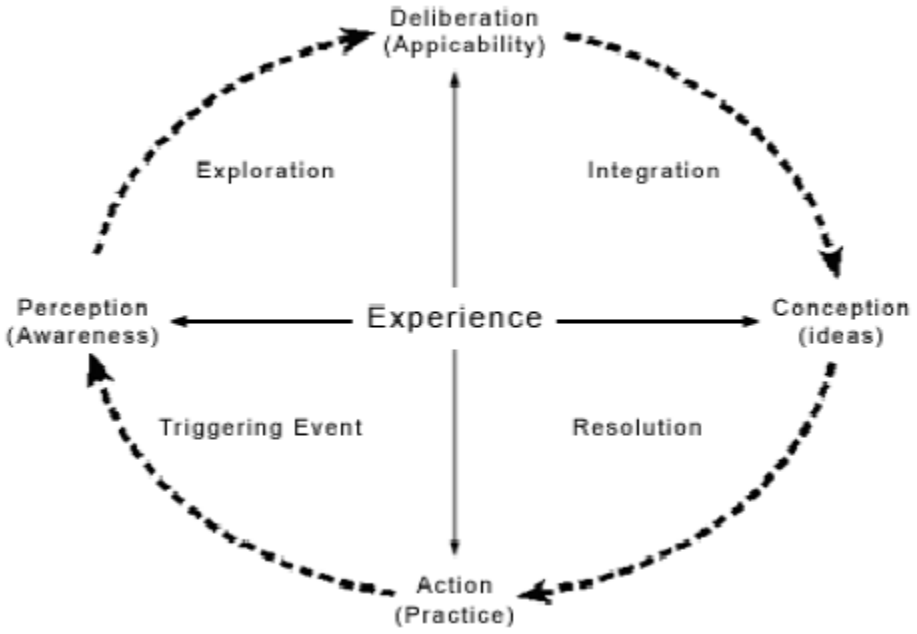


Figure 3.3 Private Inquiry Model

(Garrison, Anderson, & Archer, 2001, p22)

Teaching presence is defined as the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes (Garrison & Vaughn, 2008). Anderson and colleagues (2001) conceptualized teaching presence as having three components including instructional design and organization; facilitating discourse, and direct instruction.

Instructional design and organisation establish the curriculum, approaches and methods. These would include activities such as “re-creating Power Point presentations and lecture notes onto the course site, developing audio/video mini-lectures, providing personal insights into the course material, creating a desirable mix and a schedule for individual and group activities, and providing guidelines on how to use the medium effectively” (Arbaugh,

2008). Anderson and colleagues (2001) conceptualized facilitating discourse as the means by which students are engaged in interacting about and building upon the information provided in the course instructional materials. Therefore, facilitating discourse requires the instructor to review and remark on student comments, raise questions, and make observations to move discussions in a desired direction, keeping the discussion moving efficiently and drawing out inactive students (Anderson et al., 2001; Brower, 2003; Coppola, Hiltz & Rotter, 2002; Shea, Pickett & Pelz, 2003).

Anderson and colleagues (2001) view direct instruction as the instructor provision of academic leadership through the sharing of their subject matter knowledge with the students. They argue that a subject matter expert must play this role because of the necessity to analyse comments for precise understanding, bringing in sources of information, and directing discussions, scaffolding learner knowledge to raise it to a new level.

The instructor is accountable for the facilitation of reflection and discourse. This is done by presenting content, using various means of assessment and feedback. Instructors must have both content and pedagogical expertise in order to make connections among the ideas under discussion, identify any misconceptions, and introduce knowledge from textbooks, articles, and other materials (Arbaugh, 2008).

In this research the blended learning guidelines are rooted within the community of inquiry framework. Although Garrison and Vaughn (2008) use this framework as a map for the integration of face to face and online learning activities, this research study will adapt this framework to focus on the integration between face to face and DVD activities within a grade 12 mathematics classroom.

3.8.1. APPLYING THE COMMUNITY OF INQUIRY FRAMEWORK

In this section teaching presence will be explored and guidelines for practice will be given. The teacher or facilitator is needed to "structure, shape and assess the learning experience", if learning is to be expected to take place (Garrison & Anderson, 2003, p75). The guidelines are discussed from the point of view of a teaching presence. The dimensions of teaching presence are presented in Table 3.8. (Garrison & Anderson, 2003, pp 79-90).

Table 3.8 Dimensions of Teaching Presence

(Garrison & Anderson, 2003, pp 83)

	Social Presence	**Cognitive Presence**
Design and Facilitation	Establishes: • a feeling of trust and being welcome • a sense of belonging to a critical community • a sense of control • a sense of accomplishment • a willingness to engage in discourse • a conversational tone • a questioning attitude	• Consideration of assessment of cognitive development and knowledge at entry level • Organization and limitation of curriculum • Selection of appropriate learning activities • Provision of time for reflection • Integration of small discussion groups and sessions • Provision of opportunities to model and reflect upon critical thinking process • Design of higher order assessment instruments
Facilitation Discourse	Suggestions include: • Acknowledge and welcome participants as they enter a discussion • Be encouraging, gentle and supportive while directing discussion • Project your personality as a teacher and allow learners to get to know you as a person to an appropriate degree • Encourage learners to acknowledge individuals when responding to specific contributions\laud contributions when appropriate	Summarised as a need to : • Focus discussion on key issues • Provide stimulating questions • Identify puzzling issues arising from responses • Challenge ideas and precipitate reflection • Moderate but not overly direct discussion • Test ideas through application • Move on when discussion ebbs and has served its purpose

	• Be conversational and not too formal in communications • Express feelings but avoid becoming heated • Encourage learners to inform teacher of tensions or anxiety	• Facilitate metacognitive awareness
Direct instruction	You should : • Shape discussion but do not dominate • Provide feedback with respect • Be constructive with corrective comments • Be open to negotiation and providing reasons • Deal with conflict quickly and privately	Teachers need to : • Offer alternative ideas and perspectives for analysis and discussions • Respond directly to and elaborate on inquiries • Acknowledge any uncertainty where it exists • Make connections between ideas • Construct frameworks • Summarise discussions and move the learning on • Provide closure and predict further study

Teaching presence has the three dimensions of, instructional management, facilitating discourse and direct instruction and within each of these dimensions social and cognitive presence will be dealt with.

3.9. CONCLUSION OF THE CHAPTER

It was necessary in the quest to answer the research question: "***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?"*** to engage in discussion on a theoretical framework that would inform the exploration of this question.

Constructivism is the paradigm underlying the 2009 ISP and has already been discussed in this chapter. Next the context of the intervention was considered and elements of supportive learning environments as defined by various authors were discussed, thereby opening up the conversation for the analysis and interpretation of the data to come in Chapters Six and Seven.

Seeing that DVD technology formed an integral part of this research study it was fitting that a discussion of definitions and the types of technology be included. This research study explores a blended learning intervention and therefore it was apt to discuss the methods of blended learning. In this chapter various definitions of blended learning have been illustrated and the reasons why blended learning should be considered as an effective means of teaching and learning were discussed. There are various ingredients that constitute a blend and these were clarified further. Khan's octagonal framework, the future of blended learning and the disadvantages of blended learning were also furthermore outlined.

A blended learning programme, the BLOSSOMS project was presented here. The choice of this project as a point of discussion was made because the BLOSSOMS Project uses videos in a blended learning environment. The researcher believes that the BLOSSOMS projects' philosophies, pedagogies and approach to blended learning overlap considerably with that of the ISP and therefore it was important to highlight this initiative here.

The two approaches to learning, the 5e learning model and the community of inquiry model were discussed. "Education should be a collaborative constructivist experience where understanding is developed within a critical community of inquiry" (Garrison & Anderson, 2003, p93). In this research the blended learning guidelines are rooted within the community of inquiry framework. This intervention adapted Garrison and Vaughn's model for the integration of f2f and online activities and focused on the integration between face to face and DVD activities within a grade 12 mathematics classroom.

In the next chapter the researcher will describe the development of the DVD approach within a blended learning context and will outline the ISP approach.

CHAPTER FOUR : INSTRUCTIONAL DESIGN OF THE INCUBATOR SCHOOL PROJECT

4.1. INTRODUCTION

The mathematics crisis in South Africa was highlighted in Chapter Two and a few interventions addressing this crisis were presented. In this chapter the focus is on the GMMDU 2009 ISP. Although this case study does not focus on the instructional design of the DVD, its instructional design will be sketched in this chapter for providing a complete picture. This case study focuses on the blended learning environment of the ISP, within which this DVD approach is embedded. The instructional design of the ISP will be illustrated. Firstly instructional theories and their implications for the ISP will be discussed. Then multimedia learning will be expanded on.

The different approaches to the teaching and learning of mathematics on the ISP will be traced and the instructional design of the DVD will be sketched. The instructional strategy and content of the DVD will be specified and the production of the DVDs on this project will be detailed. The blended learning environment of the 2009 ISP will be illustrated and a typical Saturday class will be outlined.

4.2. INSTRUCTIONAL THEORIES

Instructional design is the practice of maximising the effectiveness, efficiency and appeal of instruction and other learning experiences. The process consists of determining the needs of the learners, defining the goal of instruction, and creating an “intervention" to reach this goal. Ideally the process should be informed by theories of learning and it may take place in student-only, teacher-led or community-based settings (Wikipedia: Instructional Design).

It is of importance for the success of instruction in realising its goal of learning that instructional designers base their method of instruction on theories of learning. Reigeluth (1999) defines instructional design as a process by which teachers and instructional designers decide upon a method of instruction that best influences the learners’ knowledge and skills for specific course content and specific learner population. This being the case, an instructional design theory is a theory that offers explicit guidance on how better to learn and develop (Reigeluth, 1999).

Smith and Ragan (2005) consider an instructional theory to be an integrated set of principles based on a learning theory, other relevant theories, and sound replicable research that permits one to predict the effects of specific instructional conditions on a learner's cognitive processing and the resulting learned capabilities. Reigeluth (1999) further outlines the major characteristics of instructional design theories. This author specifies that it must focus on means to attain set goals for learning. Reigeluth also prescribes methods of instruction, that is ways to support and facilitate learning and the methods of instruction. These are broken into simpler components. Whilst learning theory describes how learning occurs inside the learner's head, an instructional theory prescribes methods of instruction. The latter, therefore, has to be informed by the former.

Gagne (1985) best known for his "Conditions of Learning", was also involved in applying the concepts of instructional theory to the design of computer based training and multimedia based learning. His "Nine Events of Instruction" model was a major contribution to the theory of instruction. These events are, to gain attention; to inform the learner of objectives; to stimulate recall of prior learning; to present stimulus material; to provide learner guidance; to elicit performance; to provide feedback; to assess performance; and to enhance retention transfer.

Here it is assumed that different instructional conditions are most likely to bring about types of learning which already exist (Wikipedia: Instructional Design). The different instructional conditions mentioned here tie in well with the tenets of constructivist learning advocating learner centredness and also with blended learning which advocates different delivery methods and different pedagogies.

In addition many instructional theorists have proposed taxonomies of types of learning in the cognitive domain. Gagne (1985) states three types of cognitive behaviour namely, verbal information (for example learning to state a fact); intellectual skills (interacting with the environment by using symbols) and thirdly cognitive strategies (individual has learnt to manage own learning and thinking). Anderson (1983) speaks further of declarative knowledge and procedural knowledge. Merrill (1983) refers to remembering verbatim (the storing and retrieving of information); remembering paraphrased material (integration of ideas); using a generality (process specific information when using a general rule); and finding a generality (finding a higher level process).

The five principles of instruction according to Merrill (2006) are relevant to this research study as they tie in with the principles of constructivism underlying the blended learning environment of the 2009 ISP. These principles are the demonstration principle where learning is promoted when learners observe a demonstration, the application principle where learning is promoted when learners apply the new knowledge; and the activation principle which refers to Learning being promoted when learners activate prior knowledge or experience. In addition, the integration principle says that learning is promoted when learners integrate their new knowledge into their everyday world and the task-centered principle suggests that learning is promoted when learners engage in a task-centered instructional strategy.

It is suggested that for classroom instruction to be effective that there should be a synergistic relationship between the instructional method, the learning theory and the technology (Muniandy, Mohamad & Fong, 2007). In view of this statement we look at the convergence of the learning theory of constructivism as discussed in Chapter Three and its application to instructional design with learning from educational technology and learner centredness. One needs to bear in mind that "… in a collaborative constructivist approach, design is not a rigid template that is imposed on the learning situation. The design must be inherently flexible and adaptable to unpredictable and individual needs as they arise" (Garrison & Anderson, 2003, p78).

4.3. MULTIMEDIA LEARNING

Multimedia learning combines five basic types of media into the learning environment: text, video, sound, graphics and animation, thus providing a powerful new tool for education (Asthana,no date). Multimedia learning may be defined as "the use of text, pictures, audio, and or video to communicate information" (UKOrbit, 2002-2010) and multimedia learning describes any application that uses multiple media (graphics, text, animations, audio, and video). The ISP learning environment combines graphics, text, animations (Graphing software), audio and video. However, multimedia learning is primarily thought of as any application that uses high-bandwidth media (audio and video) and is most often delivered on CD-ROM.

Clarke (1983) claims that media are "mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p445). However Yang (1998) says that like video and television programmes, multimedia applications involve learners by offering them rich, integrated audio-visual information. This research study explores the role of multimedia in providing a supportive learning environment for the learning of mathematics in the 2009 ISP.

According to Mayer and Sims (1994) “multimedia learning occurs when students construct knowledge using visually presented animation and verbally presented narration from information presented in one or more formats”. Mayer and Moreno (1998) say that the use of instructional technology should be grounded in research based theory. Muniandy, Mohamad and Fong (2007) assert that for an effective classroom instructional reform teaching method, learning theory and technology must be promoted in parallel to form a synergistic relationship. They say further that each on its own will not be as effective as all three simultaneously and that any methodology should be embedded in a sound learning theory.

In multimedia learning Mayer and Moreno (1998) assert that the learner engages in three important cognitive processes. Selecting, the first cognitive progress is applied to verbal information that is incoming to yield a text base and is applied to visual information that is incoming to yield an image base. Organizing, the second cognitive process is applied to the word base to create a verbally-based model of the to-be explained system and is applied to the image base to create a visually-based model of the explained system. Finally, the third process of integrating occurs when the learner builds correlations between corresponding events in the verbally-based model and the visually-based model. In the ISP F2F sessions (integrated tutorials, discussions and questioning) the learners and facilitators created a text base and then applied this to the visual information of the DVDs to create an image basis. Learners then build correlations between the two.

Mayer and Moreno (1998) put forth five principles of multimedia design. The first principle is the Multiple Representation Principle. It is better to present an explanation in word and pictures rather than solely on words. The multimedia effect allows learners to build two different mental representations a verbal model and a visual model and to build connections between them. The Contiguity Principle relates to presenting corresponding words and pictures contiguously rather than separately when giving a multimedia explanation. The Split Attention principle refers to presenting words as auditory narration rather than visual on screen text when giving a multimedia explanation. The Individual differences Principle states that the forgoing principles are more important for low knowledge learners than high knowledge learners and for high spatial learners rather than low spatial learners. Finally the Coherence Principle which entails using a few, rather than many extraneous words and pictures when giving a multimedia explanation. This says that learners learn better from a condensed summary than from a longer version of the summary.

A discussion of constructivism, supportive learning environments, blended learning and the 5e learning cycle in Chapter Three and the discussion on instructional theories and multimedia learning in this chapter set the stage for the discussions of the 2009 ISP and will illustrate how these notions informed its design.

4.4. THE DIFFERENT APPROACHES OF TEACHING AND LEARNING MATHEMATICS USED IN THE ISP

The Govan Mbeki Mathematics Development Programme (GMMDP) stationed in the Mathematics and Applied Mathematics Department at the NMMU is an initiative developed in 2002 to address the crisis in mathematics education in the Eastern Cape. The Incubator School Project targeted grade 12 learners with potential in mathematics who wished to pursue careers in Science, Engineering and Technology as well as Mathematics and Science teaching.

In the following section the researcher will give an account of the development of the ISP from 2004 to 2009. In 2004 and 2005 a teacher centred approach to teaching and learning was practiced. Informed by the OBE system, this then evolved to a learner centred approach in 2007 and 2008. The use of DVDs as a teaching and learning resource was introduced in 2007. In 2009, an improved blended learning environment was created and a more learning centred approach to the teaching and learning of mathematics was adopted. Each year, from 2004 to 2009, forms individual cycles in an action research project.

The evaluation of each cycle informs the next cycle. This research study will focus on the 2009 cycle. Discussions will involve those factors which inform the 2009 ISP in Chapter Four and provide feedback for further cycles (2011) in Chapter Seven.

4.4.1. 2004/2005

The project consisted of one group of 50 grade 12 learners. The project focused on 16 problematic grade 12 mathematics topics. These were facilitated over the course of 16 Saturdays. Lecturers from the Department of Mathematics and Applied Mathematics at the NMMU took the role of the facilitators. The lecture was designed by the lecturer of the day. In addition, two other facilitators assisted with the tutorial sessions and marked homework, which had been assigned to the learners the week before. Tutorial sessions not integrated within the lesson were conducted after the lecture had been delivered. During tutorial sessions the group of 50 learners was divided into three smaller groups. Learners were required to write tests on the work covered in the previous week. Hard copies of summaries of the main points of each lesson, homework and tutorial solutions were given to learners. The learning was teacher centred, nor did it contain too much discussion or interaction.

4.4.2. 2006

In 2006 18 sets of PowerPoint slides were developed by the GMMDU team covering 18 mathematics topics from the grade 12 syllabus. The project consisted of five groups of 50 grade 12 learners in each group. The 18 topics were presented over 18 Saturdays by two facilitators in each group. Tutorial sessions were still conducted at the end of the presentations; and tests were given the week following the presentation of that particular topic. Once again the lessons were teacher centred with very little discussion and interaction.

4.4.3. 2007/2008

In 2006 a series of twenty animated PowerPoint grade 12 mathematics lessons were recorded on DVDs. These covered the various mathematics topics in the then (NATED550) grade 12 mathematics curricula. These were used during the ISP project. Tutorials were integrated within the lessons. This series of DVDs was redesigned in 2007 to encompass the new national curriculum (NCS) changes. In addition a more learner centred approach was adopted in this cycle.

4.4.4. 2009

The notion of blended learning was introduced to the ISP. DVDs, PowerPoint slides, discussions, tutorials, additional assistance with senior student tutors and group work were all part of the face to face sessions. A learning centred approach was the order of the 2009 ISP. DVDs and all copies of the lessons, tutorials, tests, extra exercises and solutions were given to all the learners. As the 2009 ISP group is the focus of this study, details of this blended learning environment will be expounded later in this chapter.

4.5. INSTRUCTIONAL DESIGN OF DVDS

A sound process of instructional design was followed in the development of the DVDs. It is a well designed DVD following the principles of instructional design as set out below. Garrison and Anderson (2003, p79) suggest the following guidelines that should be used from a design and organisation perspective. These guidelines must be considered before and during the e learning experience:

- Establishing the curriculum
- Identifying resources (content and process)
- Defining clear expectations and goals
- Addressing technological concerns
- Structuring activities (collaborative and individual)

- Setting time frames
- Devising assessment processes and instruments
- Selecting media.

The purpose of instructional design is to take full advantage of the value of the instruction for the learner. The ADDIE model is an instructional design model and consists of the five phases of Analysis, Design, Development, Implementation and Evaluation. It is a cyclical process where the outcome of each step feeds into the next step (see Figure 4.1).

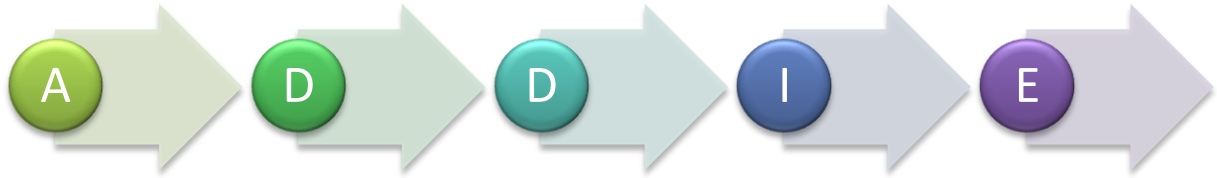


Figure 4.1 The ADDIE Model

A description of the phases follows.

Analysis: The instructional designer conducts a situation analysis that includes the identification of organisational context, target population, development team, goals, performance, media and cost analysis, audience needs. The designer also considers the learning environment, any constraints, delivery options, and the timeline for the project. All the factors identified and considered culminate in a needs analysis document.

Design: The decisions with regard to the design of the programme focus on content selection, instructional strategy and methods, media and materials, and a variety of delivery options. During this phase the learning objectives, design specifications, storyboards, sequencing and flowcharts are specified by the designer. This process results in a blueprint document for design.

Development: The design phase directs the production of the content and the learning materials. In the development phase all forms of instruction necessary to execute learning are constructed. Finances permitting, it is advisable to develop a prototype to test the usability thereof.

Implementation: The product is piloted and the procedure for training students and lecturers is developed. Formative evaluation serves to enhance the usability of the product. Evaluation of the effectiveness of the training materials takes place after delivery.

Evaluation: This phase consists of formative and summative evaluation. Formative evaluation occurs at each stage of the ADDIE process and occurs within and between phases. Summative evaluation occurs at the end of the process and provides users with the opportunity to offer feedback. Revisions are then made accordingly.

The instructional design of the DVD used in the 2009 ISP is presented in Table 4.1.

Table 4.1 Instructional Design of DVD in ISP

ANALYSIS
Organization context: GMMD unit learner projects
Target population: Grade 12 learners from schools in the PE metropole
Development team: Members of the mathematics and applied mathematics department
Goal: To provide a resource that would increase learners knowledge and capacity in mathematics and to increase their participation in and improve their performance in mathematics
Performance: The pass rates in mathematics are low and some schools have teachers that are under qualified with regard to mathematics. Learners have inadequate resources and low confidence levels with regard to mathematics. The mathematics syllabus is frequently not completed adequately, and sometimes sections are not completed at all.
Media and cost analysis: Most of the learners and the schools they attend do not have internet or broadband facilities. Yet DVD machines which are affordable are common in most homes and schools.
Learning environment: interactive f2f contact at two hours each for 14 Saturdays and take home DVDs
DESIGN
Content selection: Content of the grade 11 and grade 12 mathematics syllabus
Instructional strategy and methods: Considering constructivist principles of learning within a blended learning environment
Media and methods: f2f sessions and DVDs
Delivery system options: DVD and f2f
Learning objectives: Informed by the grade 12 mathematics syllabus individual DVDs were

designed on each mathematics topic

Design specifications: PowerPoint slides were designed and developed to present each topic comprehensively, so that the DVD could stand alone if needs be. Consideration was given to consistency. Each DVD followed the same format and used the same colour combinations

Flowcharts/sequencing: Table 4.2 showed the order in which the DVDs were designed. The logic of the content dictated the sequencing of each individual DVD. Although the DVD was designed in this linear way the learner was not restricted to this linear manner. Learners had control to select those specific parts of the DVD they wished to view.

DEVELOPMENT

DVD construction: Discussed further in this chapter

Prototype: This was evaluated by team of the GMMDU and the media people involved in the recordings

IMPLEMENTATION

Pilot: This was used in the 2007 ISP presentations

Procedure for training: Facilitators, tutors and learners were guided on how to use the DVD

Formative evaluation: conducted throughout 2007,2008 and 2009

EVALUATION

Summative evaluation: This used learner questionnaires, interviews, facilitator reports, informal conversations with learners, tutors and facilitators

4.6. INSTRUCTIONAL STRATEGY AND CONTENT OF THE DVD

Each DVD covered a particular topic in the syllabus. The topic was then divided into micro lessons (parts) (See Figure 4.2).

Figure 4.2 Two Micro Lessons

Each part of a DVD topic started with an introduction and definitions of the concepts. This was followed by fully voice explained examples pertaining to that particular concept. The complete worked out solution to all examples was presented step by step, line by line and the thought process involved in the solution of the particular problem was explained by the solver. The intention was to give learners an understanding of the thought processes involved in solving a problem and to help learners who would have had no idea where to begin (Aminifar, Porter, Caladine, & Nelson, 2007). The part ended with tutorial problems to be attempted by the learner. These were intended to give learners a way to assess their understanding of the micro lesson. Finally, a set of comprehensive solutions followed that could be viewed independently by the learners after they had attempted the tutorial problems. This approach ensured that immediate feedback was available to any learner who had struggled with the tutorial problems. The entire DVD had voice narration integrated with animated PowerPoint slides. Any further questions or problems experienced by the learner would then be addressed at the following f2f session.

The following Table 4.2 shows the content topics covered in the 2009 Mathematics DVD series.

Table 4.2 Twenty-eight Topics

DVD	TOPIC	DVD	TOPIC
Revision 1	Basic Algebra	**14**	Cubic Functions
Revision 2	Factor and Remainder Theorems	**15**	Surface Area and Volume
1	Number Patterns	**16**	Optimization Problems
2	Arithmetic Sequences	**17**	Line: Coordinate Geometry
3	Exponents and Surds	**18**	Circle: Coordinate Geometry
4	Geometric Sequences	**19**	Transformation Geometry
5	Simple & Compound Decay	**20**	Transformation Geometry
6	Logarithms: Growth & Decay	**21**	Trigonometric Identities
7	Quadratic Equations	**22**	Compound Angles
8	Annuities & Finance	**23**	Sine, Cosine & Area Formulae
9	Functions	**24**	Problems in 2D & 3D
10	Inverse Functions	**25**	Linear Programming
11	Trigonometric Graphs	**26**	Linear Programming
12	Calculus	**27**	Data Handling
13	Trigonometric Equations	**28**	Data Handling

4.7. PRODUCTION OF THE DVDS

Animated PowerPoint slides were developed to explain each mathematical concept. These slides formed the basis of the DVDs. The slides were then recorded in a studio by a member of the GMMDU team, normally a lecturer in the mathematics and applied mathematics department at the NMMU. The DVDs had both a visual component as well as an audio component. Recordings entailed using a tablet PC and presenting the PowerPoint slides with voice explanations by the lecturer. The image of the lecturer was not included as it was

believed that it would create a distraction for the learners (Aminifar, Porter, Caladine & Nelson, 2007). In addition other software packages like Autograph were used to illustrate sections requiring graph drawing. Autograph has an innovative feature which enabled the varying of parameters and therefore the learners had the opportunity to see the effect thereof on the graphs. Jacobs (2005) asserts that this constructivist approach allows the learners to construct their own mathematical knowledge. A second academic staff member of the GMMDU sat in the studio at the time of recording and evaluated the recordings to ensure that the DVDs were free of mathematical errors. Re- recording of an erroneous slide took place immediately if required. Thereafter the DVDs were edited by technical media specialist to produce master DVDs with a menu driven system. The menu system allowed learners to navigate the DVD moving backwards or forwards at their own pace and accessing sections as they wished.

4.8. THE BLENDED LEARNING ENVIRONMENT OF THE 2009 ISP

4.8.1. THE CONTEXT

Learners attended a series of five hour sessions on Saturdays. The session was divided in two parts with equal time allocated to mathematics and science with a refreshment break separating the two subject sessions. The session began with the learners writing a test based on the mathematics topics covered in the previous week. Two hours were dedicated to mathematics and during this time two DVDs were presented over a period of one hour each. The DVDs were presented to learners using a DVD player connected to a data projector. The presented sessions included viewing of the DVDs and explanations by the facilitators using a tablet PC, discussions initiated by the facilitators or the learners. This was an interactive session with work on tutorial problems, peer collaborations on problems and assistance from facilitators as well as student tutors.

Learners were each given copies of the DVDs to view at their own pace at home. It was intended that in this way all learners, learning styles and learning paces would be accommodated. All hard copies of tutorial problems, additional exercises and PowerPoint slides of the lessons were given to learners for revision at home.

A typical schedule for a Saturday session of the ISP is as follows.

Before 08:30	Transport to venue
08:30 – 09:00	Test
09:00 – 10:00	Maths Lesson One

10:00 – 11:00	Maths Lesson Two
11:00 –11:30	Brunch
11:30 –14:00	Science component of the ISP

The grade 12 learners on the ISP were split into three groups of about 60 learners each. Each group had two facilitators and suitably qualified student tutors assisting the facilitators during the sessions. All administrative issues pertaining to the group were assigned to a coordinator. The tasks of the facilitators were to facilitate the lessons and tutorials on the day and to set the weekly tests. The tasks of the student tutors were to assist the facilitators during tutorial sessions by providing support to the learners and to mark and record the weekly tests. The tasks of the co-ordinator were to assume responsibility for general administration of the group and to support the facilitators and student facilitators, to play a facilitating role during the tutorial sessions, to liaise directly with the GMMD Units office, to keep records of attendance and test results and to distribute transport refunds resource materials and write weekly feedback reports.

As technology forms an important part of the blended learning environment of the 2009 ISP the researcher reflects on the technology used in the 2009 ISP in terms of these definitions and terms.

4.8.2. INTERACTIVITY OF THE TECHNOLOGIES OF ISP

The researcher reflects on the interactivity of the technology used in the ISP context.

The synchronous physical mode refers to direct, f2f, live human contact, as took place in these instances where learners gathered in one place every Saturday morning with facilitator-led classes and lectures, interactive tutorial sessions, followed by discussions, and tests. The synchronous virtual mode refers to real-time interactivity that is, seeing each other on-screen and this component was not part of the 2009 ISP and may be considered in future ISPs.

The self-paced asynchronous mode refers to forms of learning that are not live such as online learning (email, e discussions, web searching, viewing video tapes, surveys and tests). These all require an Internet connection. This possibility in the form of viewing DVDs formed part of the ISP. Off-line learning (studying using CD roms and DVDs), which is important

when an Internet connection is expensive or not always available. This was reflected by learners viewing DVDs outside of the contact F2F time form part of this type of learning.

4.8.3. THE BLENDED LEARNING APPROACH

Table 4.3 represents a list of blends that were used in the 2009 ISP deliveries:

Table 4.3 List of Blends in the 2009 ISP

Facilitation:	**Two mathematics lecturers and one high school teacher took the roles of facilitators during these deliveries**
DVD Viewing:	**Two DVDs were presented per Saturday session**
Discussions:	**Centred around issues raised by learners, tutors and/or facilitators**
Tutorials:	**Learners worked on problems based on the concepts covered, assisted by two senior mathematics students**
Weekly Tests	**Based on the concepts covered on the previous week**
Self Study	**Take home DVDs and additional exercises**
Hard copies of lessons with solutions	**Printed copies of the lessons as well as the tutorials and their solutions were handed out to each learner**
Hard copies of tests with solutions:	**Printed copies of all test and test solutions were given to each learner.**

A schematic model of the blended learning approach is given in Figure 4.3.

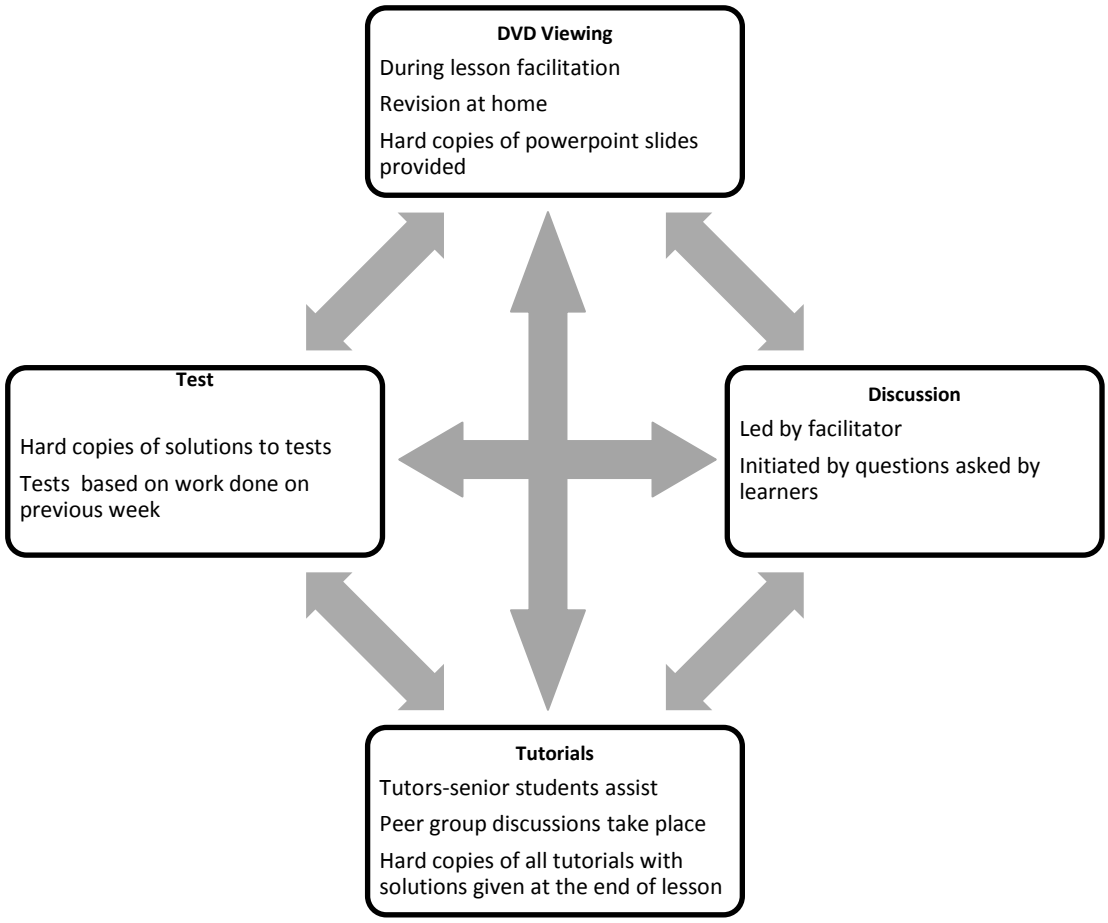


Figure 4.3 2009 Blended Learning Approach

The DVDs presented the problem solutions as students would see them in a face-to-face course. The course content was presented in text form (text-based notes, examples, formulas) and in audio-visual form (via the DVD lectures). The technologies created additional flexibility in the presentation of the course content, which enabled the course to adjust to students' learning preferences. In the face-to-face course, the content was facilitated in a learner centred approach at a pace determined by the facilitator.

Content was presented in text form and in the form of audio-visual presentations (i.e., DVD lectures and use of a tablet PC). Learners accessed the DVD lectures in their own time outside of the classroom setting. An important feature of the DVD lectures allowed student to pause, rewind, and replay the video lectures. Therefore, unlike the face-to-face lectures, the learner controlled the pace of information delivery, as well as the number of repetitions of instruction.

The assessments and tutorial problems were based on concepts facilitated in the f2f setting and covered in the particular DVD lecture. Learners who required one-on-one help interacted with the facilitator and tutors during the classroom setting, during breaks and after lessons. No additional contact help was available outside of the f2f setting. In summary, the multiple presentations of content, the continuous assessments, and the various communication tools adapted to learners' diverse learning needs, and asynchronous delivery met all the learners' needs. The course provided example problems, assessments, and practice opportunities that encouraged and required learners to think beyond the surface features of the formulas and concepts presented in the textbook.

Because learners could work at their own pace and could interact with the content materials in a manner that suited their learning preferences, they were engaged in more meaningful ways rather than being occupied as mere note takers in a face-to face lecture environment. The course did assess learners' prior knowledge, by means of a pre test. Feedbacks on tests were provided.

Finally, the course design did provide immediate feedback in the sense that learners were provided with information about their performance on the same day as the assessment was performed (Rynearson & Kerr, 2005).

4.8.4. THE 5E LEARNING CYCLE

The learning cycle that is followed in the ISP is a variation on this well-documented 5e learning cycle, a research-supported method for education (Edutech Wiki, 2010). The five phases in the cycle is summarised as follows. In the ISP presentation the Engage phase is a face-to-face introduction to the topic where the learners interest is captured. This leads to the Explore phase when the DVD on a particular topic is presented and the learners' knowledge is extended as the learner constructs knowledge in the topic. Watching the DVD presentation is interspersed and followed by the Explain phase when the facilitator leads discussion and clarifies issues to refine learners understanding. The learning cycle moves into the Extend phase when learners engage with tutorial problems applying what they have learned. Before evaluation happens, learners go home equipped with the DVD and more exercises to do at home. Therefore, learners go through another, smaller learning cycle consisting again of the Explore phase when they re-watch the particular topics on DVD and the Extend phase when they do more exercises in order to prepare for the Evaluation phase when the learners' knowledge and understanding is assessed. This happens on their return the following Saturday. It is important to note that the different phases do not stand in isolation but intermingle to the need of the learner. Diagrammatically (see Figure 4.4) the learning cycle used in the ISP is as follows, starting at the top:

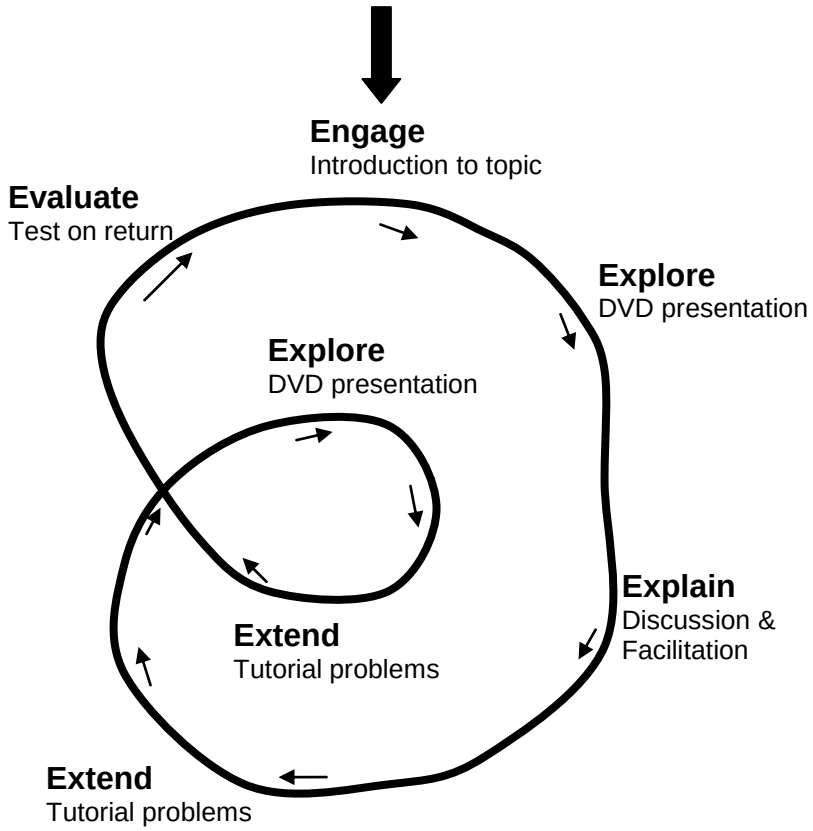


Figure 4.4 Learning Cycle used in 2009 ISP

The blended model under discussion therefore combines self-paced learning with instructor or facilitator support to develop specific knowledge and skills. In particular formal live face-to-face activities (facilitator-led), informal live face-to-face activities (mentoring by tutors and collaborative learning with peers) and the self-paced learning (DVDs) were used in all ISP deliveries (Rossett, Douglis & Frazee, 2003).

4.9. CONCLUSION OF THE CHAPTER

The instructional design of the 2009 ISP was the focus of this chapter. A discussion of the various instructional theories and multimedia learning was sketched since such theoretical issues should form the basis of and inform any programme's instructional design. The different approaches to teaching and learning used in the different cycles of the ISP are outlined with the emphasis of this research study on the 2009 ISP. The instructional design of the DVDs is detailed and the instructional strategies and content of the DVDs are given. The production of the DVDs is described and a discussion on the blended learning environment of the 2009 ISP is expanded on.

In the next chapter the researcher will outline the research design and the methodology followed in this research which allowed the research question to be answered.

CHAPTER FIVE : RESEARCH DESIGN AND METHODOLOGY

5.1. INTRODUCTION

The purpose of this research study was to explore the DVD driven blended learning environment of the 2009 ISP, with the intention of answering the research question: "***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?"*** The researcher believed that a better understanding of the question would inform the design of future ISPs and other programmes of this nature. The research design and research methodology was briefly outlined in Chapter One.

This chapter describes the research design and methodology employed in this research study fully and includes discussions on the research sample, research methods, and sources of data, data collection, data analysis, quality criteria, ethical considerations and the limitations of the study. Figure 5.1 outlines the presentation of the research process.

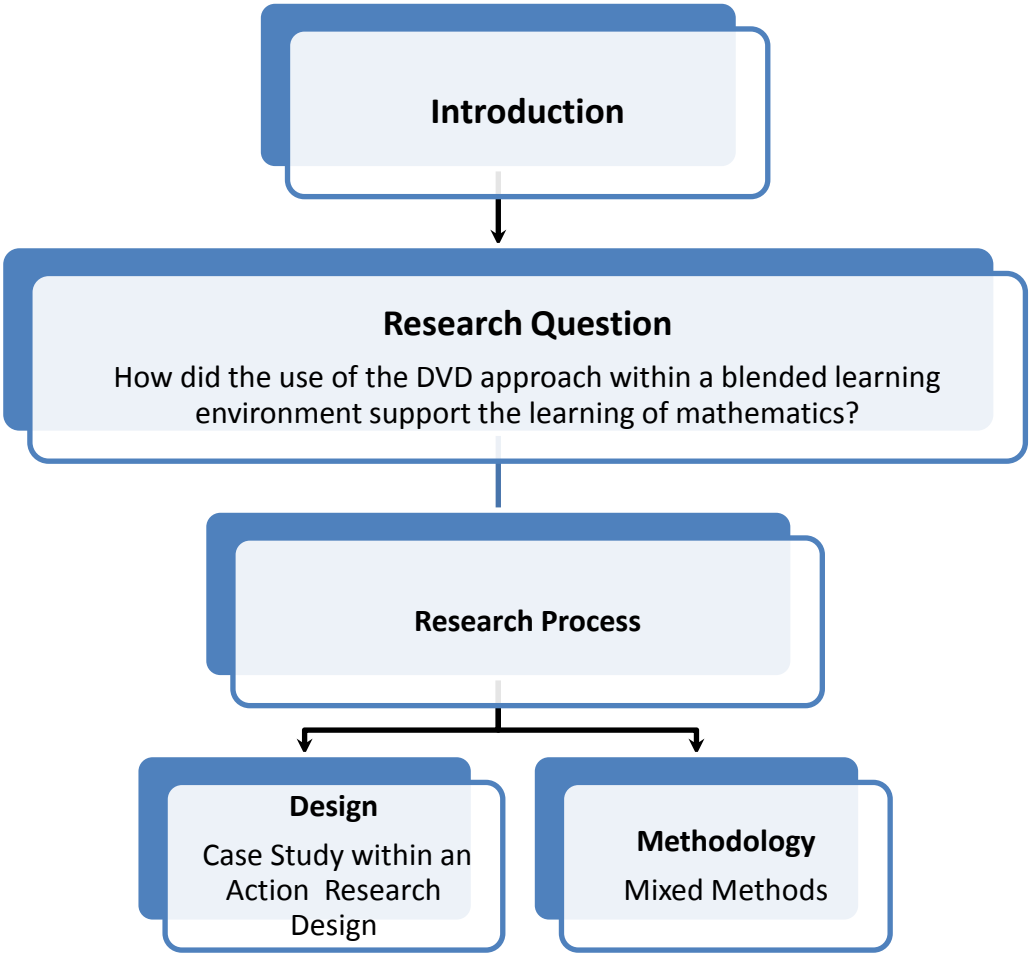


Figure 5.1 Outline of the Research Design and Methodology Chapter

5.2. THE RESEARCH QUESTION

The DVD approach to teaching and learning mathematics was explored in this research study in order to answer the following question:

> "***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?"***

The following research sub questions were formulated in order to answer the research question

1. **How did the elements present in the DVD driven approach support the teaching and learning of mathematics within a blended learning environment?**
2. **How do learners experience this blended learning approach?**
3. **What impact on learners' mastery of mathematics has the approach made?**

Table 5.1 presents a summary of the research design and describes how the research design links the research question and sub research questions to the research strategies.

Table 5.1: Research Design links Research Questions to Strategies

	Key Research Question	***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?***					
	Sub Questions	How did the elements present in the DVD driven approach support the teaching and learning of mathematics within a blended learning environment?	How do learners experience this blended learning approach?			What impact on learners mathematics has this approach made?	
	Research Design of Project	Action Research					
	Research Design of Study	Case Study					
	Methodology	Mixed Methods					
ACTION PLAN	**Data Collection methods**	**Qualitative/ Quantitative Survey**	**Group Interviews**	**Reports**	**Tests**	**Documentation**	**Instruments**
	Data Collection Instruments	Questionnaire	Interviews	Facilitator reports	Pre test vs post tes Weekly tests	Final maths exam results sheets: Participants grade 11 vs grade 12 Case study grade 11 vs grade 12 of partcipants vs those of non participants	Blended learning charts
	Data Source	Total population of ISP learners	Three groups of selected learners	Three facilitators	Total population of ISP learners	Official records of maths marks 2009 DOE School records of grade 11 marks	Researcher reflection
	Data Analysis	Analysis using statistical methods	Thematic analysis	Thematic analysis	Thematic analysis	Thematic analysis	Researcher
	Ethical Considerations	Confidentiality and anonymity, informed consent					
	Strengths of Action Research	Addresses practical problems by feeding the results of one cycle into the next thereby ensuring a continuous cycle of development					
	Limitations	The researcher is not detached or impartial , the representiveness of the findings and the extent to which generalizations can be made is limited, because of the particular setting (Denscombe ,2007).					
	Main Source of Error	Researcher judgement					

5.3. THE RESEARCH PARTICIPANTS

Four hundred grade 12 learners submitted applications to be part of the 2009 ISP. The best performing one hundred and ninety four learners were selected to be part of the ISP based on their final grade 11 mathematics results. These learners, who formed the 2009 cohort of ISP participants and their facilitators were the participants of this research study.

5.4. THE RESEARCHER

At the time of conducting this study the researcher was employed at the NMMU as a lecturer in the mathematics department. The researcher has been involved in mathematics interventions targeting grade 12 learners since 1993 and has been involved in the ISP since 2005. The researcher has experienced the transitions that the ISP has undergone since 2005 and has been involved in many facets of the introduction of DVD technology into the programme. These experiences involve the design of DVD lessons, the recording of DVD lessons, giving feedback on lessons recorded by other colleagues and facilitating sessions on the ISP, and in particular, facilitating one of the 2009 ISP groups. Therefore the researcher brings to this research study an understanding of the mathematics crisis and practical experience of working on the ISP, and an understanding of the ISP context.

5.5. THE RESEARCH DESIGN OF THE PROJECT: ACTION RESEARCH

This research case study exploring the 2009 ISP is situated within a larger action research project (2002 ISP to 2010 ISP). McNiff (2002, p15) defines action research as:

> "a name given to a particular way of researching your own learning. It is a practical way of looking at your practice in order to check whether it is as you feel it should be. If you feel that your practice is satisfactory you will be able to explain how and why you believe this is the case; you will be able to produce evidence to support your claims. If you feel that your practice needs attention in some way you will be able to take action to improve it, and then produce evidence to show in what way the practice has improved".

The research design of this research project was action research. McNiff and Whitehead (2006, p13) suggest that one would use action research if one wanted to evaluate whether ones endeavours are impacting on one's own or others learning. This is certainly the case with regard to this research project as the researcher wishes to gain an understanding of the impact of the DVDs within the blended learning situation on the mathematics learning of the learners on the learner project.

Henning (2004, p 47) calls action research a powerful methodology, that is driven by a sense of social change; and McNiff and Whitehead (2006) say that, "... you use action research when you want to find ways of taking action to improve learning with social intent " (p22). In his conceptualisation of action research Mouton (2008, p150) suggests that it is used mainly to "... gain understanding and insight into the life worlds of the participants". He says that the key research questions are exploratory and descriptive- with typical applications in classrooms and schools.

The strengths of action research are those of participation and the involvement of the participants. This results in high construct validity, low refusal rates and ownership of the findings (Mouton, 2008, p151). Denscombe (2007) describes the practical nature of action research; firstly, it is driven by a need to solve practical, real life problems; and secondly that it requires that the processes of research and action be integrated.

Self reflection is central to action research and involves learning in and through action and reflection (McNiff & Whitehead, 2002). In this research project an action research design is used since an action research design is particularly suited to research in education as it can increase understanding of what happens in particular educational contexts and it can explore the understanding of people in these contexts.

Action research was chosen as a research design because of its cyclical, iterative process is appropriate for the development of the ISPs. The nature of the research question justified an action research methodology since McNiff and Whitehead (2002) say that action research leads to the "... improvement of understanding and experience for social benefit". In this research the researcher was interested in obtaining a detailed description of learners needs in the provision of an improved DVD driven approach within the context of blended learning.

Denscombe (2007, p123) provides four defining characteristics of action research

- Practical: It researches real world problems.
- Change: This research should in gaining a better understanding of everyday problems and set out to change them.
- Cyclical process: This type of research involves feedback where initial findings indicate possibilities for change. These are implemented and then evaluated, leading to further investigation.

- Participation: Those affected by the research act as collaborators rather than subjects.

Critical points in the cycle of enquiry are that the research informs practice directly and that the process is continuing. Characteristics of action research (Adapted from de Jager, 2002, pp 8-9) that made it an appropriate choice for this research project are illustrated in Table 5.2.

Table 5.2 Characteristics and justification for using action research design

Characteristics	Justification for this study
Cyclical	This project was initiated in 2004 and has gone through many previous cycles of action research.
Qualitative	Qualitative data collection methods such as feedback from facilitators and interviews with learners were used in this research study
Collaborative	All participants in this study contributed to the end result
Informal	All participants in this study contributed to the end result
Iterative	The research spans over many cycles
Formative	Changes made continuously in this project informed by previous cycles

The Research process: Different stages of the action research

Action research is a long term investment, both intervention and research and develops in cycles of research and social action (Reason, 2000). Many researchers organize their work and reports as a cycle of steps: observe-reflect-act-evaluate-modify. This cycle then leads to another cycle (McNiff & Whitehead, 2006). This research study could have included previous cycles but the researcher focused on blended learning and therefore this research study focuses on the 2009 ISP. The 2002 – 2008 ISP's were taken as previous cycles of the larger action research project as illustrated in Figure 5.2.

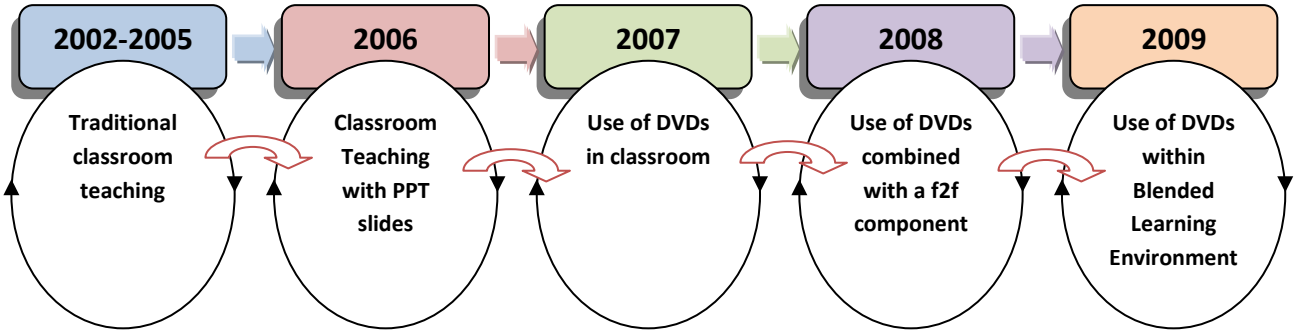


Figure 5.2 The Development of the GMMDU ISP's

Research needed to be done to inform our own reflective practice. A decision was taken in 2006 to introduce the use of technology into the ISP. After a cost analysis and a needs analysis was done (cf. Table 4.1 and Table 5.3), it was decided that the use of DVD technology would be the feasible option. This research study outlines the introduction and use of DVD technology in the ISP since 2007 and centres in particular on the use of this technology within a blended learning environment in the 2009 ISP.

Table 5.3 Cycles of this Action Research Study

Cycles	Intervention	Main themes derived from comments of learners and facilitators (Questionnaires, reports and conversations)	Needs Analysis	Decision
Cycle 1 **(2007)**	Use of DVDs Only	Use of technology not interactive. Boring and monotonous with only DVD. Difficulty with concentration using the DVD approach and one learner said that it was easy to "move your concentration elsewhere" unless you had a lecturer to intervene with discussion or explanations.	Face to face component needed.	Face to face component to be integrated within a more learner centred environment.

		Some of the DVDs did not illustrate every step of a mathematical problem and that this lead to confusion. Learners requested for more detail and more examples on the DVDs. Facilitators and tutors needed to give further explanations and discussions. They needed the facilitators' explanations to bridge gaps where the DVD skipped steps or they had problems understanding.		
Cycle 2 **(2008)**	Use of DVDs with a f2f component	Facilitation skills were absent. Facilitators too reliant on playing the DVD. No discussions. No time for questions No groupwork. Tutors not interactive.	Tutorials need to be integrated and tutors to assist learners. Questions and discussions to be encouraged. DVD needed to be facilitated in f2f session first before learners viewed them at home.	Blended learning With multiple delivery modes informed by principles of constructivism and guided by the community of inquiry framework.
Cycle 3 **(2009)**	Use of DVDs within blended learning environment.	This research study will inform.	This research study will inform.	To be taken for 2011 ISP.

5.6. MODEL FOR ACTION RESEARCH CYCLE 2009

The researcher's belief is that action research studies which address important questions regarding educational practices, what works and what doesn't can add to a body of research and add theoretical understandings of teaching and learning. A model for the action research in this research design is sketched in Figure 5.3.

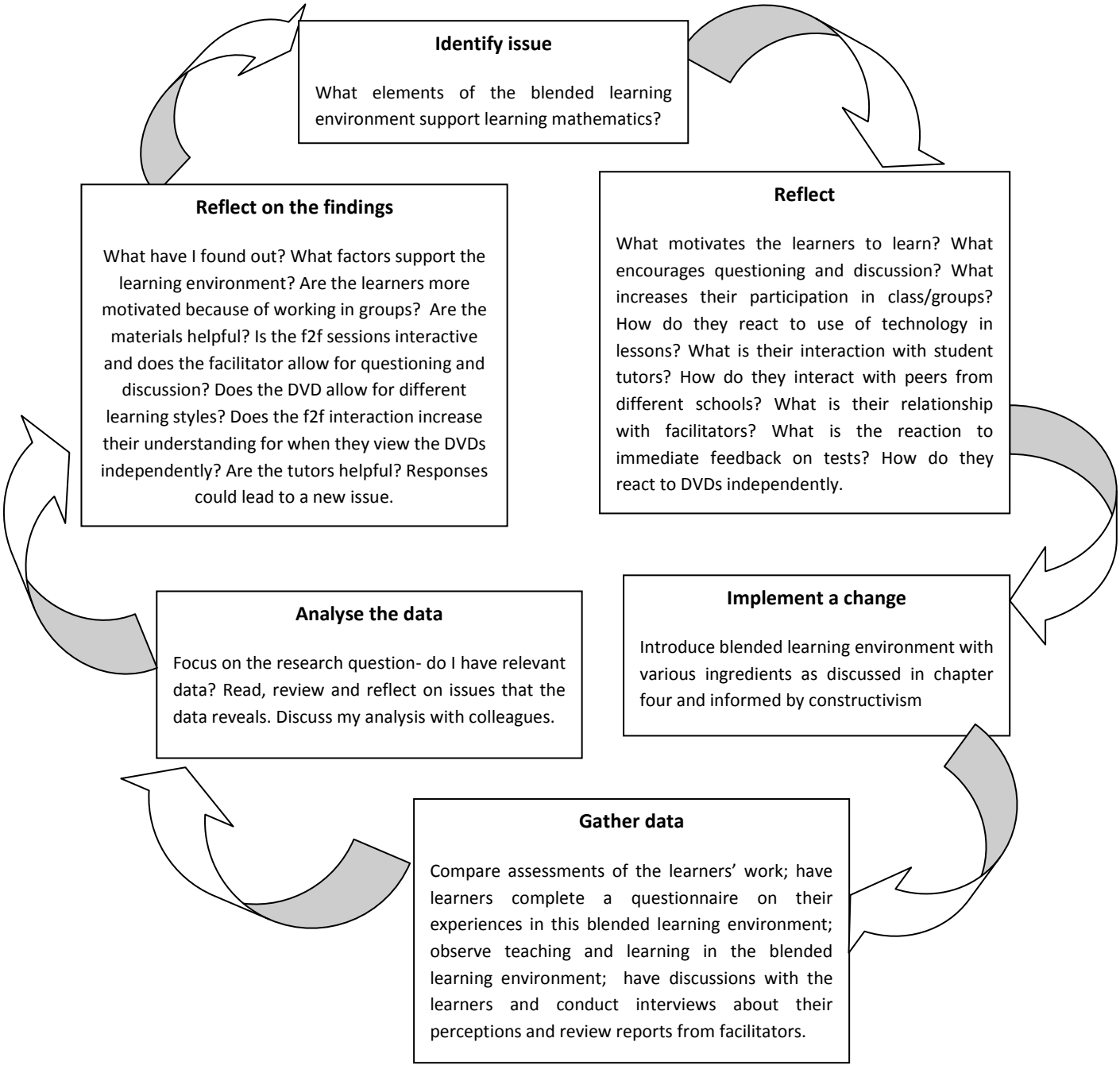


Figure 5.3 Model for Action Research Cycle of 2009 ISP

(Adapted from QCA/University of Cumbria Co-development Initiative).

The rationale for using action research in this research project has been discussed. Action research concerns itself with the aims and design of the research (Denscombe, 2007). It does not restrict or limit the researcher in terms of methods for data collection. What follows is the research design of this research study.

5.7. THE RESEARCH DESIGN OF THIS STUDY: A CASE STUDY

Situated in an action research design for the research project the exploratory case study was best suited as a research design for this study. Case study research enables one to arrive at an understanding of a complex situation and it can add value to what is already known through previous research. This is substantiated by Merriam (1998, pxii) who posits that "... investigators use a case study design in order to gain an in-depth understanding of the situation and its meaning for those involved". Yin (1984, p23) defines a case study as "... an empirical inquiry that investigates a contemporary phenomenon within a real life context when the boundaries between the phenomenon and the context are not clearly evident and in which multiple sources of evidence are used".

"Case study research… is ideal for understanding and interpreting observations of educational phenomena" (Merriam, 1998, p2) as is the case in this research study. The "educational phenomenon" or research object of this study is the blended learning approach of the ISP. Case study research generally answers questions of the "How?" and "Why?" nature, and this is certainly the case here with research question being: ***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?***

This study fulfils the following characteristics of a case study research:

- The case study in this research study has clear boundaries. It is bounded by time (occurring in 2009), place (the GMMD unit's initiative the ISP of the Nelson Mandela Metropolitan University) and subject (grade 12 mathematics).
- An in depth study of the case. The research study explores a particular case of teaching and learning mathematics using DVD technology in a blended learning environment.
- The study is of the phenomenon in its natural context.
- The study of the perspectives of the participants (learners and facilitators) to provide rich description and understanding of their experiences.

5.8. RESEARCH METHODS: MIXED METHODS

Although qualitative data gathering methods are emphasised in this case study quantitative methods were used as well. A method is "... a set of procedures and techniques for gathering and analysing data" (Strauss and Corbin, 1998, p3). Mixed methods were employed with regard to the data collection and the data analysis. A mixed method approach is defined as "the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., the use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration" (Johnson, Onwuegbuzie & Turner, 2007, p124). A mixed methods study skilfully combines qualitative and quantitative methods thus providing an elaborate understanding and therefore supporting confidence in the conclusions of the study (Green, Caracelli & Graham, 1989).

It is of importance to be able to evaluate the strengths and weaknesses of a mixed methods approach to be in a position to use it effectively. The researcher presents some of the strengths and weaknesses of the mixed method approach.

The strengths of this approach is that words, pictures and narratives can be used to add meaning to numbers and numbers can be used to add precision to words, pictures and narratives. A broader and more complete range of research questions can be answered because the researcher is not confined to a single method or approach. In addition the researcher can use the strengths of an additional method to overcome the weaknesses in another method by using both in a research study (principle of complementarity). Stronger evidence for a conclusion can be provided through convergence and corroboration of the findings (triangulation). Mixed methods can be used to increase the generalisability of the results. Insights and understandings might be missed when only a single method is used. Qualitative and quantitative research methods can be used together to produce more complete knowledge necessary to inform theory and practice. The weaknesses of mixed method research include that it is difficult for a single researcher to carry out both qualitative and quantitative research as they need to learn multiple methods and approaches, and understand how to appropriately mix them. It is also more expensive and time consuming.

Mixed methods "... focus on collecting, analysing and mixing both qualitative and quantitative data in a single study. The central premise of mixed methods is that the use of a combination of quantitative and qualitative approaches provides a better understanding of

research problems than either approach alone" (Creswell & Plano Clark, 2007, p5). They add that it is not enough to simply collect and analyse qualitative and quantitative data; they need to be mixed in order to form a more complete picture of the problem. The key factors that researchers need to consider when choosing a mixed methods methodology are the research problem, researchers qualitative and quantitative skills, resources, expectations of audiences, timing of collected data, relative weight of qualitative and quantitative approaches, how the data sets will be related or connected (Creswell and Plano Clark,2007, p80). Timing may be either concurrent or sequential, the former referring to collecting, analysing and interpreting at the same time while the latter refers to one type of data being collected and analysed first followed by the collection and analysis of the second type. The weighting of the two types of methodologies is determined by the researcher's worldview, research questions, research design, researchers experience and the target audience. Mixing of these data as shown below can be achieved in the three ways two types of data can be merged, one can be embedded within the other or they can be connected.

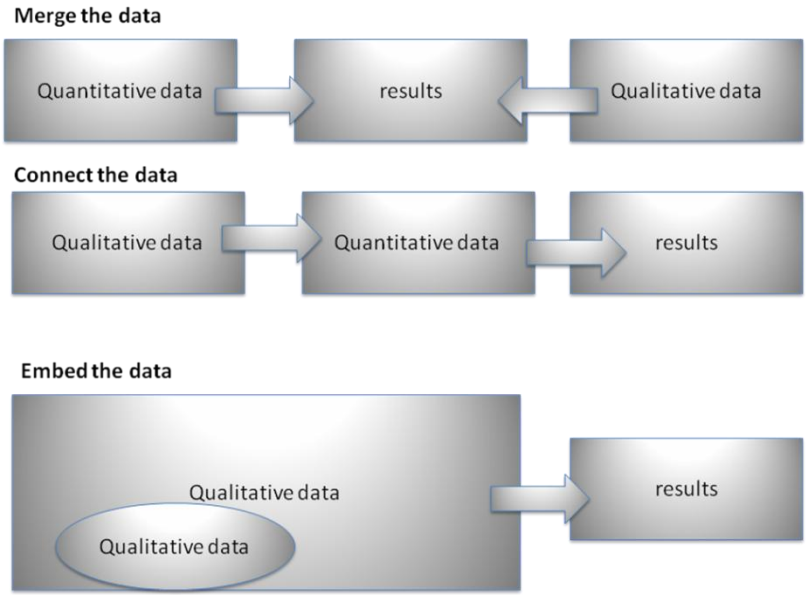


Figure 5.4 Mixing of Data in a Mixed Methods Approach

In this research study the timing was concurrent since quantitative and qualitative data sets were collected, analysed and interpreted at approximately the same time. The qualitative and quantitative methods had unequal weighting with a qualitative emphasis directed by the choice of a case study research design and the research questions that were qualitative in nature. Qualitative and quantitative data was merged. Data were collected and the two data types were analysed separately but integrated during the interpretation phase.

Among the purposes for a mixed-method design five major ones are highlighted in Table 5.4 which is based on Greene, Caracelli and Graham (1989).

Table 5.4 Five Major Purposes for a Mixed Method Design

(Based on Greene, Caracelli and Graham, 1989, p267)

Triangulation.	Tests the consistency of findings obtained through different instruments.
Complementary	Clarifies and illustrates results from one method with the use of another method. In our case, in-class observation will add information about the learning process and will qualify the scores and statistics.
Development	Results from one method shape subsequent methods or steps in the research process.
Initiation	Stimulates new research questions or challenges results obtained through one method. In our case, in-depth interviews with facilitators will provide new insights on how the programme was perceived.
Expansion	Provides richness and detail to the study exploring specific features of each method. In our case, integration of procedures mentioned above would expand the breadth of the study.

5.8.1. RATIONALE FOR USING MIXED METHODS IN THIS STUDY

Triangulation involves the practice of viewing things from more than one perspective (Denscombe, 2007, p134). Triangulation is used to validate and elucidate the findings from another approach and produce more comprehensive, internally consistent and valid findings; provide more intricate understanding and greater confidence in the conclusions and to handle any threats to the validity (Denscombe, 2007).

The use of various methods of data collection and triangulation is vital in the determination of an in depth understanding of the programme under exploration. This also adds to the rigor, breadth and depth of the study (Creswell, 1998) and answered a broader range of questions since the researcher was not confined to one method. The researcher used interviews to see whether the results converged with the results of questionnaire. This was done to provide a more elaborate analysis and to provide a better understanding and to enhance the description.

The following types of triangulation were used in this research study:

- Data triangulation: The questionnaires consisted of closed questions and open ended questions, the latter being used to give learners an opportunity to add their own voice to the issues raised. In addition group interviews with learners were conducted and to enhance the description and to gain information of the 2009 ISP from another perspective- the reports of the facilitators' were also studied.
- Methodological triangulation: Both qualitative and quantitative methods were employed and the findings from the one method (interviews) were used to corroborate that of the other (questionnaires).
- Triangulation of time periods: The previous cycles of the ISP and this main study.

The advantages of triangulation in viewing something from different viewpoints can contribute to a fuller picture and increase the accuracy and the authenticity of the findings (Denscombe, 2007).

5.9. OVERVIEW OF THE RESEARCH STEPS

A summary of the steps used to carry out this research study follow and this is elaborated on further in this chapter.

1. A Literature review on the issues directed by the research question, sub questions and methodological issues was conducted prior to the collection of the data.

2. The researcher sought and obtained ethics clearance for this study from the NMMU and requested and was granted permission to conduct this research with school learners from the DOE.

3. The researcher sought and was granted written consent from all the participants in this research study.

4. All the participants wrote a pre test based on grade 11 mathematics in February 2009.

5. The participants were asked to complete a questionnaire designed to collect biographical and conceptual data at the end of the programme (September 2009).

6. Group interviews were conducted with three groups of nine, thirteen and eleven learners in each group (c.f. 5.10.1.2).

7. Those participants remaining at the end of the 2009 programme wrote the post test based on mathematics concepts as covered in the programme (September 2009).

8. The results of the learners' weekly tests and the attendance register were collated.

9. The results of the participants' final grade 12mathematics marks were obtained.

10. The results of the non participants' (from six of the participating schools) grade 12 mathematics marks were obtained for comparison purposes.

11. The reports from the facilitators were obtained.

5.10. INSTRUMENTS AND PROCEDURES USED IN DATA COLLECTION

The Nelson Mandela Metropolitan University (NMMU) granted ethics clearance for this study (Appendix A). All the participants signed an informed consent form and in the case of the minors consent was signed by their parents or guardians (Appendix B).

In this study data were collected from the questionnaires completed by the learners (Appendix E). Group interviews with learners and reports from facilitators were also completed. In addition, the participants were required to write a mathematics pre test (Appendix D) upon entry into the ISP and a mathematics post test (Appendix F) which was written at the end of the programme.

The highest performing learners were selected to participate in the 2009 ISP on the basis of their grade 11 mathematics results. These results as well as their final grade 12 mathematics marks were compared in order to determine the effectiveness of the blended learning approach. In addition a comparison of six schools was conducted where the grade 11 and grade 12 final mathematics marks of the ISP participants were compared with those of the non participants from the same school.

Blended learning charts were used to determine the extent of blending in this DVD approach.

The data collection methods employed in order to answer the research question are shown in Table 5.5.

Table 5.5 Data Collection Methods Used

Research Sub Questions / Methods	**1. How did the elements present in the DVD driven approach support the teaching and learning of mathematics within a blended learning environment?**	**2. How do learners experience blended learning?**	**3. What impact on learners' mathematics has the approach made?**
Literature Study	✓		
Questionnaires	✓	✓	✓
Interviews	✓	✓	✓
Facilitators' Reports	✓	✓	✓
Grade 11 Results versus Grade 12		✓	✓
Participants versus Non-Participants		✓	✓
Comparison of six schools		✓	✓
Blended Learning Radar Charts	✓	✓	

The use of various methods of data collection and triangulation is vital in the determination of an in-depth understanding of the programme under investigation. In this research study, the researcher used the following types of triangulation:

- Data triangulation: Questionnaires (open ended and closed questions) and interviews.
- Methodological triangulation: Qualitative and quantitative methods
- Triangulation of time periods (Yin, 1994): Previous cycles and main study.
- Triangulation: Interviews with learners and the reports from the facilitators.

5.10.1. QUALITATIVE DATA

There are three main sources of data for a qualitative research study, interviews, observations and documents (Merriam, 2002). In this research study the qualitative data were forthcoming from the open ended questions in the questionnaire, group interviews with the learners and from the facilitators' reports.

5.10.1.1. Questionnaires

The questionnaire (Appendix E) was completed by the participants of the 2009 ISP at the end of the programme. Questionnaires were administered to the 2007 and 2008 ISP cohorts. These questionnaires were used as a basis for the development of the 2009 questionnaire. Learners were asked to complete these questionnaires voluntarily and they were asked to be honest with their responses. Their confidentiality and anonymity were assured.

The questionnaire was designed to collect biographical information and to determine how learners experienced the Incubator School Project, what factors provided a supportive learning environment in this model and what impact on/improvement in learners' mathematical ability the model had made. The questionnaire used included closed questions with a Likert 5 point scale since "Likert type scales provide great flexibility since the descriptors on the scale vary to fit the nature of the question or statement" (Schmacher, 1993, p262). Open ended questions were also included in order to tap into the learners' personal experiences and to give learners the opportunity to give extended answers to issues concerning the approach of learning.

The use of questionnaires served to raise certain issues which could then be explored further in group interviews. One has to admit that although the questionnaires were easy to administer and manage, they could be of limited value only, for examining complex social settings. Therefore the information derived from the questionnaires was complemented by data obtained from other data collection methods.

The data from the questionnaires were then recorded onto an excel spreadsheet and thereafter analysed using statistical methods for closed questions and coding for open ended questions.

5.10.1.2. Group Interviews

The primary method of data collection was the questionnaire and this was supported by data from the group interviews with learners. The researcher felt that it was appropriate to use interviews in this research project since as Seidman (1991, p11) put it : "If the researcher's goal is to understand the meaning people involved in education make of their experience then interviewing provides a necessary, if not completely sufficient avenue of inquiry". Kvale (1996, p1) describes the qualitative research interview as an "attempt to understand the world from the subject's point of view, to unfold the meaning of people's experiences". The purpose of the group interviews was to augment the information obtained from the questionnaires and to provide additional data to ensure credibility, to determine the breadth of the ideas and then correlate these ideas with those that have emerged from other data sources and so to explore these ideas in depth.

A predetermined set of interview questions formed the interview guide. These questions were informed by the research question and the sub questions, and were forthcoming from issues that arose from the questionnaires. The interviews were recorded using a video camera and thereafter each interview was transcribed. No other person was present and learners were assured that whatever they said would be kept confidential and that they would remain anonymous in the reporting of this research.

Candidates for the interviews were selected from the 2009 ISP learners. Three groups were selected as follows. The participants of the 2009 ISP (all three groups) were arranged in a list according to the sum of their weekly tests. This list was divided into five categories- low (<40), medium low (40-80], medium (80-100], medium high (100-160] and high (160-200] (Table 5.6). Three learners were chosen each from the top, middle and bottom of each category and they then comprised each group. In addition care was taken to canvass learners from a wide range of schools. The interviews were conducted in a lecture room at the university. The learners were familiar with this venue as it was used for the lessons of the ISP. The interviews lasted approximately forty minutes each and they were recorded using a video tape. The learners did not seem to be uncomfortable with the use of this technology and the decision to use video recording allowed the researcher to focus on facilitating the interviews whilst issues like body language were recorded for later viewing.

Although group interviews are valuable in eliciting a range of ideas and opinions in uncovering elements that provided a supportive learning environment there is a drawback of a "group think" as an outcome (Fontana and Frey, 2003).

5.10.1.3. Facilitators' Reports

At the end of the programme, the facilitators were required to report on the various aspects of the programme. These data were collected and recorded in an excel spreadsheet. This method was used to gain another perspective, that from the point of view of the facilitators, with regard to the teaching and learning on the ISP 2009 and more especially with regard to the learning environment of the ISP. Once again facilitators were assured that their confidentiality and anonymity would be maintained. The questions revolved around similar issues, as those highlighted in the learners questionnaires; and all the questions were open ended.

5.10.2. QUANTITATIVE DATA

Quantitative data were collected via pre tests and post tests, grade 11 and grade 12 final mathematics marks of the participants, weekly tests results, attendance records and grade 11 and grade 12 final mathematics results of the participants and those of non participants were compared.

5.10.2.1. Pre Test and Post Test

The researcher developed a pre test based on the mathematics knowledge and skills that grade 12 learners are expected to have mastered upon their entrance into grade 12. All applicants to the project wrote this pre-test. The results of the pre-test were used to determine whether a need for such interventions had been highlighted. They were also used to determine learners' mathematics needs. Those needs were then addressed by the facilitators in the delivery of the lessons in the blended learning programme.

A post test was written by the participants at the end of the programme. The questions were based on the mathematics content and skills covered during the 14 week programme. The results of the post test were compared with the results of the pre test, to determine whether the learners had overcome their problem areas, and had mastered all the concepts taught. The data were recorded on an excel database.

5.10.2.2. Grade 11 and Grade 12 Final Mathematics Marks of Participants

The end of year grade 11 mathematics marks of the participants were obtained from their respective schools and their final grade 12 mathematics marks were obtained from the Department of Education: Eastern Cape. The intention was to track the progress of the participants, and to ascertain any noteworthy improvements. The marks were only available to the researcher and hence confidentiality and the anonymity of the data were secured.

5.10.2.3. Grade 12 Final Mathematics Results of Participants and those of Non-participants

The documents of the final matriculation results were accessed from the schools that the learners had attended. The rationale for this method of data collection was to compare the mathematics results of the participants who had received the blended learning treatment in the 2009 ISP, with those of their peers at their respective schools, who had not been part of the 2009 ISP. The confidentiality and anonymity of data were handled by the researcher and then preserved.

5.11. BLENDED LEARNING RADAR CHARTS

The researcher made use of and adapted a model developed by Harding, Engelbrecht, Lazenby and le Roux (2006) to assess the scope of blending in this blended model.

This radar chart measure was an attempt to provide a visual presentation that would show at one glance, what the scope and extent of blending in a model has been, and to indicate the associated strengths and weaknesses. The Harding radar chart measure applies to a blend between face-to-face and online instruction, specifically web-based instruction. We have adapted and generalised the measure to apply it to a blend of face-to-face instruction and instruction via computer based technology that is not necessarily web-based.

Six radials were identified, each with a question to quantify the measure:

Dynamics and Access: What is the frequency of use of computer technology necessary for success in the course?

1 – Once per term

2 – Once per month

3 – Once per week

4 – Two or three times a week

5 – Daily

Assessment: How much of the assessment is done via computer technology?

1 – Little

2 – Almost half of it

3 – More than half of it

4 – Most of it

5 – All of it

Communication: How much of the communication happens via computer technology?

1 – Little

2 – Almost half of it

3 – More than half of it

4 – Most of it

5 – All of it

Content: How much of the content is available via computer technology?

1 for each component, study content, problems, tutorials, course information, course administration with a maximum score of 5.

Richness: How many enriching components does the computer technology based part of the course have?

1 for each component such as computer algebra system, graphics, Java applets, slide presentations, video and sound clips; in effect, more than text communication with a maximum score of 5.

Independence: How independent is success in the course fface-to-face contact?

1 – Fully contact lecture and tutorial driven; technology and add-on

2 – Contact lectures but computer technology based tutorials or assessment

3 – Limited regular contact

4 – Sporadic contact

5 – No face-to-face contact

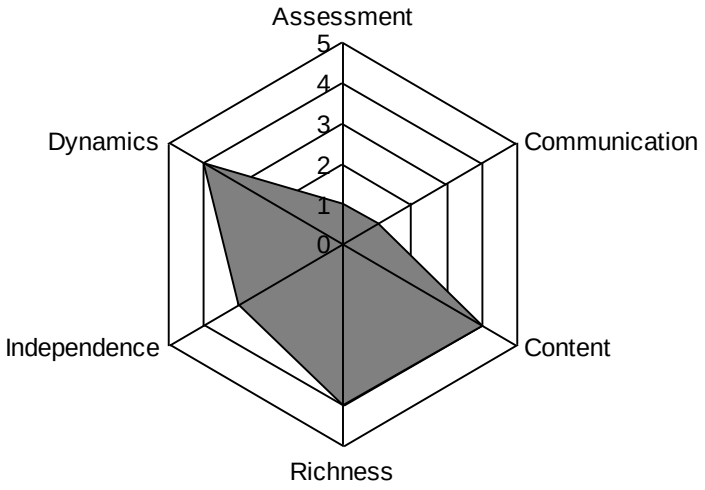


Figure 5.5 Blended Learning Radar Chart

Referring to Figure 5.5, Harding, Kaczynski and Wood (2005) explain that the area of the radial diagram shows the extent of blending that has taken place. They explain further that the first three radials dynamics, assessment and communication could be grouped under the heading of interaction, while the second three radials content, richness and independence under the heading material. The shaded area corresponds with the amount and dimensions of the blended learning that has taken place.

5.12. SAMPLE DESIGN

Denscombe (2007, p25) asserts that to be able to generalise from the findings of a survey the sample needs to be of an adequate size. The researcher decided that the whole population of learners attending the 2009 ISP would take the survey. This decision was based on the notion that the data would then be rich, comprehensive and would then contain more detail.

Probability sampling was used to select the candidates for the group interviews. Using probability sampling, the researcher chose participants that were a representative cross section of the population. In considering the representativeness of the whole population, the criterion used for the selection of participants for the group interviews is outlined. Learners on the ISP wrote weekly tests that totalled a mark of 200, by the end of the ISP. The researcher considered 5 mark categories as shown in Table 5.6.

Table 5.6 Mark Categories used in selection of Participants of Group Interviews

Categories	Marks (x)
High	(160,200]
Medium high	(120,160]
Medium	(80,120]
Medium low	(40,80]
Low	(0,40)

Three groups were established. Each group consisted of three learners from each of the top, middle and bottom from each mark category selected. The total number of learners comprised fifteen learners per group.

5.13. DATA ANALYSIS

Data can be produced by a variety of methods. In this research study both qualitative and quantitative data were collected. Qualitative data arose from answers to open ended questions in the questionnaire, group interviews and facilitator reports. Quantitative data arose from closed questions of the questionnaire, weekly test results, attendance records, and the final mathematics grade 12 marks.

"The process of analysis involves the search for things that lie behind the surface content of the data- core elements that explain what the thing is and how it works. The researchers task is to probe the data in a way that helps to identify the crucial components that can be used to explain the nature of the thing being studied, with the aim of arriving at some general principles and can be applied elsewhere to other situations" (Denscombe, 2007, p247).

Many researchers recognise stages involved in the analysis of the data. In Table 5.7 on procedures in qualitative and quantitative data analysis the researcher provides the procedures of analysis used in this research study. This procedure was adapted from that of Creswell and Plano Clark (Creswell and Plano Clark, 2007, p129).

Table 5.7 Procedures in Quantitative and Qualitative Analysis

Procedures in Quantitative and Qualitative Data Analysis		
Quantitative Procedures	**General Procedures in Data Analysis**	**Qualitative Procedures**
• Coding data by assigning numeric values • Cleaning the database • Recoding or computing new variables for computer analysis • Establishing a codebook	**Preparing the data for analysis**	• Organizing documents and visual data • Transcribing text • Preparing the data for computer analysis
• Visually inspecting data • Conducting a descriptive analysis • Checking for trends and distributions	**Exploring the data**	• Reading through the data • Writing memos • Developing qualitative codebook
• Choosing an appropriate statistical test • Analysing to answer research questions • Reporting inferential tests, effect sizes, confidence intervals • Using quantitative statistical software programmes	**Analysing the data**	• Coding the data • Assigning labels to codes • Grouping codes into themes or categories • Interrelating themes or categories
• Representing results in statements of results • Providing results in tables and figure	**Representing the data analysis**	• Representing findings in discussions of themes or categories • Representing visual models, figures, tables

• Using external standards • Validating and checking the reliability of scores from past instrument use • Establishing validity and reliability of current data	**Validating the data**	• Using researcher, participant and reviewer standards • Employing validation strategies (member checking, triangulation, peer review)

The qualitative analysis consisted of the analysis of the data from the open ended questions, group interviews and reports from the facilitators. These were analysed for themes or categories. These themes or categories were related to the elements of blended learning that provide a supportive learning environment in the ISP. Another researcher was engaged to check that the coding had been done in a consistent way to ensure validity.

Quantitative analysis was done on the pre test and on the post test, the grade 11 results and the grade 12 results, as well as the closed questions of the questionnaire. Statistical tests were used on these data in order to show trends.

5.14. QUALITY CRITERIA

A researcher must be able to demonstrate that the findings are true. In the absence of such verification the research would lack credibility. The bases of a good quality of research are reliability, validity, objectivity and generalisability (Denscombe, 2007).

5.14.1. RELIABILITY

Reliability refers to whether the research instrument is consistent i.e. If the study was repeated would it yield the same results? Interpreted it could be viewed as, having been given the data collected, do the results still make sense?

Reliability has to do with the instrumentation and in qualitative research the researcher is the primary instrument of data collection and analysis. The researcher can become more reliable through different techniques of data analysis and triangulation. There are strategies that can be used to ensure reliability (Merriam, 2002, p27) such as triangulation, peer examination, investigators position and an audit trail. An audit trail describes in detail how the data were collected, coding done and categories arrived at as well as how the decisions were made throughout the research.

5.14.2. VALIDITY

Validity may be determined by asking the question: By using certain methods are we investigating what we say we are investigating (Henning, 2004)? "Validation comes to depend on the quality of craftsmanship during investigation, continually checking, questioning and theoretically interpreting the findings" (Kvale, 1996, p241).

To validate is to check for bias, neglect, for lack of precision and so forth; to question all procedures and decisions critically, to theorise by looking for and addressing theoretical questions that arise throughout the process and to discuss and share research action with one's peers as critical reviewers (Henning, 2004).

5.14.3. OBJECTIVITY

Objectivity refers to the absence of bias in the research and is concerned with the extent to which qualitative research can produce findings that are free from the influence of the researcher. Therefore the research should be impartial and neutral in regard to the researchers influence on its outcome i.e. the data collection and analysis should be fair. A question to be asked is: Is any research free from those who conduct it (Denscombe, 2007, p300)?

> '..the human element of qualitative inquiry is both is strength and weakness - its strength is fully using human insight and experience, its weakness is being so heavily dependent on the researcher's skill, training, intellect, discipline, and creativity. The researcher is the instrument of qualitative inquiry, so the quality of the research depends heavily on the qualities of that human being' (Patton, 1988, p14).

Qualitative data interpretations are therefore a result of the researchers' construction and understandings. Denscombe (2007) suggests that to this end that the researchers "self" needs to be acknowledged and the researcher should strive to keep an open mind when collecting and analysing data. Researchers need to acknowledge that their identity, values and beliefs play a role in the process of analysing qualitative data. A researcher should give a reflexive account in the analysis of qualitative data concerning the researchers self and its impact on the research (Denscombe, 2007). Keeping an open mind can be achieved by not neglecting data that does not fit the analysis and checking any opposing explanations.

5.14.4. GENERALISABILITY

Merriam (2002) contends that generalisability refers to the extent to which the findings of the research may be applied to other research circumstances. It is usually not possible to generalize in qualitative research since small samples are used. However Merriam (2002,

p28) says "... if one thinks of what can be learned from an in depth analysis of a particular situation or incident and how that knowledge can be transferred to another situation, generalisability in qualitative research becomes possible".

5.14.5. STRATEGIES FOR PROMOTING VALIDITY AND RELIABILITY

Researchers and readers want to be able to trust a research study. Researchers need to employ certain strategies to ensure the trustworthiness of their studies. Table 5.8 summarises such strategies (Adapted from Merriam (2002, p31)) used in this research study.

Table 5.8 Strategies for Promoting Validity and Reliability

Strategy	Description
Triangulation	Used multiple sources of data and data collection methods to confirm emerging findings
Member checks	Took the tentative interpretations of the data back to the learners and the facilitators to see if they agreed
Peer review	Process of the research study, congruency of the emerging findings with the raw data and tentative interpretations were discussed with colleagues.
Researchers position	Researcher undertook a critical self reflection with regard to her worldview, assumptions and relationship to this study that would have influence bias and affect this study.
Adequate engagement in data collection	Researcher ensured that adequate data were collected such that the data became saturated.
Maximum variation	Researcher sought diversity when selecting sample for interviews-allows for greater application of the findings by other researchers
Audit trail	A detailed account of the research process carried out in this study has been given
Rich, thick descriptions	Researcher has tried to supply sufficient descriptions to enable readers to determine if this situation matches their research context or whether the findings can be transferred

5.15. ETHICAL CONSIDERATIONS

Many authors agree that a good research is one that is conducted in an ethical way. It is of the utmost importance for researchers to adhere to stringent ethical principles in all stages of their research. It is the researcher's responsibility to protect the participants in the research from harm and ensure their confidentiality.

5.15.1. ETHICAL STANDARDS AND DECISIONS APPLIED TO THIS RESEARCH STUDY

Denscombe (2007, p142) states three core principles that should inform the ethical choices and guide the activities of the researchers. The principles as they were applied in this research study follow.

Principle 1: The interest of the participants should be protected

This research ensured the confidentiality of the participants. Data were kept safe and no personal identities were revealed in the disclosure of the results.

Principle 2: Researchers should avoid deception or misrepresentation

The researcher was honest and made all the processes transparent. The researcher and the participants developed a relationship of trust. The researcher presented the data in a fair and unbiased way.

Principle 3: The participants should give informed consent

Ethical clearance was given by the Research committee of the NMMU. The DOE gave its consent for the researcher to access participants from schools in the Eastern Cape. Copies of these letters appear in the appendices (cf. Appendix A and Appendix C). Written consent was obtained from all the participants and in the case of minors consent was received from their parents. All participation was voluntary and the researcher showed respect for individual responses during interviews.

5.15.2. ETHICAL CONSIDERATIONS SPECIFIC TO ACTION RESEARCH

The activities of other colleagues may be scrutinised as a result of their activity linked to that of the practitioner who instigates the research (Denscombe, 2007, p128).

There is a notion that the action researcher is not required to gain consent from authority to conduct the research. However usual standards of ethics must be upheld when dealing with the personal information of others.

5.16. LIMITATIONS OF THE STUDY

There are some limitations inherent in this study. A researcher needs to acknowledge such limitations if they exist and to take actions to address them. The qualitative analysis is based on the thinking and decisions of the researcher and therefore this study was limited by researcher subjectivity. Researcher bias was therefore a justifiable concern.

The interviews were conducted by the researcher, and the participants knew her as a facilitator of the ISP. Their relationship with her in this position may have influenced what they said during the interviews. Either they would have tried hard to say what they thought she wanted to hear; or alternatively, they could have been less open in their responses. In an attempt to eliminate bias, the researcher sought the help of colleagues in checking the coding of the data.

The researcher's lack of experience as an interviewer may have been a limitation in this study. In addition this research is based on one year's results only and a limited number of quantitative results were obtained.

5.17. CONCLUSION OF THE CHAPTER

In this chapter a detailed description of the research methodology employed in this research study was given. A case study design with mixed methods was followed to explore the use of DVD technology within a blended learning environment. The research study employed a case study design within an action research design in keeping with the cyclical nature of this research project.

The participants comprised 194 learners and their facilitators of the 2009 ISP. A mixed methods methodology was employed to collect and analyse the data. The data were collected from questionnaires, interviews, pre tests and post tests, weekly attendance

reports, weekly test results, grade 11 and grade 12 mathematics final results of the participants, as well as those of their counterparts from their respective schools, who did not participate in the 2009 ISP.

Analysis of the data revealed themes in response to the research question and the sub questions. By comparing these themes with the literature reviewed, interpretations and conclusions were arrived at.

CHAPTER SIX : AN ANALYSIS OF THE DATA AND PRESENTATION OF THE FINDINGS

6.1. INTRODUCTION

The purpose of this case study was to explore the teaching and learning of mathematics in the 2009 ISP in order to explore how the use of DVD technology within a blended learning environment of the 2009 ISP supported mathematics learning. The researcher had the conviction that a better understanding of the learners' perception of how these different elements supported learning would feed into the next cycles of the action research project and would serve to improve the programme with regard to the design and facilitation of the ISP.

This chapter reports on the analysis and findings of the qualitative and quantitative data obtained in this study. As a result of the qualitative analysis, the pre test (questions 1-7), open ended questions of the questionnaires, group interviews, and facilitators' reports are discussed. The quantitative analysis involved closed questions in the questionnaire, grade 11 versus the grade 12 mathematics results of the participants and a comparison of six schools where the grade 11 versus grade 12 mathematics performance of the participants and non participants of the ISP was compared. In addition, an analysis of participants' weekly tests and the attendance of the participants were integrated.

The chapter then presents the major research findings as they relate to the main research question:

> ***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?***

And the sub questions:

1. **How did the elements present in the DVD driven approach support the teaching and learning of mathematics?**
2. **How do learners experience this blended learning approach?**
3. **What impact on learners mastery of mathematics has the approach made?**

6.2. RESEARCH PARTICIPANTS

Four hundred grade 12 learners from schools in the surrounding Port Elizabeth area made application to be part of the 2009 ISP. One hundred and ninety seven learners were selected to be part of the ISP based on their final grade 11 mathematics results. Fifty learners dropped out of the programme or were excluded because of poor attendance (learners who missed three consecutive classes were excluded from the programme). The remaining one hundred and forty seven learners and the three facilitators of the three groups formed the participants in this research study.

The pre tests were completed by one hundred and forty two learners, one hundred and fifteen learners completed the post test and one hundred and nine learners completed the questionnaire. Three groups of nine, thirteen and eleven learners participated in the three group interviews. Three facilitators involved in the 2009 ISP completed the facilitators' report.

The following table depicts demographic information based on the participants who completed the questionnaire:

Table 6.1 Demographic profile of participants

Age		**Gender**		**Home Language**		**Grade 11 Maths Marks (%)**	
16	3 (3%)	Female:	53 (49%)	Afrikaans	4 (4%)	0-39	1 (1%)
17	68 (62%)	Male:	56 (51%)	English	19 (17%)	40-49	7 (7%)
18	24 (22%)			Xhosa	85 (78%)	50-59	35 (33%)
19	10 (9%)			Zulu	1 (1%)	60-69	32 (30%)
20	3 (3%)					70-79	20 (19%)
21	1 (1%)					80-89	6 (6%)
						90-99	4 (4%)

Table 6.1 indicates that there was a more or less even gender split (53 female and 56 male) amongst the participants. The majority of the students were 17 and 18 years old (68 were 17 years old and 24 were 18 years old). This is the average age for grade 12 learners in South Africa. The majority of the participants indicated Xhosa as their home language (85 participants had Xhosa as their home language), Xhosa being the language of the indigenous people of the Eastern Cape. The grade 11 mathematics marks of the majority of the participants fell in the categories 50%-59% (35 learners), 60%-69% (32 learners), and 70%-79% (20 learners).

6.3. THE PRE TEST AND POST TEST

The intention of the researcher in designing and administering a pre test to the 2009 ISP cohort was firstly to gauge the learners' perceptions and feelings in regard to their mathematics learning and their understanding of mathematics and secondly to determine their prior knowledge of mathematics concepts. The former was used to determine what needs existed for the presentation of such an intervention and whether learners realised that such a need existed. The intention of the latter was to facilitate the grade 12 mathematics concepts more effectively, taking into account those mathematics concepts that needed attention, as highlighted by the results of the pre tests.

A third intention of the researcher was to make a comparison between the results of the pre test and those of the post test, to determine what progress had been made in the learners' mathematical knowledge. The post test consisted of twenty questions based on mathematics concepts covered in the ISP.

6.3.1. LEARNERS' PERCEPTIONS AND KNOWLEDGE PRIOR TO THE ISP

The first seven items of the pre test were statements relating to the participants' perceptions of the mathematics teaching and learning at school, their feelings towards mathematics as a subject, the resources used for mathematics teaching and learning and their understanding of mathematics. Participants were asked to rate the statements on a 5 point Likert scale where 1 is strongly disagree, 2 is disagree, 3 is neutral 4 is agree and 5 is strongly agree.

6.3.1.1. Learners' Perceptions Prior to the ISP

The statements, learners' responses and their means are illustrated in Table 6.2.

Table 6.2 Perceptions of Learners'

Statements	Mean	S.D	Negative	Neutral	Positive
I enjoy Mathematics.	4.21	0.76	2 (1%)	19 (10%)	162 (89%)
I like the way Mathematics is taught at my school.	3.94	0.84	8 (4%)	21 (12%)	153 (84%)
I feel I understand Mathematics well.	3.92	0.78	7 (4%)	39 (19%)	136(75%)
The textbook we use at school helps me to understand Mathematics better.	4.35	0.99	19 (11%)	35 (19%)	126(70%)
My teacher helps me to understand Mathematics better.	3.58	0.75	4(2%)	15 (8%)	163 (90%)
I feel nervous about some sections in Mathematics.	4.74	1.04	23 (13%)	59 (32%)	101 (55%)
I believe that more resources (books, examples, tutorials and DVDs etc) will help me to improve my Mathematics.	3.75	0.66	4 (2%)	5 (3%)	173 (95%)

The responses were divided into categories that were negative (strongly disagree and disagree combined), neutral and positive (agree and strongly agree combined). The statement which received the most positive response was "I believe that more resources (books, examples, tutorials and DVDs etc) will help me to improve my Mathematics". At this point it is important to note that all learners on the ISP attend schools where a predominately traditional approach to teaching and learning mathematics was practiced.

This traditional approach involves the teacher presenting a lesson on the chalkboard and learners being assigned problems from a prescribed textbook. Seeing that the teacher is central to this teaching and learning process it is therefore understandable that the next most positive statement was "My teacher helps me to understand Mathematics better".

The researcher wishes to note that having only experienced traditional classroom teaching learners may not have been aware at that point of any other possibilities of teaching and learning such as the use of technology within a blended learning environment. In addition

having only been accustomed to this learning environment learners may not have been adequately informed to perceive any shortcomings in their present learning environment, assuming that they existed. A large majority of the learners (89%) said that they enjoyed mathematics while three quarters of the learners (75%) said that they understood mathematics. However 55% said that they were nervous about some sections in the mathematics syllabus.

6.3.1.2. Learners' Knowledge of the Concepts Prior to the ISP

The next section of the pre test involved 19 multiple choice questions based on the mathematics concepts that participants would have covered in their grade 11 syllabus. The first five statements of the first section of the pre test pertained to how learners perceived their experience of mathematics teaching and learning at school. Whilst the learners' responses to these statements inclined towards being positive as shown in Table 6.2, it was surprising that the mean score for the pre test on closed mathematics questions was 36.38%. The graph in Figure 6.1 illustrates how the learners scored on this section of the pre test.

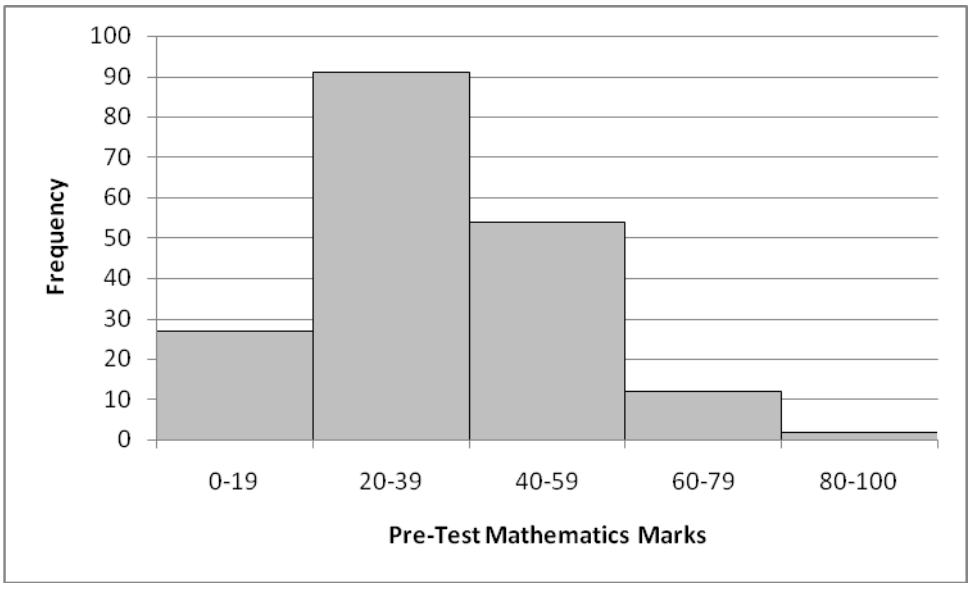


Figure 6.1 Graph of Learners' Scores on the Mathematics part of the Pre test

One hundred and eighteen learners (63%) scored below 40 % in the mathematics section of the pre test whilst twelve learners (6%) scored between 60% and 79% and only two learners (1%) scored 80 and above. The researcher would like to point out at this stage in comparison that only 1 learner (1%) obtained below 40% in their grade 11 mathematics examinations. Note should also be taken of the fact that the pre test covered concepts learners should have encountered in their grade 11 year. Interpretations of this will be discussed in 7.2.3.1.

6.3.2. PROGRESS OF THE LEARNERS

Although the pre test covered grade 11 concepts handled at school and the post test covered grade 12 concepts dealt with on the 2009 ISP, a comparison of the two tests is useful to see if there had been any progress in mathematics made by the learners since writing the pre test. Figure 6.2 illustrates how learners scored on the two tests.

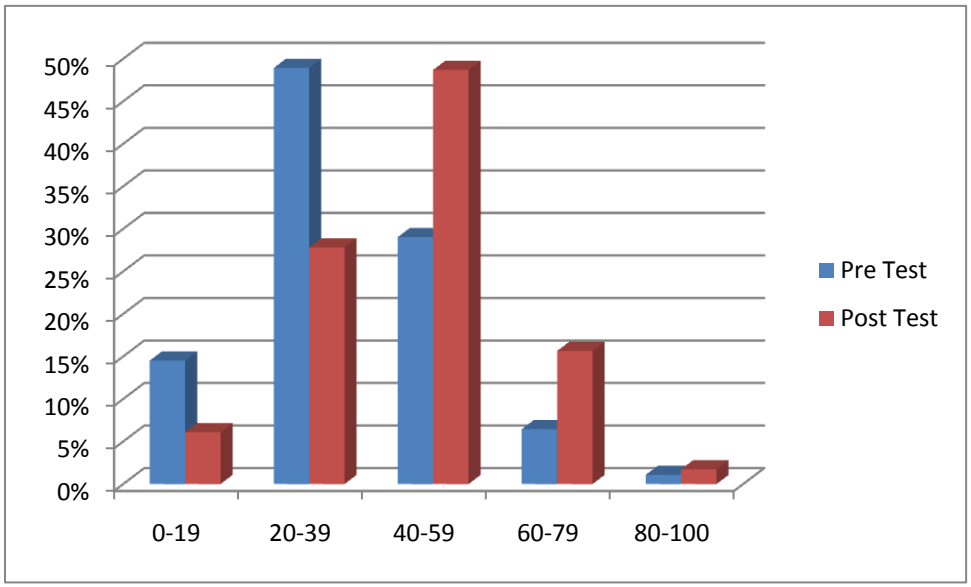


Figure 6.2 Comparison of Pre and Post test Scores

Whilst it was worrying to note that the most densely populated category in the pre test was the 20 to 39 category, the 40 to 59 category was the most populated category with regard to the post test. The 0 to 19 category decreased from 15% to 6% and the 20 to 39 category decreased from 49% to 28% whilst the categories 40 to 59; 60 to 79 and 80 to 100 increased from 29% to 49%, 6% to16% and 1% to 2 % respectively. Also noteworthy is that 64% of the learners who wrote the pre test scored below 40% whilst only 34 % of learners who wrote the post test scored below 40%.

In order to ascertain whether there had been an improvement in learners' performance from the pre test to the post test the researcher looked at the difference between the two scores as follows:

$$\text{Improvement} = \text{Post test mark} - \text{Pre test mark} \qquad \text{(Equation 6.1)}$$

Seventy three (65%) of the one hundred and twelve learners who wrote both the pre test and the post test showed an improvement with a mean improvement score of 17. The highest improvement score was 48.

6.4. ATTENDANCE

Although attendance to the ISP was not compulsory, there was a rule that stated that if a learner was absent for three consecutive sessions that would constitute an exclusion from the programme. The rationale for this was that since there were 14 sessions the learner's absence from three consecutive sessions would set them far behind in terms of the concepts covered and on their return, they would be unable to understand further concepts that were rooted in the previous lessons. In addition the learner having missed three consecutive sessions would have not participated in four assessments.

Table 6.3 shows the attendance percentage of the participants.

Table 6.3 Attendance on the ISP

Attendance %	Number of participants
57-69	18 (12%)
70-79	26 (18%)
80-89	16 (11%)
90-99	42 (29%)
100	45 (31%)

In spite of attendance not being compulsory, attendance was good on the ISP. The majority of the participants (60%) had a very good attendance rating (90%-100%). The researcher assumes that the good attendance could be an indication of the commitment levels of the learners and their belief that they were deriving benefit from their attendance to the ISP. This is substantiated by learners' responses to questions on the questionnaire as well as in the interviews.

Learners reported on their experience of the ISP that they felt motivated to learn, they had increased their confidence in mathematics and that they had developed a positive work ethic since attending the ISP. Besides the teaching and learning of mathematics on Saturdays they were encouraged by the resources (hard copies of lessons, tests, tutorials and DVDs of topics in mathematics) that they had received. It should also be noted that some learners enjoyed the environment of the ISP and said that being on the ISP had made them feel like young adults. Many reported that it was a relaxed atmosphere where they were not afraid to ask questions and had been encouraged to participate.

6.5. QUESTIONNAIRES

A questionnaire was designed to collect biographical information as presented in 6.2 and to determine how the learners had experienced the Incubator School Project, what factors provided a supportive learning environment in this model and what impact/improvement in learners' mathematical ability the model had made. The questionnaire was completed by learners at the end of the programme (c.f. 5.10.1.1).

6.5.1. LEARNERS' EXPERIENCES OF THE ISP: A QUANTITATIVE ANALYSIS

Participants were required to rate statements in the categories lectures, tutorials, materials, assessment, facilitators/tutors, assessment of the learning environment and improvement in different mathematics sections. Participants were asked to rate the statements of six categories on a 5 point Likert scale where 1 is strongly disagree, 2 is disagree, 3 is neutral 4 is agree and 5 is strongly agree. Participants rated the seventh category with 0 for no improvement, 1 for a small improvement, 2 for moderate improvement and 3 for a large improvement.

Learners were required to rate statements under each category and the researcher grouped the responses for strongly disagree and disagree as negative, neutral and strongly agree and agree as positive. The items in the tables illustrating these responses were ranked according to how positive the response was in descending order.

Lectures:

Learners were presented with eight statements pertaining to lectures and asked to rate these. The statements covered such aspects as learners' attendance, learners' benefit, teaching style, group size, participation and enjoyment level (see Table 6.4).

Table 6.4 Descriptive statistics for Lectures

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**Negative**	**Neutral**	**Positive**
Q1.1 I attended the lectures regularly	106	4.62	0.76	2 (2%)	2 (2%)	102 (95%)
Q1.2 I benefitted from the lectures presented	106	4.49	0.64	1 (1%)	5 (5%)	100 (94%)
Q1.5 The teaching style was different from what I experienced at school	106	4.46	0.89	4(4%)	10 (9%)	92 (87%)
Q1.7 The different methods of presentation used in one lesson were useful	106	4.25	0.78	4 (4%)	10 (9%)	92 (87%)
Q1.8 The group size was right	106	4.21	0.81	3 (3%)	17 (16%)	86 (81%)
Q1.3 I enjoyed the lessons presented	106	4.17	0.82	4 (4%)	16 (15%)	86 (81%)
Q1.4 I participated in the class discussion	106	3.61	1.00	13 (12%)	36 (34%)	57 (54%)
Q1.6 I preferred the teaching style to that used in school.	106	3.30	1.22	22(21%)	33 (31%)	51 (48%)

Ninety five percent of the learners said that they had attended lectures regularly, while 94% of the learners reported that they had benefitted from the lectures. It is noteworthy that only 54% of the learners said that they had participated in class discussions. Although 92% of the learners found the different methods of presentation in one lesson useful, only 48% of the learners preferred the teaching style of the ISP to that used in school.

Tutorials

Learners were presented with five statements pertaining to tutorials and asked to rate these. Statements covered whether learners found tutorials integrated with lectures helpful and enjoyable and how useful they found the DVDs to be during the tutorials (see Table 6.5).

Table 6.5 Descriptive statistics for Tutorials

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**Negative**	**Neutral**	**Positive**
Q2.1: Tutorials were helpful to my learning	108	4.51	0.65	1 (1%)	6 (6%)	101 (94%)
Q2.5: The additional exercises improved my understanding of maths	108	4.49	0.75	2 (2%)	8 (7%)	98 (91%)
Q2.2: Tutorials were useful	108	4.33	0.91	6 (6%)	8 (7%)	94 (87%)
Q2.4: I found the DVDs helpful during tutorials	108	4.31	0.76	2 (2%)	13 (12%)	93 (86%)
Q2.3: Having the tutorials during lecture time made the lessons enjoyable	108	4.19	0.87	4 (4%)	20 (19%)	84 (78%)

In general, the learners' responses were positive with regard to the statements relating to tutorials. Ninety four percent of the learners found the tutorials helpful to their learning while 91% said that the additional exercises had improved their understanding of mathematics. In addition 86% of the learners found that the DVDs were helpful during the tutorials.

Materials

The learners were presented with six statements pertaining to materials, and asked to rate these. Statements covered whether learners found materials easy to access, and whether this clarified their understanding of mathematics (see Table 6.6).

Table 6.6 Descriptive statistics for Materials

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**Negative**	**Neutral**	**Positive**
Q3.3: I found that having many different resources was a good idea	107	4.71	0.64	1 (1%)	5 (5%)	101 (94%)
Q3.1: The materials I received helped make Maths clearer	107	4.51	0.72	3 (3%)	5 (5%)	99 (93%)
Q3.6: The DVDs were well presented	107	4.27	0.93	5 (5%)	11 (10%)	91 (85%)
Q3.4: The freedom to access the resources at my own pace helped me	107	4.25	0.89	4 (4%)	14 (13%)	89 (83%)
Q3.2: I found accessing the DVD easy	107	4.22	0.86	3 (3%)	15 (14%)	89 (83%)
Q3.5: The DVDs were clear	107	4.15	0.90	5 (5%)	15 (14%)	87 (81%)

The learners responded positively to the statements in the category materials. They (94%) found that access to different resources was a good idea, while 93% of the learners believed that it made mathematics understandable for them. It should be noted should be taken that 81% (lowest score under the factor 'materials') of the learners believed that the DVDs were clear, thereby suggesting room for improvement of the DVDs, or that some mechanism should be put in place to address and clarify such issues when they arose.

Assessment

The learners were presented with four statements pertaining to assessment; and they were asked to rate these. Statements covered whether learners coped with regular tests and found them useful, found the marking of the tests fair and found the detailed solutions helpful in their understanding of mathematics (see Table 6.7).

Table 6.7 Descriptive statistics for Assessment

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**Negative**	**Neutral**	**Positive**
Q4.3: The detailed solutions to tests were helpful	108	4.25	0.87	4 (4%)	12 (11%)	92 (85%)
Q4.1: Regular tests helped me keep up with the work	108	4.01	0.98	5 (5%)	24 (22%)	79 (73%)
Q4.4: the marking of test were fair	108	3.77	1.11	14 (13%)	24 (22%)	70 (65%)
Q4.2: I coped well with the amount of work I had to study for each test	108	3.28	1.06	25 (23%)	37 (34%)	46 (43%)

The assessment category had the lowest mean of all the categories (c.f. Table 6.12) and the lowest overall percentage of positive responses (75%). Although learners (85%) found that the detailed solutions to the tests were helpful, it is important to note that only 43% of the learners said that they had coped well with the amount of work assigned for study for each test. In fact more learners (62%) were negative or neutral with this regard. Only 13% of the learners disagreed with the statement that the marking of the tests was fair.

Facilitators and Tutors

The learners were presented with eight statements pertaining to the facilitators and the tutors and asked to rate these. The statements covered issues such as whether the learners thought that their facilitators and tutors had stimulated their interest in mathematics and had helped in their understanding thereof. Learners were also asked to rate how they found their communication with both their facilitators and tutors (see Table 6.8).

Table 6.8 Descriptive statistics for Facilitators and Tutors

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**Negative**	**Neutral**	**Positive**
Q5.2: The facilitator used the different resources well.	103	4.21	0.78	3 (3%)	13 (13%)	87 (84%)
Q5.5: The facilitator helped me to understand mathematics better	103	4.21	0.84	3 (3%)	15 (15%)	85 (83%)
Q5.6: The tutors explained concepts clearly	103	4.17	0.84	4 (4%)	14 (14%)	85 (83%)
Q5.3: The facilitator explained concepts clearly	103	4.12	0.91	7 (7%)	16 (16%)	80 (78%)
Q5.7: I found it easy to communicate with the tutors	103	4.02	0.91	4 (4%)	26 (25%)	73 (71%)
Q5.1: My interest in Maths was stimulated by the facilitator	103	3.98	0.95	8 (8%)	20 (19%)	75 (73%)
Q5.8: My interest in Maths was stimulated by the tutors	103	3.78	0.97	9 (9%)	29 (28%)	65 (63%)
Q5.4: I found it easy to communicate with the facilitator	103	3.73	1.10	12 (12%))	29 (28%)	62 (60%)

The most positive responses related to the facilitators efficient use of different resources (84%) and the facilitators role in helping learners understand mathematics better (83%). It is interesting to note with regard to the explanation of concepts clearly, a greater percentage of learners 83% thought that the tutors were effective whilst 78% of the learners found that the facilitators were effective. In addition learners found it easier to communicate with tutors (71%) than they did with the facilitators (60%).

Learners' assessment of the learning experience

Learners were presented with seven statements pertaining to their assessment of the learning experience and asked to rate these. Statements were made of the value of such learning, learners' motivation to attend, their self confidence, improvement in their mathematics understanding and their enjoyment of such an environment (see Table 6.9).

Table 6.9 Descriptive statistics for "Your assessment of the learning experience"

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**Negative**	**Neutral**	**Positive**
Q6.3: I see great value in this type of learning for other learners	109	4.67	0.61	1 (1%)	2 (2%)	106 (97%)
Q6.1: I enjoyed this learning environment	109	4.55	0.83	5 (5%)	3 (3%)	101 (93%)
Q6.2: I felt motivated being there.	109	4.53	0.82	4 (4%)	8 (7%)	97 (89%)
Q6.7: I have developed a better understanding of Maths	109	4.42	0.72	2 (2%)	9 (8%)	98 (90%)
Q6.5: My self-confidence with regard to Maths has improved.	109	4.40	0.84	4 (4%)	13 (12%)	92 (84%)
Q6.6: My ability to do maths has improved.	109	4.38	0.74	2 (2%)	11 (10%)	96 (88%)
Q6.4: I have made progress in Maths	109	4.30	0.89	3 (3%)	19 (17%)	87 (80%)

The responses with regard to learners' assessment of the learning experience were very positive. The most positive responses (97% of the learners) said that they saw great value in this type of learning for other learners. It is interesting to note that this statement received the highest positive response overall in the questionnaire. Ninety three percent of the learners said that they enjoyed the learning environment, whilst 89% felt motivated to be there. Eighty percent of the learners believed that they had made progress in mathematics.

Improvement

Learners were presented with the six sections of the grade 12 mathematics syllabus and asked to rate their improvement for each section. Responses were made on a four point scale with 0 for no improvement, 1 for a little improvement, 2 for moderate improvement and 3 for a large improvement. For the purposes of the Table 6.12 the researcher decided to group the first two points in the scale together and reported them accordingly (see Table 6.10).

Table 6.10 Descriptive statistics for Improvement

				Frequency Distribution of Item Responses		
Item	**n**	**Mean**	**SD**	**None/Little**	**Moderate**	**Large**
Q7.3 Transformational Geometry	109	2.55	0.66	10 (9%)	29 (27%)	70 (64%)
Q7.2 Analytical Geometry	109	2.45	0.66	8 (7%)	43 (39%)	58 (53%)
Q7.5 Algebra	109	2.41	0.67	9 (8%)	45 (41%)	55 (50%)
Q7.4 Calculus	109	2.36	0.79	17 (16%)	34 (31%)	58 (53%)
Q7.6 Financial Mathematics	108	2.04	0.81	25 (23%)	50 (46%)	33 (31%)
Q7.1 Trigonometry	109	2.02	0.85	28 (26%)	46 (42%)	35 (32%)

The largest number 70 (64%) of learners reported that a large improvement had been made in Transformational Geometry while the smallest percentage of learners (32%) reported a large improvement in Trigonometry. The two items that learners reported little or no improvement were in Financial Mathematics and Trigonometry. This would suggest some room for improvement with regard to the presentation of the concepts on the DVDs as well as facilitation of these concepts in the f2f sessions.

The internal consistency of the summated scores is given by Table 6.11.

Table 6.11 Internal Consistency of Summated Scores

Factor	n	Cronbach's α
F1-Lectures	106	0.56
F2-Tutorials	108	0.79
F3-Materials	107	0.84
F4-Assessment	108	0.73
F5-Facil/Tutors	103	0.87
F6-RatingLE	109	0.90
F7-Improvement	108	0.67

Cronbach's alpha coefficients greater than 0.70, the recommended minimum value for reliability (Nunally, 1978), were observed for most factors, with the exception of Lectures (0.56) and Improvement (0.67) with values in the range 0.56 to 0.90. Nunally argued that in the early stages of basic research, coefficients between 0.50 and 0.69 were indicative of sufficient evidence to assume adequate reliability. For the purpose of this basic exploratory study, a cut-off value of 0.50 was used to indicate adequate reliability. The observed Cronbach's alpha coefficients relating to the factors all exceeded this cut-off point, thus confirming the reliability of the summated scores derived from the individual measuring instruments.

Table 6.12 illustrates descriptive statistics for each of the factors, as they appeared in the questionnaires (see Appendix E).

Table 6.12 Descriptive statistics for Factor Scores

									Freq. Distribution of Factor Scores			
Factor	**n**	**Mean**	**SD**	**Min**	**Q1**	**Median**	**Q3**	**Max**	**Neg.**	**Neutral**		**Pos.**	
F1-Lectures	109	4.12	0.45	2.13	4.50	4.13	3.88	5.00	1 (1%)	3	3%	105	96%
F2-Tutorials	109	4.36	0.59	1.80	4.80	4.40	4.00	5.00	1 (1%)	3	3%	105	96%
F3-Materials	109	4.34	0.62	1.17	4.83	4.50	4.00	5.00	3 (3%)	0	0%	106	97%
F4-Assessment	109	3.83	0.75	1.25	4.50	3.75	3.50	5.00	7 (6%)	20	18%	82	75%
F5-Facil/Tutors	109	4.01	0.66	1.63	4.38	4.13	3.63	5.00	3 (3%)	9	8%	97	89%
F6-RatingLE	109	4.47	0.62	1.71	5.00	4.71	4.14	5.00	3 (3%)	5	5%	101	93%
F7-Improvement	109	2.30	0.46	0.50	2.00	2.33	2.67	3.00	4 (4%)	8	7%	97	89%

The frequency distribution of factor scores was strongly positive for all the categories. Learners' responses were the most positive (97%) on the category "materials" and the categories "lectures" and "tutorials" elicited the next most positive responses (96%) from learners. The category that obtained the least positive responses (75%) was "assessment".

6.5.2. LEARNERS' EXPERIENCES OF THE ISP: A QUALITATIVE ANALYSIS

The researcher read and reread the data emanating from the open ended questions in the questionnaire, in order to get a sense of the whole picture. These data was then broken up into comments, statements and ideas. These were then grouped together or collapsed into key ideas. The researcher then searched for patterns amongst these key ideas and thereafter these were grouped as themes. This process is illustrated in Table 6.13.

6.5.2.1. Coding of Open Questions

Table 6.13 presents the level one coding, level two coding and the themes that arose as a result of the analysis of the learner responses to open ended questions in the questionnaire. Level one coding represents the actual comments, statements or ideas that originated from the open ended questions of the questionnaire. During the level two coding key ideas are presented as a result of the action of grouping of the comments, ideas and statements that

resulted from the level one coding. Finally as a culmination of the coding process, the themes are presented. The themes were informed by Thompson and Wheeler (2008).

Table 6.13 The Coding of Open Questions of the Questionnaires

Level 1 Coding **comments/statements/ideas**	**Level 2 coding** **Key Ideas**	**Themes**
Food	Physical needs	Physical Learning Environment
Money for transport		
Spacious and clean room, bright environment, conducive to learning in groups	Venue	
Developed good work ethic	Improvement	Intellectual learning environment
Confidence increased		
Fear of maths eased		
Increased my maths understanding		
Increased my maths knowledge		
Got more information on concepts	Extended Knowledge	
Learned new problem solving skills		
Learned maths outside the school syllabus		
Clear outcomes were given	Learning environment	
Expectations were given		
Friendly facilitators/tutors/learners		
Free to ask questions/engage in discussion		
Caring/loving environment		
Individual attention for problem areas		
Big classes were uncomfortable		
New concept	DVD as resource	
New way of learning		
Interesting/fun		

Used it to review work at home		
Used at own pace		
Clear step by step explanations		
New problem solving skills		
Alternate methods of solving		
DVDs too long		
Missing steps led to confusion		
Needed facilitator to explain		
Hard copies were convenient	Other resources	
All solutions given helped		
Extra exercises		
Stationery		
Clear and precise	Presentation	
Well prepared		
Fun, enjoyable		
Lively discussion		
Cared that each learner understood		
Concentrate for too long		
Not enough tutorial problems done		
Need to be more hands on		
Extend the time		
Additional explanations		
Too much work in one session		
Tutors helpful	Interaction	
Facilitators helpful		
Facilitators enthusiastic		

Facilitators approachable/easy to communicate		
Learned new skills from other learners		
Other learners friendly		
Good competition amongst the learners		
Motivated each other		
Compared with each other		
Good to be amongst those passionate about maths		
Face to face learning	New ways of teaching and learning	
DVDs		
Resources		
Discussion/tutorials		
No learner left behind		
Tests-too long, too short time, good, tricky	Assessment	
Solutions on DVDs helped check my learning		
Longer tests once a month		
Extra exercises helpful	Additional work	
Allowed me to practise more		
Preparation for tests improved understanding		
Advantage when concepts are covered before covered in school		
Concepts were related to everyday life e.g. financial mathematics, exponential growth and decay	Related to real life	
Too much work in short time	Conflict	
Added to school burdens/other learning areas to consider/other tests to write		
Often other concepts taught at school at the same time - not in sync		
Learning for tests and viewing DVDs time consuming		

Facilitators helped motivate us in reaching goals	Mentoring	Emotional learning environment
Provided guidance with regard to career options and university entrance		
Advised on work ethic and time management		
Contact people who are underperforming/failing tests		
Clear expectations for behaviour	Discipline	
Clear distinction between work and play		
Facilitators and tutors motivated us to do well	Motivation/ Confidence building	
Fear of maths eliminated		
Increased confidence to write finals		
Good to meet learners from different schools	Social issues	
Shares ideas and methods		
Need to have bonding session		

6.5.2.2. Discussion of Open Questions

Based on the analysis and the synthesis of the data collected from the open ended questions in the learners' questionnaires the following themes emerged:

Physical learning environment

Physical needs

Many Learners said that they appreciated the money that they had received for travelling and that as a result they had no need to worry about how to get to the ISP. Learners also said that they were grateful for the lunch provided and a few said that they "... thought it was good food".

Venue

A few learners mentioned that the venue enabled them to work effectively on Saturdays. The venues used were at the Missionvale Campus of the NMMU. This campus was convenient to access for the majority of the learners, as their schools and homes were in the closely neighbouring areas. The venues were large with no fixed seating and had a

blackboard and two screens one for the DVD projection and the other for PowerPoint projection. Learners noted that the venue was, “well organized and run professionally” and that, “The venue selected helped improve work ethic and made it easier to fall into and adopt work minded attitude”

Intellectual learning environment

Improvement:

In general, learners reported an improvement in their learning style, understanding, confidence, motivation, marks and problem solving skills. Learners believed that their way of learning mathematics and their problem solving skills had improved as one learner said “It has improved my learning style on mathematics and improved my skills on solving problems... this programme inspired me that maths is not a difficult subjects that I thought it was”. Their confidence in the subject improved and their fear was alleviated. One learner wrote about his improvement as a result of attending the ISP: “The programme helped a lot to me because my maths marks were around 40-50% but today I am proud to say I am 90% at maths, and it is because of this programme and all the people who helped me to succeed”. Learners also said that collaborative work with other learners had improved their mathematics and one learner said: “Chance to improve my mathematical abilities; explore different types of career fields. Improved my self confidence ... opportunity to work with than different people”

Extended Knowledge:

Learners felt that they had received more information on concepts and that this had increased their understanding. In addition they said that they had learnt concepts that were outside the syllabus, and they had also learnt new problem solving skills.

The Blended Learning Environment:

Most of the learners agreed that the DVD was a useful resource and also expressed appreciation for the blended environment within which this was embedded. They appreciated facilitators and tutors providing explanations and discussions, while pausing the DVD. They needed the facilitators’ explanations to bridge gaps where the DVD skipped steps, or where they had problems in understanding. According to the learners, tutors, facilitators and discussions with other learners had helped them view concepts from multiple angles.

Learners felt that their English proficiency had improved as a result of the blended learning approach. Only one learner suggested providing the DVDs in his mother tongue, an issue that is always contentious as there are eleven official languages in South Africa of which English is the lingua franca. Learners said that they liked the way the ISP presentations had blended the tutorials, DVDs and discussions, and that this had made it easier for them to concentrate for longer periods.

The point made by almost all learners was the ease with which learners could view the DVD and replay and pause whenever they wanted to. A few learners also said that their teacher had used these DVDs at their schools to teach certain topics such as calculus. Some learners formed study groups and watched the DVDs in their study groups over the weekends. The blended learning approach using DVDs presented a new way of learning mathematics for the learners and most of them were positive that the method had benefited their understanding of the subject. The approach had allowed them the freedom to access a variety of different resources, allowed them to work at their own pace and allowed them to revise at home.

Some learners noted, however, that at first they had needed to adjust to this new learning environment but once they had adjusted they could see the advantages of being exposed to different modes of delivery. The majority of the learners agreed that this blended environment of teaching and learning mathematics fostered a deeper understanding of the subject for them. The most important point raised by learners was the fact that the DVDs alone were not sufficient to ensure success. They believed the DVDs together with the facilitators' and tutors' explanations and discussion coupled with the hard copy resources comprised the best blended approach for learning mathematics.

One learner said that the facilitator did not explain concepts on the DVD and that she found it difficult to communicate with the facilitator. Some learners said that the facilitator needed to "encourage discussion amongst learners more".

DVD as a resource:

Learners were positive in general about the DVDs as a resource. Learners felt that the concepts were presented well and that explanations of the mathematical concepts were done well. The DVD was particularly useful to them in sections that required visual representation (graph drawing) and in certain topics that were not well presented at school for example, calculus, since as one learners said it was "not done well" at school. Many learners said that they found mathematics easy to understand because of the many examples and illustrations on the DVDs. A few learners said that they found it easier to concentrate as opposed to having someone standing in front explaining what to do. Others found it difficult to concentrate, using the DVD approach. One learner said that it was easy

to “move your concentration elsewhere” unless you had a lecturer to intervene with discussion or explanations.

Many learners said that the DVD approach had given them more insight than their school attendance provided and that they had found it helpful for understanding concepts to do a section on a DVD during a Saturday session before it was done at school. Learners also used the DVD to “test and check” their understanding of a particular concept. They found that the DVD series was a good resource to consult when faced with homework or in preparation for a test or examinations. Many learners said that the DVDs allowed them to learn at their own pace and to watch a section “over again” until they understood the concepts. This was substantiated by their comments “It helped to go watch it again if your have missed something in the class” and “I have DVDs at home so that I can go and look at the work that I don’t understand”.

It was encouraging that many learners reported on watching the DVDs at home and revising together with the resource material. This approach had helped to enhance their understanding and supported the effectiveness of the additional small learning cycle as shown in Chapter Three, illustration 3.2. Learners said that “The teaching style with the DVDs were the most positive- helped me in improving my maths marks” and “The new way of presenting lessons by DVDs and other resources not used at school and the fact that the programme (facilitators and tutors) really seemed to care about us”

Constructive criticism came from learners as they felt that some of the DVDs did not illustrate every step of a mathematical problem and that this could lead to confusion. They asked for more detail and more examples on the DVDs. Learners also reported that the notation on some of the DVDs was different to that used in their schools and that caused confusion. In addition they said that a different method of problem solving to the one they were accustomed to was used in some instances. They suggested that the DVD should cover more than one technique to solve a particular problem. One learner also suggested the use of more voice explanation on the DVD since “I have no one to ask when I am alone at home watching the DVD”.

Other resources

Learners found that hard copies of lectures, tutorials and solutions, tests and solutions and extra exercises and solutions “were convenient” and “Resources used helped us study they really made a difference to the way I used to study before”.

Presentation:

Most of the learners said that the presentation of the ISP was clear and precise and that the "The facilitators took time explaining certain parts of the DVD". Learners also said that they enjoyed the f2f sessions because the discussions were lively and that the "lessons were fun".

Learners said that the positive reason for getting there every Saturday was "Getting to class every Saturday and sitting in on a well prepared lesson". Learners felt that the career guidance was useful and said "This project was not only helpful to us with regards to school work but also introducing us to the fields of study we would like to pursue next year, offered some guidance". Particularly useful to learners was "Learning certain sections before learning them at school it was easier to understand things at school with this background knowledge".

However some learners said that they felt that the lessons could be more hands on with more time to work on tutorials and more time for discussion.

Interaction:

The majority of the responses indicated that the facilitators ("We weren't scared to talk to the facilitators") and tutors were helpful, enthusiastic and approachable as one learner said "I would say that the lecturers were the most positive aspects of the programme because you really couldn't do anything without them, the fact that they were patient and filled with lots of enthusiasm made me wake up every Saturday and attend their classes". The learners were in particular positive about the tutors' involvement in the ISP and said "The fact that there were students helping the facilitators helped a lot. It was easy to ask them anything that seemed unclear and they were always able to help me".

Most learners said that they found other learners on the programme friendly and that this interaction had benefitted them for the following reasons: They learnt new skills from them, motivated each other, compared work with each other, "They were good competition", "Being able to compare yourself to other students from other schools" and it was good to be "with others that were passionate about maths".

New Experience/ New ways of teaching and learning:

The learners reported the following as new to them:

"It was the new style of teaching by the DVDs which really helped me in improving my marks in mathematics".

"The fact that there were people/tutors around offering help. The fact that we were encouraged all the time to do better next time".

"The facilitator was inspirational. They helped us comprehend different aspects of maths".

"The DVDs were very crucial for my understanding".

"The DVD was different from a textbook since there was a "voice" explaining the concepts".

More than half of the learners felt that the approach was refreshing and a different way of learning mathematics. Many learners said that they found this way of learning enjoyable and exciting.

However, some learners felt that there was not enough time to do the exercises and examples in class. In addition some learners felt that the facilitators were going too fast. One learner said that "the pace was a bit fast and rushed".

Assessment:

Many learners said that they used the DVD to check their learning "did the examples and the tutorials first and checked solutions on the DVD". Learners said that the tests helped them keep abreast of the work done every week and they found it helpful "that we have to test our understanding of each section every week".

However the weekly tests received the most negative comments from learners. They felt that they could not cope with the amount of work they were required to learn for each test, the tests were too long, too difficult and that they suggested a test should be given every second week.

Additional work:

Learners said that "Receiving more practice and stimulation" had helped their understanding and many learners agreed that practice makes perfect and said "I got a chance to do maths more often". Many learners also said that they were encouraged to "practice more maths" and that they found it advantageous when concepts were covered on the ISP before they had covered those at school.

Related to real life:

Some learners said that they found it helpful to their understanding that certain concepts were related to everyday life for example financial mathematics, exponential growth and decay and calculus.

Conflict:

Learners said that they found the demands of school in conflict with the demands of the ISP. They said that "too much of the work was covered in short time" at the ISP and that this was difficult for them to deal with since they had other learning areas to consider at school and that they found "learning for tests and viewing the DVDs time consuming". They also mentioned that sometimes other mathematics concepts were taught at school at the same time and because of that they had more to contend with.

Emotional learning environment

Mentoring:

A learner said: "This project was not only helpful to us with regards to school work but also introducing us to the fields of study we would like to pursue next year, offered some guidance" referring to the advice and career talks the learners were exposed to during the ISP. Learners also reported that they became aware of university requirements since being on the ISP. One learner also said that the ISP "helped motivate our goals". Learners also mentioned that their work ethic improved as a result of being on the programme and that they were learning about "time management".

Discipline:

Learners believed that although there was a sense of discipline in the ISP sessions it was still fun: “It was quite fun and there was a time of learning and joking, they were never mixed”.

Motivation/ Confidence building:

Learners believed that the facilitators and tutors motivated them to do well “Encouraging everyone to make a success of their lives and to be motivated and involved”. Another learner said that the facilitators helped “To motivate student to enjoy mathematics and not fear it like me and built a strong relationship with it”. Many learners said that they were highly motivated. “We got the opportunity to rise to our potential of being good at maths”. Some learners suggested that there should be a follow up with learners who were underperforming in tests.

Social issues:

Learners reported that it felt good to meet learners from different schools, make new friends and to share ideas and methods with them. Learners suggested that a “bonding session” at the beginning would help them get to know each other.

This section represented the analysis of the questionnaires. The next section will outline the analysis of the interviews.

6.6. GROUP INTERVIEWS

Three group interviews were conducted, the first one with nine learners, the second with thirteen learners and the last one with eleven learners. Probability sampling was employed to select the learners for the group interviews.

The interviews took place after the Saturday lessons, one interview on the one before the last Saturday and two interviews back on back on the last Saturday of the 2009 ISP. Some learners were shy and could not express themselves in the interview situation whilst other learners felt free to say what they thought. The researcher followed an interview schedule (cf. Appendix G) but deviated at parts that required further elaboration or explanation.

The researcher watched the interviews a number of times, first to get a sense of what was being said, and then listened and searched for themes. The following themes emerged from the analysis of the interviews.

The learning environment differed from school:

A learner said that she enjoyed this environment; it "was new and different from school". Another learner added that at school "the teacher stands in front of the board and teaches whereas here we had two things at once" referring to the DVDs with explanations and the facilitator explaining further. Learners said they felt that the learning was more in-depth, explaining that "at school we were just given formulas and asked to apply them".

Another learner confirmed these facts and added "the facilitator was explaining things comprehensively… where things came from… my teacher only explained what she thought was important". One learner said that the DVD "brought an image" and while another said "... the graphing software helped me see transformations". Yet another added "... the visual aspect helped me remember better what I saw".

Understanding of mathematics:

Learners agreed that their understanding of mathematics did change but one learner said "... my marks at school are improving but did not show here… maybe the tests were at a higher level". A few learners agreed with "... at school topics are briefly explained but here detailed explanations improved my understanding". One learner said "at school I memorized and got good marks but here I understand why I am doing it". A learner felt that he was provided with more information here and this enabled him to understand better. One learner said that "transformations we did not do it at school helped me a lot here and put me ahead at school" and while another added "at school I help other learners by teaching them what I learnt here".

One learner said "I gained techniques here" and another said "I gained basics here". One learner said "I am confident about mathematics". A Learner explained that he "... assisted my teacher at school by giving lessons in the afternoons…this gave me more confidence." One learner said that "being here improved my work ethic... I practiced maths more". One learner disagreed saying" at school it is better in a sense … they take longer for a particular concept"

DVDs as a resource:

Learners said that they found that watching the DVDs very helpful and here the researcher presents findings of what learners used the DVD for and how they used it.

One learner advised others to "... [I] watch every day for 5 days a week" and another learner advised to "... [I] do the tutorials and use them to check where my mistakes are". One learner explained how he used the DVD by saying "at each example I would pause and do myself" and another explained that "... if I struggled with a concept at school I watch the DVD".

The majority of learners said that they used the DVD as a regular part of their study programme as illustrated by those learners who said "I had a study guide and for 2 hours a day I watch DVDs". Many learners found the DVDs a useful resource and this was substantiated by learners who said "... it was helpful when I'm writing tests at school" and "DVDs will be useful for trial exams". Many of the learners agreed that the step by step solutions helped them understand and the DVD could be adjusted to their pace of learning as said learners on this issue "I liked the step by step explanations… I could stop and rewind again if I need to", "... they were my personal teachers" and "I could use them to study anytime ".

Here the researcher presents some of the negatives mentioned about the DVD. Learners felt that the DVD was too long to watch during a Saturday morning in the face to face session. One learner said that if "... watching alone at night … if not in the syllabus I was confused" by that part of the content on the DVD which was not part of the grade 12 syllabus. A few learners also felt that sometimes they could not follow all the solutions in the problems on the DVD since there were "missing steps" and "Some steps I did not understand". One learner suggested "[I] need more voice explanation". Another Learner suggested that alternate methods for the solution of a problem should also be presented "DVD should give more than one way of solving a problem".

Other resources:

Learners found the other resources such as the hard copies of all solutions and additional problems helpful and one said "As learners we need lot of things to help us in our understandings". Another learner said that just coming on Saturdays for "Materials it was worth it". Learners said that they "Used them all the time".

Interaction in the 2009 ISP:

Learners said of the interaction in the ISP: “it was refreshing...[I] enjoyed the interaction” and they felt at ease since the “Environment was relaxed”.

Facilitators:

Learners were very positive about the interaction with their facilitators and the tutors and said “Great facilitator... would present lesson and walk around and ask if there were problems and see if there were“ and “I was not afraid to ask questions” because “I was not afraid because I knew I would not be criticized”. One learner said that “ [The] facilitator inspired me and encouraged me”. Another learner who was too shy to ask questions did so “when the facilitator went around it was easier to ask”. Yet another learner felt “tense environment … too shy … so I ask tutors for help.”

One learner said that she did not interact much with the facilitator because she “did not feel comfortable raising my hand and asking” and instead sought help from other learners and tutors.

Tutors:

Learners said that the tutors were helpful and “their facial expressions showed they were eager to help”. One learner said that it was “easier for me to ask the tutors the questions they understand where I was coming from”. Learners said that tutors gave individual attention and even if they (the learners) were shy they (the tutors) would initiate conversations with them. One learner said she felt inspired by them since the tutors were university students. More than one learner mentioned that they “felt comfortable” to communicate with the tutors since they were young and “closer to their age”.

Other learners:

Learners said that they would “exchange ideas and methods with learners from other schools” and “exposure to other methods was helpful – sometimes theirs was easier”. Learners said that they came earlier on Saturdays to “work together and discuss problems”. One learner said that they would share ideas and “if you didn’t understand others would explain”. One learner said “another person lived close to me and we formed a study group [and] watched DVDs together”.

Improvement of the ISP:

Many learners commented on the tests on the ISP saying that “more time should be given” and “not so many tests” should be written. One learner pointed out that “If I had questions from the previous week I had no time to ask [them] before the test”. Learners wrote test immediately on their arrival at the ISP on Saturdays.

A few learners commented on the group size and they believed that the “Group should be smaller, I felt excluded sometimes” ,” I lost concentration” and “felt distracted”.

More than one learner suggested that “One topic a day should be dealt with” since “If it is the first time need more time to grasp” and another learner voiced the view that he needed “ more practice” and “more discussion”.

Learners also felt that the “hours were too long” of the f2f sessions and stressed the importance of “Need to watch the DVD with a real person first”.

After much discussion about the fact that topics at the ISP were not taught in sync with topics taught at school one learner suggested “give a workshop for teachers at schools so both are the same with each other ... same terminology, same method same sections”.

6.7. FACILITATORS’ PRECEPTIONS

To understand better how learners experienced this learning environment and what impact this environment had on the learners understanding of mathematics the researcher felt that it was important to gain the insights of the facilitators. It was hoped that these insights would further elucidate how the elements supported learning in this blended learning environment. Therefore data were obtained from the three facilitators involved in the 2009 ISP. One experienced high school mathematics teacher and two were university mathematics lecturers. For this purpose data were collected in the form of weekly reports submitted by the three facilitators during the 2009 ISP. Facilitators were asked to report on the activities of the lesson of the week, the attitudes of the learners in response to their learning environment, elements of the environment which supported the learning of mathematics and disadvantages of such an environment.

The researcher read through the reports several times in order to gain an insight into the experiences of the learners on the 2009 ISP from the facilitators’ perspective. Statements or ideas were then grouped together under key ideas. These were then, in turn collapsed into themes as shown in Table 6.14. The themes overlapped with those from the analysis of the questionnaires (c.f. 6.5.2.1) but focused only on the intellectual learning environment. It is interesting to note that the facilitators’ comments did not refer to the physical learning environment or to the emotional learning environment.

Table 6.14 Responses from Facilitators

Comments/statements/ideas	Key ideas	Themes
The more serious learners reported obtaining good results	Improvement	Intellectual Learning environment
Confidence increased		
Fear of maths eased		
DVDs enabled successful test preparation		
Learners got more information on concepts	Extended knowledge	
Learnt maths outside the school syllabus- this was tedious		
Free to ask questions/engage in discussion	Learning environment	
Learners should have enough time to do tutorials		
Too much work in one session		
New concept		
New way of learning		
Used to review work at home	DVD as resource	
Good for geometry and graph animation		
Used at own pace		
Viewing over and over again		
For educators who are not equipped to teach maths to grade 12 learners		
Alternate methods of solving		
Too long		
Missing steps led to confusion		
Needed facilitator to explain		
Use as additional aid not primary teaching tool		
Good for staff shortages		

Never a substitute for a teacher		
Clear and precise	Presentation	
Well prepared/thoroughly explained		
Concentrate for too long		
Not enough tutorial problems done		
Need to be more hands on		
Extend the time		
Additional explanations needed		
Need face to face learning		
DVDs not sufficient alone		
More time for discussion/tutorials needed		
Time schedule tight to balance DVD and tutorials	Interaction	
Live interaction between facilitator and learner necessary		
DVD allowed for no rapport between learners and facilitators		
Need question time/time for further explanations/discussions- cannot be passive		
DVDs good for test preparation	Assessment	
Added to school burdens	Conflict	
Often other concepts taught at school at the same time- not in sync		
Notation on DVD different to school		

The facilitators' observations of learners' experiences of the blended learning environment were positive and encouraging in general. All the facilitators felt that the learners' confidence improved as a result of this approach and their fear of mathematics had decreased. One facilitator noted that as the project progressed, communication and engagement between the facilitators and the learners, between tutors and learners and amongst learners themselves improved. Another facilitator said that the level of

mathematics questions posed by the learners improved with time. Although learners experienced the DVD technology as "strange at first", all the facilitators agreed that the interaction within the blended learning environment was "lively and fruitful".

According to a facilitator the "DVD was a powerful resource allowing learners to work at their own pace and review solutions and procedures until they understood the concept". All three facilitators said that they believed that DVDs should be used in conjunction with other face-to-face methods of teaching and learning, thereby creating a stimulating blended environment. They believed that used in isolation the DVDs would not prove to be such a successful resource in the teaching and learning of mathematics. One facilitator noted "as a teacher it was frustrating… [I] wanted to butt in and explain in a different way or add to the explanation".

One facilitator noted that the DVD would never be "a substitute for a teacher" while another facilitator noted that "if a teacher was inadequate or there were staff shortages" schools would benefit from the DVDs. One facilitator said that the DVD was "clear and well presented, sufficient and well explained", although another facilitator mentioned that the notations used in the DVD were different in some cases to those used in schools. One of the facilitators suggested that the DVDs should illustrate different methods of solving problems. Yet another facilitator said that they felt that "certain topics are tedious and out of the syllabus". These were covered on the DVD in some cases.

A facilitator said, "It is not easy to learn mathematics (i.e. seeing a new topic for the first time) from a lecture situation. Learners need to be able to ask questions and have more time to digest early steps before moving on to more complicated concepts. For many a topic was covered in two hours where at school they would have had a slower pace". One facilitator felt that "The system last year with the PowerPoint slides was more conducive to a better rapport with the learners and gave them more opportunities to pause and get a clearer or further explanation on certain topics. It was possible to vary the pace too". Other facilitators agreed that the work allocated for one session was too much and in attempting to get through the work interaction in the classroom with regard to discussions and questions was compromised. This was substantiated by another facilitator who said that the "time schedule was too tight to get a balance between the DVD and tutorials".

6.8. WHAT ELEMENTS SUPPORTED LEARNING AND HOW THEY SUPPORTED LEARNING? RESEARCHERS COMPILATION

Using the responses of learners and facilitators the researcher tabulated the elements, that emerged as supportive of teaching and learning mathematics, in this 2009 ISP context. The questionnaire consisted of factors for example lectures, tutorials and materials (See appendix E and Table 6.12). The statements of the questionnaire which are referred to in

the analysis as items were ranked using statistical methods. This was filtered into elements. In the triangulation of this process the data from the group interviews, open questions in the questionnaire and facilitators' reports were scanned for the frequency with which issues were mentioned. These again were filtered into elements.

In keeping with the tenets of a mixed methods analysis, the elements from the first process and the second process were integrated to determine the important elements in the context of this study.

The researcher identified the elements (adapted from Thompson and Wheeler, 2008) and reflected in Table 6.15 as important to this research study:

Table 6.15 Elements of a Supportive Learning Environment of the 2009 ISP

Elements	**How elements supported learning**
Physical Learning Environment	
Comfortable learning setting	1. Classroom design with seating not fixed around movable tables supported collaborative learning activities. Learners were able to move around the room, form groups and access and were accessible to tutors and facilitators easily 2. Spacious and clean room with appropriate noise levels in keeping with the activity being engaged in. This afforded learners a comfortable environment in which to learn. 3. Modern environment that supports the use of technology enabled the use of DVD technology and PowerPoint slides to be projected simultaneously together with writing facilities like whiteboards/blackboards for traditional teaching approaches.

Supplying in Physical needs	1. Food provided catered for learners physical needs thereby allowing them to focus on the intellectual aspects of the environment. 2. Money for transport provided learners with the opportunity to attend regularly. 3. Stationery provided ensured that learners were not excluded if this was a limitation. 4. DVDs provided to each learner allowed learners to access learning outside the f2f setting. 5. Hard copies of all lectures, tutorials and test solutions were provided to support learning through a variety of materials.
Intellectual Learning Environment	
Stimulating learning environment	1. Established a culture of learning and developed a good work ethic 2. Clear outcomes of the ISP and of each session were given charting a clear course for the programme and for each session. 3. Learners were encouraged to ask questions and a non threatening learning environment ensured they felt free to engage in discussion. 4. Involved problem solving and presented new problem solving skills. 5. Expectations for learning in the DVD driven blended learning environment were communicated. 6. Learners were motivated and positive attitudes to learning, participation and achievement were cultivated. 7. Learners and facilitators felt that the amount of work to be covered in each f2f session should be realistic. 8. Learners felt that more hands on and problem solving activities should be incorporated in the f2f sessions. 9. Level of communication should be appropriate for the learners participating (especially if English is not their first language). 10. Establish contact with learners who are underperforming to determine individual issues and provide solutions. 11. Engage capable and appropriately qualified staff that have the capacity to relate to young people and the ability to work with and address their learning needs and other needs.

	12. Important to be around facilitators that are mathematics specialists and are passionate about mathematics. 13. Exposure to learners who were passionate about mathematics inspired learners.
Appropriate teaching strategies	1. The learner centred environment involved active learning, problem solving, critical thinking, and presented opportunities to receive guided support individually or in groups from facilitators and tutors. 2. The individual learner was respected and the DVD accessed outside the f2f sessions respected individual learning styles and allowed learners to work at their own pace in their own time. 3. The ISP integrated different teaching strategies and provided learners with various resources (hardcopies of all tutorials, lectures, tests and solutions and additional exercises together with own copy of DVDs. 4. Collaborative learning and group work during tutorial time was encouraged allowing for discussion and debate during the process of learning. 5. The learners' use of the DVDs engaged the learner in activities to promote lifelong learning (independent learning, self reflection and assessment, identification of his or her own needs). 6. Should allow for the management of teaching time and resources to maintain challenging, engaging, and supportive environment. 7. Use of appropriate strategies to maximise participation of all learners. 8. Encourages and promotes peer feedback and collaboration. 9. Integrates the use of technology in a blended learning environment. 10. DVD allowed learners to access learning outside of the f2f environment in their own time and at a pace comfortable to them.
Instructional processes conducive to learning	1. The tutorials and the opportunity to work on mathematics with access to guidance and supervision from facilitator and tutors provided a learning environment conducive to learning. 2. Involved the content of the grade 12 mathematics syllabus. 3. Various resources allowed learners the opportunity for additional practice, to see concepts from multiple perspectives and to test their understanding of concepts. 4. ISP facilitated support mechanisms – collaboration amongst learners,

	tutorials, mentors, and student facilitators. 5. Uses resources effectively: sections of the DVDs were highlighted during f2f presentations and paused to include explanations on PowerPoint' slides on tablet pc, questions and discussion. 6. The learning objectives were clarifies at the outset of a session and an overview of the learning tasks were given both in the f2f environment and on the DVDs. 7. The blended learning environment included the use of appropriate technology in the form of DVD technology to achieve outcomes. 8. The DVDs enabled learners to access learning out of sequence as they chose by stopping the DVD, rewinding and forwarding to sections they selected. 9. Each DVD included comprehensive presentation of concepts and contextualised concepts for learners by presenting derivations of formulae and theoretical background to concepts to encourage a deeper approach to learning as opposed to mere memorisation. 10. Additional information outside of the syllabus was presented to enhance understanding of mathematics concepts. 11. DVDs presented clear step by step solutions to problems and could be accessed at learners own time and used at learners own pace. 12. Encouraged and presented alternate methods of solution. 13. Acknowledged that facilitation of the DVD in a f2f session was necessary to bridge the gaps in learners' knowledge with explanations and discussions. 14. Should allow for the pace of presentations to be adjusted to the learners needs. 15. Attendance should be enforced to develop a good work ethic.
Adequate interaction	1. Facilitator-learner: showed enthusiasm, promoted dialogue, avoided judgement, encouraged questions, opinions and thoughts, offered guided and constructive feedback, and demonstrated commitment. 2. Tutor- learner: open to and encouraged communication, inspired learners, encouraged learners, offered constructive feedback and demonstrated commitment and enthusiasm. 3. Learner- learner: promoted peer feedback during discussions and tutorials and before tests.

	4. Social interaction between learners is part of learning- learners challenged, supported and learnt from each other.
Appropriate assessment	1. Learners used the DVDs to check their understanding of concepts enabling self reflection and self assessment. 2. Weekly tests are an important part of the learning cycle and support learners through this avenue allowing them to evaluate their learning. Weekly tests need to be allocated a reasonable time to complete and learners need to be given sufficient time to engage with content before they write a test on that content. 3. Tutorials both in the f2f sessions and on the DVDs allowed learners to assess their understanding of mathematics .
Emotional Learning Environment	
Safety ensured	1. Clear expectations of the blended learning environment and rules of the ISP were clarified at the outset. 2. Trust between facilitator and learners, tutors and learners and then between learners themselves needed to be developed to ensure effective participation. 3. A warm and encouraging environment was set up by the facilitators and tutors where there was no fear of being belittled or criticised.
Personal emotional support	1. Facilitators and tutors fulfilled the role of mentors to learners. 2. Sustained concern: learners suggested that facilitators and tutors monitor their progress and follow up with underperformers. 3. Facilitators and tutors set and communicated high expectations for learning under the assumption that all learners can improve their learning. 4. A caring and loving environment where each learner makes a difference and in the knowledge that no learner will be left behind was established (positive and inclusive supportive learning environment).
Positive discipline and self management	1. Respect was shown to all. 2. Clear expectations for behaviour were communicated and a clear distinction between work and play was established. 2. Responsibility- learners needed to demonstrate this responsibility to learning by showing initiative, working independently (during the f2f

	sessions and at home), asking questions and engaging in discussions. 3. Attitude to learning- learners needed to have a good work ethic and a positive attitude to learning.
Sense of community developed	1. The learning environment was not threatening- facilitators and tutors and other learners were friendly and helpful. 2. Trust was developed between all the role players and allowed for effective communication and participation in the ISP by all. 3. Individual differences were respected- learners from different schools shared ideas, problem solving strategies formed study groups outside of the ISP. 4. Support (academic and emotional) from facilitators, tutors and other learners was important. 5. Competition between the learners to see who would perform better in the assessments was good for learners entertaining friendly rivalry and making learning fun.
Personalised learning communities	1. Facilitators motivated learners to work and be successful and increased learners' self confidence and eased their fear of mathematics. 2. Tutors inspired and motivated learners. 3. The ISP presented opportunities for career guidance and career camps. Facilitors and co coordinators acted in an advisory capacity with regard to university requirements, career choices and admission procedures.

6.9. LEARNERS WEEKLY PERFORMANCE

Learners wrote tests based on the previous week's work. Altogether learners wrote 10 tests and the average of their tests was taken. The tests were used to chart learners' progress and to encourage learners to work consistently and methodically. The Table 6.16 illustrates the average percentage achieved by the learners.

Table 6.16 Average Test Percentages Achieved

Average %	Number of participants
0-19	21 (14%)
20-39	37 (25%)
40-59	52 (35%)
60-79	27 (18%)
80-100	10 (7%)

The largest percentage of learners (35%) achieved between 40-59%. However the next highest percentage of learners (25%) obtained averages between 20-39 %. Only 7% of the learners achieved averages in the 80-100% category.

6.10. GRADE 11 MATHEMATICS RESULTS VERSUS GRADE 12 MATHEMATICS RESULTS

Learners' final Grade 11 mathematics results were compared with their final Grade 12 mathematics results to determine if an improvement in their mathematical performance had occurred. The grade 11 examination is localised at schools whereas the grade 12 examination is national

As a measure of success for the blended model the grade 11 and grade 12 mathematics marks of the 132 ISP learners of 2009 were compared. It should be noted at the outset that this is not an ideal comparison as the grade 11 examination is a local exam for which papers are drawn up and marked at individual schools whereas the grade 12 examination is a national examination where more stringent quality measures apply.

The comparison of the grade 11 and grade 12 marks are based on the academic performance of 132 learners (n=132). Fifteen learners all from one school were excluded from this comparison. The researcher noted an unusual situation where all fifteen learners

had grade 11 marks in the interval 50 to 59; whilst their grade 12 marks were in the interval 4 to 15. This represents an inexplicable severe deterioration in marks. In addition the researcher would like to point out that the all fifteen learners had weekly test averages below 19% (c.f. 6.8).

These learners had excellent attendance to the ISP with all learners having attendance of more than 70% and nine of these learners with an attendance of more than 90%. It seems evident that the ISP had very little benefit for these learners. Perhaps one needs to question the authenticity of the grade 11 marks. It is probable that in this particular case that there was a deeper rooted problem that could not be addressed by the ISP. Another possible reason could have been that learners, although they attended diligently, did not take responsibility for their own learning. This situation did not occur at any of the other schools.

The researcher felt that a comparison of grade 11 and grade 12 marks would be a truer reflection of the reality if these learners were excluded from the statistical analysis. Further investigation is recommended but does not form part of this research study. Therefore the statistical analysis in sections 6.9 and 6.10 is based on 132 learners while the descriptive statistics for grade 11 and grade 12 marks are given in Table 6.17.

Table 6.17 Descriptive statistics for Grade 11 and Grade 12 November Marks

	Grade 11	**Grade 12**
Mean	60.99	62.37
S.D.	10.21	15.32
Minimum	30.00	0.00
Quartile 1	54.00	54.75
Median	60.00	63.00
Quartile 3	69.00	73.00
Maximum	91.00	93.00

From the Table 6.17, it may be noted that there was an increase of 1.38 on average between grade 11 and grade 12 marks.

The Figure 6.3 illustrates the comparison in the mathematics performance of the ISP participants from grade 11 and grade 12.

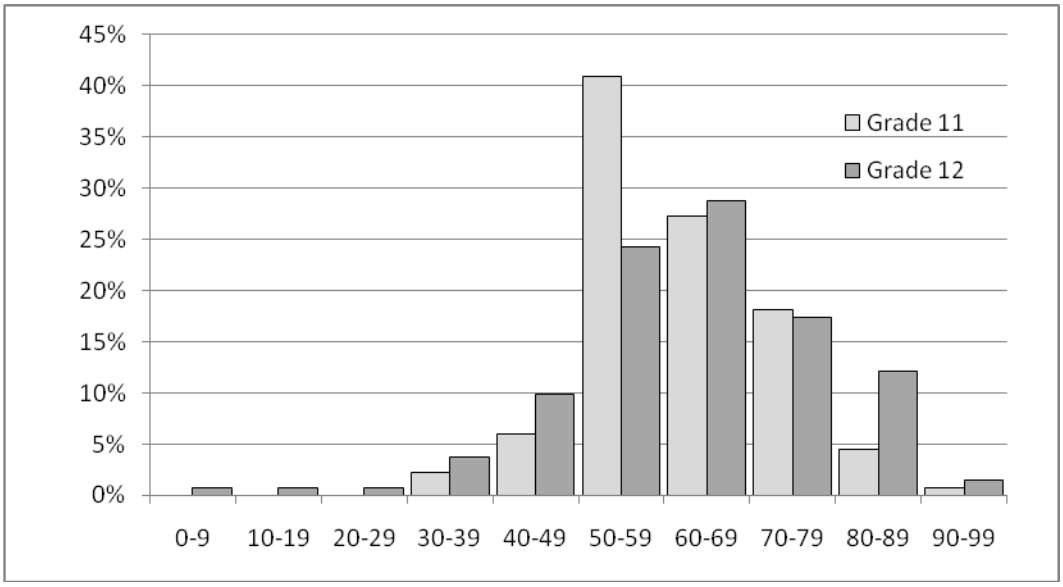


Figure 6.3 Grade 11 and Grade 12 November Results of ISP Participants

The distribution for Grade 11 marks peaked with the majority of scores being between 50 and 59 whilst the distribution for Grade 12 marks peaked with the majority of scores being between 60 and 69. It is pleasing to note that in the higher intervals from 60 upwards there is mostly an increased proportion of grade 12 learners. In the categories [60-69] there is a slight increase in grade 11 to grade 12 from 27% to 29%, in the category [80- 89] there is an increase from 5% to 17% and in the category [90-99] there is an increase from 5% to 14%. Unfortunately there also were more learners who performed badly in grade 12 compared with grade 11. In fact, only grade 12 learners obtained a mark less than 30.

The relationship between the categories of marks for grade 11 and grade 12 is depicted by Table 6.18.

Table 6.18 Grade 11 and Grade 12 November Mathematics Results

	Grade 12											
Grade 11	[0-49]		[50-59]		[60-69]		[70-79]		[80-99]		**Total**	
[0-49]	5	45%	2	18%	2	18%	1	9%	1	9%	**11**	**100%**
[50-59]	13	24%	20	37%	13	24%	5	9%	3	6%	**54**	**100%**
[60-69]	3	8%	8	22%	14	39%	8	22%	3	8%	**36**	**100%**
[70-79]	0	0%	2	8%	9	38%	9	38%	4	17%	**24**	**100%**
[80-99]	0	0%	0	0%	0	0%	0	0%	7	100%	**7**	**100%**
Total	**21**	**16%**	**32**	**24%**	**38**	**29%**	**23**	**17%**	**18**	**14%**	**132**	**100%**

It is important to note that 55% of the learners who had a mark less than 50 in grade 11 obtained a mark of at least 50 in grade 12. In considering the 50 to 59 category in grade 11, it is noteworthy that 24% of these learners deteriorated to a lower category of zero to 49 in grade 12.

A Chi squared test of independence was conducted to determine if the distribution of grade 12 marks was related to the grade 11 marks. A moderate significant relationship was noted $\left(\left(\text{Chi}^2\text{d.f.}\ =16,\ \text{n}=132\right)=32,\ 67,\ \text{p}=0.008,\ \text{v}=0.25\right)$.

Considering the results depicted in Table 6.18 it is noteworthy that for all grade 11 categories the modal grade 12 category was the same as the relevant grade 11 category, the implication being that the majority of learners remained in the same category in grade 12 as their grade 11 category.

It is important to note that there is a favourable decrease in the category 0 to 49 from 45% of learners in grade 11 to 16% in grade 12. In considering the decrease in the category 50 to 59 it is noteworthy that 13 learners who were in this category in grade 11 deteriorated to the lower category 0 to 49 in grade 12 whilst 21 learners moved to higher categories.

The researcher believes that instead of simply comparing the grade 11 mathematics results of learners with their grade 12 mathematics results that it would be more informative to focus on their improvement with regard to their initial grade 11 mathematics marks. Instead of calculating the percentage change from grade 11 to grade 12 marks based on learners grade 11 marks, which would have resulted in unrealistically large values for those learners who had extremely poor grade 11 marks, it was decided to calculate the percentage change based on the maximum improvement they could have achieved. This is calculated as follows:

$$(\text{Gr12- Gr11})\text{g} = \frac{\text{grade 12 mark} - \text{grade 11 mark}}{100 - \text{grade 11 mark}} \times 100\% \qquad \text{(Equation 6.2)}$$

The numerator here gives the difference of the grade 11 to grade 12 results. The denominator calculates the extent to which a learner can improve, for example a learner with 80% in grade 11 can only improve their grade 12 result in total by 20%. The descriptive statistics is given in Table 6.19 showing a mean increase of 6.34%, a maximum deterioration of 100% and a maximum improvement of 78%.

Table 6.19 Grade 11 to Grade 12 Percentage Potential Improvement

n	132
Mean	6.34
S.D.	26.81
Minimum	-100.00
Quartile 1	-8.25
Median	5.00
Quartile 3	22.25
Maximum	78.00

A one sample t-test was performed to determine whether the mean percentage improvement was significantly greater than zero. A small practically significant result was observed (t = 2.72; d.f. = 131; p = .007; d = 0.24). It may be concluded that the learners attending the ISP performed significantly better on average in grade 12 compared with their grade 11 mark.

Table 6.20 illustrates the frequency distribution for the various categories of percentage potential improvement in mathematics results of learners from grade 11 to grade 12.

Table 6.20 Frequency distribution: Grade 11 and Grade 12 Potential Improvement

Potential Improvement	**Frequency**		**Cumulative**	
-100 to -71	2	2%	2	2%
-70 to -31	5	4%	7	5%
-30 to -11	20	15%	27	20%
-10 to 10	54	41%	81	61%
11 to 30	31	23%	112	85%
31 to 70	19	14%	131	99%
71 to 120	1	1%	132	100%
Total	**132**	**100%**		

A total of 51 learners (38%) showed a positive improvement of at least 11%. In comparison only 27 learners (21%) had a percentage decrease of 11% or more. 19 learners from the category -10 to 10 and 51 from the categories higher, in total 70 (52%) of learners showed a positive improvement with respect to their potential. Six learners (5%) remained at a constant level of achievement.

6.11. A COMPARISON OF SIX SCHOOLS

A comparison of six schools with a total of 226 grade 12 learners, 24 of which were ISP participants and 202 non ISP participants, was performed. The intention of the researcher in performing the case study was to compare the performance in mathematics between learners from the same school who had participated in the ISP with those who did not. The researcher acknowledges that this is not an ideal comparison since the 2009 ISP selected the best learners based on their grade 11 performance in mathematics.

The participants' and the non participants' 2009 final grade 12 mathematics marks are compared with their 2008 grade 11 end of year mathematics marks and the difference in the two results is presented in Table 6.21.

Table 6.21 Difference in Grade 11 and Grade 12 Results

Grade12-Grade11 Difference	2009 ISP					
	Non Participants		Participants		Total	
-49 to -40	0	0%	1	4%	**1**	**0%**
-39 to -30	0	0%	2	8%	**2**	**1%**
-29 to -20	6	3%	1	4%	**7**	**3%**
-19 to -10	24	12%	3	13%	**27**	**12%**
-9 to 0	78	39%	3	13%	**81**	**36%**
1 to 10	72	36%	9	38%	**81**	**36%**
11 to 20	16	8%	3	13%	**19**	**8%**
21 to 30	5	2%	1	4%	**6**	**3%**
31 to 40	1	0%	1	4%	**2**	**1%**
41 to 50	0	0%	0	0%	**0**	**0%**
Total	**202**	**100%**	**24**	**100%**	**226**	**100%**

It may be noted that 46% of the non participants achieved an improvement greater than zero compared with the 59 % of the participants.

The researcher acknowledges that there was a limitation in this research study since only a small sample of learners was used. The information would have been more illustrative if data from all the learners of the participating schools could have been collated. Much difficulty was experienced by the researcher in obtaining results from schools especially of those learners who were not part of the ISP. The researcher found that simply to compare the grade 11 and grade 12 marks would not be sufficient information.

It would be more enlightening to see how learners improved with regard to the maximum by which they could improve. Using equation 6.2 the results of this improvement are categorised in intervals in Table 6.22.

Table 6.22 Improvement of Learners with regard to their Potential

Grade 11 to Grade 12 percentage potential improvement	**ISP**				**Total**	
	Non Participants		**Participants**			
-40 or worse	19	9%	3	13%	**22**	**10%**
(-40 to -30]	7	3%	0	0%	**7**	**3%**
(-30 to -20]	19	9%	2	8%	**21**	**9%**
(-20 to -10]	22	11%	2	8%	**24**	**11%**
(-10 to 0)	33	16%	3	13%	**36**	**16%**
[0 to 10)	59	29%	3	13%	**62**	**27%**
[10 to 20)	27	13%	2	8%	**29**	**13%**
[20 to 30)	10	5%	4	17%	**14**	**6%**
[30 to 40)	4	2%	1	4%	**5**	**2%**
40 or better	2	1%	4	17%	**6**	**3%**
Total	**202**	**100%**	**24**	**100%**	**226**	**100%**

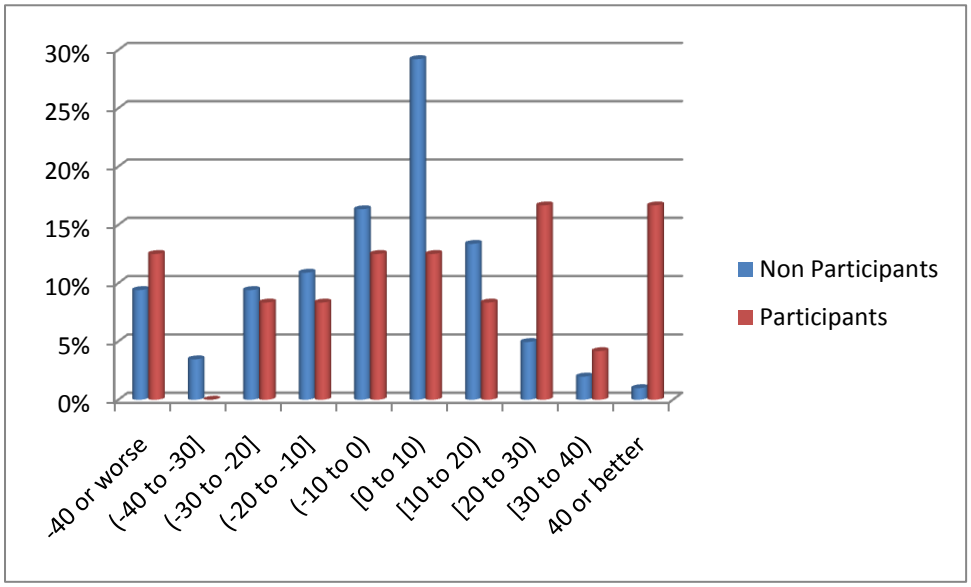


Figure 6.4 Improvement with regard to Potential

The results of the learners who were on the ISP improved remarkably whilst those learners not on the ISP generally presented lower grade 12 final results. It should be noted that the learners who took part in the ISP showed more interest in mathematics and science and were not surprisingly better performers. The results are summarised in Table 6.22.

The descriptive statistics for grade 11, grade 12, the difference between grade 12 and grade 11 performances, and this difference with regard to their possible improvement (Gr12-Gr11)g are presented in Table 6.23 for both the ISP participants and the non participants.

Table 6.23 Descriptive statistics of ISP Participants and non-ISP Participants

	Non-ISP participants (n = 202)				ISP participants (n = 24)			
	Gr11	**Gr12**	**Gr12-Gr11**	**(Gr12-Gr11)g**	**Gr11**	**Gr12**	**Gr12-Gr11**	**(Gr12-Gr11)g**
Mean	33.33	33.24	-0.09	-5.54	63.71	63.00	-0.71	6.65
S.D.	11.61	13.74	9.50	21.65	11.82	16.26	16.96	31.91
Minimum	4.00	8.00	-22.00	-73.33	30.00	30.00	-40.00	-57.14
Quartile 1	26.00	23.25	-5.00	-16.93	55.00	55.00	-10.25	-13.48
Median	31.00	32.00	0.00	0.00	65.50	64.50	3.00	7.25
Quartile 3	40.00	42.00	5.75	8.06	70.00	73.50	10.00	23.61
Maximum	77.00	79.00	32.00	55.32	83.00	93.00	32.00	66.67

The mean for (Gr12-Gr11)g for non participants is -5.54 whilst the corresponding mean for participants was equal to 6.65 implying a much higher improvement with regard to potential improvement for the participants.

To verify that the differences between non ISP and ISP learners are statistically significant a t-test of independence was conducted. These results are reported in Table 6.24.

Table 6.24 Comparison of ISP Participants and non-ISP Participants

	Comparison Non-ISP vs. ISP								
	Non-ISP (n = 202)		ISP (n = 24)						
	Mean	Std.Dev.	Mean	Std.Dev.	Difference	t-value	df	p	Cohen's d
Gr11	33.33	11.61	63.71	11.82	30.38	-12.10	224	.000	2.61
Gr12	33.24	13.74	63.00	16.26	29.76	-9.83	224	.000	2.12
Gr12-Gr11	-0.09	9.50	-0.71	16.96	-0.62	0.27	224	.785	-
(Gr12-Gr11)g	-5.54	21.65	6.65	31.91	12.19	-2.46	224	.014	0.53

The large significant differences observed for grade 11 and grade 12 marks respectively were to be expected given that the learners with a better grade 11 mathematics mark were selected for the ISP group. An improvement result was the significantly superior improvement percentage of 6.65% observed for the ISP group compared with the 5.54% deterioration for the Non ISP group. The difference between the groups can be described as moderate based on Cohen's d statistic being in the 0.50 to 0.80 interval.

Table 6.25 Comparison within the ISP Participants and non-ISP Participants

Comparison within groups							
	t-values		df	p-values		Cohen's d values	
	Gr12-Gr11	(Gr12-Gr11)g		Gr12-Gr11	(Gr12-Gr11)g	Gr12-Gr11	(Gr12-Gr11)g
Non-ISP	-0.13	-3.64	202	.894	.000	-	0.26
ISP	-0.20	1.02	24	.840	.317	-	-

According to the results depicted in Table 6.25 only the deterioration of 3.64% was found to differ significantly from zero, a difference that can be described as a small difference based on Cohen's d value falling in the 0.20 to 0.50 interval.

6.12. FINDINGS OF THE RESEARCH STUDY

The researcher analysed the data and presented the findings that relate to each sub research question. The following major findings are presented in Table 6.26.

Table 6.26 Findings of the Research

FINDINGS	**RESEARCH SUB QUESTION(S)**
Researchers compilation from the literature and research	
1. Participants indicated how the elements present in this DVD approach imbedded in a blended learning environment supported their learning and the researcher added, adapted and compiled a list of elements.	1
Physical Learning Environment	
2. Learners indicated that the physical learning environment was supportive in facilitating their participation in this project.	2
Intellectual Learning Environment	
3. Learners indicated that there was an improvement in how they learned mathematics.	2/3
4. Learners cited that there was an extension of their mathematics knowledge.	2/3
5. The majority of participants found that the intellectual learning environment was beneficial to their learning of mathematics.	2
6. Learners cited the DVD as a resource that was significant to their learning of mathematics.	2
Emotional Learning Environment	
7. Learners indicated that there was an improvement in how they perceived mathematics.	2
Learners Performance	
8. The majority of learners improved their mathematics mark in the final exams as compared with the marks of their peers at their schools who did not attend the ISP 2009.	3
Researchers Reflection of the Blended learning environment	
9. The ISP blended learning approach offers a fair blend between face to face and computer technology based learning.	2

6.13. CONCLUSION OF THE CHAPTER

This chapter has presented the findings of this research study. Learners' perceptions as well as facilitators' perceptions with regard to the main research question "How did the use of the DVD approach within a blended learning environment support the learning of mathematics" were disclosed. The data included learner questionnaires, group interviews, facilitator reports, learners' mathematics results, attendance records, weekly test results and the results of non participants.

The researcher has included extensive representations of quotations, since it was through these that the researcher hoped to show the reality of the learners and the programme under study.

In the next chapter the interpretation of the findings will be presented. This chapter will summarise and conclude the study and present some recommendations.

CHAPTER SEVEN : INTERPRETATION AND SYNTHESIS OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

"When we have arrived at the question, the answer is already near." Ralph Waldo Emerson

7.1. INTRODUCTION

Technology is pervading all levels of mathematics teaching and learning in our world. It is bringing into focus the change from conventional pencil and paper learning to a blend of technology and pencil and paper learning environments. The 2009 ISP is one such learning environment which blends technology with pencil and paper in the teaching and learning of mathematics. The purpose of this case study was to explore the 2009 ISP to explore how the elements present in the DVD driven approach support learning via the teaching of mathematics in a blended learning environment. It was hoped that this understanding would enhance the ISP for future learners in this project.

The research study composed data from the questionnaires, group interviews, facilitator reports and the final mathematics results of participants. Additional data from learners' attendance records and weekly test records were also analysed. Participants in this study were learners who had participated in the 2009 ISP and their facilitators. The data were analysed and grouped into themes which were directed by the research question and sub questions. The study was based on the following research question:

> ***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?***

and sub questions:

1. **How did the elements present in the DVD driven approach support the learning of mathematics?**
2. **How do learners experience this blended learning approach?**
3. **What impact on learners' mastery of mathematics has the approach made?**

This chapter will attempt to interpret and synthesize the findings presented in Chapter Six. The chapter is presented as interpretation of the findings based on sub research questions. In Chapter Six the findings of this research study were illustrated by organising the data into themes. In this chapter it is the researcher's intention to create an understanding of the findings by integrating the findings with the literature, research and practice. Here the

literature on supportive learning environments, community of inquiry and blended learning is taken into consideration.

7.2. INTERPRETATIONS AND SYNTHESIS OF FINDINGS

This section interprets the findings directed by each of the sub research questions. Included in this section is the researcher's reflection on the blended learning environment. In response to the first sub research question a discussion of the elements identified by the literature and the research will be presented. Interpretation and discussion of both the first and second sub research questions will be aligned to the themes: Physical learning environment, Intellectual learning environment and Emotional learning environment. Interpretation and discussion of the second sub research question emanate from the findings of the questionnaires, interviews and facilitator reports.

In reaction to the last research question the findings that arose from the quantitative data analysis of grade 11 and grade 12 final mathematics results will be interpreted. In section 7.2 it is the intention of the researcher to provide interpretative insights into the findings that were presented in Chapter Six. The researcher analyses, interprets and synthesizes the findings that relate to each sub research question.

7.2.1. THE ELEMENTS IN THE DVD DRIVEN APPROACH THAT SUPPORTED THE LEARNING OF MATHEMATICS

The first research question set out to determine how the elements that were present in the DVD approach within a blended learning environment supported the learning of mathematics. Following an extensive review of the literature on supportive learning environments and the data analysis of this research the researcher added to, adapted and established a list of elements that support learning in this blended learning DVD approach to teaching and learning mathematics.

The ISP provided a comfortable and safe environment for learners to learn. Food was provided and travel expenses were paid for. The ISP aligned its efforts with the school efforts, and engaged in communication with parents and schools. In addition the ISP learners improved their social and language skills, fostered good relationships with peers, students and facilitators. The ISP provided opportunities like engineering winter school and examination preparation sessions. Learner centred classes and cooperative learning were both used, feedbacks of assessments were individually provided. The ISP created a caring environment and held high expectations for all learners and enthusiasm, caring and an active interest in learners was an essential constituent of the ISP. The ISP provided support for all learners enabling learners to feel a sense of bonding and belonging, were academically engaged and displayed optimistic attitudes towards learning. Every learner

was valued, high expectations were communicated to all, and positive relationships with peers were encouraged. Discipline was enforced. Positive relationships were encouraged all round and meaningful learner engagement was fostered. Finally family, school and community involvement were important features of the ISP project.

The majority of the elements discussed here are generic to any supportive learning environment. In a blended learning environment that employed a DVD driven approach to the teaching and learning of mathematics further elements needed to be considered and highlighted. This discussion will highlight the elements that are characteristic of this DVD approach and the elements indicative of blended learning in this context, thus leading up to answering the main question of this study.

Thompson and Wheeler (2008) assert that all factors impacting the development of learners need to be considered when creating a learning environment. The three aspects as advocated by Thompson and Wheeler (2008) (c.f. Table 3.1) were used by the researcher in the analysis and interpretation of the findings in this research study. Discussion is therefore directed by the physical, intellectual and emotional aspects of the learning environment.

The characteristics of the ***physical learning environment*** consisted of the learning setting i.e. the venue used for the f2f sessions and the resources supplied to learners and used in the ISP. These elements of the physical learning environment impacted the learners in this study positively. Learners pointed out elements that involved the learning setting and their physical needs. To encourage collaborative learning and the effective participation in learning the furniture in the learning setting was movable, the room was comfortable in terms of cleanliness and spaciousness and the noise levels were appropriate to the activities in which the learners were engaged. Learners were provided with all their stationery requirements and all relevant learning materials.

The spacious, clean, noise free and technology friendly environment was welcomed by the learners. They said that this spurred them on to develop good work habits and a positive attitude towards learning. Learners also believed that the learning environment facilitated cooperative learning effectively. This is probable due to the spacious environment and to the fact that the chairs and tables were not fixed. This allowed the learners' easy movement and access to facilitators, tutors and other learners. Learners were provided with all their stationery requirements, and all relevant learning materials. In keeping with the tenets of blended learning, provision was made for both traditional and technology driven approaches to the teaching and learning mathematics.

The researcher discovered that in this study the money given to the learners for transport and the food provided to them played an important role in facilitating the learners' participation in the ISP. Blended learning was accomplished through the use of 'blended' physical resources. As advocated, by blended learning experts, a variety of resources were used in the ISP. In order to maximise learners' participation and performance in mathematics learners were provided with their own copy of each DVD and hardcopies of all the lectures, tutorials, additional exercises, tests, test solutions and stationery. Learners were positive that the variety of resources contributed to their successful learning of mathematics.

The ***intellectual learning environment*** includes the development of a stimulating learning environment, considering appropriate teaching strategies and instructional processes, and ensuring effective interaction and assessment. The elements of such an environment should challenge all learners to be active participants in meaningful learning and allow for all learners to be given the opportunity to be successful learners.

Learners may not always know what is expected of them in a new learning environment and therefore, this needs to be clarified at the outset. With this knowledge learners can decide whether to commit to the programme from the beginning and those learners who remain will more likely participate fully therefore ensuring a successful programme. One learner echoed this view when he said, "Before selecting learners, be clear what is expected of them so that those who agree are committed and don't feel stuck in the programme. I think that it'll reduce dropouts and even if there are fewer learners you'll know it will be more successful". The use of technology is new to many learners and this aspect needs to be introduced to them from the beginning. It is important to orientate the learners to the learning environment. For learners the most intimidating issue in learning can be the confusion created by uncertain processes or unclear outcomes.

Explanations of the different modes of delivery and the role that technology would play in the ISP were outlined. An explanation of the integration of the DVD, slides, handouts, tutorials, tests discussions and questioning was also given. At the outset of the ISP expectations for the DVD approach were communicated to the learners. Expectations for learning in this "new approach" using DVDs embedded in a blended learning environment were explained to the learners. At the beginning of each f2f sessions all the outcomes of the lesson were clarified to the learners.

Clarity of outcomes and the setting out of expectations sets the tone for a supportive learning environment. The establishment of a non threatening environment, a culture for

learning and a good work ethic was considered important in supporting learning and was encouraged.

Motivation of the learners and inculcation of positive attitudes were important to the ISP. Learners rated the element of motivation highly on their list of supportive elements of the ISP. One of the learners expressed it in this way, "the positive part of the programme was the motivational words spoken and it boosted my self confidence and I had a better understanding of mathematics". There has always been much negativity surrounding the learning of mathematics, and there are high expectations for learners to perform well in mathematics since it is a gateway subject to many of the science and technology related careers, which are so highly in demand in our economy.

Research has suggested that learners may have a fear of mathematics. Their ability to do mathematics and to be motivated can increase their self confidence; and hence, their belief in their ability to do mathematics. Further activities involving problem solving, discussion, tutorial sessions and questioning all contributed to establishing a stimulating learning environment for learners. It is through active problem solving and regular work that mathematics is learned.

In keeping with the tenets of learner centredness, activities that involved active learning, problem solving and critical thinking were considered in the teaching strategies used in the ISP. Facilitators and tutors provided guided support helping learners to think through problems, encouraging them to make attempts and using the mistakes learners made to enter into discussion in keeping with the constructivist notion that learners are not consumers of content but rather they are constructors of content (Jonasson, 1991).

At the core of the DVD approach is the consideration of learners various learning styles. Since each learner had their own copy of the DVDs, they were able to access learning outside of the formal learning setting at the learners' own pace rewinding and playing sections back until they were satisfied. The DVDs were designed in such a way to be able to function as a complete unit since they completely covered each mathematics topic. Activities on the DVD engaged learners in independent learning, self reflection and the assessment and identification of their own needs. It was the intention through this to promote lifelong learning.

The instructional processes revolved around the content of the grade 12 mathematics syllabus and additional information was provided to enhance learners understanding of these mathematics concepts. To encourage a deeper approach to learning, the DVD design included comprehensive presentations of content including the contextualisation of concepts, derivations of formulae and theoretical background to concepts. These issues were not called for by the grade 12 mathematics syllabus. In addition a step by step exposition of the solutions to problems was included in the DVDs for those learners who had no idea where to begin with the problem at hand. Learners' had no contact when viewing the DVDs at home alone; and in anticipation of this shortcoming, voice explanations were given taking into account as far as possible questions and issues that might arise around the solution of a problem or the discussion of a concept.

As advocated by blended learning the instructional process of the ISP included an initial facilitation of the DVDs in the f2f sessions in order to bridge any gaps in the learners' knowledge. It was through this opportunity that learners' were able to question, enter into discussion, and seek explanations. Although the DVD formed such an important component of the blended learning environment, the participants were firm that its success lies in the blending of this DVD approach with other traditional f2f approaches.

Interaction played a significant role in the f2f sessions of the ISP. Facilitator-learner interaction was crucial in setting an effective learning scene. This interaction ensured a non threatening learning environment, which was established where open dialogue, questions and discussions were encouraged in a non judgemental way. The facilitators' enthusiasm and the passion for mathematics inspired the learners. The tutor- learner interaction brought into play in addition other elements. Learners felt more comfortable with their interactions with tutors since they were close to the same age, were of the same culture as the majority of learners, and they felt motivated and inspired by the tutors' ability to do mathematics and by their success at university. Learner-learner interaction promoted peer feedback, the sharing of ideas and the techniques of problem solving and learning and collaborative work. The social interaction of the learners served to support, challenge and encourage one another.

Assessment formed an important part of the teaching and learning of mathematics in this DVD driven approach. It is through this avenue that learners could determine what their understanding of mathematics concepts were given that they have worked through the sections independently first. The forms of assessment present in this approach were self assessment via the DVD, formal assessment via the writing of weekly tests in the f2f

sessions and self assessment during tutorials both in the DVDS as well as in the f2f sessions. The aspect of formal assessment was problematic for learners and this corroborated by the results of weekly tests. Learners' experience of the assessment on the ISP will be discussed in section 7.2.2.

The ***emotional learning environment*** consisted of establishing the safety of learners, their personal emotional support, positive discipline and self management and the development of a sense of community. In order to effect participation a warm, safe and encouraging environment was established where clear expectations were expressed and trust developed, amongst the various role players. A sense of community was encouraged in the ISP with the aim of giving the learner a sense of belonging, and creating an environment conducive to learning mathematics. In this community, learners' individual differences with regard to learning styles were respected and different problem solving strategies and thinking were encouraged. The academic and emotional support of the learners played an important role in this community of learning.

On a more personal level facilitators and tutors acted as mentors, motivating and inspiring individual learners and thereby increasing self confidence in their ability to do mathematics, and alleviating their fears of mathematics. Advice with regard to career choices, university requirements and procedures was given to learners, and opportunities for career guidance and career camps were presented to learners.

The preceding discussion presented the elements characteristic of the blended learning environment using the DVD driven approach for the teaching and learning of mathematics in this study. In the following section, the researcher will interpret the findings that were synthesised from data derived from the questionnaires, interviews and facilitator reports in response to the sub research question "How did learners experience this blended learning approach?"

7.2.2. LEARNER'S EXPERIENCE OF THIS BLENDED LEARNING APPROACH

The second research question set out to determine how the learners experienced this DVD approach within a blended learning environment. Ludtke, Robitz, Troutwein and Kunter (2009, p120) assert that "From a phenomenological point of view, moreover, students' ratings are the most appropriate source of data for assessing the learning environment: a given students' behaviour can be more affected by his or her interpretation of the classroom context than by any objective indicator of that context". Here learners' perceptions of the context of the blended learning environment in which the DVD approach was embedded will be discussed.

The definition of blended learning that best reflects blended learning depicted in the ISP was proposed by Singh and Reed (2001, p2): Blended learning focuses on optimizing achievement of learning objectives by applying the "right" learning technologies to match the "right" personal learning style to transfer the "right" skills to the "right" person at the "right" time. In the ISP the right technology to suit the community of learners who attended was the DVD technology. Whilst most of the learners did not have access to computers and internet they all had access to a DVD player. The participants were grade 12 learners engaged with activities of school and could only attend f2f sessions on Saturday. The DVDs allowed learners to access mathematics learning at a time and place suitable to them. The list of blends present in the ISP were f2f facilitation of DVDs, discussions emanating from issues raised by learners, tutors and facilitators, tutorials, weekly tests, DVDs used for self study at home and hard copies of all resources and tests. The main attributes of the blended learning environment of the ISP were as follows:

- Teaching strategies were consistent with constructivist philosophies of teaching and learning
- It cultivated a community of inquiry approach to learning encouraging dialogue, discussion and collaboration between facilitators, tutors and learners
- It used learning activities that promoted high level thinking processes
- It assessed of learners progress in the content
- It acknowledged that learners learn through practice and application
- It provided support materials in the form of DVDs and hardcopies
- It instilled learner responsibility for learning
- It encouraged active participation both independent and collaborative

The above characteristics are mutually beneficial with each both supporting and requiring the others to create a supportive learning environment for the effective learning of mathematics.

Learners indicated that the ***physical learning environment*** was supportive in facilitating their participation in the ISP. Poverty in many of the areas of the Eastern Cape is well documented and for many learners in these areas going without breakfast is a reality and having no pocket money or access to money is commonplace. Many learners said that the money given to them for their transport to the Saturday classes enabled them to attend and that they appreciated the food that was provided for them.

The majority of learners were positive that the class size was right; however, a few learners said that they felt distracted by such a large group and found it difficult to participate in the activities. This intervention was initiated with the aim of reaching as many learners as possible and financial constraints of the project dictated the class sizes and the number of personnel that could be employed in this project. The researcher suggests that effective facilitation skills and the appropriate use of tutors would address this issue of class size in taking individual learners needs into consideration. The use of instructional strategies which involve group work, peer assessment and co operative learning would compensate for large class sizes.

The perceptions of an overwhelming majority of the learners were that the elements of physical learning environment were supportive in facilitating their participation in the project. The clean, noise free, spacious and technology friendly environment however new to learners was welcomed and this spurred them on to develop good work habits , a positive attitude towards learning, it facilitated collaborative learning activities, allowed them easy access to support from facilitators and tutors and allowed for interaction to take place. Although not mentioned by other researchers, in this research study comments from learners illustrated that the provision of money and food was important to them since it enabled them to attend and participate in the ISP. Coming from a situation of limited resources it may be assumed that the initial motivation for learners' attendance to the ISP was in order for them to receive the resources provided and once they were there they may have realised other benefits. The provision of a favourable physical learning environment for learners is likely to have influenced their learners' participation in the ISP, and contributed to their success in the ISP.

The majority of participants found that elements of the ***intellectual learning environment*** were beneficial to their learning of mathematics. Learners commented that as a consequence of these various elements there was an improvement in the manner in which they learned mathematics, an improvement in their ability to do mathematics, an improvement in how they perceived mathematics and an extension in their mathematics knowledge.

A blended learning environment has the potential to increase participation and improve understanding (the majority of the learners said "I have made progress in mathematics and added "My ability to do mathematics has improved"). The blended learning environment ("new way of learning") although unusual to learners who were accustomed to a teacher centred approaches to learning was nevertheless "enjoyable" for most of the learners.

Additional support in the form of materials (discussion here does not include the DVD) does increase mathematics learning.

Learners indicated that there was an improvement in how they learned mathematics. In the open ended questions of the questionnaire learners responded with the most number of positive responses in the category "materials". The majority of the learners found that access to different resources was a good idea and they believed that it made mathematics understandable for them. One learner described her experience with the variety of resources, "…the pages (hardcopies *of all activities*) they giving us. We learn thing we haven't learnt from school which help us to know better in our own schools". It is highly probable that the only resource learners would have encountered at their schools would be mathematics textbook. The variety of resources given to them on the ISP seems to have presented the concepts from different perspectives and probably presented many exercises and problems for them to engage with. This surely has the potential to lead to a better understanding of concepts. In addition, it is likely that the solutions to exercises could have helped learners with self assessment and directed their learning further.

Learners perceived the use of various resources and additional materials including the DVDs, as being helpful in their understanding of mathematics. It may be said that the resources provided support for a better understanding since they presented a number of opportunities for learners to work on mathematics; they presented many exercises for learners to work through mathematics problems and to improve their problem solving skills; provided guided support in the absence of a facilitator or tutor in the form of complete solutions to mathematics problems; they allowed learners to reflect on their tests by checking against solutions for tests given; and they made learners aware of different

problem solving techniques. Access to various materials provided the support for a better understanding. One learner described how the resources improved her understanding and said "... receiving more practice and stimulation and learning certain sections here before learning them at school, it was easier to understand things at school with this background knowledge".

More opportunities to work on mathematics and more time on task resulted in an improved work ethic and a lessening of a fear of mathematics.

According to Merrill (1991), learning is an active process in which learners build new ideas or concepts based upon their present and past knowledge, experiences and interactions. Learners mentioned that because of their participation in the ISP they spent more time "practicing" their mathematics. They stated that this gave them a "work minded attitude" referring here to a better work ethic. A consequential improvement in their mathematics results can effect a continuation of the cycle of work, understanding and good results. Having successfully completed a problem can motivate learners to try other problems and hence to improve their work ethic. Success breeds success. The majority of learners felt positive that their ability to do maths had significantly improved. Glasersfeld (1989) believes that a learner's motivation to learn is strongly dependent on the learner's confidence in their potential for learning. Their belief in their ability to solve new problems comes from having successfully solved problems in the past (Prawat & Floden, 1994). Learners gained confidence and motivation to embark on more difficult challenges by virtue of their successful completion of prior challenging tasks.

Learners through collaboration with their peers, tutors and facilitators and access to materials, have increased their problem solving skills

It is likely that learners were exposed to different ways of problem solving, simpler methods, and alternative methods through their collaboration with learners from other schools, discussions with facilitators and tutors and access to a variety of materials. At some of the schools learners attend only one method of problem solving is taught and many learners often memorise this without any understanding. Garrison and Anderson (2003, 79-90) suggest that teachers need to "offer alternative ideas and perspectives for analysis and discussions".

It seems likely that learners were able to discover for themselves methods of problem solving through tutorial problem solving sessions and facilitator led discussions. Tutorials and discussions on mathematics concepts enabled them to see other problem solving

strategies. The materials given to learners presented alternate solutions to problems and it is probable that this developed their problem solving skills and capacity. Access to additional materials including the DVDs, a deeper approach to teaching and learning mathematics, and collaboration between others in the programme extended learners knowledge base. Access to various materials provided the support for a better understanding. The in depth manner in which the concepts were dealt with formed a good grounding for a meaningful understanding. Collaboration holds the potential for new understanding and new learning.

Concepts were presented in a comprehensive and in-depth manner and hence extended learners knowledge of mathematics.

Learners felt that they had received more information on concepts taught and that their learning was more "in depth" and that this helped their understanding of mathematics. Learners said "... at school we were just given formulas and asked to apply them", "... my teacher only explained what she thought was important", "the facilitator was explaining things comprehensively… where they came from". These statements all suggest a surface approach to learning mathematics at school as opposed to a deeper understanding encouraged by the ISP. Learners appreciated the explanations given and felt that this contributed to their better understanding of mathematics. Learners need to understand the theoretical background and the foundations underlying mathematics concepts as far as possible before they can apply formulae. Much research affirms that the reason for poor performance on tasks that require critical thinking and problem solving is that the school curriculum emphasizes memorization rather than insight and understanding. This is substantiated by the rationale behind the Blossoms Project (Larson & Murray, 2008, p4) which states that "much teaching of mathematics in high schools is done formally, often in theorem and proof mode, and the style of student learning is too often rote memorization for an exam, and then forgetting" (c.f.3.5.1).

In addition, this approach to teaching could be suggestive of the capacity of the teacher to teach mathematics as "... outdated teaching practices and teachers lack of basic content knowledge is contributing to poor teaching of mathematics" (Mji & Makgato, 2006, p254). Hofmeyer (2008) adds concerning the teachers in South Africa that, "... less than 15% of the current mathematics teachers have the required qualifications to teach mathematics".

A deeper approach to teaching and learning mathematics, and collaboration between others in the programme extended learners knowledge base. Interaction between all participants in the ISP contributed to a supportive blended learning environment according to learners. Engelbrecht and Harding (2002) stress that a sound balance between teacher centred and learner centred activities should be maintained and that the interaction should

be carefully planned. Facilitators provided feedback and corrected any misconceptions about the content. Tutors guided learners through problem solving activities and learners collaborated with each other in tutorial sessions. Collaboration holds the potential for new understanding and new learning.

The opportunity to address problem areas and address questions to facilitators and tutors can improve mathematics understanding. Dialogue and collaboration with other learners have the potential to improve learning. Learners through collaboration with their peers, tutors and facilitators can significantly increase their problem solving skills.

Learners cited that there was an extension of their mathematics knowledge. Learners believed that access to resources, collaboration with peers, tutors and facilitators and engaging in tutorials and discussions led to a meaningful understanding of mathematics. However the results of the weekly assessments of most learners did not reflect the impact of the elements of the intellectual learning environment which learners commented had supported their mathematics learning. Criticisms from learners were made that the formal assessments were too long with too little time allocated for the assessment. The test marks then would not have been a true indication of learners' ability having had only had one week to engage with the concepts to be assessed. In addition the average learners struggled to keep abreast of the concepts taught and assessed weekly considering that they were in their final year of school with demands from six other subject areas as well. In many instances the mathematics concepts taught on the ISP were not synchronized with those taught at school and this added to the learners load.

The DVDs provided insight into certain concepts that went beyond the scope of the grade 12 mathematics syllabus and learners' knowledge was thereby extended

Theoretical background and additional topics related to the concepts in the grade 12 syllabus were presented on the DVDs. Although some of the learners were not in favour of this since they felt it was not important as they would not be examined on these topics in their final examination, it is important to consider the issue of lifelong learning of mathematics. It seems to be common practice to "teach to the exam" where learners are encouraged to simply work through a number of past examination papers in preparation for their examination. This encourages rote memorization of mathematics procedures without any real understanding of the mathematics concepts. As a consequence of this superficial learning of mathematics, learners are not able to cope with mathematics at tertiary level which calls for a deeper understanding of concepts.

Interaction with facilitators, tutors and other learners was important in creating a supportive learning environment where learners did not feel threatened and were free to participate.

The majority of learners indicated that interaction (between facilitators, tutors and other learners) played an important role in facilitating their mathematics learning. It seems that learners felt comfortable with the facilitators, tutors and other learners and that these interactions allowed for discussions, one on one engagement and a chance to pose individual problems or address problem areas. Learners also said that they found the facilitator led discussions in the ISP beneficial to their learning of mathematics. This is probably due to as Arbaugh (2008) suggests facilitators having both content and pedagogical expertise to draw connections between the concepts under discussion, to identify misconceptions, and introduce knowledge from other materials.

One learner said that although she was uncomfortable with the facilitators she felt comfortable addressing her problems with the tutors. The majority of learners were positive that the facilitator helped me to understand mathematics better, and believed that tutors explained concepts clearly. More learners believed that the tutors explained concepts more clearly, when compared with the facilitators. It is probably due to the fact that the majority of the learners were Xhosa speaking, while many of the tutors themselves were Xhosa speaking themselves. It seems that the learners felt more comfortable asking the tutors than the facilitators for help. This is likely since the tutors being a few years older than the learners and from the same cultural background as the learners probably made this communication easier.

Learners need to believe that they are capable of achieving mathematics learning. Facilitators, tutors and other learners motivating learners in this belief can be effective to learners' success. The majority of learners believed the facilitators were friendly, inspiring, motivating, caring, open to questions and not intimidating. According to Garrison and Vaughn (2008) trust must be created amongst learners in a community of inquiry to ensure open communication. This they add leads to meaningful communication. Such a community of inquiry should support interaction, encourage questioning, interaction with peers and small group discussions. And in turn this will lead to camaraderie being created and the sense of belonging to a group. Teaching and learning which occurs in a friendly atmosphere has the potential to benefit learning by allowing questioning, discussion and being open to critical views.

The various elements of the learning environment support the learning of mathematics and can be beneficial in achieving learning outcomes**.** Northrup (2001) states that as levels of interaction rise, their level of learning increases. Interaction on all levels can be an integral part of learners' mathematics learning. It is this support, feedback and mentoring that learners need in order to affect learning and succeed in mathematics. Whilst the onus lies with the facilitators and tutors to create a supportive environment the learners also have a responsibility to participate in their own learning. "Human learning is constructed not only by interacting with the content but also by working together with colleagues and instructors" (Alonso, Lopez, Manrique and Vines, 2005, p220).

Dialogue and collaboration with other learners had the potential to improve learning.

Learners provide support for each other since they find themselves in the same situation, compete with each other and motivate and share ideas and methods with each other. It is likely that learners understand each other since they are in the same situation (grade 12), similar age groups, come from similar backgrounds and generally share similar interests. According to learners accounts they support each other emotionally and intellectually by offering different perspectives on working mathematics, different methods and in addition add a dimension of competition with each other. Some learners reported that they formed study groups with learners they had met on the ISP and would meet to discuss and work on mathematics outside the ISP. Learners from different schools, with different skills and from different backgrounds construct understanding together, which they would not have done alone. Conceptual growth comes from the negotiation of meaning, the sharing of multiple perspectives and the changing of our internal representations through collaborative learning (Merrill, 1991).

Inclusion of all learners and monitoring the needs of all learners was challenging because of time constraints but this needs to be negotiated within aspects of group work and collaborative learning strategies.

In his theory of purposeful learning, Spencer (1998) stresses that a critical element in a supportive learning environment is the "interactive teaching techniques that enable a continuous checking for participant learning so instruction can be modified for optimal learning". The facilitators tried as far as possible to gauge participant learning through questioning and discussions and they modified their facilitation accordingly. Some learners felt that they were being left out of the discussions and did not feel comfortable to ask questions of the facilitator.

Inclusion of all the learners may be difficult because of time constraints but this can be negotiated within aspects of group work and collaborative learning strategies. Given that the learning styles of learners differs research (Brown & Voltz, 2005;Thorne,2003) advocates that the facilitation of blended learning programmes should take this into consideration when designing activities. Monitoring the needs of all learners may be challenging in the given time. Following up with learners is not always possible in the timeframe given.

A facilitator should be able to adapt the learning experience in order to create a worthwhile learning experience for the learner. Learners wrote weekly tests and through this avenue facilitators were able to assess the learning of the concepts taught, however no modifications to the method of instruction could be made, as the tight schedule of the f2f sessions could not allow for this. The researcher wishes to point out here that monitoring all learners' needs was not easy with a large group size.

Facilitating discourse requires the facilitator to review and comment upon student comments, raise questions, and make observations to move discussions in a desired direction, keeping discussion moving efficiently and drawing out inactive students (Anderson et al., 2001; Brower, 2003; Coppola et al., 2002; Shea et al., 2003). This is often not possible with large group size. In the blossoms project a suggestion was made "Teachers in high schools need appropriate technology-enabled means to leverage their skills in order to further engage and excite the students" (Larson & Murray, 2008, p4).

Perkins (1992, p53) asks and affirms of the question whether there is any partnership between technology and constructivism that is particularly advantageous in instructional design. Firstly the constructivist perspective places demands on the educational setting that cannot be easily met because of a shortage of resources. Secondly "coaching-like" interactions are favoured by the constructivist agenda but with the present teacher: learner ratios this is hardly likely to become a reality. Therefore technologies offer particular help in ensuring the building of "more intimate supportive environments called for by the constructivist perspective" (Perkins, 1992, p54). In the ISP there was a partnership between the f2f environment and the DVD environment allowing many opportunities for learning to take place.

The presentation needed more time for discussion and engagement with problems during the tutorials.

Time is necessary for new learning to occur. During the interviews some of the learners said that they felt that the lessons could be more hands on with more time to work on the

tutorials. More than one learner suggested a slower pace “it is the first time ... need more time to grasp” and while another learner said he needed “more practice” and “more discussion”. It seems that the learners were suggesting they needed more time, discussion and work on tutorials on a particular concept. Driscoll (2002) states, that the combination of any form of instructional technology with definite tasks constitutes blended learning and produces successful learning. However more time in the f2f sessions was not possible due to scheduling constraints.

Learners were very positive about the use of the f2f and DVD mode of presentation. Learners’ comments indicated that learners could consult the DVD if they had not understood something in the f2f sessions. However some learners mentioned that the reverse was true saying that if they had encountered problems whilst watching the DVD there was no avenue in a tight schedule of the ISP to address these problems.

Some of the learners also felt that the f2f presentations needed to have included more time for discussion and engagement with problems. It is possible that some learners need constant support and confirmation about their work. It can also be said that some learners may find it difficult to make a transition from teacher centred approaches to learning to more learner centred approaches.

Gagnon and Collay (2001, p10) suggest the use of “guiding questions”, to keep active learning going, to encourage reflection, to anticipate questions from learners, to frame other questions to encourage them to explain and support them in thinking for themselves. The purpose of the f2f sessions was to initiate the learners to the concept of the day, to introduce the DVD and salient aspects of the concept and to encourage questions, and discussions and to work on limited number of tutorial problems. Thereafter the onus was on the learners to follow up at home with more problem solving using the DVDs provided to them.

Anderson and colleagues (2001) conceptualize facilitating discourse as the means whereby students are engaged in interacting with and building upon the information provided in the course instructional materials. In this way the facilitator encourages the learner to be an active not a passive learner in the learning process supporting and challenging the learner to become an effective thinker. The emphasis is shifted from the instructor and the content, and towards the learner (Gamoran, Secada, & Marrett, 1998).

The blended learning environment ("new way of learning") was unusual to learners who are accustomed to a teacher centred approaches to learning.

Most of the learners agreed that the DVD was a useful resource and they also expressed appreciation for the blended environment within which this was embedded. They appreciated facilitators and tutors providing explanations and discussions while pausing the DVD. They needed the facilitators' explanations to bridge those gaps where the DVD skipped steps or they had problems in understanding. Anderson and colleagues (2001) view direct instruction as the instructor provision of academic leadership through the sharing of their subject matter knowledge with the students. They argue that a subject matter expert must play this role because of the necessity to analyse comments for precise understanding, bringing in sources of information, and directing discussions, scaffolding learner knowledge to raise it to a new level. It has become increasingly evident that the use of technologies can facilitate and enhance learning (Gribbins, Hadibi, Urbaczewski & Vivian, 2007). However many researchers are quick to point out that technology alone is not effective (Singh, 2003, Garrison and Vaughan, 2008). There needs to be a blending of different modes of delivery in order to enhance the learning process. According to learners, tutors, facilitators and discussions with other learners, helped them to view concepts from multiple angles. However learners perceived that a lack of prompt feedback from the facilitator was a source of confusion, anxiety and frustrations. Hara and Kling (2001) conducted a study of online courses, finding that feelings of isolation were a stress factor for online students as would probably have been the case with many learners on the ISP viewing the DVDs at home alone.

Learners felt that their English proficiency improved as a result of the blended learning approach. Only one learner suggested providing the DVDs in his mother tongue, an issue that is always contentious as there are eleven official languages in South Africa of which English is the lingua franca. Learners said that they liked the way the ISP presentations blended with the tutorials, DVDs and discussions and that this made it easier for them to concentrate for longer periods.

The point made by almost all the learners was the ease with which learners could view the DVD and replay and pause whenever they wanted to. A few learners also said that their teacher used these DVDs at their schools to teach certain topics such as calculus. Some learners formed study groups and watched the DVDs in their study groups over the weekends. The blended learning approach using DVDs presented a new way of learning mathematics for the learners and most of them were positive that the method benefited their understanding of the subject. Blended learning is a mix of appropriate delivery techniques and technologies to enhance the ability of the learner to learn achieving the

desired outcome of the learning experience (Maguire & Zhang, 2007). The approach allowed them the freedom to access a variety of different resources, allowed them to work at their own pace and allowed them to revise at home.

Some learners noted, however, that at first they needed to adjust to this new learning environment but once they had adapted they could see the advantages of being exposed to different modes of delivery. Constructivism scholars (Brown, Collins & Duguid, 1989; Ackerman 1996) see learning as "... an active process where learners should learn to discover principles, concepts and facts for themselves, hence the importance of encouraging guesswork and intuitive thinking in learners" (Wikipedia: Constructivism). The majority of the learners agreed that this blended environment of teaching and learning mathematics fostered a deeper understanding of the subject for them. The most important point raised by learners was the fact that the DVDs alone were not sufficient to ensure success. They believed the DVDs together with facilitators' and tutors' explanations and discussion coupled with the hard copy resources were the best blended approach for learning mathematics. "A critical community of learners, from an educational perspective, is composed of teachers and students transacting with the specific purposes of facilitating, constructing, and validating understanding, and of developing capabilities that will lead to further learning. Such a community encourages cognitive independence and social interdependence simultaneously." (Garrison & Anderson, 2003, p23).

There is a shift in the educational paradigm from the rigid teacher centred approach to a learner centred approach as innovations in new technologies offer "new ways to think of producing, distributing and consuming academic material" (Seely, Brown & Duiguid, 2000, p210). As technology becomes more advanced there are more opportunities for a learning centred approach. The most important is that it promotes a more learning centred approach moving away from the traditional passive dissemination of information by teacher or instructor. Equally important is also the idea that learning is a "continuous process not a one- time event" (Singh, 2003). Blended learning allows learners who cannot be present for classes at that time or place the convenience to access learning. In addition blended learning accommodates learners with different learning styles. Learners are allowed to learn in their own way and at their own pace. The variety of the methods in the blended programme adds to the richness of the blended programme and allows many opportunities for learning to take place. Collaboration with peers and immediate testing and feedback of their learning are also cited in research as benefits to blended learning (Rovai and Jordan, 2004).

However learners felt that the formal assessments were too long with little time being allocated for the assessment. The test marks then would not have been a true indication of learners' ability having only had one week to engage with the concepts to be assessed. In addition the average learners struggled to keep abreast of the concepts taught and assessed weekly considering that they were in their final year of school with demands from six other subject areas as well. In many instances the mathematics concepts taught on the ISP were not synchronized with those taught at school and this added to the learners load. Norman and Spohrer (1996) taking into consideration the dimensions of learner centred instruction question the effectiveness thereof: how much do learners learn? Tests do necessarily indicate the depth of understanding or the skills acquired. In this case however one has to take into account whether the learners had sufficient time to engage with the concepts taught in order to display this required depth of understanding.

The various elements of the intellectual learning environment support the learning of mathematics and can be beneficial in achieving learning outcomes. Whilst the onus lies with the facilitators and tutors to create a supportive environment the learners also have a responsibility to participate in their own learning.

Giving the theoretical background of concepts before application and verifying the use of appropriate conjectures and formulae in presenting a concept contributed to a deeper understanding of the concept.

Learners were positive in general about the DVDs as a resource. Ninety one learners (85%) felt that the concepts were presented well and that explanations of the mathematical concepts were done well. This learner was positive about the DVD and said, "My experience with the DVD was very positive it highlights the basic important theory like work you need to know for the different sections of work". The DVD was particularly useful to them in sections that required visual representation (graph drawing) and in the topic of calculus since it was "not done well" at school. Many learners said that they found mathematics easy to understand because of the many examples and illustrations on the DVDs. Adding related graphics to text, words near visuals, and audio rather than text to complicated graphics have been shown to improve learning (Carman, 2002). In addition, Javed and Vale (2006, p144) assert that "while physical objects become more abstract when modelled onscreen (e.g. science simulations) mathematical objects already inherently abstract become concrete".

Many learners said that the DVD approach gave more insight than school attendance provided and that they found it helpful for understanding concepts to do a section on a DVD during a Saturday session before it was done at school.

The convenience of the technology in terms of access any time and as many times as needed was an advantage in mathematics learning.

Many learners said that the DVDs allowed them to learn at their own pace and to watch a section "over again" until they understood the concepts. Learners said "I could stop and rewind again if I need to" and "they were my personal teachers" describing how effective the use of the DVDs was to them. It is likely that many of the learners would have been unable to pay to attend extra tuition in mathematics and the DVDs to some degree fulfilled that need. It was encouraging that many learners reported on watching the DVDs at home and revising the work together with the resource material. A learner substantiated this by saying," They (DVDs) are more interesting than reading a book for hours. I got to learn new ideas and methods of solving mathematics problems". This approach helped to enhance their understanding and supports the effectiveness of the additional small learning cycle as shown in Chapter Three (illustration 3.2). Another learner said in his home language Afrikaans, "Om die les op DVD het my as individu baie byvoordeel,juis vir spesifieke rede dat ek nie iets onmiddelik verstaan en kan toe pas nie. Omdat ek die les oor en oor kan kyk kon ek baie maal fyner tegnieke optel". Meaning that the DVD was an important resource to him since he was unable to understand concepts immediately and watching the DVD over and over again afforded him the opportunity to pick up the finer techniques pointing out how the DVD approach would indeed be advantageous in mathematics learning.

The DVDs performed to some degree the role of a personal tutor taking learners through concepts and allowing them to work through these concepts.

Class time allocated to certain concepts is limited and f2f time on the ISP is limited and the DVD provided more opportunities for learners to work through these concepts at their own pace outside of these sessions bringing into focus the issue that learning is not viewed as a once off event. A learner said, "In actual fact I found watching it (*the DVD*) at home to be better than in lectures because I could take a break whenever I felt tired. The explanations were simple enough to understand too, even though English is my second language". A few learners said that they found it easier to concentrate as opposed to having someone standing in front explaining what to do while others found it difficult to concentrate using the DVD approach. One learner said that it was easy to "... move your concentration elsewhere" unless you had a lecturer to intervene with discussion or explanations. This raises the issue of different learning styles which can be addressed in a blended learning environment with a variety of presentation modes.

Step by step guide to problems with voice explanations had the potential to increase mathematics learning.

Learners reported that they benefited from the step by step illustration of the problems on the DVDs. The complete worked out solutions of all the examples were presented step by step, line by line and the thought process involved in the solution of the particular problem was explained by the solver. The intention was to give learners an understanding of the thought processes involved in solving a problem and to help learners who would had no idea where to begin (Aminifar, Porter, Caladine, and Nelson, 2007). The step by step exposition of problems, voice explanations, graphics and visuals on the DVD guided learners to a better understanding of the mathematics concepts.

Self assessment via the DVD was useful in preparation for tests and exams.

Learners also used the DVD to "test and check" their understanding of a particular concept. They reported pausing the DVD and attempting the problems on their own before viewing the solutions. They found that the DVD series was a good resource to consult when faced with homework or in preparation for a test or examinations. It is probable that since the DVD dealt with concepts in a "comprehensive" way and the colourful presentation with animations and voice explanations made the DVDs a more attractive resource than the textbook.

Learners cited that the DVD as a resource was significant in their learning of mathematics. The DVD embedded in a blended learning environment can support the achievement of learning outcomes. Communication of expectations is needed to create a culture of accountability and commitment to learning. However the DVDs success lies in the responsibility of the learners to access the learning via the DVD failing which its impact will be minimal. As Singh and Reed (2001) suggest that the characteristics of the learner must be considered in the designing of an effective delivery option and that the motivation of the learner to obtain this learning is an important element. In addition the DVD experience cannot function optimally in isolation, there needs to be additional support and interaction obtained from the f2f sessions.

According to a facilitator the "DVD was a powerful resource allowing learners to work at their own pace and review solutions and procedures until they understood the concept". The DVDs were designed to be complete units on a particular mathematics topic and learners said that they (the DVDs) were like their personal tutors. The theoretical background provided on the mathematics concepts allowed learners to reach a more

meaningful understanding of mathematics, allowing learners to see how formulae and other assertions were arrived at. This enabled a deeper approach to learning mathematics and not merely a rote memorization of formula. Sanchez, Encinas, Fernandez and Sanchez (2002) say that providing learners with a good classification and structuring mathematical information will facilitate a deeper and more efficient learning. The in depth manner in which the concepts were dealt with formed a good grounding for a meaningful understanding.

Criticisms of the DVD

Constructive criticism came from learners as they felt that some of the DVDs did not illustrate every step of a mathematical problem and that this could lead to confusion. They asked for more detail and more examples on the DVDs. In a solution of mathematics problems the learners could experience feelings of hopelessness if the steps in the solution are missing and they needed further explanation not given by the DVD. This may be addressed in the development of the DVD where all possibilities for confusion and common problem areas are brainstormed and determined in the design phase and can be addressed the production of the DVD. This can also to be addressed in the facilitation of the DVD during the f2f sessions. However not every learners query can be addressed in this way. Provision should be made so that learners can make contact with such issues with a possible 24-hour response service (see recommendations).

A few learners pointed out that the notation differed from that which was used at their schools and this was confusing for them. Although the notation differed from what they were accustomed to learners should acquaint themselves with alternate notations. These alternate notations could in any case appear in their other educational experiences in the future. Learners are unrealistic when suggesting that the DVD was too long. They should work out a schedule on how to view each DVD keeping in mind that they can stop and come back to view again at their convenience.

The DVD embedded in a blended learning environment can support the achievement of learning outcomes. Communication of expectations is needed, in order to create a culture of accountability and commitment to learning. Attitude and motivation of individuals are major ingredients in virtual learning success, compared to learning success in the classroom (Keller, 1983). It is with this notion in mind that the researcher asserts that the DVDs success primarily lies in the responsibility of the learners to access the learning matter via the DVD failing which its impact will be minimal.

Learners believed that because of the elements of the ***emotional learning environment*** there had been an improvement in how they perceived mathematics. Learners need to believe that they are capable of achieving mathematics learning and that their motivation can be effective to learners' success. Setting and communicating high expectations for learners can increase the motivation levels of learners. One learner indicated how he felt motivated, "To motivate student to enjoy mathematics and not fear it like me and built a strong relationship with it". Many learners said that they were highly motivated. Another learner reflected on how this environment affected her motivation to do mathematics, "We got the opportunity to rise to our potential of being good at maths". Increases in the motivation levels of learners can improve their perception of mathematics and result in an improvement in their participation and performance levels.

Setting and communicating high expectations for learners did increase motivation levels of learners.

The majority of the learners responded positively that they felt motivated to attend classes on the ISP. Learners said that the facilitators and tutors had been instrumental in motivating them to do well. One learner said that "encouraging everyone to make a success of their lives and to be motivated and involved" was the key for him. Many learners have a negative view of their ability to do mathematics and hence are fearful of the subject. Many learners even those with an interest in mathematics and the capacity to do mathematics lack focus and direction to study and they need a nurturing nudge to help them develop a good work ethic. Ward et al (1998) identified one of the most critical success factors as "give attention to all aspects of the student by providing for their social, personal and academic development and raising their self esteem and self confidence". Most of the learners said they felt positive that their self confidence in mathematics had improved.

The fact that the learners were treated as individuals and were expected to work independently made them feel that they were "university students" as one learner said. In addition it seems that having exposure to the tutors, members of their own community who has achieved such learning surely brought into focus for the learners their own ability to achieve this and inspires them. It is probable that the learners recognised the tutors as role models.

Norman and Spohrer (1996) in considering one of the dimensions of learner centred instruction as engagement describe it as the capacity to provide prompt and convincing

interaction and feedback to learners. They are of the opinion that engagement motivates learners. In addition, a teachers or facilitator's belief in their own ability to do mathematics can influence learners' belief in their ability to do mathematics and motivate them to learn. This can improve their self esteem and give them the confidence to work harder and perform better in mathematics. Another important fact influencing learners' motivation is that all learners on the ISP whatever their prior results had been treated as equals in the programme.

The playing fields were levelled whereas at school the teachers know the learners past track record with mathematics and the learners are treated accordingly. Learners also believed that their fear of mathematics was eased by the facilitators who motivated them to strive to enjoy mathematics and therefore they reached their "... our potential of being good at mathematics". Once this had been done learners said that they "built a strong relationship with it (mathematics)". Mathematics is seldom perceived by many as a fun activity and sometimes the negativity and the lack of capacity in the teachers can be transferred to their teaching of mathematics and their learners. As noted in the Blossoms project (Larson and Murray, 2008, p90): "Many high school students, both young women and young men, are turned off from studying math and science, seeing it as hard work with little relevance to their lives". Increases in the motivation levels of learners can improve their perception of mathematics and induce an improvement in their participation.

In the foregoing section the researcher interpreted the findings related to the categories the physical learning environment, the intellectual learning environment and the emotional learning environment in response to the second sub research question: "How did learners experience this blended learning approach?" The following section involves the interpretations and the synthesis of findings related to the last sub research question: "What impact on learners mastery of mathematics has the approach made?"

7.2.3. THE IMPACT OF THIS APPROACH ON LEARNERS MASTERY OF MATHEMATICS

The majority of learners improved their mathematics mark in the final exams as compared with the marks of their peers at their schools who did not attend the ISP 2009. It became clear from the quantitative data that not all the learners responded to this particular blended learning approach. This is not a surprising finding, however unfortunate. Within a blended environment learners need to take ownership and responsibility and sadly this seemed to not always be the case. The DVDs are intended for follow-up study at home and such homework projects cannot always be enforced. The fact that a percentage of learners performed worse in the grade 12 exam, should necessarily be attributed to the blended approach of the ISP. The grade 12 paper, as mentioned before could have been more difficult which makes the improvement of the higher performers even more impressive.

7.2.3.1. Pre test and Post test

It is interesting to note the comparison of the grade 11 results and the pre test which both assessed concepts covered in the grade 11 mathematics syllabus. Only one learner received (1%) below 40% in their grade 11 examination, yet one hundred and eighteen learners (63%) scored below 40% in the pre test.

One interpretation could be that the grade 11 marks since the exam is set by the school and marked by the teacher at the school would not have been a true indication of the learners' ability. Possible reasons for this could have been that, it was an easy exam, learners knew what to expect, and the marking was too lenient. Another interpretation for the deterioration in the pre test mark could be that certain concepts may not have been covered at schools i.e. the syllabus had not been completed. This is corroborated by learners' responses in the paragraphs they were requested to write on how they had experienced the pre test. One learner wrote "It was too complicated because at school we don't learn these sections and I tried my best. I only recognised questions 8; 3; 14 but others were difficult to me and I didn't even concentrated well because the sections where complicated. But next time I will try my best trust me". This was echoed by another learner "This was not a very difficult test, it was okay. I would have done better had my school covered all the curriculum for Gr 11. However, I still did enjoy it. I don't think I did well with trig though". One of the learners had a mark of 26% in the pre test, 40% in the grade 11 examination and 87% in grade 12 examinations: this was his response on what he felt about the pre test: "This test gave me a challenge and it's varies from the tests I have written, it covers a lot of topics at a same time so that's great. In my school we didn't cover geometry and we did a bit of trigonometry. I faced a lot of challenges in Paper 2 but I managed to escape with victory. If I could get more resources to study mathematics and science then I could be the great, I can be". In addition "The test was average. I have done most of the things at school but some of the things weren't covered at my school because there wasn't enough time last year. I think that the reason why some things couldn't come to mind was because I was a bit nervous, whenever I write a test at school I prepare for it before hand and I find the test easy."(37% pre test, 80% grade 11, 88% grade 12).

As a third interpretation, learners could have learnt and forgotten the concepts taught in grade 11 since the pre test was taken in February of the next year. This would indicate rote memorization of the concepts without any proper understanding. A learner said "Although I am use to a higher standard I have not studied this work since last November and I have forgotten many approaches" and "I found this test easy but tough. We did most of the questions here but I still find it hard to solve graph questions like the question above. I would say that it is important to remind & do revision of the November tests because I find myself stuck in other questions even though we've done them". The contradiction in "easy

but tough" suggests that the learner recognizes the questions as familiar but has forgotten methods to solve the problems.

The issue of language of instruction can be a barrier to learning and assessment as one learner said "The test was okay. It's about the same way that we write tests at our school. The only difficulty was the language. We are used to getting maths in Afrikaans. All of these sections were covered last year".

If one focuses on the learners that have achieved 60% and above in the post test there have been in general improvements from the results of the pre test with the largest increase being 48%.

7.2.3.2. Weekly Tests

It is worrying that 46% of the learners had a test average below 40%. This statistic can be corroborated by learners' responses in the questionnaire where only 43% said that they could cope with the amount of work they had to study for weekly tests. Learners said that they had too little time to engage with the concepts that were in the test. The learners were given a week to engage with two sections in mathematics, learners may have not seen these sections prior to their ISP session and therefore one week to study two sections in addition to contending with other school activities that may have included other tests as well would have been challenging. If the tests form part of the learning cycle of the ISP then there is a shortcoming if learners are unable to participate in these assessments effectively and yet derive benefit as they claim from this participation and the assessment opportunities.

7.2.3.3. Grade 11 performance versus Grade 12 performance

All the learners who achieved above 70% in grade 12 mathematics examination had with the exception of two learners more than 80% attendance in the ISP. It is unfair to attribute the success of these learners simply to excellent attendance, however one could say that regular attendance can improve the work ethic, focus on the task at hand and ultimately learners understanding of mathematics. Learners attending regularly would have had the benefit of access to all the support of the ISP.

It is not an ideal situation to compare grade 11 and grade 12 marks since one exam is internally set, moderated and marked by the school concerned whereas grade 12 examinations follow more stringent rules. The fact that so many learners actually performed better in their grade 12 examinations could be testament to the efforts of the ISP.

Fifty two percent of learners improved their mathematics result in the grade 12 examination and 5% maintained their grade 12 marks when compared to their grade 11 marks. There could be many possible reasons for learners' marks deteriorating in grade 12. Learners' needed to take responsibility for their own learning and it is possible that they did not follow up with DVD watching at home. Perhaps they relaxed thinking that since they were attending ISP they need not work anymore on mathematics than that. Learners also needed to be proactive in terms of accessing help from other learners, facilitators and tutors. If they failed to engage in questioning, discussing and forming study groups their mathematics understanding would not have benefitted.

All but one learner entered the ISP with a grade 11 mathematics mark of above 40%. It is possible that the grade 11 marks were not a true reflection of their abilities as shown by the pre test or that the intervention was not sufficient to bridge the vast gap in their mathematics knowledge that existed. Perhaps the problems with mathematics that learners experienced were too deep seated to have been successfully addressed in ISP. This intervention then would have been a case of too little too late.

Learners' success rate depends on many factors such as motivation, dedication, work ethic but ultimately the onus for learners' success lies with the learners themselves. Learners spent two hours a week on f2f sessions on the ISP and outside of this learning context they needed to integrate all their resources and opportunities given to them in order to succeed. Learners needed to be committed to their learning and should have set dedicated time aside to work on mathematics and to incorporate the DVDs in their learning. Ward et.al. (1998) maintained that one of the most critical success factors is to "develop students' responsibility and accountability by making negotiation, inclusive decision making and personal responsibility features of the programme". If the f2f sessions were not consolidated with independent work at home success would not be guaranteed. The fact that so many learners actually performed better in the grade 12 examinations could be a testimony to the efforts of the ISP.

In the comparison of six schools it was found that a smaller percentage of the non participants achieved an improvement greater than zero, while the participants had an improvement greater than zero. The results of the learners who were on the ISP improved remarkably whilst those learners not on the ISP generally presented lower grade 12 final results. It should be noted that the learners who took part in the ISP showed more interest in mathematics and science and were not surprisingly better performers.

The majority of learners improved their mathematics mark in the final exams as compared with the marks of their peers at their schools who did not attend the ISP 2009. The DVD approach in the blended learning environment did impact on the learning of the participants as opposed to the non participants. The participants did have the advantage of following a structured programme of support, feedback and mentoring in additional to regular schooling. Not all the participants showed an improvement in their mathematics performance. The success of a programme depends, to a considerable extent on learners' acceptance and use of the programme. Attitude and the motivation of the individuals both play a major part in virtual learning success, more so than in the classroom (Keller, 1983). Learners, although they attended the f2f sessions, diligently needed to access the DVDs outside of the learning setting. This would have required some measure of dedication and many hours, an effort not all learners would have been willing to make. For learners accustomed to more teacher centred approaches to learning the shift of responsibility for their learning to themselves would not have been an easy one. Lanham and Zhou (2003, 282) affirm that "The shift in learning accountability from the instructor to the student in e-learning is one of the major hurdles that exist in the transition to online courses".

It should be noted that the learners on the project were chosen for their interest and previous better performance in mathematics and therefore, it is reasonable to assume that they would have performed better. The DVD approach embedded in a blended learning environment holds the potential to impact on learners' mathematics performance. Attending the f2f sessions only is insufficient; the learner needs to integrate this learning with self directed learning using the DVDs. The onus lies with the learner to take responsibility for and to direct his/her own learning. Allen and Clarke (2007) say that learners need to become responsible for their own learning within an environment of constructive feedback and guidance. It should also be noted that improvement and success are also largely a consequence of learners' personal characteristics, motivation and determination. Various researchers have shown that learning in an online environment requires a significant amount of discipline and self motivation (Golladay, Prybutok & Huff, 2000; Serwatka, 2003).

7.2.4. ASSESSMENT OF THE BLENDED LEARNING ENVIRONMENT

The ISP blended learning approach offers a fair blend between face to face and computer technology based learning.

The discussion here is the result of the researcher's reflection on the 2009 ISP blended learning environment. With regard to determining how successful the approach of the 2009 ISP was in terms of blended learning the researcher made use of and adapted a model

developed by Harding, Engelbrecht, Lazenby and le Roux (2005) to assess the scope and extent of blending of this blended model.

This radar chart measure was an attempt to provide a visual presentation that shows at one glance what the scope and extent of blending in the model is and to indicate the associated strengths and weaknesses. The Harding radar chart measure applies to a blend between face-to-face and online instruction, specifically web-based instruction. Here the researcher has adapted and generalised the measure to apply to a blend of face-to-face instruction and instruction via computer based technology that is not necessarily web-based.

The 2009 ISP blended model was assessed by the researcher using the measures of this instrument (c.f. 5.11) and these findings were integrated with the findings from questionnaires, interviews and facilitator reports.

Dynamics and Access: What is the frequency of the use of computer technology necessary for success in the course? Score - 4.

Learners view the DVDs for the first time at Saturday sessions with a facilitator discussing and explaining the concepts on the DVD. Thereafter learners are expected to view the DVD at least once at home during the week, in total at least two to three times per week. In addition learners are expected to view the DVDs more often if they need to at their own pace and at times that are convenient to them. Learners would have needed to reflect on their learning and assess their understanding of concepts in order to determine how many times they needed to watch the DVDs.

Assessment: How much of the assessment is done via computer technology? Score - 2.

Little formal assessment is done by means of the Technology. However learners can use the tutorial section of the DVD for self assessment purposes, pausing the DVD and working through the problems and then viewing the solutions to check their understanding of the concepts being studied. As self assessment forms an important part of this blended learning approach the researcher has allocated a score of 2 (almost half of it) to this component.

Communication: How much of the communication happens via computer technology? Score - 1. Little communication occurs via the DVD. Communication is one-way as the DVD presentation flows and two-way communication only happens on a face-to-face level once a

week. This issue arose in interview and questionnaire responses where learners said that that if a question or a problem arose whilst watching the DVD at home there was no means of contact to receive clarification. This highlights an aspect of the ISP which requires further discussion and development.

Content: How much of the content is available via computer technology? Score - 4.

All the content is given on the DVDs and it is supplemented face-to-face during the introductory facilitation of the DVDs. The content of the grade 11 and 12 mathematics syllabus was presented. The DVD presented additional topics to enhance the understanding of the topics in the grade 12 mathematics syllabus. PowerPoint slides were designed and developed to present each topic comprehensively so that the DVD could stand alone if needs be.

Richness: How many enriching components does the computer technology based part of the course have? Score - 4.

In addition to voice-over presentations, animations are given, graphics and step-by-step exposition of examples and problems are presented. Graphing software was used to illustrate concepts through mathematical investigation. These components were well received by the learners who believed that this enhanced their learning of mathematics. Mayer and Moreno(1998) in their multiple representation principle state that explanations in words and pictures allow learners to build two mental representations. They also allow learners to build correlations between the two. ". A learner confirmed that the DVD "brought an image" while another said the graphing software helped me see transformations". Yet another added "... the visual aspect helped me remember better what I saw".

Independence: How independent is success in the course from face-to-face contact? Score – 3. There is limited regular face-to-face contact one day per week on a Saturday between educators and learners.

The radar chart taking these six dimensions into consideration is given in Figure 7.1.

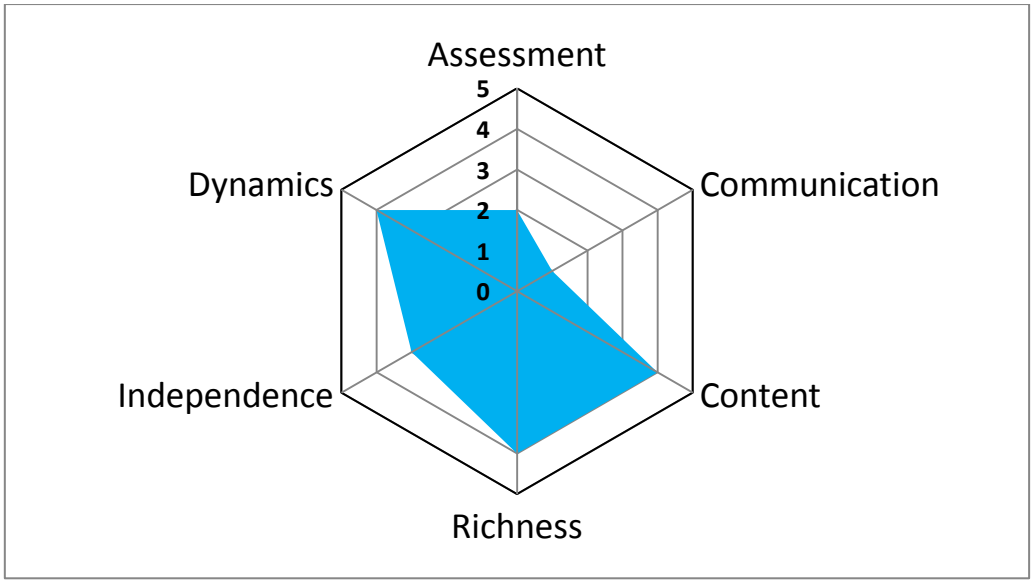


Figure 7.1 Radar Chart for 2009 ISP Blended Model

The ISP blended model offers a fair blend between face-to-face learning and computer technology based learning although it is not well-balanced around the centre. The ISP model is deficient with respect to interaction, but especially with respect to assessment and communication. The model is strong with respect to material however.

7.3. CONCLUSIONS

Mortera- Gutierrez (2006, p314) asserts that "The successful implementation and use of blended learning requires the understanding of the strengths of the different mediums, how learners learn, engage in this type of learning process and how they use information from each different medium and how they handle online (or other distance education modality) and the traditional f2f teaching methods in a combined form". The purpose of this research study was to explore how the use of DVD technology with a framework of blended learning supported the teaching and learning of mathematics to answer the research question: ***How did the use of the DVD approach within a blended learning environment support the learning of mathematics?***

The researcher believed that a better understanding of the ISP would inform the design of future ISPs and other programmes of this nature. Given that the research was a case study, the findings may not necessarily be generalisable to other courses however it is hoped that knowledge gained from this study may contribute to alleviating the mathematics crisis experienced in this country by describing an implemented blended learning intervention

and presenting its pitfalls and successes. The study should be of value to anyone who is involved in or is considering the implementation of similar programmes.

A DVD approach within a blended learning environment was used in this ISP. The rationale for implementing DVD technology was that it represented "relatively accessible and affordable technologies" (Niewoudt, Niewoudt & Monteith, 2007, p29) to the learners who attended this project. The DVDs were designed to be used as an independent learning resource with fixed mathematics content. In the 2009 ISP the use of this DVD technology was embedded in a blended learning environment as it was decided that technology alone is not effective and that blended learning is better than either traditional teaching methods or the use of technology alone. In so doing a learning environment was created that drew on the strengths of both methods and offered the potential to be richer than either f2f or technology alone.

Learners attended f2f sessions on Saturdays during which two DVDs of one hour each were played, interspersed with this facilitation learners worked on tutorial problems. This was an interactive session with discussions, questioning, and assistance and guidance from tutors and facilitators. These contact sessions allowed for facilitator led discussions, tutor interaction, and independent and collaborative work on assigned tutorial problems. Learners were given hardcopies of all the resources used in the f2f2 sessions. These included their own copies of the DVDs to view at home. Opportunities for self assessment formed part of the DVDs and learners were formally assessed on their return to the f2f session the following Saturday. One of the main advantages of using DVD technology within a blended learning approach is the accessibility of the mathematics content and presentations outside of the classroom to a particular learner who in general has no internet access.

In this study we have shown that using the DVD approach within a blended learning environment did led to an improvement in learners perceptions on mathematics, an improvement in the manner in which they learned mathematics, an extension in their mathematics knowledge. This approach also provided learners with a supportive environment in which to learn mathematics.

The findings of this research indicated that:

- This "new way of learning" was exciting and fun and developed in learners a **good work ethic**.

- The DVD approach provided **more insight** than mere school attendance providing in depth explanations and theoretical background of mathematics concepts which improved learners understanding.
- The different **components of the DVD** such as voice-over presentations, animations, graphics, graphing software and the step-by-step exposition of examples and problems were all well received by the learners who believed that it enhanced their learning of mathematics.
- DVDs allowed learners to **access** mathematics learning outside of the classroom at their own time and at their own pace.
- Learners felt that **facilitators and tutors** explanations and guidance were necessary to **bridge the ga**p where the DVD skipped steps or they had problems in understanding.
- **Dialogue and collaboration** with other learners improved their problem solving skills.
- More time spent working on mathematics fostered **independence**. Although f2f sessions provided a supportive learning environment learners spent more time on their own working through mathematics problems independently.
- The various **activities** encouraged a deeper approach to the learning of mathematics.
- The various **resources** provided learners with support for a better understanding of mathematics.
- Setting and communicating high expectations for learners can increase the **motivation** levels of learners.

The following constraints of the DVD approach within a blended learning environment were mentioned in this research:

- **Assessments** were not helpful since learners had insufficient time to engage with the concepts which were assessed. The assessments were too long with inadequate time allocated to complete them.
- This blended learning model increased their already burdened **workload.**
- DVD technology is deficient with regard to **communication**. Learners spontaneously formed study groups for watching the DVDs over weekends. Perhaps study groups could address this problem in a sense that communication will happen between learners in the context of the DVD technology.

This case study has been able to show that using a DVD driven approach within a blended learning environment for the teaching and learning of mathematics is likely to have had a positive impact on learners by providing them with a supportive learning environment in which to learn mathematics. This research study has also been able to show that using a DVD driven approach within a blended learning environment for the teaching and learning of mathematics may in fact be more effective than learner performance is able to demonstrate.

Qualitative results indicated that both learners' and facilitators' experiences were largely positive with concerns identified that offer opportunities for improvement. Learners valued the blended environment of learning and expressed their appreciation for the different components. The face-to-face discussions extended learners' concentration whereas the DVDs provided opportunities for repeated watching. Most learners attributed their better understanding of the mathematical concepts to the DVD approach that was used in conjunction with the other traditional modes of delivery. It is significant that the facilitators reported positively on the blended learning model and observed increased levels of confidence and communication amongst the learners. The value of blended learning was again emphasized.

Quantitative results indicate that there is a statistically significant difference when comparing the mean scores for learners' grade 11 and grade 12 results, although this is not of practical value. In the face of the declining results for mathematics in South Africa in the 2009 grade 12 examination (Motshekga, 2010) our results seem to suggest that the DVD approach of blended learning could have in some way contributed to the improvement in mathematics results that was noted amongst many of the ISP learners, especially for the better learners. It is disappointing that a large group of the borderline learners did not seem to benefit from this blended learning approach. This finding is reason for concern as these are the learners that should be targeted and the reason for this disappointing deterioration has to be investigated. If learners do not assume accountability and commitment for learning the impact of this DVD approach will be minimal.

The final phase in this action research cycle is that of implementing changes before a new cycle begins. For the blended model changes are implemented annually, based on feedback from both learners and facilitators. DVDs are revised and streamlined and concerns expressed by students are addressed such that some example problems show too few steps. The presentation during Saturday morning sessions is also adapted along suggestions from facilitators and learners alike.

7.3.1. A BLENDED LEARNING FRAMEWORK FOR THE 2009 ISP

In answering the research questions and sub questions and as a result of the synthesis of the research findings and conclusions the researcher summarises the contributions made by this research and presents a blended learning framework for the DVD approach. This framework is presented in Table 7.1.

Table 7.1 Framework for Blended Learning of the 2009 ISP

<table>
<tr><th colspan="4">Framework for Blended Learning of the 2009 ISP</th></tr>
<tr><td>Impact</td><td colspan="3">Improved
Participation
Confidence
Work ethic
Motivation
Mathematics understanding
Mathematics performance
Language skills
Problem solving skills</td></tr>
<tr><td>constraints</td><td colspan="3">Assessments not helpful
Workload increased
Communication via DVD deficient</td></tr>
<tr><td></td><td colspan="3">ELEMENTS</td></tr>
<tr><td>Learner Experience</td><td>PHYSICAL
Classroom design
Spacious, clean, noise free environment
Support use of technology
Food
Money</td><td>INTELLECTUAL
Culture of learning
Clarified outcomes
Non threatening environment
Problem solving
Appropriate level of communication
Capable staff
Learner centred
Discussions
Questioning
Catered for individual learning style
Variety of teaching strategies
Variety of resources
Collaborative learning
DVD use
Prompt feedback
Participation maximised
Interaction
Facilitators and tutors
Peer support
Self assessment
Weekly formal assessment</td><td>EMOTIONAL
Clear expectations
Trust developed
Warm and friendly environment
Confidence instilled
High expectations set
Respect
Responsibility for learning
Positive attitude to learning
Support
Career guidance
Mentoring</td></tr>
<tr><td>Foundation for design and implementation of the 2009 ISP</td><td colspan="3">Constructivism
DVD approach
Community of inquiry model
5e learning cycle model
High level thinking activities
Assessment
Practice and application
Support materials
Learner responsibility for learning
Active participation, independent and collaboration</td></tr>
</table>

Various aspects were taken into consideration in the design and implementation of the 2009 ISP. Constructivism was the paradigm underlying the intervention and its principles for example learner centredness and the role of the instructor as facilitator were put into practice in the ISP. The DVD approach employed the use of DVDs which represented easily accessible and affordable technology and formed an important ingredient in the blended learning environment. The principles of the three core elements teaching presence, social presence and cognitive presence informed the design and implementation of the 2009 ISP.

The five cycles of engage, explore, explain, expand and evaluate represent the 5e learning cycle which was employed in the 2009 ISP. Assessment took the form of weekly tests and included self assessment which the learner performed whilst viewing the DVDs at home. Tutorial problems allowed learners to engage with the concepts discussed, practice problem solving and apply the theory that was presented to them.

Problems presented on the DVDs, during tutorials, discussions and questioning in the f2f sessions involved activities that required a deep level of thinking. A variety of support materials was supplied to learners which enabled learners to view concepts from different perspectives, with many opportunities to access learning. Active participation was encouraged both independently at home and during the f2f sessions and collaboratively during the f2f sessions. Learner responsibility was stressed at the beginning of the programme and expectations and outcomes were clarified at the beginning of the programme and at the beginning of each lesson.

Learners' experiences were identified as the three main themes of physical learning environment, intellectual learning environment and emotional learning environment. The findings of this research study report that an impact was noted in various aspects. There was an improvement in learners' motivation and participation in mathematics learning and learners confidence increased. Participants noted an improved work ethic, improved language skills, increased problem solving skills and mathematics understanding also improved. In general learners' mathematics performance improved.

7.4. RECOMMENDATIONS

Based on the findings, analysis and conclusions the researcher offers recommendations. These recommendations are directed to

- Practice
- Teachers and schools
- Further research

7.4.1. RECOMMENDATIONS AND ISSUES FOR PRACTICE

- To prevent learners feelings of isolation when using DVDs at home the option of introducing a "Helpline" in the form of a short messaging service (sms) should be explored since most learners have cell phones (see Dr math in Chapter Two). This would provide a support system to assist learners with any questions and problems they encounter.

- Train facilitators and tutors well with regard to

  Effective management of resources

  Facilitation skills

  Presentation skills

  Interaction skills

  Addressing the needs of learners

- Careful consideration should be given to the selection of staff by selecting staff (facilitators, tutors and co coordinators). They should be chosen for their capacity to relate to, engage with and assist young learners and their ability to identify and address their learning and other needs.

- The scheduling of the ISP should be adjusted so that more time could be allocated for the facilitation of each section. This should include explanations, tutorials, discussions and questioning.

- Alignment of the mathematics syllabus with that of the participating schools so that the same section is covered in the ISP at the same time as at the school would ease

the load of learners, since they would be able to focus on, one topic at any given time.

- Encouraging lifelong learning and extend learners by continuing to extend learners knowledge by including topics not in the syllabus if they will enhance a particular mathematics concept further. Elaborate on and expose learners to additional problem solving techniques.

- Ideally learners should start the ISP in grade 11 and then follow up to grade 12 in the following year. This way all concepts are covered and all learners start more or less on an even footing in grade 12 ensuring thereby more chance of success. If this is not possible introduce a week to refresh grade 11 concepts before the start of the programme.

- Establish a system of monitoring individual learner's progress on a weekly basis and for addressing any issues of concern.

- Implement a test strategy that would enable learners to participate effectively as follows: one section of mathematics covered per week and to be tested in the week thereafter on the first section and then every week thereafter on the section covered the previous Saturday and the Saturday before that, hence two sections per week with each section appearing in two tests. This would give learners the opportunity to have two weeks per section to engage with the content and two opportunities to be assessed on these concepts. This system is likely to improve their understanding of the concepts and hence their performance in the tests.

7.4.2. RECOMMENDATIONS AND ISSUES FOR TEACHERS AND SCHOOLS

- Involve teachers in the ISP programme encouraging them to attend sessions on Saturdays and enlisting them to assist in the classroom activities thereby allowing them to acquire skills to be able to implement blended learning in their classrooms.

- One of the main reasons for poor performance by learners in mathematics could possibly be linked to the lack of teacher content knowledge and skills. Introduce mathematics teacher training with regard to facilitating the DVD approach in a blended learning environment for those schools that participate in the ISP.

7.4.3. RECOMMENDATIONS FOR FURTHER RESEARCH

The researcher recommends that further research be conducted in the following areas

- In the light of the action research design of the project, the researcher recommends that further cycles of action research be employed to gain a better understanding of how the recommendations of this study were implemented and what impact this has had on teaching and learning mathematics in the ISP.
- This research study explored the effectiveness of the ISP in an urban area of the Eastern Cape. However the crisis in mathematics education is very noticeable in the rural areas of the Eastern Cape. For this and other reasons an ISP will be established in the Cacadu district in 2011. The effectiveness of such an intervention needs to be monitored and researched.
- The mathematics DVD series formed the basis for the design and implementation of two accredited mathematics skills upgrading programmes for in service teachers. These were presented in 2009 and 2010. To what extent teachers used the DVD in the teaching of mathematics in their classrooms is uncertain as no monitoring took place. The effectiveness of these programmes needs to be monitored and researched.
- It was expected of the learners who participated in the ISP to play a peer supporting role at their respective schools, thereby assisting the non ISP learners. ISP learners need to be trained in fulfilling this role and the effectiveness of such peer support interventions need to be monitored and researched.
- It became clear that not all learners who participated in the 2009 ISP were successful. A study should be undertaken to determine the reasons why these learners did not succeed in mathematics.
- To further generalise the findings of this study, future studies using a broader population are strongly recommended.

7.5. SUMMARY OF THE RESEARCH STUDY

The framework of this research study was outlined in **Chapter One** and the background and rationale for this research study, a description of the research problem and the significance of this study were presented. The context in which this study took place was described and the participants were introduced. Included as well are the research aims, research questions, research methodology and methods.

The background to this research study sketches a problematic education system. This situation is mainly the consequence of the policies of apartheid which wreaked havoc on the education of the majority of people in South Africa. However sixteen years after the demise of apartheid there is a national education crisis bigger than ever before especially with regard to the teaching and learning of mathematics. This crisis is highlighted in the Eastern Cape because of a number of challenges faced by the province in the transformation of its education system.

These challenges include the competence levels of teachers, the lack of resources, a neglected infrastructure, high levels of poverty, lack of dietary provision, historic structural weaknesses and an inadequate culture of teaching and learning. These challenges have huge implications for the pass rates of learners', especially in subjects such as mathematics. These problems impact on their meeting of university entrance requirements and success at tertiary level.

Over the last few years universities have initiated outreach programmes to develop the mathematics of secondary school learners. It is hoped through such interventions, that the mathematics crisis can be addressed. This study explores one such intervention initiated by the GMMDU under the title of ISP. The purpose of this research study was to explore the blended learning approach supported by DVD technology to identify elements that provide a supportive learning environment in order to answer the research question:

How did the elements present in the DVD driven approach support the teaching and learning of mathematics within a blended learning environment?

Knowledge gained from answering the research question will inform further policy and design of future ISP's and may contribute in some small way to alleviating the mathematics crisis experienced in the Eastern Cape. This study should be of value for those involved with or considering such programmes.

In **Chapter Two** the focus was on the reform of the South African education system, and the crisis in mathematics education. Included in this chapter was a presentation of some of the interventions aimed at improving mathematics education in South Africa.

There is a national crisis in mathematics education in South Africa and there is an urgent need to address this crisis since not many school leavers have the necessary mathematics knowledge to enter into professions to meet South Africa's economic needs. The literature reviewed in this chapter focused on mathematics supplementary initiatives for grade 12

learners which involved technology in the teaching and learning of mathematics. Examples of interventions aimed at improving mathematics education at secondary school such as The Dinaledi School Project, the Khanya Technology in Education Project, the Mathematics and Science Education Project (MSEP), the Zenex Foundation, Mindset Learn and Dr Math were presented. This expose of was given so as to give one the opportunity to position and contrast the 2009 ISP, the intervention which is the focus of this research study against other interventions with similar aims.

Chapter Three reviewed the literature relevant to this study. Firstly, the literature relevant to the research question was reviewed on supportive learning environments. Blended learning was the context of teaching and learning mathematics in the 2009 ISP and the definitions and dimensions of blended learning were presented and some of the benefits and challenges of blended leaning were discussed. The Blossom Initiative using videos was presented in this chapter. Constructivism and learning cycles were discussed in relation to the research study. The chapter concluded with the community of inquiry being positioned as the theoretical framework for this research study.

Holtz (2004, pp1-2) describes a supportive learning environment as “the creation of a caring, rigorous and relevant learning community that provides support to all learners in aiding them to reach their highest potential”. It was the aim of this research study to explore the DVD driven approach to teaching and learning mathematics in order to determine how the elements present in the DVD driven approach to the teaching and learning of mathematics provided support to the learners on the 2009 ISP. A review of the available international and national literature on supportive learning environments was conducted and a synthesis of the elements of such environments was presented (Table 3.1).

Blended learning has become very popular both in education and training settings. The multitude of definitions of blended learning is an indication of the diverse nature of blended learning. The researchers’ belief is that the definition of blended learning that best reflected the blended learning of the 2009 ISP was that proposed by (2001, p2):

Blended learning focuses on optimizing the achievement of learning objectives by applying the “right” learning technologies to match the “right” personal learning style to transfer the “right” skills to the “right” person at the “right” time.

The following principles are established by this definition:

- The focus is on matching the appropriate technology to achieve the learning objective- the most appropriate technology for the ISP was DVD technology since it was affordable and easily accessible to the learners of whom very few had access to computers in their homes or schools.
- Acknowledgment of individual learning styles
- Level of knowledge varies according to the individual

The definition of blended learning within the context of the 2009 ISP can be described as:

Traditional facilitator led instruction where learners ask questions and engage in discussion, where there is interaction with other learners and therefore the opportunity to learn from each other. In addition learners also have access to self paced learning materials and therefore are able to learn at their own pace in a manner suitable to their own learning styles.

The BLOSSOM project is sponsored by an association of educators from around the world who want to ensure that the larger populations of their countries are exposed to quality education via distance and e-Learning technologies. The vision of BLOSSOMS similar to that of the DVD driven approach of the 2009 ISP is to "develop a repository of video modules, and via an appropriate technology for each high school using them, bring via these blended learning modules into the classroom a world-class expert in pedagogy and in the area of math or science knowledge being studied by the students" (Larson &Murray, 2008, p85). Each module will be designed pedagogically to run in harmony with the regular in-class teacher, the subject matter covering a specific area of mathematics or of a physical science. Each module will build on the prerequisite material studied, but will present a math or science concept in a mind-expanding and exciting form to develop deeper and richer skills in the students and to enhance their critical-thinking skills, simultaneously motivating the pursuit of science, mathematics or engineering as a career(Larson &Murray, 2008).

Constructivism encourages, acknowledges and accepts the fact that learners are independent. Constructivism's central idea is that human learning is *constructed*; the first notion is that learners construct new understandings by using what they already know and the second notion is that learning is active rather than passive (Hoover, 1996). The foregoing notions of constructivism were important in the light of the 2009 ISP since the learners had to take responsibility for and regulate their own learning outside of the f2f sessions. It is unfortunate that not all learners were able to achieve this. Glasersfeld (1989) emphasises that learner's construct their own understanding and that they do not simply mirror and

reflect what they read. It is of importance to educators to understand constructivism and its implications to learning and teaching. Since as mentioned previously constructivism views learning not as a transfer of knowledge from teacher to learner, the role of teacher is redefined as that of a facilitator who provides learners with opportunities to investigate the adequacy of their present understandings. This was achieved in the f2f sessions of the ISP by employing instructional strategies such as questioning, discussion, explorations and collaborative work. Facilitators need to recognize the prior learning that learners have and to provide the learning environment to match this knowledge to the present experiences they are facing. Facilitators need to focus on problems of importance to the learner rather than themselves and to encourage peer interaction so that learners may compare their understanding with that of other learners. Learners on the 2009 ISP reported that they found their interaction with other learners had contributed to their improved understanding of mathematics. This was a result of their sharing of problem solving skills and different methods of solution, comparing and competing with each other and supporting each other. Time is necessary for the new knowledge to be built and this was the tension in the ISP as learners reported that one week was insufficient to engage with two mathematics topics and be assessed on them the following week. This they maintain accounted for their poor performance in the weekly tests and was probably the reason for a better performance in general in their final matriculation examination.

Garrison and Vaughn (2008, p9) define a community of inquiry as "... a cohesive and interactive community of learners whose purpose is to critically analyse, construct, and confirm worthwhile knowledge". The three core elements of the community of inquiry are social presence, cognitive presence and teaching presence. "A critical community of learners, from an educational perspective, is composed of teachers and students transacting with the specific purposes of facilitating, constructing, and validating understanding, and of developing capabilities that will lead to further learning. Such a community "encourages cognitive independence and social interdependence simultaneously" (Garrison & Anderson, 2003, p23). In the context of the 2009 ISP the guidelines for the blended learning environment are rooted in the community of enquiry framework.

This research study adapted the model of Garrison and Vaughn for the integration of f2f2 and online activities and focused on the integration between f2f and DVD activities. In the application of the community of inquiry framework guidelines are suggested for the facilitator to "structure, shape and assess the learning experience" (Garrison and Anderson, 2003, p75) from the point of view of the teaching presence with its three dimensions of instructional management, facilitating discourse and direct instruction. The elements pertaining to the intellectual learning environment of a supportive learning environment of

the 2009 ISP (Table 7.3) align in many ways with the guidelines as suggested by Garrison and Anderson (2003).

The development of the ISP between 2007 and 2009 and the structure of the ISP of 2009 were presented in **Chapter Four**. The instructional design of the 2009 ISP was the focus of this chapter. A discussion of instructional theories and multimedia learning was sketched since such theoretical issues form the basis of and inform any programmes instructional design. The different approaches to teaching and learning used in the different cycles of the ISP were outlined with the emphasis of this research study on the 2009 ISP. The instructional design of the DVDs was detailed and the instructional strategies and content of the DVDs were given. The production of the DVDs was described and the blended learning environment of the 2009 ISP was introduced.

Reigeluth (1985,p7) defines instructional design as a process whereby teachers and instructional designers decide upon a method of instruction that best influences the learners knowledge and skills for specific course content and specific learner population. This being the case, an instructional design theory is a theory that offers explicit guidance on how better to learn and develop (Reigeluth, 1999, p5). It is these instructional design principles that ultimately impact on how learners experience a supportive learning environment and what elements contribute to this experience. The design of the DVDs form part of the larger research project and the DVD approach within a blended learning environment. This is the focus of this research study. The design of the DVDs followed a sound process of design using the principles of instructional design.

Chapter Five described the research methodology and methods applied in this study. A qualitative approach to research was decided on and an action research design was followed in the research project. A case study design was implemented for this research study. A mixed methods approach to data collection and data analysis was employed. A variety of methods were used. The chapter discussed these methods, and the ways in which they were applied in the context of this study.

Within the framework of an action research design for the research project the case study was best suited as a research design for this study with its aim of exploring the use of DVD technology within a blended learning environment. The research study employed such a case study design within an action research design in keeping with the cyclical nature of this research project. The participants comprised 194 learners and their facilitators of the 2009

ISP. A mixed methods methodology was employed to collect and analyse data. Data was collected from questionnaires, interviews, pre tests and post tests, weekly attendance reports, weekly test results, facilitator reports, grade 11 and grade 12 mathematics final results of participants as well as those of their counterparts from their respective schools that did not participate in the 2009 ISP.

Chapter Six reported on the analysis of the qualitative and quantitative data obtained in this study and presented the major research findings as they relate to the research sub questions. The qualitative and quantitative analysis of the Pre tests, Post tests, learners' attendance register, learners weekly tests, Questionnaires, Group interviews, Facilitators reports, grade 11 and grade 12 final mathematics marks, comparison of six schools (grade 11 versus grade 12 performance comparing participants and non participants of the ISP) were presented.

Chapter Seven concluded the study by analysing and interpreting the nine findings. In this chapter the thesis' central research question "***How did the elements present in the DVD driven approach support the teaching and learning of mathematics within a blended learning environment?"*** was addressed.

7.6. FINAL WORD

"The fact that the DVD technology is easily accessible and affordable supports a case that the DVD approach could also help to address the shortage of adequately qualified teachers and the lack of teaching resources at previously disadvantaged schools in South Africa. Solving the education crisis in South Africa is an enormous challenge and needs to be addressed at governmental level. Yet by offering workable local solutions the crisis is indeed alleviated and enables individual learners to secure a future and realise their dreams. The blended learning approach described here is the initiative of one tertiary institution, driven by people who undertake the programme on top of an already full schedule. The target group of learners is a small local group and contributes in a small way to alleviating the post-apartheid South African education crisis. Although such efforts are valiant it is important that government should take cognisance of such workable solutions and magnify these to a country wide level" (Padayachee & Harding, to be published).

APPENDICES

APPENDIX A: CERTIFICATE OF ETHICS NMMU

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Nelson Mandela Metropolitan University
for tomorrow

Chairperson of the Faculty RTI Committee (Faculty of Science)
NMMU
Tel. +27 (0)41 504-2249 Fax. +27 (0)41 504-2389

504-
504 III

Ref: [H09-Sci-MAT-005]

Contact person: Ms A Denakie

Date 12 June 2009

Ms P Padayachee
NMMU
Faculty of Science
Department of Mathematics and Applied Mathematics
6019

Dear Ms Padayachee,

TITLE OF PROJECT: Using action research to investigate a DVD driven model for teaching and learning mathematics at secondary school level within the framework of blended learning.

Your above-entitled application for ethics approval served at the May **2009** ordinary meeting of the FRTI Committee (Faculty of Science).

We take pleasure in informing you that the application was approved by the Committee.

The Ethics clearance reference number is **H09-Sci-MAT-005**, and is valid for three years. Please inform the FRTI Committee, via your faculty officer, if any changes (particularly in the methodology) occur during this time. *An annual affirmation to the effect that the protocols in use are still those, for which approval was granted, will be required from you. You will be reminded timeously of this responsibility, and will receive the necessary documentation well in advance of any deadline*

We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

.....
Chairperson: Faculty Research, Technology and Innovation Committee (Faculty of Science)

cc: Department of Research Capacity Development
Faculty Officer, Faculty of Science

APPENDIX B: CONSENT FORM TO THE LEARNERS

NELSON MANDELA METROPOLITAN UNIVERSITY
RESEARCH STUDY INFORMATION AND INFORMED CONSENT FORM

A. RESEARCHER'S DETAILS	
Title of the research project	Using action research to investigate a DVD driven model for teaching and learning mathematics at secondary school level with a framework of blended learning.
Reference number	H09-Sci-MAT-005
Principal investigator	**Pragashni Padayachee**
Address	**Department of Mathematics and Applied Mathematics, Nelson Mandela Metropolitan University, Summerstrand South Campus**
Contact telephone number (private numbers not advisable)	**041-5042756**

B. **THE FOLLOWING ASPECTS HAVE BEEN EXPLAINED TO ME, THE PARTICIPANT:**	
Aim:	The investigator is studying what factors provide a supportive and encouraging learning environment within the DVD driven model of mathematics learning, how learners experience blended learning and what impact on learners' mathematical ability this model has. The information will be used as part of Pragashni Padayachee's PhD thesis at the NMMU.
Procedures:	I understand that my participation in this study will consist of the following: • Writing of the pre-test • Attendance at the 14 learner project sessions • Writing of the weekly tests • Completing a questionnaire • Participation in the interviews • Writing of the post test
Confidentiality:	My responses and my results will be kept confidential. My identity will not be revealed in any discussion, description or scientific publications by the investigators.
Voluntary Participation:	My participation in this study is voluntary, no pressure was exerted on me to consent to participation and I understand that I may withdraw at any stage without penalisation.

C. DECLARATION BY OR ON BEHALF OF PARTICIPANT	
I, the participant and the undersigned	(full names)
ID number	
OR	
I, in my capacity as	(parent or guardian)
of the participant	(full names)
ID number	

I, the participant, was invited to participate in the above-mentioned research project	
that is being undertaken by	Pragashni Padayachee
From	The Department of Mathematics and Applied Mathematics, NMMU
I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE ABOVE-MENTIONED PROJECT:	
Signed/confirmed at Port Elizabeth	On 01 January 2009
Signature of participant	Signature of witness: Full name of witness:

D. **STATEMENT BY OR ON BEHALF OF INVESTIGATOR**		
I,	**Pragashni Padayachee**	**declare that:**
	I have explained the information given in this document to the participant.	
Signed/confirmed at Port Elizabeth on 07 February 2009		
Signature of interviewer	Signature of witness:	
	Full name of witness:	

E. **IMPORTANT MESSAGE TO PARTICIPANT**	
Dear participant/representative of the participant **Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in this research project and agree to participate. Thank you for your/the participant's participation in this study. If you have further questions concerning matters related to this research,**	
Kindly contact	**Pragashni Padayachee**
at telephone number	**41 42756**

APPENDIX C: CONSENT FROM DEPARTMENT OF EDUCATION

Province of the
EASTERN CAPE
DEPARTMENT OF EDUCATION

EDUCATION SUPPORT PROGRAMMES ✉ 46 Park Drive, St. Georges Park, Port Elizabeth, 6001 REPUBLIC OF SOUTH AFRICA
☎ + 27 083 233 2319
Reference/Enquiries: **DR. J.M. JANSEN**

4 AUGUST 2009

Ms P Padayachee
Faculty of Sciences
Nelson Mandela University
P.O. Box 77000
PORT ELIZABETH
6058

Dear Ms Padayachee

USING ACTION RESEARCH TO INVESTIGATE A dvd DRIVEN MODEL OF TEACHING AND LEARNING MATHEMATICS AT SECONDARY SCHOOL LEVEL WITHIN THE FRAMEWORK OF BLENDED LEARNING

I apologise for my response at this late stage, but I only received your request on 2 August 2009.

Permission is hereby granted to conduct the above-mentioned research. The approval of research is however subject to the following conditions:

- All the arrangements concerning your research should be done by you and the Department of Education should not be responsible for costs involved.
- Your involvement in the schools should be negotiated with the principals to ensure minimum disruption of teaching time.
- The principal, educators, learners and parents are under no obligation to assist you with your research project.
- The schools, principals and educators should not be identifiable from the results of your research project.
- All information from the schools and the Department of Education should be treated as highly confidential.
- A copy of this letter should be submitted to the principal of the school or schools where the intended research is to be conducted.
- **Data collection should not be done in the 4th term of the school year.**
- A copy of the treatise on completion of the research must be submitted to the District Office, Education Support Programmes at the above address.

We trust that the results you obtain from your research will add to the exsisting body of knowlege will assist the educators in the teaching of this important subject.

Yours truly
JM Jansen
DR. J.M. JANSEN
DCES: EDUCATION SOCIAL SUPPORT PROGRAMMES

APPENDIX D: THE PRE TEST

LEARNER PROFILE

Name: …… **School: ……**

Address: **……**

……

Cellphone number: ……

Grade 12 subjects:

Grade 11 November 2007 Mathematics mark:

Rate the following on a scale from 1 to 5 where 1 is strongly disagree, 2 is disagree, 3 is neutral 4 is agree and 5 is strongly agree.

1. I enjoy Mathematics.

1	2	3	4	5

2. I like the way Mathematics is taught at my school.

1	2	3	4	5

3. I feel I understand Mathematics well.

1	2	3	4	5

4. The textbook we use at school helps me to understand Mathematics better.

1	2	3	4	5

5. My teacher helps me to understand Mathematics better.

1	2	3	4	5

6. I feel nervous about some sections in Mathematics.

1	2	3	4	5

7. I believe that more resources (books, examples, tutorials and DVDs etc) will help me to improve my Mathematics.

1	2	3	4	5

GMMD Unit Learner Projects: (VWSA and SET)

Pre Test

SPECIAL INSTRUCTIONS:

- You may use calculators
- You should answer all questions by selecting the correct option on the answer sheet provided.
-

1. The following expression $\frac{16^{\frac{3}{4}} \times \sqrt{3} \times 4^{\frac{1}{2}}}{27^{-\frac{1}{2}} \times 8^{\frac{2}{3}}}$ simplifies to:

a) $\frac{4}{3}$
b) 36.95
c) 36
d) 62.35
e) None of the above

2. If $2^{x^2-2x} = 8$, then the correct solution is:

a) $x = 1$ or $x = 3$
b) $x = -1$ or $x = -3$
c) $x = -1$ or $x = 3$
d) $x = 1$ or $x = -3$
e) None of the above

3. A financial advisor offers you the investment opportunities listed below. The most favourable interest rate over a period of one year or more is:

a) 7.2% per annum compounded daily
b) 7.35% per annum compounded monthly daily
c) 7.5% per annum compounded quarterly
d) 7.7% per annum compounded annually
e) None of the above

Given:
$A = P(1 + i \times n)$
$A = P(1 + i)^n$

4. The factorization of the expression $-x^2 + 7x - 10$ is:

a) $(x-2)(x+5)$
b) $(x-2)(x-5)$
c) $(2-x)(x-5)$
d) $(2-x)(x+5)$
e) None of the above

5. The vertices of a triangle PQR are the points $P(1,2), Q(4,6)$ and $R(-4,12)$. Which of the following statements about ΔPQR is true:

a) PQR is a right triangle with right angle $\hat{P}$
b) PQR is a right triangle with right angle $\hat{Q}$
c) PQR is a right triangle with right angle $\hat{R}$
d) PQR is a not a right triangle
e) None of the above

6. If $3\cos x + 0.2 = -0.794$ then.

a) $x = 70.65^\circ$ or $x = 289.35^\circ$

b) $x = 70.65^\circ$ or $x = 109.35^\circ$

c) $x = 109.35^\circ$ or $x = 250.65^\circ$

d) $x = 250.65^\circ$ or $x = 289.35^\circ$

e) None of the above

7. If you simplify $\dfrac{-\cos(180^\circ + x)\tan(-x)}{\cos 180^\circ \sin(90^\circ - x)\tan(360^\circ + x)}$ the following is the correct answer.

a) $\cos^2 x$

b) $-1 - \sin x$

c) $1 - \cos^2 x$

d) $-1 - \cos^2 x$

e) None of the above

8. The table below gives the number of questions answered correctly by 30 students on a 20 question written portion of a mathematics test.

Marks	12	13	14	15	16	17	18	19	20
Students	1	0	3	3	3	5	6	5	4

The mean, median and mode for this set of data is:

a) mean $= 17.2$, mode $= 18$, median $= 18$

b) mean $= 17.2$, mode $= 18$, median $= 16$

c) mean $= 17.2$, mode $= 18$, median $= 17$

d) mean $= 4.8$, mode $= 18$, median $= 18$

e) None of the above

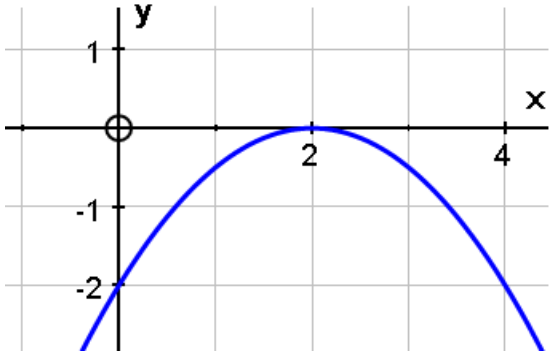
9. The solution to the inequality $x^2+5x<6$ is:

a) $\{x\in R:-6<x<1\}$
b) $\{x\in R:-6\le x\le 1\}$
c) $\{x\in R:-2<x<3\}$
d) $\{x\in R:-6>x>1\}$
e) None of the above

10. The solution to $2\sqrt{x-3}+3=x$ is:

a) $x=7$
b) $x=3$
c) $x=3$ or $x=7$
d) $x=-3$ or $x=-7$
e) None of the above

11. The equation of the parabola is:

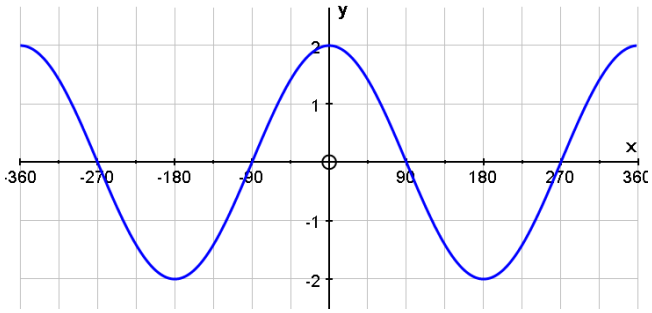


a) $y=2(x-2)^2$
b) $y=\frac{1}{2}(x-2)^2$
c) $y=-2(x-2)^2$
d) $y=-\frac{1}{2}(x-2)^2$
e) None of the above

12. The turning point for the parabola $f(x) = -x^2 + 2x - 3$ is:

a) $(1, -2)$
b) $(-1, -6)$
c) $\left(-\frac{3}{2}, -\frac{33}{4}\right)$
d) $(2, -3)$
e) None of the above

13. The following is the equation of the graph



a) $y = 2\cos x$
b) $y = -2\cos x$
c) $y = -\frac{1}{2}\cos x$
d) $y = \cos 2x$
e) None of the above

14. Consider the following set of data

50,67,78,31,69,62,46

The lower quartile (Q1) and upper quartile (Q3) is

a) $Q_1 = 31,\ Q_3 = 78$
b) $Q_1 = 46,\ Q_3 = 69$
c) $Q_1 = 31,\ Q_3 = 69$
d) $Q_1 = 46,\ Q_3 = 78$
e) None of the above

15. $A(-3,9)$ and $B(9,-3)$ are two given points. The co-ordinates of C and D where C is the midpoint of AB and D is the midpoint of OB with O the origin, are:

a) C(3,3) and $D\left(\frac{9}{2},\frac{3}{2}\right)$

b) $C\left(\frac{9}{2},\frac{3}{2}\right)$ and $D(3,3)$

c) C(3,3) and $D\left(\frac{3}{2},\frac{9}{2}\right)$

d) $C(\frac{3}{2},\frac{3}{2})$ and $D\left(\frac{9}{2},\frac{3}{2}\right)$

e) None of the above

$$\left(\frac{x_1+x_2}{2};\frac{y_1+y_2}{2}\right)$$

16. Sketched is the graph of $g(x)=\frac{a}{x}$. The value of a is:

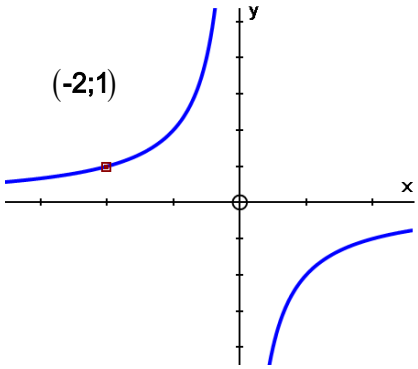
a) $a=-2$

b) $a=-1$

c) $a=-\frac{1}{2}$

d) $a=\frac{1}{2}$

e) None of the above



17. If $A+B=90^\circ$ and $13\sin B=5$, evaluate $\frac{\tan B-1}{\sin A-\cos A}$. The following represents the correct answer.

a) $\frac{5}{13}$

b) $\frac{13}{12}$

c) $\frac{12}{13}$

d) 1

e) None of the above

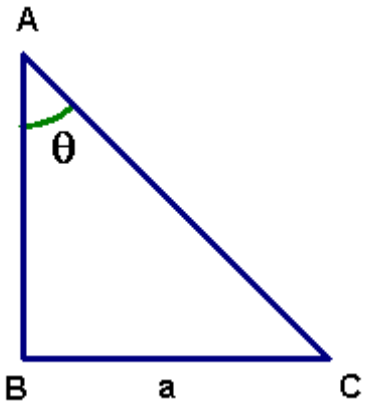
18. The inequality which represents “The sum of x and y must be at most 350” is.

a) $x + y \leq 350$
b) $x + y < 350$
c) $x + y \geq 350$
d) $x + y > 350$
e) None of the above

19. Consider the following points $A(3,1)$, $B(2,-4)$, $C(5,-3)$. Point A is rotated anticlockwise through an angle of 90°, point B is reflected on the y axis and point C is rotated clockwise about the origin through an angle of 180°.The resultant points are $A', B',$ and C' respectively. The coordinates of these points are:

a) $A'(1,3), B'(-2,-4), C'(-5,3)$
b) $A'(1,3), B'(-2,-4), C'(5,3)$
c) $A'(-1,3), B'(-2,-4), C'(3,-5)$
d) $A'(-1,3), B'(2,-4), C'(-5,3)$
e) None of the above

20. In the figure below, the angle at B is 90°.



AB is equal to:

a) $\dfrac{a}{\tan\theta}$

b) $a\tan\theta$

c) $\dfrac{\tan\theta}{a}$

d) $a\sin\theta$

e) None of the above

Write a short paragraph.

In this paragraph say how you experienced this test. Compare the test to tests you have written at school in grade 11. Were all the sections covered at your school in grade 11? What were the most difficult questions for you? Comment on anything else you may think is important.

……
……
……
……
……

APPENDIX E: QUESTIONNAIRE

Mathematics Learner Project Questionnaire

This questionnaire forms part of a research project entitled: "Using action research to investigate a DVD driven model for teaching and learning mathematics at secondary school level with a framework of blended learning".

Participation in this project is voluntary. However, your participation is crucial to the success of this project and will be greatly appreciated. Your honesty will be valuable to the results of this project. Note that in Section B there are no right or wrong answers. Answer the question as best you can as we are interested in how YOU experienced the project.

Your responses to this questionnaire will be used to determine how learners experienced the Mathematics Learner Projects, what factors provided a supportive and encouraging learning environment in this model and what impact/improvement in learners' mathematical ability the model has made?

Instructions:

Please **answer all the questions**

Section A – Biographical Information

1	Gender	Female	Male		
2	Age		Years		
3	Home language	Afrikaans	English	Xhosa	Other: (specify)

4 Grade 11 Mathematics mark(percentage)

5 School

Section B – Perceptions regarding the Mathematics Learner Project

	Please indicate to what extent you agree with each of the statements below by circling the appropriate number.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1.	**Lectures**					
1.1	I attended the lectures regularly	1	2	3	4	5
1.2	I benefited from the lessons presented	1	2	3	4	5
1.3	I enjoyed the lessons presented	1	2	3	4	5
1.4	I participated in the class discussion	1	2	3	4	5
1.5	The teaching style was different to what I experienced at school	1	2	3	4	5
1.6	I preferred the teaching style to that used in school	1	2	3	4	5
1.7	The different methods of presentation used in one lesson were helpful	1	2	3	4	5
1.8	The group size was right	1	2	3	4	5
2.	**Tutorials**					
2.1	Tutorials were helpful to my learning	1	2	3	4	5
2.2	Tutorials were useful	1	2	3	4	5
2.3	Having the tutorials within the lecture time made lessons enjoyable	1	2	3	4	5
2.4	I found the DVDs helpful during tutorials	1	2	3	4	5

2.5	The additional exercises improved my understanding of Maths	1	2	3	4	5
3	**Materials**					
3.1	The materials I received helped to make Maths clearer	1	2	3	4	5
3.2	I found accessing the DVD easy	1	2	3	4	5
3.3	I found that having many different resources (DVD, additional exercises, test solutions, tutorial solutions etc) was a good idea.	1	2	3	4	5
3.4	The freedom to access the resources at my own pace helped me.	1	2	3	4	5
3.5	The DVD 's were clear	1	2	3	4	5
3.6	The DVDs were well presented	1	2	3	4	5
4.	**Assessment**					
4.1	Regular tests helped me keep up with the work.	1	2	3	4	5
4.2	I coped well with the amount of work I had to study for each	1	2	3	4	5
4.3	The detailed solutions to the tests were helpful	1	2	3	4	5
4.4	The marking of tests was fair	1	2	3	4	5
5	**Facilitators/Tutors**					
5.1	My interest in Maths was stimulated by the facilitator	1	2	3	4	5
5.2	The facilitator used the different resources well.	1	2	3	4	5
5.3	The facilitator explained concepts clearly	1	2	3	4	5
5.4	I found it easy to communicate with the facilitator	1	2	3	4	5
5.5	The facilitator helped me to understand mathematics better	1	2	3	4	5
5.6	The tutors explained concepts clearly	1	2	3	4	5
5.7	I found it easy to communicate with the tutors	1	2	3	4	5
5.8	My interest in Maths was stimulated by the tutors	1	2	3	4	5
6	**Your assessment of the learning experience**					
6.1	I enjoyed this learning environment	1	2	3	4	5
6.2	I felt motivated being there.	1	2	3	4	5
6.3	I see great value in this type of learning for other learners	1	2	3	4	5
6.4	I have made progress in Maths	1	2	3	4	5
6.5	My self-confidence with regard to Maths has improved.	1	2	3	4	5
6.6	My ability to do maths has improved.	1	2	3	4	5

6.7	I have developed a better understanding of Maths	1	2	3	4	5

		No	Small	Moderate improvement	Large Improvement
7	Compared to your previous Maths ability, please indicate to what extent you have improved since attending the Maths learner project by circling the appropriate option for the following Maths areas:				
7.1	Trigonometry	0	1	2	3
7.2	Analytical Geometry	0	1	2	3
7.3	Transformational Geometry	0	1	2	3
7.4	Calculus	0	1	2	3
7.5	Algebra	0	1	2	3
7.6	Financial Mathematics	0	1	2	3

8	What were the most positive aspects of this programme?
9	What were the most negative aspects of this programme?
10	What suggestions do you have for improving this programme?
11	Any additional comments?

Thank you for completing this questionnaire

APPENDIX F: THE POST TEST

LEARNER PROFILE

Name: …… **School: ……**

GMMD Unit Learner Projects: (VWSA and SET)

Post Test

SPECIAL INSTRUCTIONS:

- You may use calculators
- You should answer all questions by selecting the correct option on the answer sheet provided.

1. Consider the sequence 1; 4; 11; 22; 37…. The formula for the nth term or the general term of the sequence is:

a) $T_n = n^2 + n + 1$

b) $T_n = 2n^2 + 3n + 2$

c) $T_n = 2n^2 - 3n + 2$

d) $T_n = 2n + 2$

e) None of the above

2. If the $11th$ term of an arithmetic sequence is 32 and the sum of the first 11 terms is 187. Then the $21st$ term of this sequence is:

a) 62
b) 63
c) 64
d) 52
e) None of the above

3. In a particular sequence the $1st$ term of the sequence is $\frac{3}{2}$ and the $4th$ term is -12. If the sequence is geometric then the $2nd$ and $3rd$ terms of the sequence are:

a) 3 and 9
b) 3 and -9
c) -3 and -6
d) -3 and 6
e) None of the above

4. $\frac{\log 81 + \log 16}{2\log 3 - \log\left(\frac{1}{4}\right)}$ when simplified is equal:

a) 3
b) 2
c) 4
d) 8
e) None of the above

5. The solution to the inequality $x^2 - 2x \leq 15$ is:

a) $\{x \in R : -15 < x < 1\}$
b) $\{x \in R : -5 \leq x \leq 3\}$
c) $\{x \in R : -5 < x < 3\}$
d) $\{x \in R : -3 \leq x \leq 5\}$
e) None of the above

6. Mr. George buys a bakkie for his business. The bakkie cost him R120 000. He pays 20% in cash and the balance is paid using a bank loan. The interest is 11% per annum compounded monthly. The monthly repayments if he repays the loan over four years are:

a) $R2481{,}17$
b) $R1411{,}16$
c) $R24810{,}17$
d) $R3436,21$
e) None of the above

7. If $x-1$ and $x+2$ are factors of $x^3 + ax^2 - 7x + b$ then the values of a and b are:

a) -4 and 4
b) 4 and 10
c) -4 and 10
d) 4 and 5
e) None of the above

8. The table below gives the number of questions answered correctly by 40 students on a 20 question mathematics test.

Marks	12	13	14	15	16	17	18	19	20
Students	2	0	4	4	4	6	8	6	6

The mean, median and mode for this set of data is:

a) $\text{mean} = 17.2$, $\text{mode} = 18$, $\text{median} = 18$
b) $\text{mean} = 17.2$, $\text{mode} = 18$, $\text{median} = 16$
c) $\text{mean} = 17.1$, $\text{mode} = 18$, $\text{median} = 17.5$
d) $\text{mean} = 4.8$, $\text{mode} = 18$, $\text{median} = 18$
e) None of the above

9. The inverse of a function is $f^{-1}(x) = \frac{1}{4}x - 2$. The equation of the function is:

a) $y = 8x - 16$
b) $y = 4x + 8$
c) $y = 8x + 16$
d) $y = -4x + 8$
e) None of the above

10. The equation of a circle with centre (1,-2) and a point (-2,-1) on the circle is:

a) $x^2+2x+y^2+4y-5=0$

b) $x^2-4x+y^2+8y+10=0$

c) $x^2+4x+y^2-8y+10=0$

d) $x^2-2x+y^2+4y-5=0$

e) None of the above

11. The image of point $P(-1,\sqrt{3})$ after rotation about the origin through an angle of 135° is:

a) $\left(\frac{\sqrt{2}-\sqrt{6}}{2},\frac{-\sqrt{6}-\sqrt{2}}{2}\right)$

b) $\left(\frac{\sqrt{2}-\sqrt{6}}{2},\frac{\sqrt{6}-\sqrt{2}}{2}\right)$

c) $\left(\frac{\sqrt{2}-\sqrt{6}}{2},\frac{-\sqrt{6}+\sqrt{2}}{2}\right)$

d) $\left(\frac{\sqrt{2}+\sqrt{6}}{2},\frac{\sqrt{6}-\sqrt{2}}{2}\right)$

e) None of the above

12. The co ordinates of B are:

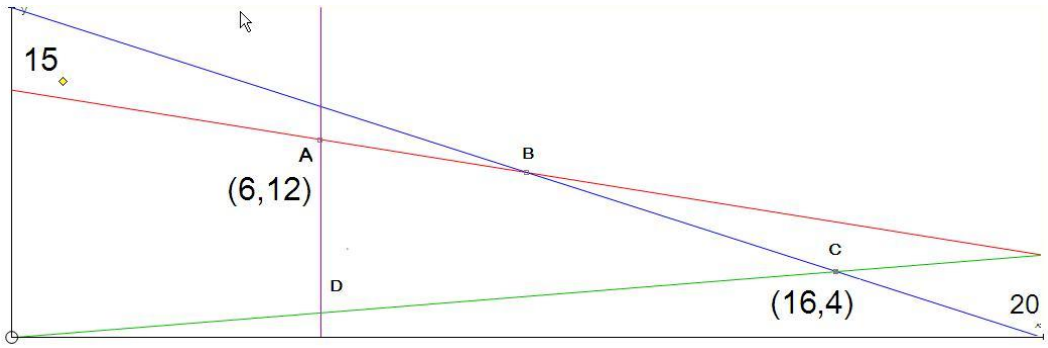
a) (11,12)

b) (10,14)

c) $(10,10)$

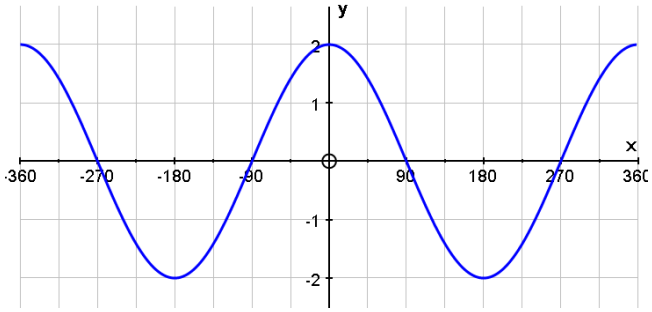
d) (15,13)

e) None of the above



13. The graph below represents a trigonometric graph with the following equation:

a) $y = 2\cos x$
b) $y = -2\cos x$
c) $y = -\frac{1}{2}\cos x$
d) $y = \cos 2x$
e) None of the above



14. Consider the data set below

24	19	21	27	20	17	32	22	26	18	13	23
30	10	13									

The lower quartile (Q1) and upper quartile (Q3) is

a) $Q_1 = 13,\ Q_3 = 32$
b) $Q_1 = 21,\ Q_3 = 32$
c) $Q_1 = 17,\ Q_3 = 26$
d) $Q_1 = 10,\ Q_3 = 26$
e) None of the above

15. $A(-1,5)$ and $B(7,7)$ are two given points. The equation of the perpendicular bisector of AB is given by:

a) y = $-\frac{1}{4}x + 18$
b) y = $-\frac{1}{4}x - 18$
c) y = $-4x + 18$
d) y = $4x + 18$
e) y = $4x + 8$

16. Sketched is the graph of $g(x)=\frac{a}{x}$ point (-2,1) on the graph. The value of a is:

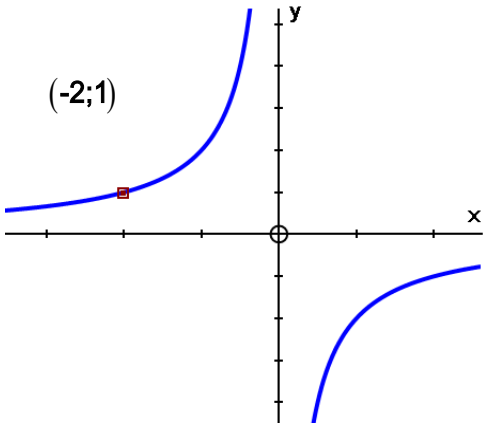
a) $a=-2$

b) $a=-1$

c) $a=-\frac{1}{2}$

d) $a=\frac{1}{2}$

e) None of the above



17. If $\sin 13^\circ \cos 13^\circ = p$ then $\sin(26^\circ)$ is:

a) $2p^2$

b) p

c) $\frac{p}{\sqrt{1+p^2}}$

d) $2p$

e) None of the above

18. Given that $x>0$ and $y>0$, the inequality which represents "The ratio of y to x must be at least 3:2" is.

a) $3x+2y\geq 3$

b) $y\leq \frac{3}{2}x$

c) $y\geq \frac{3}{2}x$

d) $2x+3y>6$

e) None of the above

19. Consider the following points $C(-3,7)$. Point C is rotated clockwise about the origin through an angle of 180°. The coordinates of the resultant point is:

a) $C'(7,-3)$

b) $C'(-7,3)$

c) $C'(-7,-3)$

d) $C'(7,3)$

e) None of the above

20. Given $f(x)=\dfrac{x^3-5x+7}{x}$, the derivative $f'(x)$ is:

a) x^2-5+7x^{-1}

b) $2x-7x^{-2}$

c) $2x-5-7x^{-2}$

d) $2x-7x^{-1}$

e) None of the above

APPENDIX G: INTERVIEW GUIDE

1. How, if at all, was teaching and learning mathematics in this project different from school?
2. Comment on the following
    a. Use of DVDs
    b. Use of PowerPoint's
    c. Materials
    d. Interaction between facilitators and learners
    e. Interaction between tutors and learners
    f. Interaction between learners from different schools
3. What were the positive aspects of this project for you?
4. What were the negative aspects of the project for you?
5. Did your understanding of mathematics change? If yes explain how.

APPENDIX H : TABLE OF FINDINGS, INTERPRETATIONS AND CONCLUSIONS OF THE RESEARCH STUDY

Findings	**Interpretations**	**Conclusions**
1. Learners indicated how the elements present in this DVD approach imbedded in blended learning environment support learning. **(SUB RESEARCH QUESTION 1)**	Following an exhaustive review of literature on supportive learning environment and the data analysis of this research the researcher added to, adapted and established a list of elements that support learning in this blended learning DVD approach to teaching and learning mathematics	The majority of the elements discussed are generic to any supportive learning environment. In a blended learning environment in particular there are in addition further elements which need to be considered and highlighted. The use of DVD technology further adds to this list of elements that are unique to this technology use.
2. Learners indicated that the physical learning environment was supportive in facilitating their participation in this project. **(SUB RESEARCH QUESTION 2)**	Poverty in many of the township areas of the eastern cape is well documented and for many learners in these areas going without breakfast is a reality and having no pocket money or access to money is common. It is little wonder then that many learners said that they appreciated the food that was given to them. This intervention was initiated with the aim of reaching as many learners as possible and financial constraints of the project dictated the class sizes and the number of personnel that could be employed in this project. The researcher suggests that effective	Providing a supportive physical learning environment can influence learners' participation in the ISP and contribute to their success in the ISP.

	facilitation skills and the appropriate use of tutors would address this issue of class size in taking individual learners needs into consideration. The use of instructional strategies which involve group work, peer assessment and co operative learning would compensate for large class sizes. The fact that the learners were treated as individuals and expected to work independently made them feel that they were university students. This improved their self esteem and gave them the confidence to perform better in mathematics. The spacious and technology friendly environment however new to them was welcomed and this spurred them on to develop good work habits and a positive attitude towards learning.	
3. Learners indicated that there was an improvement in how they learnt mathematics. **(SUB RESEARCH QUESTION 2/3)**	Additional support in the form of materials can increase mathematics learning. More opportunities to work on mathematics and more time on task can result in an improved	A blended learning environment has the potential to increase participation and improve understanding (80% said "I have made progress in mathematics and 88% said "My ability to do mathematics has improved").

	work ethic and a lessening of a fear of mathematics. A consequential improvement in their mathematics results can effect a continuation of the cycle of work, understanding and good results. The opportunity to address problem areas and question to facilitators and tutors can improve mathematics understanding. Dialogue and collaboration with other learners have the potential to improve learning.	
4. Learners cited that there was an extension of their mathematics knowledge. **(SUB RESEARCH QUESTION 2/3)**	Learners through collaboration with their peers, tutors and facilitators and access to materials increased their problem solving skills Concepts were presented in a comprehensive and in-depth manner and hence extended learners knowledge of mathematics from simply applying formulae to now understanding the reasoning behind concepts The DVDs provided insight into certain concepts that went beyond the scope of the grade 12 mathematics syllabus and learners knowledge was extended	Access to additional materials including the DVDs, a deeper approach to teaching and learning mathematics, and collaboration between others in the programme extended learners knowledge base. Access to various materials provided the support for a better understanding. In depth manner in which the concepts were dealt with formed a good grounding for a meaningful understanding. Collaboration holds the potential for new understanding and new learning.

5. The majority of participants found that aspects of the intellectual learning environment were beneficial to their learning of mathematics. **(SUB RESEARCH QUESTION 2)**	Clarity of outcomes and setting out expectations sets the tone for a supportive learning environment. Learners may not always know what is expected of them and this needs to be clarified at the outset. The use of technology is new to many learners and this aspect needs to be introduced at the outset. Attitudes of facilitators, tutors and other learners is important in creating a supportive learning environment where learners do not feel threatened and are free to participate. Learners need to believe that they are capable to achieving mathematics learning and their motivation can be effective to learners' success. Having exposure to someone of their own community who has achieved such learning brings into focus for the learners their own ability to achieve this and inspires them (tutors as role models) Teaching and learning which occurs in a friendly atmosphere has the potential to benefit learning by encouraging questioning, discussion and being open to critical views. Learners provide support for each other since they find themselves in the same situation, compete with each	The various elements of the intellectual learning environment support the learning of mathematics and can be beneficial in achieving learning outcomes. Interaction on all levels can be an integral part of learners' mathematics learning. It is this support, feedback and mentoring learners need in order to affect learning and succeed in mathematics. Whilst the onus lies with the facilitators and tutors to create a supportive environment the learners also have a responsibility to participate in their own learning.

	other and motivate and share ideas and methods with each other. Inclusion of all learners may be difficult because of time constraints but this can be negotiated within aspects of group work and collaborative learning strategies. Monitoring the needs of all learners may be challenging in the given time. Following up with learners is not always possible in the time given. Resources were helpful and useful since many of the learners come from schools were textbooks alone are a scarcity. The presentation however lively and well presented needed in addition more time for discussion and engagement with problems during tutorials. The blended learning environment ("new way of learning") was unusual to learners who were accustomed to a teacher centred approaches to learning. Self assessment via the DVD was useful in preparation for tests and exams. The DVDs performed to some degree the role of a private	

	tutor taking learners through concepts and allowing them to work through these concepts. However the formal assessments were too long with little time allocated for the assessment. The test marks then would not have been a true indication of learners' ability having only had one week to engage with the concepts to be assessed. In addition the average learners struggled to keep abreast of the concepts taught and assessed weekly considering that they were in their final year of school with demands from six other subject areas as well. In many instances the mathematics concepts taught on the ISP was not synchronized with those taught at school and this added to the learners load.	
6. Learners cited the DVD as a resource was significant to their learning of mathematics. **(SUB RESEARCH QUESTION 2)**	Giving theoretical background of concepts before application and verifying the use of appropriate conjectures and formulae in presenting a concept can contribute to a deeper understanding of the concept. The convenience of the technology in terms of access any time and as many times can be an advantage to mathematics learning.	The DVD imbedded in a blended learning environment can support the achievement of learning outcomes. Communication of expectations is needed to create a culture of accountability and commitment to learning. However the DVDs success lies in the responsibility of the learners to access the learning via the DVD failing which its impact will be minimal. In

	Step by step guide to problems with voice explanations has the potential to increase mathematics learning Learners are unrealistic which suggesting that the DVD was too long. They should work out a schedule of how to view each DVD keeping in mind that they can stop and come back to viewing at their convenience. In a solution of mathematics problems the learners could experience feelings of hopelessness if steps in the solution are missing and they needed further explanation not given by the DVD. This may be addressed in the development of the DVD where all possibilities for confusion and common problem areas are brainstormed and determined in the design phase and can be addressed. This can also to be addressed in the facilitation of the DVD during the F2F sessions. However not every learners query can be addressed in this way. Provision should be made with regard to learners contact with such issues with a possible 24 hour response. Although notation differed from what they were accustomed to learners should acquaint themselves with alternate notations which may	addition the DVD experience cannot function optimally in isolation, there needs to be addition support and interaction in the f2f sessions.

	appear in their other educational experiences in the future.	
7. Learners indicated that there was an improvement in how they perceived mathematics. **(SUB RESEARCH QUESTION 2)**	Setting and communicating high expectations for learners can increase motivation levels of learners.	Increases in motivation levels of learners can improve their perception of mathematics and result in an improvement in their participation.
8. The majority of learners improved their mathematics mark in the final exams as compared to the marks of their peers at their schools who did not attend the ISP 2009. **(SUB RESEARCH QUESTION 3)**	The DVD approach in the blended learning environment did impact the learning of the participants as opposed to the non participants. The participants did have the advantage of following a structured programme of support, feedback and mentoring in additional to regular schooling. It should be noted that the learners on the project were chosen for their interest and previous better performance in mathematics and therefore it is reasonable that they would have performed better.	The DVD approach imbedded in a blended learning environment holds the potential to impact on learners' mathematics performance. Attendance alone is insufficient. The onus lies with the learner to direct their own learning. Improvement and success is also largely a consequence of personal characteristics, motivation and determination.
9. The ISP blended learning approach offers a fair blend between face to face and computer technology based learning. **(SUB RESEARCH**	Dynamics and access: Learners are expected to access learning outside of the f2f sessions by viewing the DVD at least once at home following the f2f facilitation of the DVD. The onus lies with the learners to access the DVDs however	The extent and scope of blending of the DVD approach imbedded in a blended learning environment is a fair blend between f2f and technology. The model is strong with respect to materials and deficient with

QUESTION 1/2)	many times they need to and at a pace that is convenient to their style of learning. Assessment: Little formal assessment is done via the technology. Weekly tests are written in the f2f2 sessions. However learners are expected to use the DVDs for purposes of self assessment, working through the tutorials and checking their understanding of concepts. Self assessment forms a large part of the DVD driven approach to learning mathematics. Communication: This model is deficient in this sense that the DVD represents one way communication. This issue was raised by learners who pointed out the shortcoming of needing explanations to the problems, steps and concepts on the DVD whilst watching at home and having a sense of isolation and hopelessness at not being able to reach anyone. Content: All the grade 12 mathematics content is provided on the DVDs. This is supplemented by facilitation of these DVDs during the f2f sessions. Richness: The DVD has many enriching components such as voice explained presentations,	regard to assessment and communication.

	animations, step by step exposition of problems and the use of graphing software. Independence: The model has limited f2f contact and therefore its success depends on the learners to access the DVDs outside of the f2f sessions.	

REFERENCES

Ackerman, E. (1996). Perspective Taking and Object Construction. Two keys to Learning. In Y. Kafai & M. Resnick (Eds), Constructivism in Practice: Designing, Thinking and Learning in a Digital World (pp 25-35). New Jersey: Lawrence Earlbaum Associates.

Adler, J.; Brombacher, A. & Shan, S. (2000). Submission by Mathematics Education Community to the Council of Education Ministers (CEM). Retrieved February, 5, 2010, from www.acamic.sun.ac.za/mathed/AMESA/NGO.htm

Ajam, T. & Janine, A. (2007). Fiscal Renaissance in a Democratic South Africa. Journal of African Economies, Vol. 16(5).pp 745-781.

Allen, J. & Clarke, K. (2007). Nurturing Supportive Learning Environments in Higher Education Through the Teaching of Study Skills: To Embed or Not to Embed? International Journal of Teaching and Learning in Higher Education 2007, Volume 19, Number 1, 64-76

Alonso, F.; Lopez, G.; Manrique, D. & Vines, J. M. (2005). An instructional model for web-based e-learning education with a blended-learning process approach. *British Journal of Educational Technology,* 36(2), 217-235.

Aminifar, E.; Porter, A.; Caladine, R. & Nelson, M.I. (2007). Creating mathematical learning resources – combining audio and visual components. Proceedings of the 7th Biennial Engineering Mathematics and application Conference, pp 934-956. Melbourne, Australia: MAC.

Anderson, J. (1983). The Architecture of Cognition. Cambridge, MA: Harvard University Press.

Anderson, T.; Rourke, L.; Garrison, D. R. & Archer, W. (2001). Assessing teaching presence in a computer conferencing context. ***Journal of Asynchronous Learning Networks, 5***(2).

Retrieved July 14, 2009 from
http://www.aln.org/publications/jaln/v5n2/v5n2_anderson.asp

Arbaugh, J. B. (2008). Does the Community of Inquiry Framework Predict Outcomes in Online MBA Courses? The International Review of Research in Open and Distance Learning, 9(2), pp 1-21.

Asmal, K. (2001). Educational change and transformation: key strategic shifts 1994-2001. In Education in South Africa: Achievements since 1994. Retrieved May 12, 2010, from www.education.gov.za.

Asmal, K. (2000). Call to action: Mobilising citizens to build a South African Education and Training system for the 21st Century. Parliamentary Media Briefing, September 2000. Retrieved July, 10, 2007, from www. archive .pmg.org.za.

Asthana, A. (no date). Multimedia in Education-Introduction, the elements of educational requirements, classroom architecture and resources, concerns. Retrieved March, 23, 2010 from www.encyclopedia .jrank.org/articles/pages/6821/multimedia-in-educ.html.

Bates, A. W. & Poole, G. (2003). Effective Teaching with Technology in Higher Education: Foundations for success. San Francisco, CA: Jossey-Bass.

Bauersfeld, H. (1995). The Structuring of the Structures: Development and Function of Mathematizing as a Social Practice. In P. Steffe & J. Gale (Eds.), Constructivism in Education. Hillsdale, New Jersey: Lawrence Erlbaum Associate Publishers.

Bernstein, A. (a). (2004). Centre for development and enterprise. Natal witness. Bold moves needed for mathematics and science crisis. 19 November 2004. Retrieved November, 24, 2009, from www.cde.org.za/artcile.php?a_id=305

Bernstein, A. (b). (2004). From Laggard to World Class. Research Report no. 13. Retrieved May 20, 2009, from www.cde.org.za/artcile.php?a_id=50

Bonk, C.J.; Kim, K.J. & Zeng, T. (2005). FUTURE DIRECTIONS OF BLENDED LEARNING IN HIGHER EDUCATION AND WORKPLACE LEARNING SETTINGS in Bonk, C. J. & Graham, C. R. (Eds.), Handbook of blended learning: Global Perspectives, local designs. San Francisco, CA: Pfeiffer Publishing.

Botha, R. J. (2002).The Introduction of a system of OBE in South Africa: Transforming and Empowering a Marginalized and Disenfranchised Society. 46th Annual Meeting, Comparative and International Education Society (CIES), March 6-9, 2002, Florida.

Brower, H. H. (2003). On Emulating Classroom Discussion in a Distance delivered OBHR Course: Creating an online community. Academy of Management Learning and Education, 2(1), pp 22-36.

Brown, A. R. & Voltz, B. D. (2005). Elements of effective e- learning design. The International Review of Research in Open and Distance Learning, Vol 6(1) 2005.Retrieved October, 15, 2010, from http://www.irrodl.org/index.php/irrodl/article/viewArticle/217/300.

Brown, S.; Collins, A. & Duguid, P. (1989). Situated Cognition and the Culture of Learning. Educational Research 18, 32-42.

Brownstein, B. (2001). Collaboration: The Foundation of Learning in the Future. Education, 122(2), p240.

Burger, D. (2009/10). S.A. Year book (2009/10).Retrieved June, 15, 2010 from www.gcis.gov.za/resource_centre/sa_info/yearbook 2009/10/Education_pdf.

Butgereit, L. (2007). Math on MXit: Using MXit as a medium for mathematics education. Meraka INNOVATE Conference for Educators, CSIR,Pretoria, 18-20 April 2007, pp13.

Butgereit, L. (2008). "Dr Maths rocks! Using instant messaging to help pupils with mathematics homework". In P. Cunningham & M. Cunningham (Eds.), IST-Africa 2009 Conference Proceedings, IIMC International Information Management Corporation, Windhoek, Namibia, 7-9 May 2008, pp8

Cameron, L. (2009). Dinaledi Schools Initiative boosts maths, science pass rates. Retrieved March, 20, 2010, from www.engineeringnews.co.za/article/dinaledi-schools-initiative-boosts-maths-science-pass-rates-2009-08-11

Carman, J. (2002). *Blended learning design: five key ingredients*. Retrieved May, 25, 2010, from http://www.knowledgenet.com/pdf/Blended%20Learning%20Design_1028.PDF

CDE (2007). SA making inadequate progress on maths and science challenge. Media Release 3 October 2007. Retrieved April, 23, 2010 from http:www.cde.org.za/article.php?a_id=265

CELT. (2008). Five suggestions for the enhancement of teaching and learning. Retrieved April, 22, 2010 from http://celt.tufts.edu/downloads/tipstemplatesupportiveenvironment.pdf

Clarke, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, pp 445-459.

Clynick, T. & Lee, R. (2004). From laggard to World class: Reforming mathematics and science education in South Africa. Johannesburg. The Centre for Development and Enterprise, Research Report 13.

Coppola, N.W.; Hiltz, S.R. & Rotter, N.G. (2002). Becoming a Virtual Professor: Pedagogical roles and asynchronous learning networks. Journal of Management Information Systems, 18(4), pp 169-189.

Creswell, J. W. (1998). Qualitative Inquiry and Research Design: Choosing among five designs. Thousand Oaks, California: Sage Publications Inc.

Creswell, J. W. & Plano Clark, V. L. (2007). Designing and Conducting Mixed Methods Research. Thousand Oaks, California : Sage Publications Inc.

Crouch , L. & Vinjevold, P. (2006). South Africa: Access before quality, and what to do now? Profesorado: revista de curriculum y formacion del prefesorado 10(1):1.

Daniels, G. (2007). SA – maths = crisis. *Mail and Guardian Online*. Retrieved on March 16, 2008, from http://www.mg.co.za/articlePage.aspx.articleid=300522&area=/the_teacher/teacher_features

De Jager, A. (2002). An integrated and holistic approach to assessment in outcome- based learning in South Africa. PhD thesis. University of Pretoria.

Denscombe, M. (2007). The Good Research Guide for small- scale social research projects. Maidenhead, Open University Press.

Dhanarajan**,** G. (2001). Learning Technologies: Where is the challenge? *Education, Communication and Information*, Volume1, Number1 2001.

DoE (2000). South Africa. Department of education. A South African curriculum for the twenty first century: Report of the Review Committee on the Curriculum 2005. Presented to the Minister of Education,Prof Kader Asmal. Pretoria, 31.05.00.

DoE (2000). South Africa. Department of Education. Instructional leadership. School management teams. Pretoria: Department of Education.

DoE (2001). South Africa. Department of Education. National Strategy for mathematics, science and technology education. Pretoria. Government Printer.

DoE (2001a). South Africa .Department of Education. Education in South Africa: Achievements since 1994. Pretoria. May 2001. Retrieved May, 12, 2009, from http://www.dhet.gov.za/LinkClick.aspx?fileticket=sOiQt9GSMpk%3D&tabid=92&mid=495

DoE (2002). South Africa. Department of Education. Report on some of the key programmes of the department of education presented at the parliamentary media briefing on 15 August 2002. Retrieved on August, 16, 2008, from http://www.search.gov.za/info/previewDocument.jsp?dk=%2Fdata%2Fstatic%2Finfo%2Fspeeches%2F2002%2F02081610461001.htm%40Gov&q=%3Cphrase%3E+(project+management)&t=Asmal%3A+Parliamentary+Media+Briefing+(Education+progress+report)%2C+August+2002

DoE. (2003). National Curriculum statement: Mathematics, Grades 10-12. Retrieved May, 23, 2009, from http://www.education.gov.za/LinkClick.aspx?fileticket=WBtQtdS0Azk%3D&tabid=246&mid=594

DoE. (2003). National Curriculum statement: Mathematical literacy, Grades 10-12, p10-11). Retrieved May, 23, 2009, from http://www.education.gov.za/LinkClick.aspx?fileticket=25TyZ4RTmKc%3D&tabid=246&mid=594

DoE (FET). (2009/2010). Dinaledi School Project plans for 2009/2010. Retrieved December 6, 2010, from www.thutong.doe.gov.za/ResourceDownload.aspx?id=37448

Driscoll, M. (2002). Blended Learning: Let's get beyond the hype. IBM Global Services. Retrieved February 19, 2010, from http://www-07.ibm.com/services/pdf/blended_learning.pdf

DST. (2002). Department of Science and Technology. South Africas national research and development strategy. Pretoria, South Africa.

Dutta, S. & Mia. I. (2009/2010).The Global Information Technology Report 2009-2010.

Engelbrecht, J. & Harding, A. (2002). Cooperative learning as a tool for enhancing a web-based

E- learnity. (2000). E-learning: The future of learning. E- learning Ltd, Cirencester.

Calculus course, Proceedings of the ICTM2, Crete, July 2002.

Fallon, C. & Brown, S. (2003). E-learning standards: A guide to purchasing, developing and deploying standards conformant e-learning. Florida: St Lucie Press.

Festa, P. (2000). E-learning-transforming the teaching of soft skills. London. IRS. Competency Summer.

Fontana, A. & Frey, J. H. (2003). The Interview: From Structured Questions to Negotiated Text. Collecting and Interpreting Qualitative Motions. In N. Denzin & Y Lincoln (Eds.), The Handbook of Qualitative Research. London- Sage.

Frenzel, A. C.; Pekrun, R. & Goetz, T. (2007). Perceived learning environment and students' emotional experiences: A multilevel analysis of mathematics classrooms. Learning and Instruction, 17, pp. 478–493.

Gagne, R. (1985). The Conditions of Learning and the Theory of Instruction, 4th edition. New York: Holt, Rinehart &Winston.

Gagnon, G. W., & Collay, M. (2001). Designing for learning: six elements in constructivist classrooms. California: Corwin Press.

Gamoran, A.; Secada, W. G. & Marrett, C. B. (2000). The organizational context of teaching and learning: Changing theoretical perspectives. In M. T. Hallinan (Ed.), Handbook of Sociology of Education (pp. 37-63). New York: Kluwer Academic/Plenum Press.

Gardiner, L. (1994). Redesigning Higher Education: Producing dramatic gains in student learning. ASHE-ERIC Higher Education Report 7. Washington DC: George Washington University.

Garrison, D. R. & Anderson, T. (2003). E-Learning in the 21st Century: A Framework for Research and Practice, 2003, p. 23.

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. ***American Journal of Distance Education, 15***(1), pp 7-23.

Garrison, D. R and Vaughan, N. D. (2008). Blended Learning in Higher Education Framework, Principles and Guidelines. John Wiley and Sons.

Gauteng Department of Education (GDE). (2003). Annual Report 2002/03. Johannesburg.GDE.

Gibbins, L.M.; Hadibi, R.; Urbaczewski, A. & Vician, C. (2007).Technology-enhanced learning in blended-learning environments: a report on standard practices. Communications of the Association for Information Systems Volume 20, 2007.pp 741-759

Glasersfeld, E. V. (1989). Constructivism in education. In T.Husen & T. N. Postlethwaite(Eds.), The International Encyclopaedia of Education Research and Studies: Supplementary Volume 1.Oxford: Pergamon Press: 162-163.

GMMDU. (2006).Bosberaad. Minutes. NMMU. November 2006.

GMMDU. (2008). Bosberaad. Minutes. NMMU. November 2008

Golladay, R., Prybutok, V. & Huff, R. (2000). Critical success factors for the online learner. Journal of Computer Information Systems, 40(4), pp.69-71.

Graham, C. R. (2005). Blended Learning Systems: Definition, Current Trends, and Future Directions. In C.J. Bonk & C.R.Graham (Eds), The Handbook of Blended Learning: Global Perspectives local designs. San Francisco, CA. Pfeiffer Publishing.

Graham, C.R.; Allen, S. & Ure, D. (2003). Blended-Learning Environments: A review of the research literature. Unpublished manuscript, Provo,UT.

Graham, C.R.; Allen, S. & Ure, D. (2005). Benefits and Challenges of blended-learning environments. In M. Knosrow-Pour (Ed.), Encyclopaedia of Information science and technology (pp253-259). Hersey: P.A: Idea Group.

Green,J.C., Caracelli,V.J.& Graham,W.F. (1989).Toward a conceptual Framework for mixed methods evaluation design. Educational Evaluation and Policy Analysis, 11(3) pp255-274.

Hannafin , M.J. (1997) . The Case for Grounded Learning Systems Design: What the Literature Suggests About Effective Teaching, Learning, and Technology. This address is based on an article originally published in *Educational Technology Research & Development* (1997), *45*(3), 101-117.

Hara, N. & Kling, R. (2001). Students' distress with web based distance education courses: An ethnographic study of participants' experiences. Centre for Social Informatics, SLIS, Indiana University [online]. Retrieved November, 20, 2009, from http://www.slis.Indiana.edu/csi/wp00-01.html.

Harding, A., Kaczynski, D., & Wood, L. (2005). Evaluation of Blended learning: Analysis of qualitative data. *Uniserve Science Blended Learning symposium proceedings*, pp. 56-62.

Harding, A.; Engelbrecht, J.; Lazenby, K.; le Roux, I. (2006). Blended Learning in Undergraduate Mathematics at the University of Pretoria. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of Blended Learning: Global Perspectives, Local Designs*. San Francisco, Pfeiffer Publishing, 400 - 418.

Hassana,R.A. &Woodcock,A.( ) Blended learning :Issues and Concerns. Retrieved May, 20, 2009, from http://stcex.tvtc.gov.sa/NR/rdonlyres/6885EBB6-DD85-4EA3-B8E8-51FAF0ED2EA4/0/934.pdf

Heinze, A., Procter,C. (2004). Reflections on the Use of Blended Learning. Education in a Changing Environment. University of Salford, Salford, Education Development Unit.

Hennik, R. (2003). E-Learning, blended learning or continued traditional classroom- based education? International Journal Continuing Engineering Education and Lifelong learning. Vol 13 Nos.5/6 pp 567-577.

Henning,E. (2004). Finding your way in Qualitative Research. Van Schaiks Publishers. Pretoria.

Hlongwane, A. (2009, January, 4).Matric doesn't add up. The Sunday Tribune .p.1.

Hofmeyr, D. (2008). Getting the talented poor to good schools: The ISASA mathematics and English programme. Paper presented at JET Educational Services/ Murray & Roberts Conference: "What's working in school development" 28-29 February 2008. Birchwood Centre, Johannesburg.

Holtz, F. (2004). Enhancing Supportive Learning Environments and Student Achievement through Project ALERT. Excerpt—ALERT Educator/Spring '06. Retrieved April, 25, 2010, from http://daretodifferentiate.wikispaces.com/file/view/319_EnhancingSLE_and_SA.pdf

Hoover, W.A. (1996). The practice implications of constructivism. SEDL letter, Volume 9(3).Retrieved May, 14, 2010, from www.sedl.org/bulbs/sedletter/V09no.3/practice.html.

HSRC. (1999). Media briefs. Top Class black graduates not yet readily available. August 1999.

Jacobs, K.I. (2005). Investigation of interactive online visual tools for the learning of mathematics, Internat J Math Ed Sci Tech 36(7) Taylor& Francis, London, (2005)761-768. C938

Jaffer, S.; Ng'ambi, D. & Czerniewicz, L. (2007). The role of ICTs in higher education in South Africa: One strategy for addressing teaching and learning challenges. International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2007, Vol. 3, Issue 4, pp. 131-142.

Jansen, J. D. (1998). Curriculum reform in South Africa: A critical analysis of outcomes-based education. *Cambridge Journal of Education*, 28(3), pp.321-331.

Javed, S. & Vale, C. (2006). Effects of blended online learning on students' performance in vocational mathematics. International Journal of Technology, Knowledge and Society, 2(6), 143-154.

Johnson, R. B & Onwuegbuzie, A. J. (2004). Mixed Methods Research:

A Research Paradigm Whose Time Has Come. Retrieved November, 15, 2010, from http://www.aera.net/uploadedFiles/Journals_and_Publications/Journals/Educational_Researcher/Volume_33_No_7/03ERv33n7_Johnson.pdf

Johnson, R.B.; Onwuegbuzie, A.J.; & Turner, L.A. (2007). Towards a Definition of Mixed Methods Research. Journal of Mixed Methods Research. Vol 1 (2) Sage Publications. pp.112-133

Jonassen, D. H. (1991). Objectivism versus constructivism: do we need a new philosophical paradigm? *Educational Technology Research and Development,* 39 (3), pp. 5-14.

Khanya Educational Technology Project. (2010). Retrieved April, 30, 2010, from www.khanya.co.za

Keller, J. M. (1983). Motivational design of instruction. In C.M Reigeluth(Ed.),Instructional design Theories and Models: An overview of their current status. Hillsdale, NJ. Erlbaum.

Kerres, M. & de Witt, C. (2003). A Didactical Framework for the Design of Blended Learning arrangements. Journal of Educational Media, 28(2-3), pp.101-113.

Kgosana, C. (2008). SA needs teachers. News24. Retrieved February, 10, 2009, from www.news24.com/South Africa/News/SA-needs-teachers-20080601.

Kim, W. (2007). Towards a Definition and a Methodology for Blended Learning. In: Proceedings of the 1st International Workshop on Blended Learning. Edinburgh, Scotland (August 2007)

Kirkley, S. E & Kirkley, J. R. (2005).Creating Next Generation Blended Learning Environments Using Mixed Reality, Video Games and Simulations. Techtrends. Vol 49 (3), pp.42-89.

Kvale, S. (1996). Interviews: An Introduction to Qualitative Research Interviewing. London: Sage Publications.

Lanham, E. & Zhou, W. (2003). Cultural Issues in Online Learning- Is Blended Learning a Possible Solution? Journal of Computer Processing of oriental Languages. Vol 16(4). pp275-292.

Larson, R. C. & Murray, M. E. (2008). Open Educational Resources for Blended Learning in High Schools: Overcoming Impediments in Developing Countries. Journal of Asynchronous Learning Networks, V. 12, No. 1, pp.85-103.

Lorsbach , A.W. (no date). The Learning Cycle as a Tool for Planning Science Instruction. Retrieved on 8 April 2010 from http://www.coe.ilstu.edu/scienceed/lorsbach/257lrcy.htm

Luca, J. (2006). Keynote speech. In D. Tolhurst & S. Mann (Eds.), Conferences in Research in Practice in Information Technology. Vol 52

Ludtke, O.; Robitzsch, A.; Trautwein, U. & Kunter, M. (2008). Assessing the impact of learning environments: How to use student ratings of classroom or school characteristics in multilevel modelling. Contemporary Educational Psychology. Vol 34(2). pp. 120-131.

Maguire, C., & Zhang, J. (2006). Effective Blended Learning for Development. Compilation of materials for workshop on *Designing and Delivering Blended Distance Learning Programs through GDLN*, sponsored by World Bank Tokyo Development Learning Center and DGHE Indonesia. (Jakarta, November 2006).

Maguire, C. & Zhang, J. (2007). Blended Learning in the Development Context: Experience with GDLN in Asia-Pacific. Tokyo Development Learning Center Japan/World Bank Distance Learning Partnership Project.

Mail & Guardian online. (2009). Mantashe: Education struggles with apartheid legacy. Retrieved February 2010, from http://www.mg.co.za/article/2009-10-08-mantashe-education-struggles-with-apartheid-legacy

Martin, D. (2002). Standard SEVEN – Create and maintain safe and supportive learning environments. Retrieved June, 23, 2010, from http://teacherlearner.wordpress.com/professional-standards-for-teachers/standard-seven-create-and-maintain-safe-and-supportive-learning-environments/

Mathematics Education Community, Submission to the Council of Education Ministers (CEM) (2000). Retrieved February, 10, 2010, from http://academic.sun.ac.za/mathed/AMESA/NGO.htm

Maths 4 stats. (no date). About Maths 4 stats. Retrieved October, 11, 2009, from http://www.statssa.gov.za/maths4stats/about.asp).

Mayer, R. E. & Moreno, R. (1998). A Cognitive Theory of Multimedia Learning: Implications for design Principles. Retrieved April, 10, 2010 from http://www.unm.cdu/moreno/PDFS/chi.pdf.

Mayer, R. E. & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual- coding theory of multimedia learning. Journal of Educational Phychology 86,389-401.

McMillan, D. & Chavis, D. (1986). Sense of community: A definition and theory. Journal of Community Psychology, Vol 14, No.1, pp6-23.

McNiff, J. (2002). Action Research: Principles and Practice.2nd edition. Routledge and Falmer. New York and London.

McNiff, J. & Whitehead, J. (2002/2006). Action Research: Principles and Practice. Routledge and Falmer. New York and London

Merriam, S. B. (1998). Case Study research in Education. A Qualitative Approach. Jossey-Bass Publishers. San Francisco. California.

Merriam, S. B. (2002). Qualitative Research in Practice: Examples for Discussion and Analysis. San Francisco, CA: John Wiley & Sons Inc.

Merrill, M. D. (1983). Component Display Theory. In C.M. Reigeluth(Ed). Instructional design theories and models: An overview of their current status, 279-333. Hillsdale NJ: Lawrence Erlbaum Associates.

Merrill, M. D. (1991). Constructivim and instructional design. Educational Technology, 31(50), pp45-53.

Merrill, M. D. (2006). First Principles of Instruction. In C.M. Reigeluth &A. Carr (Eds.), Instructional design Theories and Models iii. Lawrence Erlbaum Associates Publishers.

Mgwebi, G. (2009). Dismal EC matric performance: OBE to blame? Retrieved July, 17, 2010 from http://www.afesis.org.za/Local-Governance-Articles/dismal-ec-matric-performance-obe-to-blame.

Milne, A. J. (2006). Designing Blended Learning Space to the Student Experience. In Oblinger, D.G. (Ed.), Learning Spaces. Retrieved September, 23, 2010, from www.educause.edu/learningspaces

Mji, A. & Makgato, M. (2006). Factors associated with high school learners' poor performance: A spotlight on mathematics and physical science. South African Journal of Education. Vol 26 (2) pp. 253-266.

Mmekoa, E. (2005). SAIDE conducts a formative evaluation of Mindset Learn. SAIDE Newsletter, Vol. 11(2). Retrieved December 7, 2009, from http://www.saide.org.za/resources/newsletters/vol_11_no.2_2005/content/mindsetmultimedia.htm

Mortera-Gutiérrez, F. J. (2006). Faculty best practices using blended learning in e-learning and face-to-face instruction. Int. J. E-Learning, 5(3): pp.313-337

Motshekga, A. (2010). Statement by the Minister of Basic Education, Mrs Angie Motshekga, MP, on the announcement of the National Senior Certificate Grade 12 examination results for 2009 at the Media Centre, Union Buildings, Pretoria, 7 January 2010

Mouton, J. (2008). How to succeed in your Masters and Doctoral Studies: A South African Guide and Resource Book. Van Schaik publishers. Pretoria.

Mphala, D. & Tshishonge, N. (2008). Innovation Insights 10. Case study 2 Khanya Project. Published for Public Services Innovation CPSI. Retrieved October, 21, 2009, from www.cspi.co.za.

Muniandy, B.; Mohamad, R. & Fong, S.F. (2007). Synergising pedagogy, learning theory and technology in instruction: How can it be done? US-China Education Review: From knowledge to Wisdom, Vol 4 No.9 September 2007, 46-52.

Needham, R. A.; Powell, D. & Bentley, M. L. (1994). Using Big Books in Science and Social Studies. Paper presented at the Annual Meeting of the International Reading Association, Toronto, Canada, 1994. Retrieved April, 8, 2010 from http://faculty.mwsu.edu/west/maryann.coe/coe/inquire/inquiry.htm

Nicholson, Z. (2009). Matric maths crisis looms. *Weekend Argus.* Retrieved February 2010, from http://www.iol.co.za/index.php?set_id=1&click_id=13&art_id=vn20090726064117725C376939&singlepage=1

Nieuwoudt, S.; Nieuwoudt, H. & Monteith, J. (2007). Influence of a video-class system on learners' study and learning strategies and their achievement in mathematics. African Journal of Research in Mathematics, Science and Technology Education, 11(1), 29-35.

Norman, D. & Spohrer, J. (1996). Learner- centred education. Communication of the ACM,39(4) pp24-27.

North, M. (2008). How Mathematically Literate are the Matriculants of 2008?, A Critical Analysis of the 2008 Grade 12 Mathematical Literacy Examinations. In M. D. Villiers (Ed.), AMESA PROCEEDINGS 2010, Durban, Kwa-Zulu Natal.

Northrup, P. T. (2001) A framework for designing interactivity into Web-based instruction. *Educational Technology* **41**:2 , pp. 31-39.

Nunally, J. (1978). Psychometric theory. 2nd Edition. New York: McGraw-Hill.

Ocampo, M. L. (2004). A brief history of educational inequality from apartheid to the present. Seminar paper from Global Perspectives on Human Language: the South African Context. Retrieved November, 11, 2009, from http://www.stanford.edu/~jbaugh/saw/Lizet_Education_Inequity.html

Oliver, R. (1999). Exploring strategies for online teaching and learning. Distance Education, 20(2), 240-254.

Osguthorpe, R. T & Graham, C. R (2003). Blended learning Environments: Definitions and Directions. The Quarterly Review of Distance Education, 4(3). pp227-233

Padayachee, P. & Harding, A. (to be published). Towards alleviating the post-apartheid education crisis in South Africa. In A. Kitchenham (Ed.), Blended Learning across Disciplines: Models for Implementation. IGI Global: Hershey, Pa.

Patton, M. Q. (1988). The evaluator's responsibility for utilization. Evaluation Practice, 9(2), 5-24.

Perkins, D. N. (1992). Technology meets Constructivism: Do they make a marriage? In T.M. Duffy & D.H. Jonassen (Ed.), Constructivism and the Technology of Instruction: A Conversation. Lawrence Erlbaum associates publishers: New Jersey.

Peter, K. (2009). FirstRand Foundation Chair in Mathematics at Rhodes. Rhodes University Communication. Retrieved August, 20, 2010 from, www.ru.ac.za/modules/bloginclude/blog.content.php?blog_id=569

Pontius, J. L. & Harper, S. R. (2006). Principles for good practice in graduate and professional student engagement. New Directions for Student Services.no115 .San Francisco: Jossey-Bass

Pratt, D. D. (2005). Communication skills Online three years down the line: reflecting on design principles in blended learning. In Proceedings of the 7th Annual Conference on World Wide Web Applications, August 2005.Auckland Park: University of Johannesburg. Retrieved August, 15, 2009 from http://www.uj.ac.za/www2005/documents/Pratt%20DD.pdf

Prawat, R. S. & Floden, R. F. (1994). Philosophical Perspectives on Constructivist views of learning. Educational Psychologist, 29 (1).

QCA/Unity of Cumbria Co Development Initiative.

Reason, P. (2000). In P. Reason and H. Bradbury (Eds.), Handbook of Action Research. London: Sage.

Reddy, V., Van der Berg, S., Lebani, L. & Berkowitz, R. (2006). A trend analysis of matric maths performance. In V. Reddy (Ed.), *Marking matric: colloquium proceedings*. Cape Town: HSRC Press. pp. 139-160.

Reigeluth, C.M. (1999). What is instructional-design theory and how is it changing? In C.M.Reigeluth (Ed).instructional-Design theories and Models: A New Paradigm of Instructional Theory.Volume ii. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Rossett, A., Douglis, F. & Frazee, R.V. (2003). Strategies for Building Blended Learning. Retrieved March, 29, 2010, from http:\\www.learningcircuits.org/2003/jul2003/rossett.htm.

Rossett, A. & Frazee, R. V. (2005). Blended Learning Opportunities. AMA Special Report, Retrieved December, 20, 2010, from http://www.cedma-europe.org/newsletter%20articles/TrainingOutsourcing/Blended%20Learning%20Opportunities%20-%20AMA%20 (Jun%2006).pdf

Rovai, A. P. & Jordan, H. (2004). Blended Learning and Sense of Community: A Comparative Analysis with Traditional and Fully Online Graduate Courses. The International Review of Research in Open and Distance Learning. Vol 5, No 2 (2004)

Rynearson, K. & Kerr, M. S. (2005). Teaching Statistics online in a blended learning Environment. Journal of Computing in Higher Education. Fall 2005, Vol 17(1),71-94.

Sanchez, J.C.; Encinas, L.H.; Fernandez, R.L. and Sanchez, M.R. (2002). Designing hypermedia tools for solving problems in mathematics. Comput. Educ., 38: 303-317.

Schumacher, S. 1993. Research in Education. Addison-Wesley Educational Publishers Retrieved December, 11, 2009, from http://www.amazon.com/Research-Education-James-H- McMillan/dp/0673523160/ref=pd_rhf_p_t_1 - #

Seely Brown, J. & Duguid, P. (2000). The Social life of information. Boston: Harvard Business School Press.

Seidman, I. E. (1991). Interviewing as qualitative research: A guide for researchers in education and the social sciences. New York: Teachers College Press.

Serwatka, J. (2003). Assessment in on-line CIS courses. Journal of Computer Information Systems, 43(3), 16-20.

Shea, P.; Pickett, A. & Pelz, W. (2003). A follow-up study of teaching presence in the online program. Journal of Asynchronous learning networks 7(2),61-80.

Shea, P. J.; Frederickson, E. E.; Pickett, A. M. & Pelz, W. E. (2003). A preliminary investigation of teaching presence in the SUNY learning network. In J. Bourne & J.C. Moore (Eds.), Elements of Quality Online Education: Into the mainstream pp279-312. Needham, M.A: Sloan-C.

Simkins, C.; Rule, S. & Beinstein, A. (2007). Doubling for Growth. Addressing the maths and science challenge in South Africa's schools. A report for the centre for development and enterprise.

Singh, H. (2003). Building effective blended learning programs. Educational Technology 43(6) pp51-54.

Singh, H. & Reed, C. (2001). A White Paper: Achieving success with Blended Learning, ASTD State of the Industry Report, American Society for Training and Development, March 2001.

Smith, P. L., & Ragan, T. J. (2005). ***Instructional design*** (3rd Ed.). Hoboken, New Jersey: Wiley.

Spencer, K. L. (1998). Purposeful teaching: Design and instruction for adult learners. Retrieved June 1, 2009, from http://www.rcmp-learning.org/docs/ecdd1140.htm

Strauss, A. & Corbin, J. (1998). Basics of Qualitative Research Techniques and Procedures for developing Grounded Theory. London: Sage Publications

Stumpf, R. & Foxcroft, C. (2005). What is Matric For? Seminar Proceedings: Matric: What is to be Done? University of South Africa, 23 June. Pretoria: Umalusi.

Teddlie, C. & Tashakkori, A. (2009). Foundations of Mixed Methods Research. Integrating Quantitative and Qualitative Approaches in the Social and Behavioural Sciences. Thousand Oaks, California : Sage Publications Inc.

Thompson, N. E. & Wheeler, J. P. (2008). Learning environment: Creating and implementing a safe, supportive learning environment. Journal of Family & Consumer Sciences Education, 26(2), pp. 33-43.

The Global Information Technology Report (2009/2010). Retrieved October 2, 2010, from http://www.mathsexcellence.co.za/article.html Retrieved on 5 April 2010)

Thorne, K. (2003). Blended learning: how to integrate online & traditional learning. London Ans Sterling. Kogan Page.

UKOrbit. (2002-2010). Computer Glossary. Retrieved May, 29, 2010, from http://www.ukorbit.com/computer-glossary.htm

Umalusi. (2008). Improving the quality of teaching: Making a difference in Public Schooling. Retrieved October, 2, 2009. http://www.umalusi.org.za/ur/publications/20080910Improvingthequalityofteaching.pdf

University of Cape Town Schools Development Unit. (2010). School based projects.MSEP. Retrieved April, 20, 2010, from www.sdu.uct.ac.za

Urdan, T. & Weggen, Z. (2000). Corporate e-learning: Exploring a new Frontier. Retrieved February 8, 2009, from,

http://wrhambrecht.com/research/coverage/elearning/ir/ir_explore.pdf

Valiathan, P. (2002).Blended Learning Models. (online). Retrieved December, 20, 2008, from http://www.learningcircuits.org/2002/aug2003/valiathan.html.

Van der Berg, S. (2008). How effective are poor schools? Poverty and educational outcomes in South Africa. In Studies in Educational Evaluation. Volume 34, Issue 3, September 2008, pp145-154.

Voos, R. (2003). Blended Learning-What is it and where might it take us? Sloan-C View 2.1. Retrieved May, 25, 2010, from http://www.aln.org/publications/view/v2n1/blended1/html

Ward, K.; St Leger, P.; Beckett, D. and Harper, G. (1998). Providing Education and Training for At-Risk and Unemployed Young People, Successful Learning Project, Department of Education, Victoria.

Wikipedia. Instructional Design. Retrieved on from July, 21, 2009, from http://en.wikipedia.org/wiki/Instructional_design.

Wikipedia. Education in South Africa. Retrieved on February, 25, 2010, from www.en.wikipedia.org/wiki/Education_in_South_Africa

Wikipedia: Constructivism. Retrieved on March, 28, 2010, from http://en.wikipedia.org/wiki/Constructivism_(learning_theory)

Yang, P. J. (1998). Networked multimedia and foreign language education. CALICO Journal volume 15(1-3),75-88.

Yin, R. K. (1984). Case Study Research: Design and Methods. Beverly Hills, California: Sage Publications.

Yin, R. K. (1994). Case Study Research: Design and Methods. London: Sage Publications.

Zenex Foundation: Educating for Impact in Science Mathematics, Science and Language. Retrieved April, 25, 2010, from www.zenexfoundation.org.za/pdf/zenex%20brochure.As%20reproz.pdf