THE INTEGRATION OF TECHNOLOGY IN MATHEMATICS AT SECONDARY SCHOOLS IN THE WESTERN CAPE TO ENHANCE LEARNER PERFORMANCE:
AN EVALUATION OF THE KHANYA PROJECT

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A minithesis submitted in partial fulfilment of the requirements for the degree of Masters in Information Management in the Department of Economic and Management Sciences, University of the Western Cape.

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KEYWORDS

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ABSTRACT

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Abstract

There is a dire need to transform Mathematics education in the schooling system in South Africa as this is evident by the poor learner performance in the Mathematics examination results. There is a high failure rate in Mathematics at schools and the number of learners taking Mathematics up to the grade twelve level is on the decline. This study investigates the integration of computer technology in Mathematics education to improve learner performance.

Educationists believe that there is an inherent potential in technology to transform education. However, there is insufficient evidence to support that technology impacts positively on the teaching/learning process. The Western Cape Education Department (WCED) initiated the Khanya intervention project to integrate ICT in Mathematics education at secondary schools in the Western Cape. This large scale project encompasses installing computer labs in schools with the necessary educational software.

A comprehensive Mathematics program called Mastermaths is installed for curriculum delivery in Mathematics lessons. Mastermaths is a multimedia Mathematics programme designed by Mathematics educators in collaboration

with software developers. This Learning Management System consists of the matric mathematics syllabus in its entirety, inclusive of Mathematics lessons in modular format, exercises, worksheets and tests. The software and its contents are upgraded from time to time, driven by the updated mathematics syllabus.

A quantitative study was done on the standardised grade twelve examination results before and after the infusion of technology in Mathematics education. The research construct investigated the data at three levels. Statistical analysis was done for all the Grade twelve Mathematics Higher Grade examination results before using technology in education (Pre-IT years) and after using computers in Mathematics (Post-IT years) in three stages. In stage one, a composite analysis was done for all the Higher Grade examination results in the Pre-IT and Post-IT years. In stage two, schools were grouped into waves, according to the number of years that schools had access to computers for curriculum delivery in Mathematics. In stage three, schools in each wave were further categorised according to the socio-economic background of the communities that the schools were located in. An analysis was then done on the Mathematics Higher Grade examination results in the Pre-IT and the Post-IT years. The same procedure used to analyse the Mathematics Higher Grade examination scores is adhered to in the analysis of the Mathematics Standard Grade examination results for the Pre-IT years and the Post-IT years.

The findings of the study indicate that there was an overall increase in the Mathematics standardised examination results after technology integration but there were also schools that showed no increase and some schools had a decline in examination results. The levels of increase in the Mathematics examination results after using technology varied among schools. The findings correlate with international large scale ICT projects that indicate ICT can at times improve outcomes in Mathematics, although individual effects are often weak and findings are inconsistent (Kulik, 2003).

May 2008

DECLARATION

I, Indren Govender, declare that "The Integration of Technology in Mathematics at Secondary Schools in the Western Cape to enhance Learner performance: An evaluation of the Khanya Project" is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Indren Govender May 2008

Signed:…………………….

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Chapter One

1. Introduction

1.1 Background

In 2001, the minister of education in the Western Cape stated "Research and learner results, particularly in our poorest schools, indicate that prospects for Mathematics in South Africa are dire" (Zille, 2001). The concern about the state of Mathematics performance at schools is well documented. A survey conducted by the International Association for Educational Achievement to assess Mathematics performance at schools in 41 countries produced results that were indicative of South Africa's mean score of 275, which was well below the international mean of 487 (HSRC, 2005). An average of 11% of the total complement of grade 12 learners register and pass Mathematics on the Higher Grade (Smith, 2005).

The Western Cape Education Department (WCED) investigated various initiatives to improve Mathematics performance, particularly in schools serving poor communities. In April 2001, the Khanya Technology in Education Project was initiated by the WCED and was referred to as the Khanya Project. This project explored the utilisation of information and communications technology (ICT) for curriculum delivery, especially in Mathematics education. Computer labs, comprising of 25 networked computers with the necessary hardware, software and internet connection were installed in schools that served learners from a disadvantaged background.

A comprehensive Mathematics program called Mastermaths was installed for the teaching/learning of the subject. Mastermaths is a multimedia Mathematics programme designed by Mathematics educators in collaboration with software developers. This Learning Management System consists of the matric mathematics syllabus in its entirety, inclusive of Mathematics lessons in modular format, exercises, worksheets and tests. The software and its contents are upgraded from time to time, driven by the updated mathematics syllabus.

From the period 2002 to 2005, the Khanya intervention project has installed computer labs in 845 schools and aims to successfully complete implementing computer technology in all schools in the Western Cape by 2012. The primary objective of the Khanya Project, shifting from a broad perspective to specifics, is "to create a technology rich province thereby narrowing the digital divide and harnessing the power of technology to deliver curriculum in order to improve the quantity and quality of learner results, especially in Mathematics" (Khanya, 2002).

1.2 Value of Research

A hundred million rand project of such a large scale needs to be evaluated to assess the value or return on investment. The Khanya management team has expressed interest in the results of this study that can be used in the further development and progress of the project. In addition, other provinces in the country consider the Khanya Project as a model for technology integration in education, with the project being the recipient of various awards for its achievement. An assessment will be informative to guide policy and practice in Mathematics education as well as in the other subject areas that intend infusing Information and Communications Technology-mediated learning for curriculum delivery. The South African government strategy document on ICT in education reports that “the South African government is seeking a co-ordinated interdepartmental approach to generating ICT-enabled learning.” (HSRC, 2005).

1.3 Aims and Objectives

The research topic is: “The integration of technology in secondary school education to enhance learner performance in Mathematics”. The key objective of the Khanya Projects is to implement technology in schools for curriculum delivery in Mathematics education in at attempt to improve learner performance. The key research question of this study: Does ICT integration in Mathematics education impact on learner attainment? The researcher seeks to statistically analyse examination scores of learners before using computers in Mathematics education and after technology integration, in an attempt to determine the effect of technology on levels of achievement in Mathematics. This research study attempts to determine the successful integration of ICT in Mathematics education on the basis of results or evidence emerging from the statistically analysed standardised examination scores of the Pre-IT and Post-IT phases.

1.4 Research Hypotheses

A hypothesis is a hunch, an educated guess that is advanced for the purpose of being tested (Neuman, 2000). Mouton (1996) states that when we first formulate a statement without knowing whether we have any empirical warrant to accept it as reasonably valid or even true, we call this a hypothesis. A good hypothesis is empirically testable, which means that we must be able to specify clearly what data would provide support or rejection for it (Mouton, 1996). The research hypothesis to be tested is: Computer integration in Mathematics education for curriculum delivery enhances learner performance.

There are various ICT integration projects in schools in developed countries such as the United States of America (USA), United Kingdom (UK) and Australia. The researcher will conduct a comprehensive study of large scale ICT implementation projects in countries that have explored using technology in education; relating to the Khanya Project. A lack of large scale ICT projects in developing countries limited the literature survey of this study to ICT projects in developed countries. This study will attempt to establish the ICT integration strategy and the assessment of the technology infused projects, including the pedagogical aspect of constructivist learning paradigm. An empirical study will be conducted to investigate the effect of technology integration in Mathematics education. The quantitative methodology will be used in an attempt to determine the effect of computer aided instruction on learner attainment.

1.5 Plan of Development

This research report comprises of the following five chapters that comply with the research process:

Chapter One

The introduction describes the background of the research and the motivation for the research problem. The aims, objectives and research hypotheses are also highlighted.

Chapter Two

The literature review explores ICT implementation in developed countries over a period of time and ICT projects in South Africa. A study is made of the ICT strategy, the process of integration and the outcomes thereof. The pedagogical transformation as a result of technology infusion in education is explored. The Khanya Project which forms an integral component of this research will be introduced.

Chapter Three

The research design and methodology discusses the research plan, methodologies and instruments used to collect and collate the data for statistical analysis. Limitations or gaps in the research design are discussed. The unfolding of the three levels of the research design is explored.

Chapter Four

The findings of the study are discussed and interpreted, including positive and negative findings in the context of the hypothesis.

Chapter Five

The conclusions and recommendations include a summary of the findings with the literature reviewed. Aspects that need further research and the implications of this study are highlighted.

Chapter Two

2. Literature Review

2.1 Introduction

"Rarely in the history of education has so much been spent by so many" (Coleridge, 2003). Governments and the private sector of developed countries have invested enormous sums of money to install ICT projects in schooling systems. This report explores the effect of these large scale ICT projects on learner performance, especially in the field of Mathematics. The effective use of ICTs in education refers to the positive contribution ICTs make towards the process of teaching and learning (Patrick, 2000). It encompasses improving the quality and outcomes of teaching and learning. There is a need to understand how learning is advanced through the use of ICT in education, in such a way as to propose that the implementation of technology will help to solve a particular set of problems, thus implying a return on investment (Bergh, 2002).

Globally, most of the major ICT implementation programmes have occurred in developed and economically rich countries in Europe and the United States of America. This literature review evaluates the impact of technology on education in these countries with the emphasis on Mathematics education. There is a lack of large scale ICT studies in developing countries. The organisation, Trends in International Mathematics and Science Study (TIMSS) collects educational achievement data in Mathematics and Science globally, analyses the data and provides information about trends in performance over a period of time. According to TIMSS, difficulties in Mathematics learning as well as the low results that students often obtain in this field are frequently reported (TIMSS, 2003). For teachers too, Mathematics is traditionally a sector where they experience major problems in finding appropriate pedagogical approaches suited to overcome the difficulties encountered by a considerable number of learners (Bottino, 2004). In addition, enrolment for Mathematics is essential together with a favourable pass for learners to study in the field of science and engineering at university level. The report also examines the pedagogical dimension of teaching and learning with ICT. The Khanya Project is contextualized in relation to the literature reviewed, which provides the basis for the development of the research design.

2.2 Literature Survey of ICT Projects in Education

2.2.1 OECD Countries

The Organisation for Economic Co-operation and Development (OECD) is based in Europe and comprises of thirty member countries. The OECD is best known for its research and publications in the field of economic and social issues; from macroeconomics to science innovation and education. The Centre for Education Research and Innovation (CERI) is a major division of the OECD Directorate for Education. CERI is responsible for education research and analysis in European countries and countries outside Europe that subscribe to the OECD. It disseminates its work to a wide range of audience including researchers, policy-makers and practitioners.

Over the last decade, the governments of OECD countries have invested heavily in ICT in their respective schooling systems. Technology is deployed for a range of purposes encompassing improving school information systems, teaching ICT skills and improving teaching and learning. The cost of implementing technology of such a scale across all OECD countries is estimated at sixteen billion dollars (OECD, 1999). The key principle for implementing ICT in schools is that there is a belief that ICT offers a powerful tool to improve the outcomes of education: to improve the quality of teaching and also the quality of students' learning (OECD, 2001).

Results of studies conducted by OECD indicate that having computers in schools is one thing but using them is another (OECD, 2004). Table 2.1 reflects the different patterns of computer use existing in countries with the same ratio of learners per computer. Even in countries with the highest levels of investment in ICT, computers do not seem to be used most of the time. Denmark and Japan both have five learners per computer (Table 2.1). However, in Denmark 23% of learners use a computer almost every day, 45% few times in a week, but only 2% of learners in Japan use computers almost everyday. Differences are also noted between Korea and the United Kingdom. The table also shows that only in a handful of countries do computers appear to be used regularly at schools. From these patterns it can be deduced that an under-utilisation of investment in ICT exist in schools in certain countries.

Table 2.1 Learners per computer and frequency of use of computers at school

		Learners using computers at high school %				
Country	Number of Learners per computer	Almost everyday	Few times a week	Between once a week and once a month	Less than once a month	Never
United States	3	20	23	28	21	8
Australia	4	15	44	27	11	3
Hungary	4	6	74	10	4	5
Korea	4	4	25	29	14	28
New Zealand	4	21	22	26	23	8
United Kingdom	4	23	48	13	10	5
Austria	5	11	42	31	9	7
Canada	5	15	26	31	21	8
Denmark	5	23	45	25	6	1
Japan	5	2	24	33	16	25
Finland	6	4	32	41	18	5
Iceland	6	5	36	40	13	6
Sweden	6	15	33	30	15	6
Switzerland	6	3	27	36	21	13
Belgium	7	2	25	35	19	20
Italy	8	4	47	20	11	18
Czech Republic	9	5	36	44	7	8
Ireland	9	2	22	27	16	32
Germany	12	1	22	28	27	21
Greece	12	4	41	27	9	19
Mexico	12	8	46	16	10	20
Portugal	14	5	29	25	26	15
Poland	15	2	42	34	10	12
Slovak Republic	15	4	38	30	7	21
Turkey	25	7	39	8	6	40

Source OECD : PISA Database

In the OECD countries, limited experimental studies are conducted, providing insufficient evidence on the impact of technology upon learning outcomes. This is due to two main reasons (OECD, 2004): It is difficult for such evidence to pick up the wider learning outcomes that ICT might be expected to improve, and secondly, it is a challenge for results to keep up to date with the rapidly evolving potential of technology. Within these constraints, synthesis of existing research provides some qualified support for proponents of the use of technology to improve learning. (Kulik, 2003) stated that ICT can at times improve outcomes in Mathematics, although individual effects are often weak and findings are inconsistent.

CERI identified various barriers to ICT improving the quality of teaching and learning at schools. Limited resources is one of the factors that affect the educational use of ICT in most OECD countries as well as the inadequate use of the available technology at schools. One of the key findings in the survey done on principals, highlighted three obstacles in schools reaching their ICT developmental goals, each of which affected 60 % or more of all learners across the OECD schools. These are (OECD, 2004):

- Difficulty in integrating computers into classroom instruction.
- Teachers lack of knowledge in using computers as a teaching tool.
- Teachers not having enough time to prepare lessons that use computers.

It was evident from the findings that, besides upgrading educators' computer skills, the development of pedagogical skills was equally relevant to adapt to the new teaching tool: ICT.

The findings from case studies (Richard, 2002) reflect that the staff of the school must buy into the ICT policy since they are the key role players in integrating ICT into the curriculum. Therefore, it is important to understand how innovations in education come to be adopted or rejected by educators. Research on this topic has been conducted by Rogers, (1995) who has contributed a widely accepted conceptual framework for the issue. The starting point is to view schools as social systems composed of individuals with varying degrees of openness to technological innovations. The rate at which an innovation is adopted within the school is a function of certain characteristics of the organization staff, the innovation and the information disseminated about it. An innovation will be adopted more swiftly if the innovation is compatible with the adopters' current practices and values. Rogers (1995) divides potential adopters into five categories, based upon socio-economic status, communication behaviours and personality values:

- innovators
- early adopters
- early Majority
- late Majority
- laggards.

Change agents can affect adoption decisions positively by providing knowledge and training and reassuring potential adopters that an innovation will meet their needs. Sufficient professional development opportunities and support, compensated time off for training and an adequate ICT infrastructure present the optimal conditions for advancing the adoption of technology by a school staff. Diffusion of ICT in schools can stall or retreat without appropriate leadership or the aspects just described (Rogers, 1995).

Both infrastructural and educator competencies are required for the successful implementation of technology in schools. During the initial stages of implementing technology in schools, a reliable and user-friendly infrastructure is critical. As educators become more technically competent, their general pedagogical abilities and their ability to integrate ICT into the curriculum become more significant. Educators need time and support to experiment with integrating technology in their teaching. The most successful staff development programmes teach both ICT skills and related pedagogical skills, including how to integrate ICT in teaching. Richard (2002), states that several reports claim that standards in education are higher due to ICT access, but one study reported lower standards and another cautioned that teaching ICT skills in content area lessons took time from regular subject matter and therefore resulted in less content being covered.

2.2.2 United Kingdom

In 1998, the British government initiated a large scale "ICT in School Programme". The British Educational Communications and Technology Agency (BECTA) was commissioned to manage this ICT project that deployed technology in schools in the United Kingdom (UK) and conduct research on the impact of ICT in education. As government's partner in the strategic development and delivery of its e-strategy, BECTA had three key goals:

- To advise government on the contribution that technology can make to education.
- To develop and implement ICT in schools across the UK and establish effective programme management.
- To provide insight through analysis and research.

BECTA consulted academics from universities in the UK to conduct research on ICT in education in order to fulfil its goal of collating, analyzing and interpreting research evidence relative to technology in education. The evidence from the research (Becta, 2003) shows the positive effects of specific uses of ICT on pupils' attainment in almost all of the national curriculum subjects. The most substantial evidence was in English, Science and Mathematics. It is evident that there is a strong relationship between the ways in which ICT is used and pupils' attainment (Becta, 2003). This suggests that the pedagogical approach is a crucial component to successfully infuse ICT in education.

Two major UK studies conducted by BECTA investigated the effects of ICT on pupils' attainment in Mathematics. The first study developed a range of assessment methods based on those used by previous large scale projects, including new methods designed to measure attainment in conceptual understanding and intellectual processes. The findings (Becta, 2003) showed that learners who used subject-based Mathematics software achieved statistically higher scores in tests than those learners who were taught similar concepts through traditional methods. The results provided significant evidence of a positive impact of ICT on pupils' learning in Mathematics, in classes where ICT is integrated into the Mathematics curriculum. Mini-studies that were conducted, provided additional evidence of the positive effect of ICT on attainment in mathematical reasoning using a programming language called Logo and in Boolean logic skills using databases (Becta, 2003).

The second major study reported additional evidence that technology had a positive relationship to pupils' learning of mathematical skills (Harrison, 2002), and the learners' results varied in relation to the amount of time learners spent using technology in Mathematics lessons. It was evident (Becta, 2003) that those learners who used the tools of ICT in Mathematics lessons more frequently, outperformed the lower end users of ICT in Mathematics. An analysis carried out by BECTA found that improved results are output across the curriculum in schools that make more use of ICT. The findings reflect that schools that are well resourced in ICT, manage their technology efficiently, practice sound ICT teaching and learning and make good use of the resources achieved higher results compared to schools where these aspects were lacking (Becta, 2003).

2.2.3 United States of America

According to the International Data Corporation, the United States of America is ranked number one as the nation most prepared for the information age (Howell & Lundall, 2000). The USA has the greatest levels of connectivity of all countries and the highest levels of internet use. By 1999 (US Dept. of Ed, 2003), the majority of the schools had computers and more than 50% of the computers were multimedia models with sound cards and cd-rom, and in 2002, 98% of American schools had internet access. In the past ten years, forty billion dollars has been spent on upgrading and maintaining the technical infrastructure of America's public schools and on training its teachers to use that technology well (Dickard, 2003). Reports suggest that learners from different socio-economic strata and different racial and ethnic groups have different access to computers. A digital divide separates the information–rich and the information-poor segments of society, but the digital divide is beginning to narrow (Kulik, 2003). Many reports present strong assertions that technology can catalyse changes in the content, methods and overall quality of the teaching and learning process, triggering changes away from the lecture-driven instruction and towards constructivist, inquiry-oriented classrooms (US Dept. of Ed, 2003).

Meta-analytic approaches were used to locate studies and analyse the results. Meta-analytic reviews use objective procedures to locate as many studies of an issue as possible (Kulik, 2003). They describe features and outcomes of the studies using objective and quantitative methods. Finally, meta-analysts use statistical methods to describe overall findings and to chart the relationships between study features and outcomes (Kulik, 2003). Most of the reviews on technology in education use effect size measures to summarize findings. An effect size specifies the number of standard deviation units separating the outcome scores of treatment and control groups in a study. Effect sizes may be positive or negative. It is positive when the treatment group outperforms the control group and it is negative when the control group comes out on top. An effect size of about 0.2 is considered to be small, 0.5 is considered moderate and 0.8 is large in size (Cohen, 1977). When effect sizes in education are above 0.25, results are considered large enough to be educationally meaningful (Slavin, 1990).

Sixteen controlled studies were conducted on the effectiveness of integrated learning systems (ILSs) in Mathematics. Each of the sixteen studies found that Mathematics standardised test scores are at least slightly higher in the group taught with ILS; and the ILS effect in nine of the studies were large enough to be considered both statistically significant and educationally meaningful (Kulik, 2003). The median ILS effect in the sixteen studies was to increase Mathematics test scores by 0.38 standard deviations, or from the 50^{th} to the 65^{th} percentile. Another review of ILS effectiveness reported similar results. Bekker (1992) reviewed thirty two studies of ILS effectiveness. The median effect on Mathematics achievements in these studies was an increase in test scores of 0.40 standard deviations. An effect size of 0.40 is equivalent to an increase in test scores from the 50^{th} to the 66^{th} percentile. Evaluations have found evidence suggesting (Kulik, 2003) that ILS effects would be stronger if learners spent more time on ILS instructions. In typical ILS implementations, students spend only 15% to 30% of the recommended time with these programs.

2.2.4 South Africa

The only large scale ICT project in South African schools that preceded the Khanya Project is the Gauteng Online Project (GoL). This project was initiated in the year 2001 with an amount of R 500 million from the Gauteng government and another four million rands from public-private partnerships to complete and maintain the project. The project involves the provision of an average of 25 networked computers, special devices such as integrated big screen TV sets, a DVD, video recorder and a satellite dish with internet access in each school that would benefit the 500 000 learners in Gauteng Province. Teachers were trained in basic IT skills and how to use the Microsoft office package.

Research that was conducted on the GoL project states that there was very limited use of ICT in the teaching of subject matter. There was no effective plan for integrating ICT in curriculum delivery therefore leveraging ICT in the teaching learning process was not evident. The internet is used for research and the application packages for typing assignments and projects. Teachers provided evidence of the necessity for ICT training to promote professional development in integrating technology into classroom teaching.

2.3 ICT and Pedagogic

The South African national department of education stipulates that participation in the information society means that "Every South African learner will be ICT capable (that is, use ICTs confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and to be full participants in the global community) by 2013", (DOE, 2003). Full participation in the information society is enabled by successful e-education, which, according to the DOE (2003) incorporates learner-centered pedagogy, inquiry-based learning, collaborative work and the development of higher level thinking skills. The adoption and integration of computers is a challenging and complex process for schools, particularly where there is limited previous experience in the use of ICTs to support teaching and learning (Strydom, 2005). More recently, ICT integration is viewed as using computers to learn rather than learning to use computers.

Hokanson & Hooper (2000) state that what is important about computer use is not being able to wordprocess, or view a multimedia presentation, but the ability to interact with the computer in the manipulation and creation of knowledge through the rapid manipulation of various symbol systems. They add that the value of ICT lies in improving the capability to generate thought. This concept of "generative use" underpins the Piagetian cognitive constructivist view of knowledge and learning which assumes that knowledge is not a product that can be transmitted from one person to another, but a process of individually constructing knowledge (Strydom, 2005). Jonassen and Reeves (1996) use the term "cognitive tools" to refer to the role of ICTs in enhancing the learners' cognitive powers during thinking, problem-solving and learning. If teachers' epistemological assumptions are defined by constructivist theories of learning, then they are likely to extend the use of computers to generative uses (Strydom, 2005). This may be the reason for educators' beliefs that computers can be integrated into the curriculum to support learners' individual development.

The assumption underlying the introduction of computers into schools is the understanding that computers can impact positively on performance and heighten student motivation, facilitating the re-engagement of student interest in subjects such as Mathematics (Dwyer, 1994). Although there is large-scale research to suggest that this is the case, there is a dearth of in depth case study type research in the area of how the introduction of computers into the lesson forces a change in pedagogical practice (Harding, 2005). The need to understand the processes underpinning educators' appropriation of a novel technology arises out of a body of research indicating that it is not the computer itself that is responsible for positive learning gains, but rather how the computer is used by a teacher (Cox, 2005). Previous research (Hardman, 2005) into how computers are used in schools has suffered the following limitations:

- They fail to account for the teacher's epistemic assumptions regarding the novel technology.
- They lack a sufficiently nuanced understanding of the social, historical and contextual structures that occur in an environment.
- They do not deal with the relationship between tools within the context of their use, leading to a failure to appreciate that use of a novel tool is

almost certainly contingent upon how other tools in the system are used (Russell & Schneiderheinze, 2005).

In their search for alternative models to explain learning, many researchers have turned to Vygotsky's notion of mediation, where a more competent peer or adult is viewed as assisting performance, bridging the gap between what the child knows and can do and what the child needs to know (Hardman, 2005). Vygotsky's study (as cited in Hardman, 2005) conceptualized this gap between unassisted and assisted performance as the zone of proximal development (ZPD) that 'space' where learning leads to development. Every experience that the child has is mediated through tools. Figure 2.1 illustrates the basic Vygotskian triadic representation of mediation, where the subject acts on the object using mediational tools. Vygotsky's findings are that humans use tools to change the world and are themselves transformed through tool use. This representation reflects learning as a transformation process rather than the transmission of knowledge. Computers can be viewed as the mediational tool used to facilitate learning.

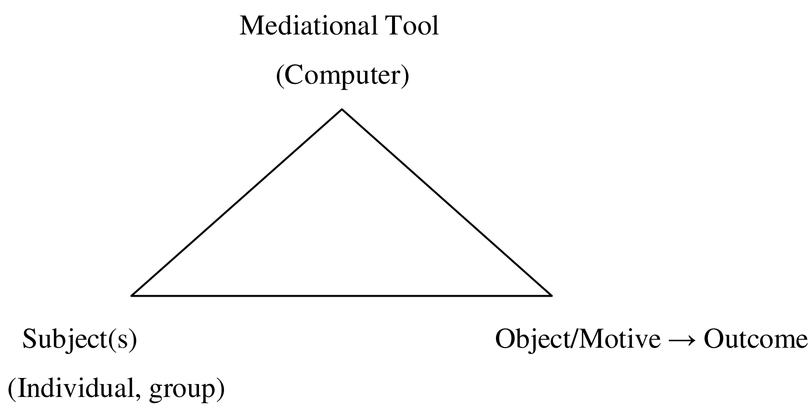


Figure 2.1 Source: First generation Activity Theory

2.4 The Khanya Project

In April 2004, one year after the launch of the Khanya Technology in Education Project, a research team from the University of Cape Town was consulted to evaluate the project. It is unusual for a newly launched programme to ask for an outcome evaluation so early in its existence. Programmes have a development trajectory of their own, and outcomes evaluations are usually not feasible at such an early stage. Only once it is stable in its service delivery and operationally mature, do outcome evaluations become more feasible (Louw & Muller, 2004).

It was too soon to produce a definitive evaluation of outcomes since the programme was still "settling down", developing and perfecting its delivery system amongst other things. It was too early in the development of the programme to expect it to deliver unequivocal outcomes (Louw & Muller, 2004). Nevertheless, it was accepted that research could still be conducted, serving a formative function to provide early feedback to Khanya on how it is doing in terms of achieving one of its key objectives (Louw & Muller, 2004): To assess whether learner performance in Grade 12 Mathematics improves as a result of curriculum delivery via technology. Technology comprised of computer hardware and the computer aided instruction software program Mastermaths.

Two research designs are utilised to strengthen conclusions about the programme effects. The first design involves a comparison of learner performance in schools using ICT in Mathematics education with schools not using computers for Mathematics. The main outcome of interest was learner performance. In the second design, essentially a time series design, learner performance is compared in Mathematics in 10 randomly selected schools from a list of 126 Khanya schools. This is referred to as the "Time Series Study" (Louw & Muller, 2004). The Grade 12 examination scores are analysed over the short time series of 2001 to 2003. The argument is that if the Khanya intervention is successful in the schools, one shall see a gradual change post-Khanya over time as depicted in Figure 2.2.

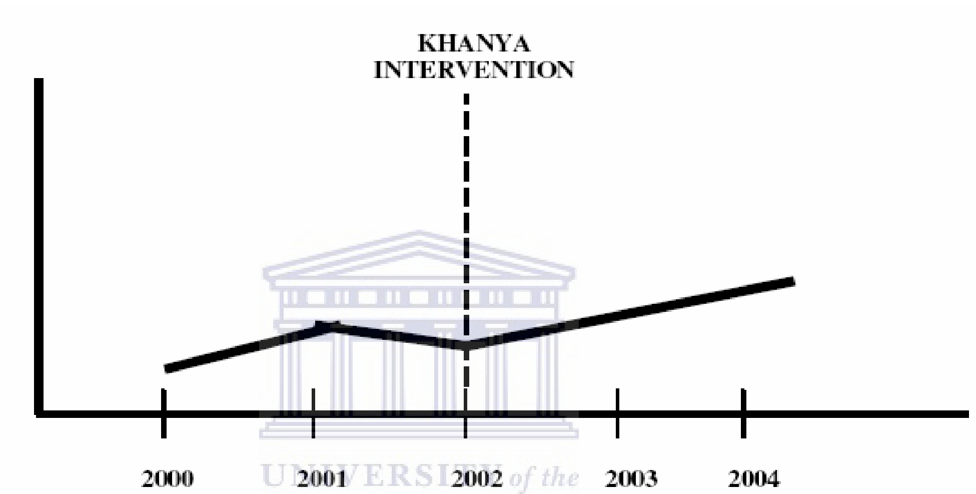


Figure 2.2 Source: Learner performance and mastermaths – Khanya Project

The results indicated that the Khanya intervention improves Mathematics performance in Grade 12 learners, although the evidence was not conclusive, since some of the schools showed no change after the intervention. It was found that in some of the schools, the technology was under-utilised, which could be the reason for the varying results. The researcher will attempt to adopt this theoretical framework inclusive of another dimension that will include an analysis of examination results of schools from varying socio-economic backgrounds to conduct research on the Khanya Project.

2.5 Conclusion

ICT has the potential to improve outcomes in Mathematics teaching/learning, although individual effects are sometimes weak and findings are inconsistent. Two of the challenges experienced by European countries are:

- Difficulty in integrating computers into classroom instruction
- Teachers' lack of knowledge in using computers as a teaching tool

Training and support of educators is imperative in order for them to buy into this innovation in education. Successful staff development programmes teach both ICT skills and related pedagogical skills, including how to integrate ICT in teaching.

The findings in the United Kingdom showed that learners who used subject-based Mathematics software achieved statistically higher scores in tests than learners who were taught similar concepts through traditional methods (BECTA, 2003). The second major study in the UK also confirmed that those learners who use ICT in Mathematics more frequently, perform much better than learners that use technology to a lesser extent. In the United States of America, many meta-analytic approaches are used to quantitatively analyse standardised examination scores. Sixteen of the studies conducted found that Mathematics standardised test scores are at least slightly higher in the group of learners that used ICT in Mathematics education. Nine of the sixteen studies showed a statistically significant difference in results after technology integration. Evaluations provide evidence that suggest that a high frequency of the use of technology provides a more positive effect on tests results (Kulik, 2003).

Some Nordic countries, Australia and New Zealand are among the countries that appear to have made investments in educational ICT that are large enough to allow most learners to gain access to the technology fairly frequently; and they are countries in which the technology does not appear to sit unused or to be infrequently used (OECD, 2005). In this group of countries investment in equipment has often been completed by extensive teacher training and patterns of computer use by learners both within the school and outside it, more often point to uses that emphasise educational and learning purposes. In these countries, one can observe an awareness of the importance of treating improved educational uses of ICT as a specific case of the general need to improve teaching and learning and to reform schools. A basic problem in gaining improved educational benefits from ICT, no matter how strong the benefits in terms of the production of ICT skills for the labour market and for everyday living, is that too frequently countries have seen it mainly as a technological issue, and not as an issue in school reform and school improvement (OECD, 2005).

Under the right circumstances, technology has been seen to have a positive impact in education. Literature has shown that to improve the quality of research, experts agree that there should be more longitudinal studies that chart the progress of the same learners over several years (Bergh, 2002). Also of significance, is that the impact of ICT's should be thoroughly investigated, to ascertain a qualified and viable "return on investment", (Bergh, 2002). Sayed's research (Sayed, 1998) confirms the need for investigations of ICTs in education in South Africa, suggesting that processes are required that will evaluate ICTs that are participatory and interactive, and that policy-makers should be involved in order to create a climate favourable for sustaining educational changes.

When trying to assess the educational impact of ICT, countries have different expectations about the ways in which ICT can improve educational outcomes (OECD, 2005). Two broad positions on the benefits that should be expected from investing in educational ICT can be observed. In the USA, there is a popular view that ICT can be judged by the extent to which it is able to improve learner performance in standardised examinations (Archibald, 2001). Another view is that ICT is an ideal tool for the achievement of lifelong learning: raising the motivation to learn (by giving learners more control over the content, timing the mode of their learning); and developing key learning skills such as co-operative learning, problem solving, information acquisition and analysis and autonomous learning (OECD, 2005).

The general belief is that ICT offers a powerful tool to improve the outcomes of education: improving the quality of teaching and learning, hence resulting in enhanced learner performance. The hypothesis of this mini-thesis research project: “Computer integration in Mathematics education for curriculum delivery enhances learner performance”, is tested in the chapter Research design and methodology. Research is conducted on the Khanya Project, an initiative of the Western Cape Education Department, that explores the infusion of technology for curriculum delivery in Mathematics education. A study is conducted on the standardised matric Mathematics examination results for the pre-Khanya years and the post-Khanya intervention in an attempt to determine the effect of using computers in Mathematics lessons on learner performance.

Chapter Three

3. Research Design and Methodology

3.1 Introduction

The aim of the research is to determine if technology integration in Mathematics education enhances learner performance. The research design describes the plan or blueprint of an investigation to obtain answers to research questions or problems (Babbie & Mouton, 2001). The design focuses on the end product, the study that is being planned and the kind of results that are expected. The terms "quantitative" and "qualitative" are used frequently to identify different modes of inquiry or approaches to the research process. Burns (2000) describes qualitative research as being naturalistic, involving the importance of subjective experience of individuals, an ideographic approach and as a holistic analysis, as opposed to the criteria of reliability and statistical compartmentalisation of quantitative research.

3.2 Quantitative Research

The researcher will use the quantitative research approach to determine the quantity or extent of the phenomenon, i.e. technology in education being studied on learner achievement. Learner achievement is measured by data in the form of numbers. In addition, analysis is done by using statistics, tables and charts with discussions on how what they show relates to the hypothesis which will enable the researcher to obtain measurements and analysis of the properties of the phenomenon under investigation. The data collected from the Western Cape Education Department (WCED) is used to compute pass rates, average pass rates and various statistical analyses which are all quantitative measures.

Traditionally, quantitative research has its goal to make claims about an entire population of cases on the basis of a subset of a population (Ercikan, 2006). The population most often consists of people. In the context of this research study, the Grade 12 learners represent the population. One can characterise this class of research as making inferences of a certain type, from a sample of specimens to the entire population from which the specimens derive (Ercikan, 2006). The statistical apparatus provides a set of procedures to assess such issues, as the probability of making an erroneous inference about the population. Thus, if a statistical comparison in a study suggests a difference between pre-technology and post-technology Mathematics examination results and the statistical results are associated with a value of $p < 0.05$, the researcher knows that there is a probability of less than 5% that the difference between results prior to ICT and post ICT is mere coincidence.

Since it is generally impossible to study an entire population, researchers typically rely on sampling to acquire a section of the population to perform an experiment or observational study (Easton, 2006). It is important that the group selected be representative of the population, and not biased in a systematic manner. Randomisation is employed to achieve an unbiased sample. The most common sampling designs are simple random sampling and stratified random sampling (Easton, 2006). Simple random sampling is the basic sampling technique where a group of subjects (a sample) for study is selected from a larger group (a population). Each individual is chosen entirely by chance and each member of the population has an equal chance of being included in the sample. There may be factors which divide up the population into sub-populations (groups/strata) and we may expect the measurement of interest to vary among the different sub-populations (Easton, 2006). This has to be accounted for when selecting a sample from the population in order to obtain a sample that is representative of the population. This is achieved by stratified sampling. Stratified sampling techniques are generally used when the population is heterogeneous, or dissimilar, where certain homogeneous, or similar, sub-populations can be isolated (Easton, 2006). Simple random sampling is most appropriate when the entire population from which the sample is taken is homogeneous.

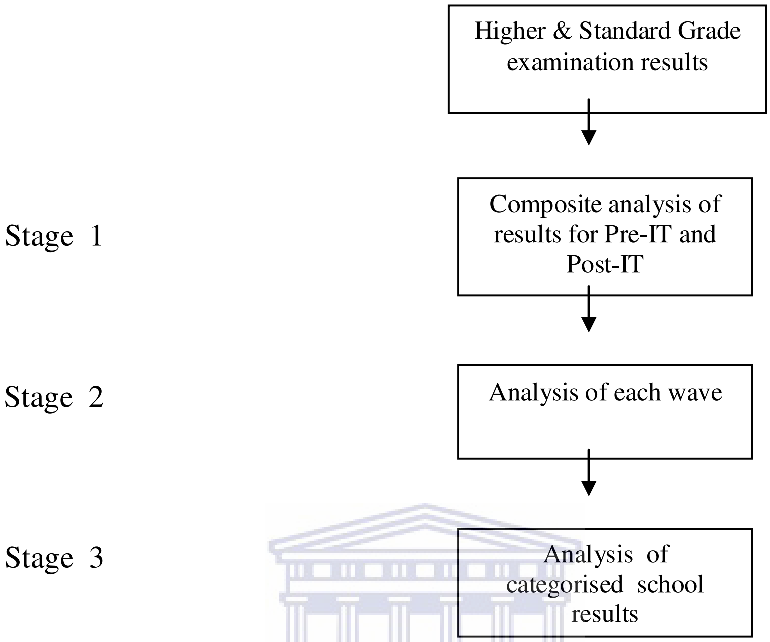
The main features of quantitative research are (Neuman, 2000) that

- It tests the hypothesis with which the researcher begins
- Concepts are in the form of distinct variables
- Measures are systematically created before data collection and are standardized
- Data are in the form of numbers from precise measurement
- Theory is largely causal and is deductive
- Procedures are standard and replication is assumed
- Analysis proceeds by using statistics, tables or charts and discussing how what they show relates to hypotheses

The Khanya Project study is aligned to the above attributes. Quantitative research relies on a positivist approach (Neuman, 2000) to social science. Neuman defines positivism as the approach of natural science that assumes cold, observable facts, quite distinct from ideas, values or theories. Burns (2000) states that research is positivist if there is evidence of quantifiable measures of variables, hypothesis testing and the drawing of inferences. The researcher will statistically analyse Grade twelve standardised Mathematics examination results for the period 1999 to 2005, which comprises of data in the form of numbers. Therefore a quantitative approach will be most suited for this investigation. Qualitative research follows an interpretive approach to understand a concept. Qualitative research will be appropriate in exploring learner perceptions and attitudes to ICT infusion in Mathematics education, but this research study investigates learner performance in the Mathematics Grade 12 standardised examinations prior to ICT integration compared to learner results after leveraging ICT in Mathematics education.

3.3 Research Procedure

The research procedure follows the design model below which represents the stages in the research process. Data for the years 1999 to 2005 was collected from the Examination Section of the Western Cape Education Department's (WCED) examination database. The data consist of the schools' details; including the school name, the grade of learners (Higher Grade or Standard Grade), the number of learners enrolled for the Grade 12 Mathematics examinations and the number of learners that passed the examination. Personal information such as the names of learners and the actual mark obtained by individual learners in the Mathematics examination could not be divulged due to confidentiality and ethical reasons. The Grade 12 Mathematics examination is the research instrument. The Higher Grade and the Standard Grade are two different Mathematics examinations; with Mathematics Higher Grade testing the more complex concepts. The Mathematics Higher Grade and Standard Grade results are therefore analysed separately in keeping with standardisation. Data is statistically analysed at three levels, as reflected in Stage 1, Stage 2 and Stage 3 of the model.



3.3.1 Stage One

Data for the Grade 12 standardised Mathematics examination results was collected over a period of seven years (1999 to 2005). This period of seven years comprised of the Pre-IT and a Post-IT period i.e. when no computers were used in Mathematics lessons (Pre-IT) and when ICT was used in the curriculum delivery of Mathematics (Post-IT). The years 1999 to 2001 are the Pre-IT years and from the year 2002 to 2005, groups of schools were selected for the Khanya intervention project, forming the Post-IT years. Since technology was implemented at different months of the same year for groups of schools, it seems reasonable to include a third analysis as the year of implementation together with the analysis of the Pre-IT and Post-IT years

A longitudinal study is conducted for the years 1999 to 2005. Longitudinal Research examines features of people or other units at more than one time (Neuman, 2000). It is a powerful approach, especially seeking answers to questions about system or social change over time. In stage one, the examination results are statistically analysed based on the proportion of learners passing prior to being exposed to ICT in Mathematics education, as compared to the results of learners who used computers in Mathematics education. The Higher Grade results for all the schools are analysed separately from the Standard Grade results of all schools. No covariates, such as socio-economic measures for learners are taken into account at this stage of the investigation. A stratified analysis is done where each school is considered a stratum. Data is statistically analysed for pre-IT, during the year of IT implementation and post-IT; to determine if the proportion of those passing within the particular school improves across time. The Cochran-Mantel-Haenszel methodology is used to test for changes in proportions across the implementation levels (Pre-IT, year of IT implementation and Post-IT). This is a stratified version of a Chi-square test. The analyses was done using the FREQ (frequency) procedure in the software package SAS. A more sophisticated analysis using Generalised Linear Models is also done on the data. In this analysis, logistic regression is used to model the outcome of pass/fail and account for the dependence of observations within the same school. The correlation structure for this dependence was taken to be compound symmetry.

3.3.2 Stage Two

For each year from 2002 to 2005, a group batch of schools received the Khanya intervention Programme, where computer labs were set up at schools for Mathematics education using the Mathematics software programme, Mastermaths. Each group of schools for each year is referred to as a wave. The first batch of schools to receive the Khanya intervention programme in 2002 is referred to as the pilot wave, the next wave, in 2003, the second wave, in 2004 the third wave and in 2005 the fourth wave. Therefore, for each year from 2002 onwards, a new set of learners were writing the Grade 12 Mathematics examinations after receiving Mathematics education via computers. In the second stage of the research design, data for each wave is analysed as a unit since all schools in a specific wave have been exposed to ICT in Mathematics education for approximately the same period of time. The grade twelve, also referred to as the matric standardised examination scores for the Pre-IT and the Post-IT years in each wave is analysed

3.3.3 Stage Three

For the purpose of validity, further analysis is conducted in stage three in an attempt to use triangulation. Winberg (1997) defines triangulation as finding ways of getting alternate and divergent viewpoints on research findings or the research process, which will improve the quality of the analysis. Schools in each wave are heterogeneous, varying with regard to location, demographics, resources and poverty index. The WCED ranks schools in five quintiles, based on the relative poverty of the communities surrounding the schools. Schools in quintile one are situated in the poorest communities, while those in quintile five are situated in the least poor communities. Each school is allocated a poverty index value in relation to its socio-economic status. Each wave of schools will be classified into their respective quintiles. The simple random sampling technique will not be appropriate since students in schools in each wave vary regarding socio-economic factors. The stratified random sampling design would have been the suitable methodology to select schools from a large population in order to analyse the Mathematics examination results for pre-technology and post-technology. However, the stratified random sampling design is not used since the condensed population qualifies using the population in its entirety. An experimental approach comprising of selecting a group of schools that use ICT (experiment) and comparing learner performance with another selected group of schools that do not use ICT (control) will not be necessary since each school acts as its own experiment and control, i.e. examination results for each school have been collected for three years prior to technology integration and post technology. Therefore reliability of the data will be implemented. Analysis of results for each of the five quintiles will provide a stronger indication of the effect of ICT in Mathematics education for the various types of schools in their respective quintiles. A linear regression is applied to determine whether there is a relationship between social status and improvement in pass rate. The number of learners enrolled for Mathematics in each school for the Pre-IT and Post-IT years is also explored in Stage Three.

3.4 Conclusion and Limitations

The research design reflects the three levels in which this the study will be conducted. Starting from a composite analysis of the matric standardised examination results in stage one to a structured analysis in stage two by grouping schools into waves. Each wave contained schools that had the Khanya intervention programme for the same time period. In the final stage three, further categorisation is established where schools in each wave are classified into quintiles, depending on the socio-economic background of the schools. Statistical analysis is conducted in each of the quintiles for the pass rates and the enrolment of learners in the pre-IT and Post-IT years.

A key limitation to this study is that vital data including learner details and learner marks for the grade twelve examinations could not be accessed due to confidentiality and ethical issues. An investigation of the symbol distribution of the Mathematics examination results for the Pre-IT and Post-IT years would have provided a clearer understanding of not just the pass rates for the Post-IT years compared to the Pre-IT years, but the quality of pass rates as well. Impact studies of systems are effective over a prolonged time frame in order to conduct a comprehensive study, but the Khanya Project is still in its infant stage. Longitudinal studies that chart the progress of the same learners through different grades up to grade twelve would have provided a more comprehensive set of results. Consideration should be given to these factors in further studies of technology in education.

Chapter Four

4. Results

4.1 Introduction

The results for each of stage one, stage two and stage three were analysed independently. Stage one was a composite analysis of all the grade 12 Higher Grade results and all the Standard Grade results for the years 1999 to 2005. Stage two comprised of an analysis of the Higher Grade and Standard Grade results in accordance with the wave format. In the final stage three, the schools in each wave were grouped according to their social index. The results were then statistically analysed for the various categories of schools according to their socio-economic status.

4.2 Stage one Results

The Higher Grade and the Standard Grade Mathematics scores for all schools were each statistically analysed for the three phases i.e.

- Pre-IT:

  The years when Mathematics was taught in the classroom in the conventional way without IT intervention.

- Implementation year:

  The year of IT implementation in Mathematics lessons.

- Post-IT :

  The years when technology was integrated in Mathematics education.

A stratified analysis was done where each school was considered a stratum. The Cochran-Mantel-Haenszel methodology was used to test for changes in proportions across the implementation levels (Pre, during and Post). The analysis was done using the **PROC FREQ** (frequency procedure of *SAS*®) in the software package *SAS*®.

The frequency table (Table 4.1) shows that there was no significant difference for the Higher Grade results (p = 0.35). The proportions passing the examinations goes from 69 %, 68 % and 71 % for the period Pre-IT, During IT and Post-IT respectively.

Table 4.1
Frequency Table of Higher Grade Mathematics Learners (summarised over schools) according to whether passed or failed and whether the examinations were Pre-IT, in the year of the IT implementation and Post IT implementation and with the relevant percentages added

		Failed	Passed	Total
Pre IT	# learners	534	1215	1749
	Table Percentage	11.9%	27.08%	38.98%
	Row %	30.53%	**69.47%**	
Year IT	# learners	244	513	757
	Table Percentage	5.44%	11.43%	16.87%
	Row %	32.23%	**67.77%**	
Post IT	# learners	575	1406	1981
	Table Percentage	12.81%	31.33%	44.14%
	Row %	29.03%	**70.97%**	
Total # of Learners		1353	3134	4487
	Row %	30.15%	69.85%	85

The pass rate for Pre-IT was 69.47 % and this rate dropped to 67.77 % during the year of IT implementation and then increased to 70.97 % during Post-IT implementation. Therefore there was a small increase of 3.20 % for Post-IT and the p-value associated with this increase was 0.35, indicating that the increase was not significant.

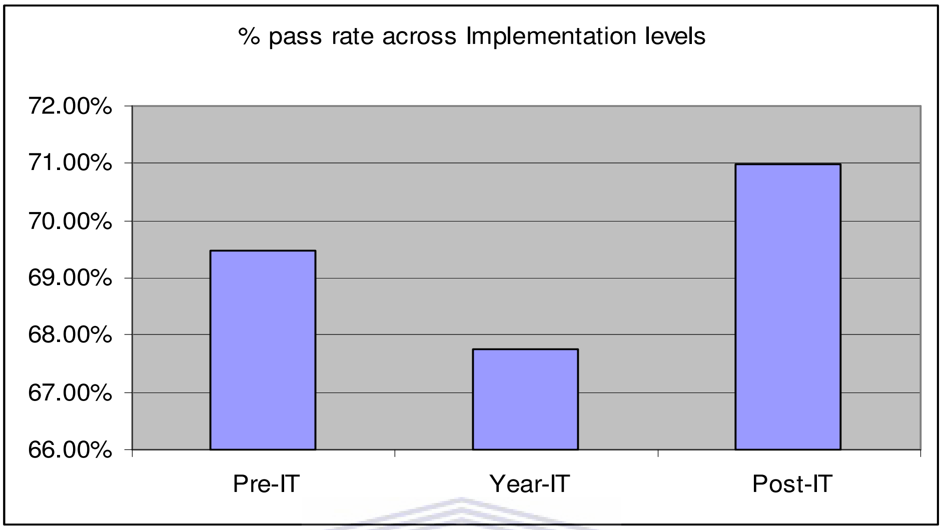


Figure 4.1
The % pass rate over the three levels of implementation for the Higher-grade Mathematics examination

The results for the Standard Grade (Table 4.2) indicate that the proportion of learners passing the Mathematics examination increases from 46% (Pre-IT), 54% (year of IT implementation) to 57% (Post-IT). This was a significant difference, especially compared to the Higher Grade results.

Table 4.2
Frequency Table of Standard Grade Mathematics Learners (summarised over schools) according to whether passed or failed and whether the examinations were Pre-IT, in the year of the IT implementation and Post IT implementation and with the relevant percentages added

		Failed	Passed	Total
Pre IT	# learners	12202	10393	22595
	Table Percentage	28.75%	24.49%	53.24%
	Row %	54.00%	**46.00%**	
Year IT	# learners	3395	39.81	7376
	Table Percentage	8.00%	9.38%	17.38%
	Row %	46.03%	**53.97%**	
Post IT	# learners	5358	7111	12469
	Table Percentage	12.62%	16.76%	29.38%
	Row %	42.97%	**57.03%**	
Total # of Learners		20955	21485	42440
	Row %	49.38%	50.62%	100.00

The pass rate for Pre-IT was 46 % and this rate increased to 53.97 % during the year of IT implementation and then increased to 57.03 % for Post-IT implementation phase (Table 4.2). Therefore there was a net increase of 11.03 % for Post-IT and the p-value associated with this increase was 0.0001, therefore the increase was significant.

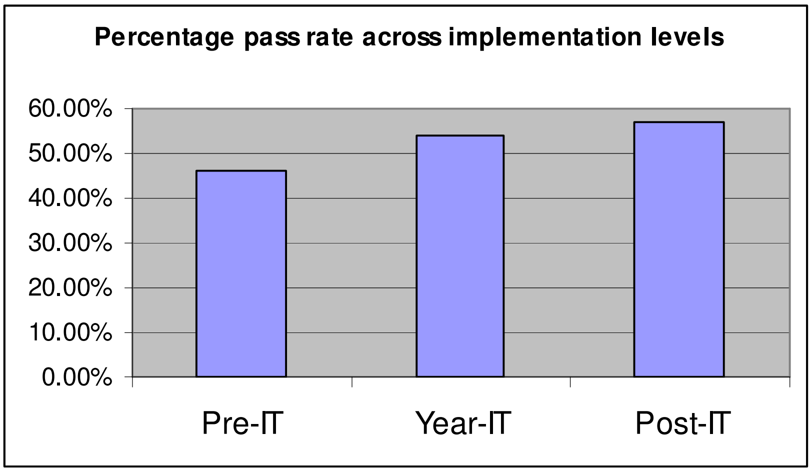


Figure 4.2
The Percentage pass rate over the three levels of implementation for the Standard-Grade Mathematics examination

4.3 Stage Two Results

At this stage, each wave of schools is analysed separately for the Higher Grade and Standard Grade Mathematics standardised examination results of Grade twelve.

4.3.1 Stage Two Higher Grade Results

For the pilot wave of the Higher Grade, there were 11 schools. Eight of the 11 schools were considered for analysis since the other 3 schools had too few numbers of learners enrolled for the Mathematics Higher Grade examination. The years 1999 to 2001 are the Pre-IT years when no computers were used in Mathematics lessons. The Khanya intervention programme was implemented in the latter part of 2001, therefore the years 2002 to 2005 are the Post-IT years when technology was integrated in Mathematics education.

Six out of the 8 schools showed an increase in pass rates for Post-IT as reflected in Table 4.3. There was an increase in pass rate from 68% to 73% after technology integration; a small increase of 5%. The p-value was 0.06 which is a 0.01 increase of 0.05 and may not be deemed to be significant.

Table 4.3
Pilot Wave Higher Grade pass rate for Pre-IT and Post-IT

School	Pre-IT	Post-IT	Increase or Decrease
Bridgton	90%	75%	decrease
Garlandale	76%	78%	increase
Harold Cressy	39%	45%	increase
Klein Nederburg	39%	45%	increase
Livingstone	99%	98%	decrease
Luhlaza	43%	84%	increase
Sarepta	59%	61%	increase
South Pennin.	92%	93%	increase
	68%	73%	Pass rate increased in six schools

The associated Chi-squared Test Statistic for the summarised table for all Higher Grade Pilot Wave schools was equal to 3.32, 1 degree of freedom with a p-value of 0.069 which is not significant.

Thus there was a small improvement in the pass rate after infusing ICT in Mathematics education. The Chi-Squared test performed above was not completely valid because it is the summary over the total number of schools, during the academic years 1999 to 2005 in the first wave.

The pass rates before ICT and after ICT in Mathematics Higher Grade for the pilot wave are shown in Figure 4.3 below. For eight of the schools in Figure 4.3 the pass rates were approximately equal before and after implementation, with a very small increase in pass rate after ICT infusion in Mathematics education, except for Luhlaza with an increase of 41% and Bridgton High School that had a decrease of 15%

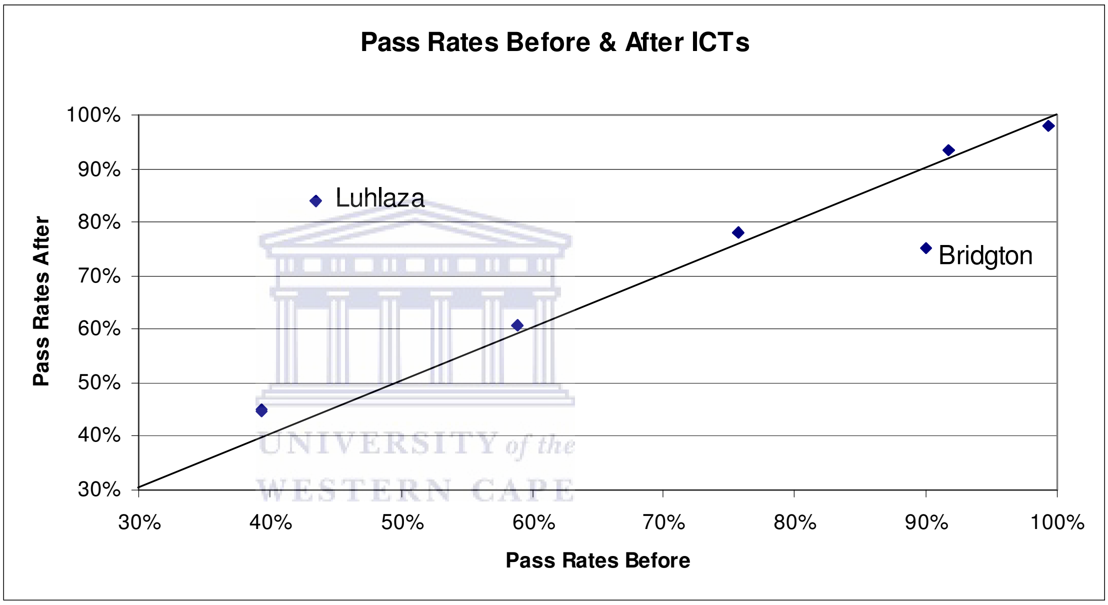


Figure 4.3
Pass rates for Pre-IT and Post- IT implementation in the first wave HG schools

For the second wave, the years 1999 to 2001 are the Pre-IT years. The project was implemented in 2002, therefore the years 2002 to 2005 are the Post-IT years. The Higher Grade results of 23 schools were analysed. Seventeen of the 23 schools showed an increase in pass rates for Post-IT as reflected in Table 4.4. There was an increase in pass rate from 72% to 73% after technology integration: a very small increase of 1 %. Although the overall percentage increase was only 1% for this wave, 74% (17 out of 23) of the schools had an increase in pass rate after technology implementation (Figure 4.4).

Table 4.4
Second Wave Higher Grade pass rate for Pre-IT and Post-IT

School	Pre-IT	Post-IT	Difference	Increase or Decrease
Atlantis	73%	88%	+15	increase
Berg Rivier	22%	57%	+35	increase
Bernadino Heights	60%	46%	-14	decrease
Blackheath	67%	65%	-02	decrease
Cosat	77%	91%	+14	increase
Grabouw	100%	95%	-05	decrease
Groenberg	63%	67%	+04	increase
Kasselsvlei	88%	63%	-25	decrease
Kensington	70%	83%	+13	increase
Ladismith	92%	94%	+02	increase
Luckhoff	43%	45%	+02	increase
Mondale	58%	84%	+26	increase
New Orleans	36%	80%	+44	increase
Oudtshoorn	96%	98%	+02	increase
Pacaltsdorp	38%	86%	+48	increase
Piketberg	96%	100%	+04	increase
Proteus	47%	52%	+05	increase
Rylands	70%	89%	+19	increase
Schoonspruit	81%	70%	-11	decrease
Simon's Town	58%	72%	+14	increase
Sinethemba	14%	34%	+20	increase
Worcester	40%	53%	+13	increase
Zwartberg	95%	91%	-04	decrease
	72%	**73%**		Pass rate increased in 17 schools

Figure 4.4 illustrates that the majority of the schools in the second wave had an increase in pass rate after using technology in Mathematics teaching. The majority of the schools fell above the line of no change. Schools such as Pacaltsdorp and New Orleans had high increases of 48% and 44% respectively.

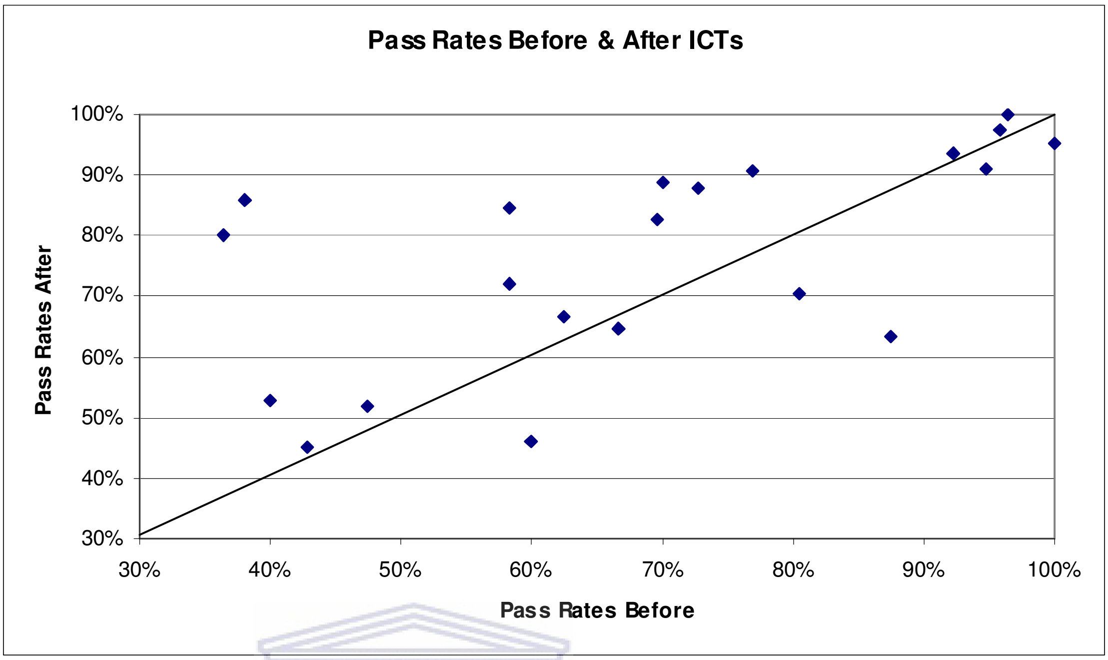


Figure 4.4
Pass rates before and after IT implementation for the Second Wave Higher Grade schools

In the third wave, the years 2000 to 2002 are the Pre-IT years while the years 2003 to 2005 are the Post-IT years. The examination results of 12 schools were analysed. Only 4 of the 12 schools showed an increase in pass rates for Post-IT as reflected in Table 4.5. There was an average decrease of 10% in the pass rate after technology integration. Figure 4.5 represents the pass rates before IT integration and after IT integration. Most schools had a small decrease in pass rates after using ICT in Mathematics education except Malibu and Spine Road that had decreases of 16% and 17% respectively. The only high increase in pass rate for Post-IT was Sophumelela that had an increase of 15%.

Table 4.5
Third Wave Higher Grade pass rates

School	Pre-IT	Post-IT	Inc/Dec
Belgravia	75%	80%	+05%
Bellville High	100%	97%	-03%
Bulumko	40%	39%	-01%
Cravenby	81%	76%	-05%
Gordon	29%	27%	-02%
Kwamfundo	50%	50%	00%
Kylemore	75%	83%	+08%
Malibu	74%	58%	-16%
Norman Hen.	79%	76%	-03%
Percy Madala	67%	75%	+08%
Sophumelela	33%	48%	+15%
Spine Road	67%	50%	-17%
	78%	68%	-10%

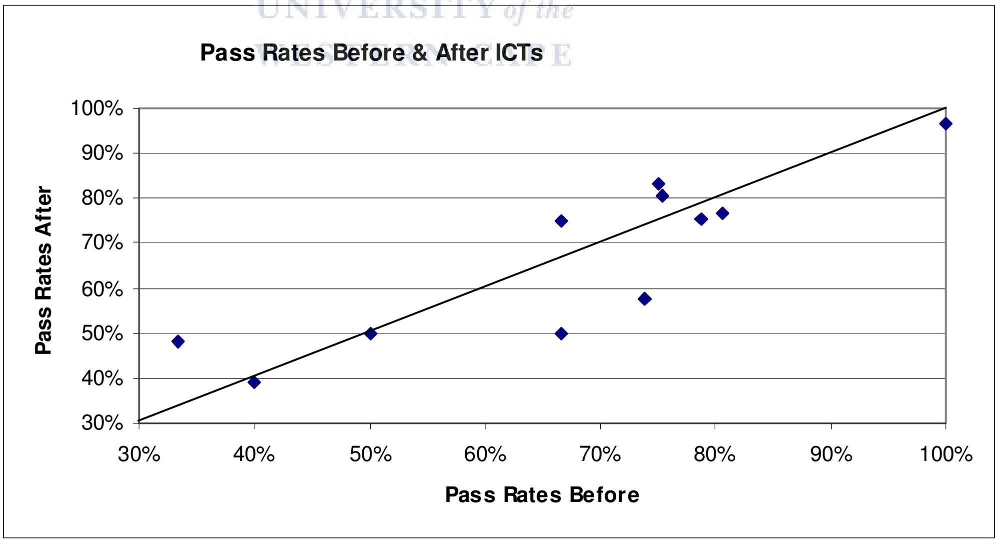


Figure 4.5
Pass rates before and after IT for the Higher Grade Third Wave Schools

Most of the learners in schools that fell into wave four were enrolled for Mathematics Standard Grade, therefore an analysis could not be done on these waves since the numbers of results were too small, however an analysis is done for these schools in the Standard Grade section.

4.3.2 Stage Two Standard Grade Results

The Standard Grade examination scores of all eleven schools in the pilot wave were taken for analysis. The percentage pass rate was calculated for all schools for the years 1999 to 2005 (Table 4.5). The years 1999 to 2001 are the Pre-IT years when no computers were used in Mathematics while the years 2002 to 2005 are the Post-IT years when computers were used in Mathematics lessons.

Table 4.6

Standard Grade Percentage pass rate for Pre-IT and Post-IT years in the Pilot Wave

Year	Percentage Pass
1999	59
2000	61
2001	53
2002	67
2003	62
2004	67
2005	61

A severe drop in the pass rate occurred from 2000 to 2001 (Figure 4.6). Possible reasons could be too high standards of the examinations. In 2002 the pass rate increased by 14%. The year 2002 was the first year that computers were used in the Mathematics curriculum. Computers were installed in the second half of the year therefore ICT was only used for the latter part of the year in Mathematics education. The pass rate was reasonably stable for years 2002 to 2005. The average pass rate for the post-IT years (2002-2005) was higher than the pass rates for the pre-IT years (1999-2001) as shown in Figure 4.6. From Figure 4.6 below it appears that computers had a positive effect on the learner performance in the standardised matric Mathematics examinations.

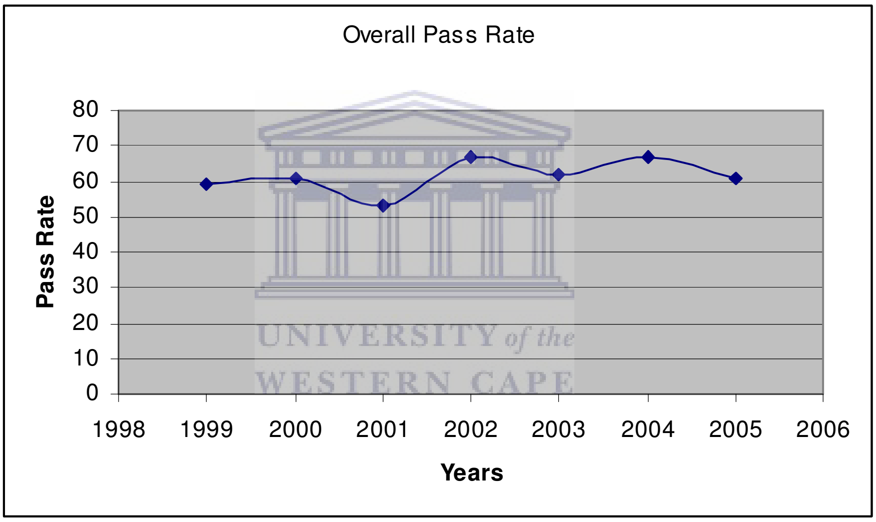


Figure 4.6

Overall results of Standard Grade scores in the First Wave

The Standard Grade examination scores of all 42 schools in the second wave were taken for analysis. The percentage pass rate was calculated for all schools for the years 1999 to 2005 (Table 4.7). The years 1999 to 2001 were the Pre-IT years. The year 2002 was the implementation year when computers were installed in the second wave schools. The years 2003 to 2005 were the Post-IT years.

Table 4.7

Standard Grade pass rate for Pre-IT and Post-IT years in the second Wave

Year	Percentage Pass
1999	44
2000	44
2001	51
2002	58
2003	54
2004	59
2005	60

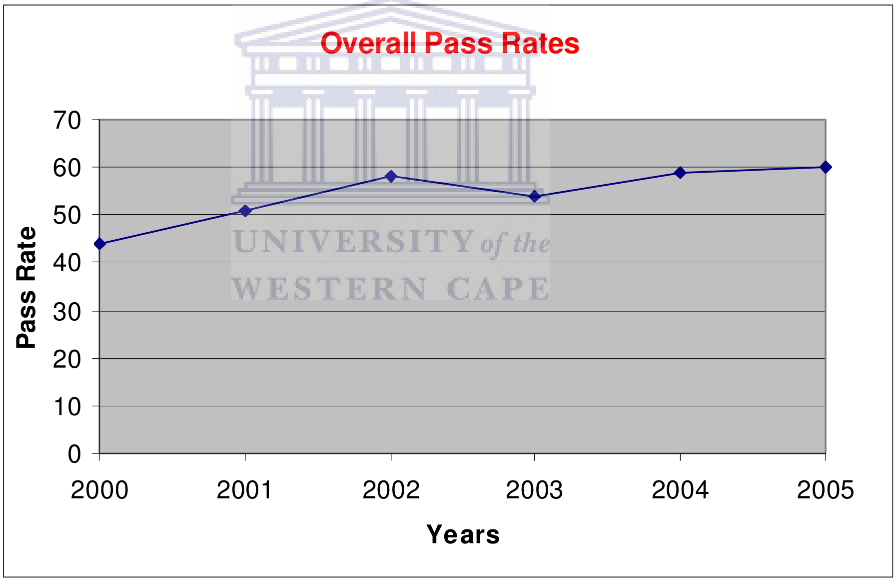


Figure 4.7

Overall results of Standard Grade scores in the Second Wave

In Figure 4.7 the pass rate from 1999 to 2000 for the Pre-IT years was consistent (44%) and then increased to 51% in 2001. For the Post-IT years, the pass rate increased to 59% in the year 2002. In the year 2003, the pass rate decreased to 54% and then increased to 60% in 2004, and remained consistent for 2005. The average pass rate for the Post-IT years was higher than the average pass rate for the Pre-IT years. It appears that using computers in Mathematics education impacted positively on student performance.

The Standard Grade examination scores of all 30 schools in the third wave were taken for analysis. The percentage pass rate was calculated for all schools for the years 2000 to 2005 (Table 4.8). The years 2000 to 2002 were the Pre-IT years while the years 2003 to 2005 were the Post-IT years.

Table 4.8 Standard Grade pass rate for Pre-IT and Post-IT years in the Third Wave

Years	Percentage Pass
2000	35
2001	42
2002	51
2003	58
2004	57
2005	48

There was a gradual increase in the pass rates for the Pre-IT years 2000 to 2002 (Figure 4.8).The pass rate continued to increase for the Post-IT year 2003 remaining stable for 2004 until it declined in the year 2005. The lower pass rate could be explained by the higher standards in the Mathematics examination in that year since the majority of the schools showed a decline in the pass rate for the year 2005. The average pass rate for the Pre-IT years was 43% while the average pass rate for the Post-IT years was 54%. Therefore there was an increase of 11% in the pass rate for the Post IT years.

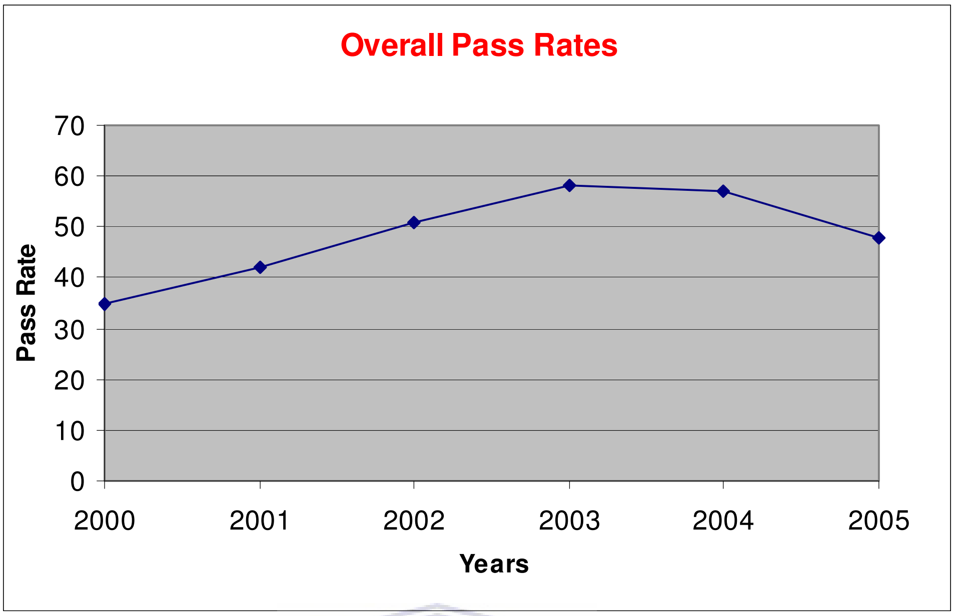


Figure 4.8

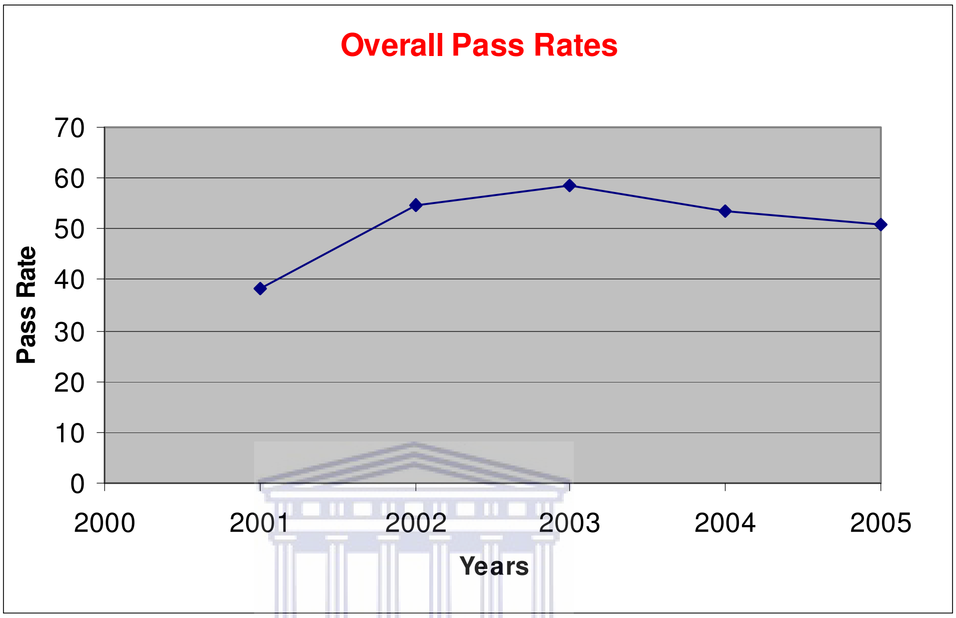
Overall results of Standard Grade scores in the Third Wave

The results for all twenty two schools in the Fourth Wave were analysed. There was a steady increase in the pass rates for the Pre-IT years 2001 to 2003 (Table 4.9). There was a decrease of 4% in the Post –IT year 2004 and a further drop of 3% in 2005.

Table 4.9
Standard Grade pass rate for Pre-IT and Post-IT years in the Fourth Wave

Years	Percentage Pass
2001	38%
2002	55%
2003	58%
2004	54%
2005	51%

Figure 4.9
Overall results of Standard Grade scores in the Fourth Wave



For the fifth wave, computers were installed in schools at various times in the year 2005. In some schools, the Khanya Labs were only set up in the latter part of the year 2005; therefore technology was not used adequately in Mathematics education that warrants analysis of the examination results for that wave.

4.4. Stage Three Results

Schools were categorised into groups according to the socio-economic status of the communities in which the schools were located. Each of the groups, starting from the affluent schools that were grouped into the low poverty (LP) Quintile up to Quintile one which consisted of schools from the poorest communities. The poverty levels increased, moving from the low poverty (LP) Quintile down to Quintile one. The Mathematics examination results were analysed in an attempt to determine how ICT integration in Mathematics education affects the different classes of schools regarding the pass rates and enrolment figures for the schools. This analysis of homogenous groupings was significant in order to determine the effect of ICT on the Mathematics performance of students from across the socio-economic spectrum.

4.4.1 Stage Three Higher Grade Results

Table 4.10 represents schools from all five quintiles of the first wave that were analysed for the pass rates and enrolment of students for Mathematics during pre-technology and post-technology.

Table 4.10

Higher Grade pass rates and enrolment figures for schools classified into social index for the first wave

School	Social Status	Quintiles	Improved Enrolment	Improved Enrolment	PreTech Enrol.	PostTech Enrol.	PreTech Pass Rate	PostTech Pass Rate	Improved Pass Rate
South Pennin.	0.31	LP	62%	44	48	91.5	92%	93%	1%
Sarepta	0.36	LP	37%	16	34	49.5	59%	61%	2%
Garlandale	0.37	LP	11%	4	37	41.25	76%	78%	2%
Livingstone	0.38	LP	20%	33	149	182.25	99%	98%	-1%
Harold Cressy	0.41	LP	-18%	-27	160	133.5	39%	45%	6%
Klein Nederburg	0.57	4	39%	16	33	48.75	39%	45%	6%
Excelsior	0.61	3	77%	3	2	4.5	100%	83%	-17%
Bridgton	0.69	2	-50%	-8	20	12	90%	75%	-15%
Mandlenkosi	0.72	2	136%	17	4	21	75%	68%	-7%
Luhlaza	0.77	2	-20%	-4	23	18.75	43%	84%	41%
Oscar Mpetha	0.79	1	148%	23	4	27	75%	36%	-39%

The schools were sorted according to their social status; starting from the more affluent schools(South Penninsula with Quintile LP and social status of 0.31) proceeding down to the poorest school (Oscar Mpetha with Quintile 1 and social status 0.79). All four schools in the LP Quintile had an increase in the pass rate except Livingstone that had a small decrease of 1%. Four schools also showed a substantial improvement in the enrolment for Mathematics except Harold Cressy that had a drop of 18% in enrolment. The one school in Quintile 4 had a significant improvement in enrolment of 39% together with an increase of 6% in pass rate. The only school in Quintile 3 improved enrolment by 77% but its pass rate declined by 17%. Of the three schools in Quintile 2, two schools enrolment dropped by 50% and 20% while one school experienced an improvement of 136%.In two of these schools, the pass rate decreased while one school had an increase of 41%. In the poorest school (Quintile 1) there was a substantive improvement of 148% in the enrolment but a 39% drop in the pass rate.

A scatter-plot was drawn for the bivariate variables together with the trendline (Table 4.10). The regression function and the r^2 values were derived. The coefficient of determination r2 indicates the percentage change in the dependent variable that can be explained to the independent variable. The correlation coefficient r, calculates the strength of the linear relationship between the dependent and the independent variable.

The social index value is small for the affluent communities and numerically larger for the poorer communities (Table 4.10). A straight line was fitted to all 11 points. The R squared was equal to 0.0203. When $r^{2\text{ falls}}$ in the range:
$0 < r^2 < 0.25$ it is indicative of a very weak relationship. From the fitted line it could be deduced that there was a very weak correlation between social status

and pass rate. Only 2% of the variability in the "improvement of the pass rate" could be explained by the social status.

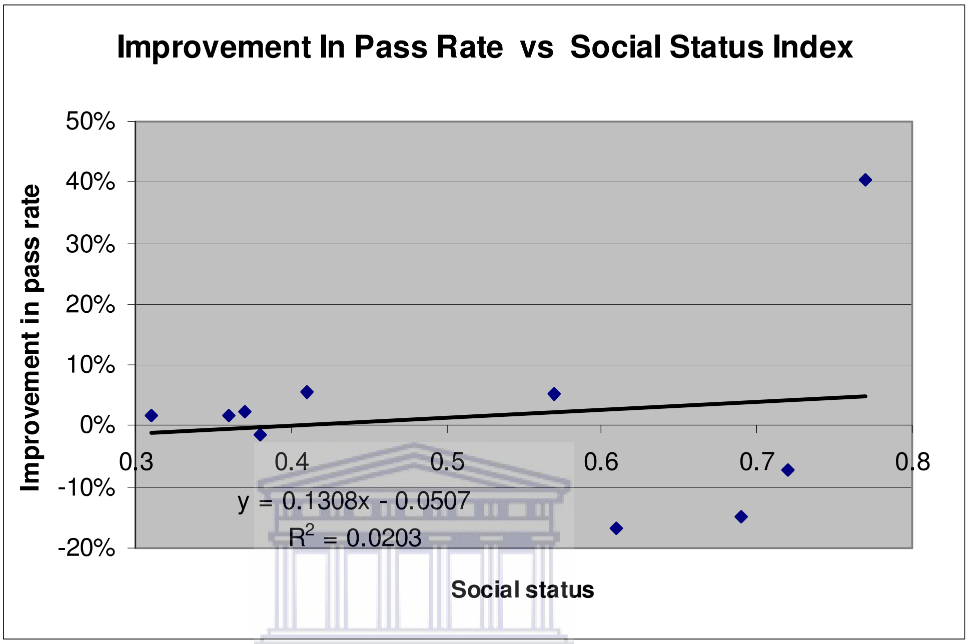


Figure 4.10
The improvement in Higher Grade Mathematics pass rate for the different social index in the first wave schools

A study of the improvement in the enrolment figures for the Post-IT period in the different socio-economic categories was also conducted. From the graph that follows (Figure 4.11), it is evident that two schools, Mandlenkosi and Oscar Mpetha from the poorer communities experienced extremes in enrolment of 136% and 148% respectively after ICT integration in Mathematics education. However, there is a weak correlation between improvement in enrolment and social status since the r^2 value was less than 0.25. Social status explained only 7 % of the variation in improvement in enrolment.

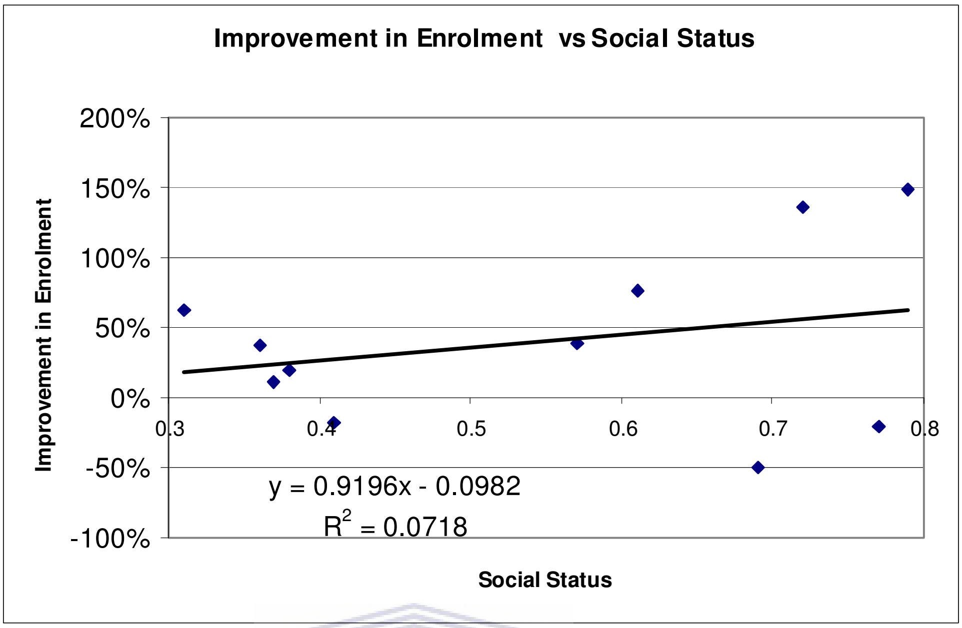


Figure 4.11
The improvement in Higher Grade Mathematics enrolment for the different social index in the first wave schools

In the second wave, the majority of the schools (5 out of 8), categorised in the LP Quintile had an improvement in the enrolment with Bernadino Heights showing a marked improvement of 94% (Table 4.11). Rylands High had a 0% improvement while the remaining two schools showed a small decline in the enrolment. Six of the eight schools improved their pass rates in Mathematics. Therefore, there was an overall improvement in the enrolment and pass rates for the LP schools. All schools in the 4th Quintile had a vast improvement in the enrolment and all schools except two schools had an increased pass rate. Three of the five schools in Quintile 3 improved their enrolment and had an improved pass rate. There was only one school in Quintile 2 that had a drop in the enrolment but an improvement of 44% in the pass rate. Of the two schools in the 1st Quintile, Sinethemba had an improvement of 104% in enrolment while Worcester had a drop of 79% in enrolment. Both of the same schools had an improved pass rate of 20% and 13%, respectively.

Table 4.11

Higher Grade pass rates and enrolment figures for schools classified into social index for the second wave

School	Social Status	Quintiles	Improved Enrolment	Improved Enrolment	PreTech Enrol.	PostTech Enrol.	PreTech Pass Rate	PostTech Pass Rate	Improved Pass Rate
Oudtshoorn	0.27	LP	22%	17.75	73	90.75	96%	98%	2%
Simon's Town	0.29	LP	44%	6.75	12	18.75	58%	72%	14%
Piketberg	0.32	LP	-9%	-2.5	28	25.5	96%	100%	4%
Grabouw	0.36	LP	19%	2.75	13	15.75	100%	95%	-5%
Ladismith High	0.38	LP	57%	10.25	13	23.25	92%	94%	2%
Rylands	0.38	LP	0%	0.25	80	80.25	70%	89%	19%
Kensington	0.39	LP	-6%	-1.25	23	21.75	70%	83%	13%
Bernadino Heights	0.4	LP	94%	17.75	10	27.75	60%	46%	-14%
Zwartberg	0.48	4	43%	275.25	498	773.25	95%	91%	-4%
Mondale	0.49	4	34%	9.75	24	33.75	58%	84%	26%
Luckhoff	0.51	4	107%	16.25	7	23.25	43%	45%	2%
Blackheath	0.52	4	72%	6.75	6	12.75	67%	65%	-2%
Atlantis	0.54	4	77%	13.75	11	24.75	73%	88%	15%
Proteus	0.55	4	6%	1.25	19	20.25	47%	52%	5%
Groenberg	0.6	3	-17%	-1.25	8	6.75	63%	67%	4%
Kasselsvlei	0.6	3	48%	15	24	39	88%	63%	-25%
Schoonspruit	0.6	3	24%	9.75	36	45.75	81%	70%	-11%
Berg Rivier	0.61	3	55%	6.75	9	15.75	22%	57%	35%
Pacaltsdorp	0.66	3	-120%	-15.75	21	5.25	38%	86%	48%
New Orleans	0.73	2	-38%	-3.5	11	7.5	36%	80%	44%
Sinethemba	0.8	1	104%	30.25	14	44.25	14%	34%	20%
Worcester	0.8	1	-79%	-10.75	19	8.25	40%	53%	13%

There is a greater increase in the pass rate in the poorer schools compared to the LP schools (Figure 4.12). There is a weak correlation between the social status and improvement in pass rate. Only 12 % of the variation in improvement in pass rate is explained by the social status.

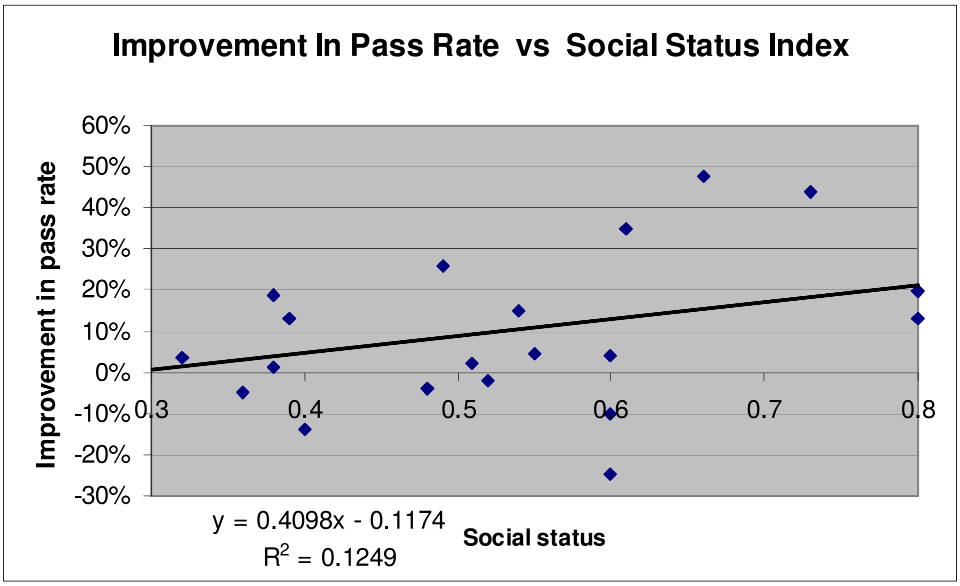


Figure 4.12
The improvement in Higher Grade Mathematics pass rate for the different social index in the second wave schools

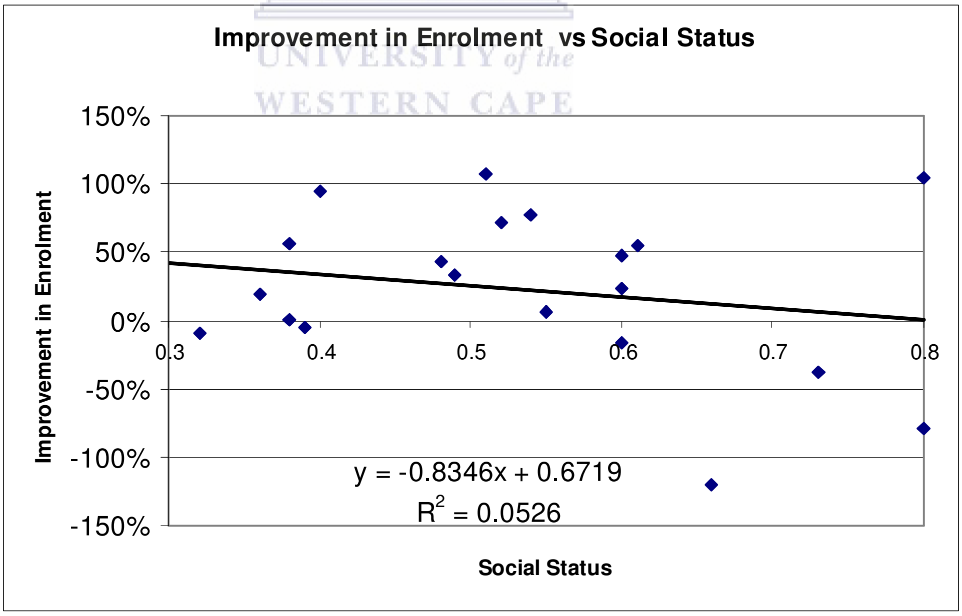


Figure 4.13
The improvement in Higher Grade Mathematics enrolment for the different social index in the second wave schools

In the second wave, the enrolment figures vary for the different categories of schools. No clear relationship could be determined for the schools in different social status compared to improvement in enrolment.

In the third wave, two of the three schools in the LP Quintile had an improved Mathematics enrolment with Gordon showing a substantial improvement of 130% while all three school's pass rate declined by a small margin (Table 4.12). All four schools in Quintile four had significant improvements in the enrolment but only Belgravia had an improved pass rate. Both schools in the third Quintile had enormous improvements of 163% and 129%, but Bulumko had a minimal decline in pass rate of 1%. All three schools in Quintile one had remarkable increases in enrolment while two schools improved their pass rate by 8%.

Table 4.12

Higher Grade pass rates and enrolment figures for schools classified into social index for the third wave

School	Social Status	Quintiles	Improved Enrolment	Improved Enrolment	PreTech Enrol.	PostTech Enrol.	PreTech Pass Rate	PostTech Pass Rate	Improved Pass Rate
Bellville HTS	0.12	LP	11%	13	110	123	100%	97%	-3%
Norman Henshil.	0.2	LP	-30%	-16	61	45	79%	76%	-3%
Gordon	0.36	LP	130%	26	7	33	29%	27%	-2%
Belgravia	0.44	4	47%	35	57	92	75%	80%	5%
Cravenby	0.48	4	9%	3	31	34	81%	76%	-5%
Malibu	0.52	4	54%	17	23	40	74%	58%	-16%
Spine Road	0.56	4	38%	7	15	22	67%	50%	-17%
Sophumelela	0.7	2	163%	26	3	29	33%	48%	15%
Bulumko	0.76	2	129%	18	5	23	40%	39%	-1%
Kwamfundo	0.79	1	167%	20	2	22	50%	50%	0%
Kylemore	0.79	1	100%	8	4	12	75%	83%	8%
Percy Madala	0.82	1	120%	9	3	12	67%	75%	8%

More schools in the lower quintile (low socio-economic status) experienced a higher pass rate as compared to schools in the relatively higher socio-economic communities (quintiles LP and 4) (Fig. 4.14). However the correlation between the schools is weak because the r^2 value is also below 0.25. Social status only accounts for 14% of the variation in improvement in pass rate.

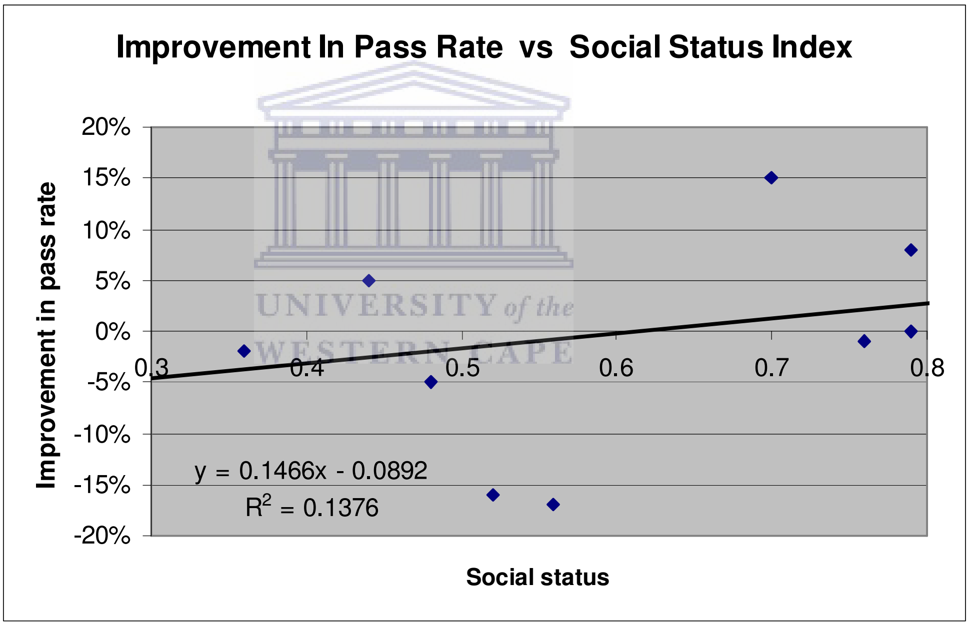


Figure 4.14
The improvement in Higher Grade Mathematics enrolment for the social index in the third wave of schools

The majority of the schools in all of the quintiles showed an increase in enrolment but the five schools from the poorest communities (quintiles 1 and 2) each had an extensive increase of more than 100% (Fig. 4.15). The correlation between social status and improvement in enrolment was