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Investigating the integration of ICT in Mathematics and Science in Swaziland classrooms

Mini-dissertation submitted by

Armstrong Siboniso Simelane

In partial fulfilment of the requirements for the degree

Magister Educationis

(Computer Integrated Education)

In the

Faculty of Education

Department of Science, Maths and Technology Education

University of Pretoria

Supervisor: Professor Sarah Howie

Co-Supervisor: Mrs. Maryke Mihai

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DECLARATION OF ORIGINALITY

I declare that the dissertation, which I hereby submit for a Master's degree in Education (Computer Integrated Education) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Armstrong Siboniso Simelane:

Date: 15 July 2013

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DEGREE AND PROJECT	M.Ed Investigating the integration of ICT In Mathematics and Science in Swaziland Classrooms	
INVESTIGATOR(S)	Armstrong Simelane	
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SUMMARY

Investigating the integration of ICT in
Mathematics and Science in Swaziland classrooms

By

Armstrong Siboniso Simelane

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Department: Department of Science, Maths and Technology Education
Degree: Magister Educationis in Computer Integrated Education

The purpose of this study is to investigate the status quo of the integration of Information and Communication Technology (ICT) in Swaziland Mathematics and Science form four classrooms. The rationale is to understand the status in order to propose an appropriate strategy for policy and practice in education.

The research design is a survey conducted in the Manzini region, the most central, largest region with the largest number of schools. The study focused on all schools that had computers for the purpose of education. There were 149 participants from 43 schools. All Mathematics, Science, and ICT teachers were included in the study, including head teachers.

The study instruments were adapted from the Second Information Technology in Education Study (SITES) undertaken under the auspices of the International Association for the Evaluation of Educational Achievement. Permission to adapt South African instruments was granted through the Centre for Evaluation and Assessment at the University of Pretoria. Four types of questionnaires were adapted and used.

The data was analysed using descriptive statistics. The study revealed that very little had been done by Swaziland to integrate ICT in Mathematics and Science classrooms. The status quo indicated that the Student Computer Ratio was very high (14:1). In terms of ICT literacy 67% of the ICT teachers were diploma holders, 72% of the Mathematics, 78% of the Science teachers had no ICT qualification and most of

the learners were not competent. The computers were found old and out of date and lacking maintenance. The lack of School ICT policy as a possible factor that could explain the pedagogical use of ICT was found to be a major obstacle in the integration of ICT in the classrooms, and this was a major thematic area that has to be addressed. This is viewed as an obstacle by Mathematics, Science and ICT teachers together with their principals. The elimination of this obstacle could possibly ensure sufficient funding, appropriate knowledge and skills, efficient leadership, proficient teachers and competent students, and thereby give impetus to ICT integration in Mathematics and Science classrooms.

It was then concluded that Mathematics and Science teachers do not integrate ICT in their practice, despite being core subjects. The channelling of more resources by government to ICT education was strongly recommended.

Key words*: ICT, Integration, ICT policy, thematic areas, Obstacles, Classrooms, N computing, form four, learning management systems, Television white space*.

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ACRONYMS AND ABBREVIATIONS

CEA	Centre for Evaluation and Assessment
CET	Computer Education Trust
CIE	Computer Integrated Education
E	Emalangeni – Swaziland currency
ECOS	Exams Council of Swaziland
ECCD	Early Childhood Care and Development
EMIS	Education Management Information Systems
GoS	Government of Swaziland
ICT	Information and Communications Technology
MoET	Ministry of Education and Training
MoICT	Ministry of Information and Communications Technology
MTN	Mobile Telephone Networks, Swaziland
NCC	National Curriculum Centre
NGO	Nongovernmental Organisation
NICI	National Information and Communication Infrastructure
PVE	Prevocational Education
SADC	Southern African Development Community
SCOT	Swaziland College of Technology
SG	Swaziland Government
SIGCSE	Swaziland International General Certificate of Secondary Education
SITES	Second Information and Technology in Education Study
SPTC	Swaziland Posts and Telecommunications Corporation
TPD	Teacher Professional Development
TVWS	Television White Space
UNISWA	University of Swaziland

CHAPTER ONE

The study in context

1.1 INTRODUCTION

The purpose of this study is to investigate how to integrate Information and Communications Technology (ICT) in Swaziland Mathematics and Science classrooms, both of which are core subjects. Case studies around the world have shown that the integration of ICT in Science learning can enable innovative classroom practices (Webb, 2008), but although Swaziland boasts a literacy rate of 81.3%, there are low levels of ICT literacy (Mashwama, 2007), a serious concern as industrial society becomes more information-based (Voogt, 2009a).

In order for the country to make this move, King Mswati III declared in 2010 that Swaziland should strive to be a ‘first world country’ by 2022, which suggests a realisation that the world has become dependent on technology for optimal daily functioning. If Swaziland is to be an active player and all children are to become computer literate, ICT should be introduced into education. That ICT is a vital tool for teaching and learning in the classroom is reinforced by the World Bank’s 2010 report, which envisaged that, because Swaziland is not naturally resource-rich, the acceleration of its growth and global competitiveness would probably be driven by knowledge and technology (Marope, 2010).

This chapter introduces an investigation into the integration of ICT in Form four Mathematics and Science classrooms in Swaziland secondary schools and outlines the situation prevailing in secondary education within the country’s overall education system. It begins by presenting the statement of the problem and rationale (section 1.2), followed by the research setting in terms of geographical, political and socio-economic status of the country (section 1.3). The status of ICT in the current education context, focusing on Information and Communication Technology is discussed in section 1.4, followed by the introduction of ICT in Swazi schools (section 1.5). The issues of ICT access is also presented in section 1.5, and then section 1.6 explains its pedagogical applications. section 1.7 poses the research questions and the aim of the study, followed by concept clarification, chapter summary and outline of chapters in sections 1.8, 1.9 and 1.10 respectively.

1.2 STATEMENT OF THE PROBLEM AND RATIONALE

My experience of teaching in Swaziland schools for the past 20 years has revealed that although Information and Communication Technology (ICT) has been introduced in a number of schools, Mathematics and Science teachers have not attended any workshops on how to integrate ICT into their practice. There has been no policy document to guide the integration of ICT in teaching, nor any pre-service training.

Low levels of ICT literacy are being experienced in Swaziland, even though teachers and students have access to ICT resources. In many schools, teachers are grappling and struggling with the question of how to use ICT for instructional purposes (Brummelhuis & Kuiper, 2008), particularly at a time when an increasing number of computers that have been donated to schools by the Swazi government, the Computer Education Trust, the *Coca-Cola Foundation* and other corporate donors, are lying idle or reportedly stolen (MoET, 2010).

ICT is a platform that can make an important contribution to education in the present knowledge society (Drent, 2005), however the general consensus in many government-aided schools is that ICT is one of the subjects better left to private schools to implement. This contradicts a declaration by the world summit on the Information Society of the United Nations Educational Scientific and Cultural Organization (UNESCO) which declared technology as a double-edged sword in reconfiguring access, including to education, and at the same time changing the dynamics of the classroom (Davis, 2008).

In Swazi schools currently there is no localised ICT syllabus or any guiding policy for the integration of ICT in the curriculum (Government of Swaziland 2006 ICT policy). The schools are at liberty to choose what to teach, who may teach, when to teach and how much to charge parents as a computer subject fee. As a result, ICT education is varied in Swaziland, with some schools teaching Computer Studies at secondary and high school level, whilst others have introduced Computer Literacy at primary school level. School leavers and other individuals, with or without an internationally recognised computer certificate, are entrusted by parents and teachers to impart computer skills and knowledge to the learners. The subject fee ranges from 20 US$ - 60US$ (E150–E450) per year, which is three to nine times higher than the average subject fee for Mathematics and Science subjects. The computer subject fee covers the salary of the teacher because at present the parents pay the teacher.

However, 98% of school children in Swaziland currently graduate from the state school system without having seen or touched a computer in the classroom. The average number of computers is less than one per school and where one is available it is generally used for administrative rather than educational purposes. In general, teachers are not trained in the use of computers in education and ICT is not included in the school curriculum (James, Hesselmark & Sibiya, 2002).

In recent years, 130 schools have received an average of 20 donated computers per school from the government and the Computer Education Trust (Kunene, 2010). Due to pressure from parents who built computer laboratories and paid the stipulated subject fees, these schools started teaching ICT without a strategic plan from the MoET to integrate ICT into the classrooms. Thus, in the midst of these challenges, ICT teachers in Swaziland rely mostly on workshops to inform them about what to teach, when and how to operate within the context of the national curriculum, and examination requirements. There is no guiding policy for the integration of ICT in the classrooms, although the government's 2010 National Information and Communication Infrastructure (NICI) plan set the end of 2012 as the target date for the availability of a local Information and Communication Technology syllabus for schools (MICT, 2010).

This research, therefore, investigates how to integrate ICT in Swazi Form four Mathematics and Science classrooms. Research has shown that the integration of ICT in education is not a simple process (Drent, 2005), and to assist the process, Tiyla (2008) has listed major thematic areas to consider:

Preparing schools to accept ICT
Procurement and installation of the technology
Training of teachers to use the technology
Content development and management

Planning for continuous evaluation and research
Integrating curriculum
Computer literacy and Science courses
Provision of on-going technical support
Provision of on-going curriculum support
Development of partnerships

The integration of ICT into the curriculum can benefit learners in at least two important ways: firstly, by providing an opportunity to learn useful ICT skills and, secondly, by making it possible for learners to become creators of knowledge in their own right (Howie, Muller & Paterson, 2005).

The study also addresses the basic questions about what has been done, what should be done and what is doable in the integration of ICT in Mathematics and Science classrooms to transform the country to an information society (Voogt, 2009) and bridge the digital divide which exists between Swaziland and developed countries.

1.3 THE RESEARCH SETTING

The study is set in the Kingdom of Swaziland, an independent monarchy in South-eastern Africa, bounded on the east by Mozambique and on the southeast, south, west, and north by South Africa. It covers an area of 17 363 sq km (6704 sq m). October 2009 statistics from the Government Statistics Department and the CSO (Central Statistics Office) estimate the population to be above a million (1 018 449, with 481 428 males and 537 021 females).

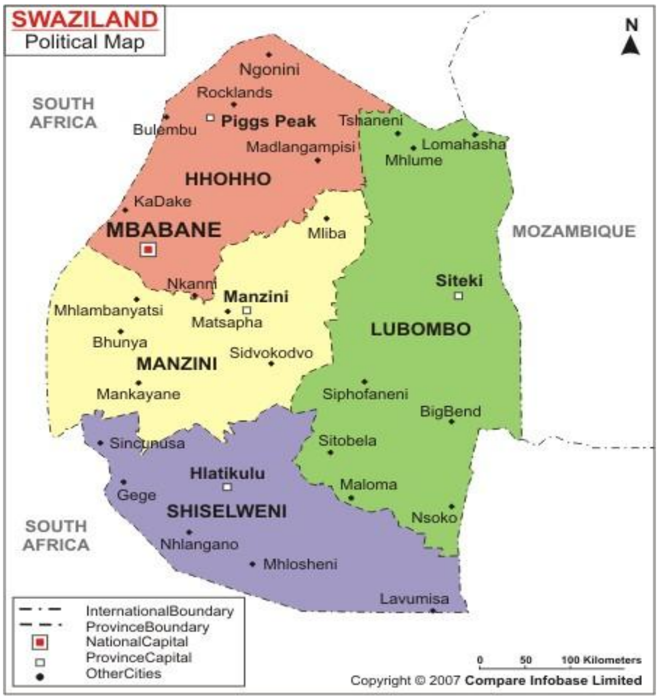

Figure 1.1: The Kingdom of Eswatini

The Kingdom of Eswatini is one of the 12 members of the Southern African Development Community (SADC) currently ruled by King Mswati III, the second last born of King Sobhuza II. As a former protectorate of Britain, the Kingdom follows the British education system, which has seen it change from Cambridge University O (ordinary) level and A (advanced) level certificates to the International General Secondary Certificates in Education (IGSCE or HIGSCE).

Currently, the Swaziland International General Secondary Certificates in Education (SIGSCE) is benchmarked with the British Education system by the Cambridge International Examination syndicate (CIE). However, the SIGCE series does not provide a local equivalent for the syllabi of Computer Studies (0420) and Information and Communication Technology (0417) which is provided by the University of Cambridge International Examination syndicate (MoET, 2009).

1.4 THE STATUS OF ICT IN THE SWAZILAND EDUCATION SYSTEM

The Swaziland government website (MoET**,** 2009) has revealed that the country's education and training system is divided into four main sub-sectors, namely Pre-Primary (now Early Childhood Care and Development) (ECCD), Primary education, Secondary education and Tertiary / Post-secondary education.

1.4.1 Early Childhood Care and Development and ICT

This is the first stage of education in Swaziland. Early Childhood Care and Development (ECCD), caters for all children from three to six years of age, or until they are absorbed by the school system. Government is not the main service provider but rather a number of private institutions and church organisations offer this service to the communities. The national average is 71 preschools per region in the four regions (MoET, 2009). The role played by government is to regulate those pre-schools who, of their own accord, have registered with the regional inspectors. The assistance available is in the form of learning materials and workshops for teachers. Government does not pay the teachers so it is for these institutions to decide whether or not to offer ICT.

Pre-schools offering ICT harness the technology, especially computers, to teach primary and secondary colours and show shapes to the pre-schoolers. *Microsoft Word* and *Paint Brush* are the most popular application packages that are used. There is nearly one in each town or suburb and nationally there are about 22 preschools offering ICT in the country (MoET, 2012).

1.4.2 Primary Education and ICT

There are 541 primary schools in Swaziland, with government being the main provider. Primary education is offered mostly for seven years, with the age range from six to thirteen (Isaacs, 2007). The government has taken the responsibility of introducing free primary education in line with the demands of Universal Primary Education (UPE) and education for all (Jansen, 2005), an exercise that resumed in 2010. This is constitutional in Swaziland. The introduction of ICT in primary schools has been facilitated by an organisation called 'One Laptop per Child', which in donated 300 mini laptops and 200 mini laptops to Masiphula and

Mizper primary schools. Elulakeni and Maliyaduma primary schools established a computer laboratory with help from Canada while the Rotary Foundation made a donation to Endzingeni Primary School. These schools follow a syllabus developed by an international UNESCO consultant Boris Kostik and a national consultant, Philemon Gumedze.

1.4.3 Secondary Education and ICT

There are three divisions and groups at this level of education in Swaziland, namely the junior certificate level, high school level and the prevocational education level.

1.4.3.1 Junior certificate education and ICT

Swaziland has more than 200 secondary or high schools (MoET, 2009), a small percentage of which are privately run, but most are government controlled. The curriculum followed is the local junior certificate, which is also offered by Lesotho. The junior certificate level (JC) covers Forms one to three, with the students sitting for a JC examination. ICT is taught in some of the schools that received a donation of computers from CET, but there is no examination conducted at this level (MoET, 2009).

1.4.3.2 High School Education and ICT

After passing the JC exam the students apply for admission into Form four (High School), which is a two-year programme. ICT as an examinable subject is available to a number of schools (about three schools in 1998 and 24 in 2012). The syllabus followed is the University of Cambridge IGSCE syllabus, which presents a challenge for government now that the Swaziland International General Certificate in Education (SIGCE) series has been introduced. This series does not provide a local equivalent to the syllabi of Computer Studies (0420) and ICT (0417) (MoET, 2009). The students' performance under this syllabus code 0417 is not encouraging.

1.4.3.3 Prevocational Education and ICT

Prevocational education (PVE) was set up in Swaziland with donor aid from Canada, as a programme running parallel with the high school curriculum in selected schools known as 'pilot schools', of which to date there are 16 in the country (MoET, 2009), with four per geographical region. The pre-vocational computer laboratories were set up in 2005 with ideal ICT equipment (computers, printers, scanners) but this is now out of date and maintenance is lacking, nor is Internet access guaranteed. Prevocational Information Technology syllabus code 0214 covers the basics and operational knowledge of *Microsoft Office,* and as such the programme is viewed as less demanding than the IGCSE 0417 syllabus. Most of the schools are interested in adopting this syllabus but it is offered by the Prevocational Education Pilot schools (James et al., 2002).

1.4.4 Post-Secondary Education and ICT

Various tertiary institutions exist in Swaziland, namely Ngwane Teacher Training College (NTTC), William Pitcher College (WPC), Swaziland College of Technology (SCOT), Limkokwing University of Creative Technology, Southern African Nazarene University (SANU) and the University of Swaziland (UNISWA). ICT is offered in teacher training colleges as a foundation course to aid the students in typing assignments, projects and term papers. The Swaziland College of Technology (SCOT) has been engaged by the Ministry of Education and training to train teachers for ICT. The college is planning to upgrade Diploma in Computer Science holders with education. This in-service course is expected to run for one year. UNISWA has assisted with computer crash courses to introduce a programme for teachers in information technology to ensure a smooth introduction of computer education in schools (Isaacs, 2007).

1.5 INTRODUCTION OF ICT IN SWAZI SCHOOLS BY THE CET

One way to review the introduction of ICT in Swaziland begins with marking in bold letters the role played by the Swaziland Computer Education Trust (CET). This is a non-profit making organisation that was set up 1999 with funding from private business sources within Swaziland, to address the paucity of technical education across the country's state school system (James, Hesselmark & Sibiya, 2002). CET facilitates the development of the necessary pedagogical materials (Isaacs, 2007) and the delivery of professional pre-service and in-service training (INSET) for all Swaziland teachers.

CET installed 20 PCs in a computer lab in each of the 187 secondary and high schools across Swaziland and ensured their sustainable use by providing full technical and maintenance back-up support facilities. CET has partnered with School Net Africa and the Open Society Initiative for Southern Africa (OSISA) to upgrade its existing Technical Services Centre which serves to source, refurbish, and distribute second hand computers to Swazi schools. CET has also replenished computers in 77 schools and helped a number of schools in the rural areas by converting a classroom into a computer laboratory.

The focus for CET has shifted to offering affordable broad band wireless internet to schools through the TVWS technology, a standard for wireless regional area network in the television frequency spectrum (MOET, 2012)

1.6 PEDAGOGICAL USE OF ICT IN SWAZILAND

Although ICT may be popular in some Swazi schools, there are fears and debates that schools may be wasting money, with uncertainty that surrounds the attitude, skills and applied knowledge the teachers may have. This has led to the feeling that ICT education in schools should be left to private schools. Hokanson and Hooper (2000) state that computers were predicted to improve both teaching and student achievement, whilst Clark (1994) lamented that computers had not produced improvements in test scores. This could deepen doubts as to whether ICT would promote learning for Swazi learners and this may continue to promote criticism on time spent by children on computers and also fully entrench the belief that computers put children's physical and emotional health at risk and even threaten the loss of the child itself (Scoter, 2008).

To address such doubts from a pedagogical perspective it is important first to understand how teachers in Swaziland are making use of ICT to enhance students' learning experiences (Ainley, Enger, Searle, 2008). The pedagogical use of ICT in Swaziland may be conceptually arranged into three phases, as shown below.

Figure 1.2: The Three Phase Model

This follows a pattern similar to neighbouring South Africa, where Blignaut and Howie (2009) have shown that the integration of ICT is also conceptualised into three phases being: Readiness to use ICT, system-wide ICT integration, and Integration of ICT at all levels.

1.6.1 The introduction phase

In this phase schools received a donation of 20 to 45 computers from the Computer Education Trust, accompanied by students' training manuals, "likusasa lakho manuals'.These provide learners with the elementary skills in computing. Schools nominated and sent two teachers to the University of Swaziland for a two-week training course on *Windows* and *Microsoft Office*, who when they returned to school helped interested learners become accustomed to the computers. To date there are 130 schools that have received computers from CET. Teachers use study periods to teach the learners because schools classified under this phase normally do not include the subject in the normal timetable.

1.6.2 The implementation phase

During this phase MoET donates 10 to 17 computers to schools, and head teachers are expected to make a requisition from the Ministry. This computer batch lays a foundation for the meaningful learning of ICT and the project is sustained through funding from the Republic of China and Taiwan. It is expected that schools under this phase should include the subject in the curriculum. Other schools have engaged contractors to offer the training service.

A recognisance survey carried out in these schools has revealed that the companies are financially exploiting the ignorance of some parents, for example, by supplying very old computers, and from a batch of 40 computers only nine could function properly. A close inspection has revealed that some were originally white (former colour) and have been spray-painted black (a newer colour), and where new CPU cases are supplied with the systems the interior includes the mother board, the processor, memory and the hard drive, all of very low specifications, poorly configured, and lacking the basic software for learning such as typing tutors and encyclopaedias. They come with *Microsoft Office 2003* preinstalled.

Schools under this phase are allowed by the subject panel to charge a subject fee from E50-E70 in the primary section, E120-150 in the secondary section and E170-E250 for the high school section. This money is used to pay the salary of the ICT teachers and maintenance and repair of the computers.

1.6.3 The integration phase

This is the critical phase and the expectations are that schools entering this phase should have an ICT policy, and purchase five computers per year to replace the old and refurbished ones from CET. In addition, ICT as a subject should be included in the curriculum and be examined by Cambridge International Examinations.

The MoET guidelines for ICT makes it clear that ICT in schools should benefit, support and promote learner-centred education, the minimum expected ICT infrastructure includes a well-designed laboratory with burglar proofing and alarm, Internet access, networked computers, air-conditioned laboratory and a standby generator or solar power input.

Schools striving to be in this phase have invested in N-computing, whereby a number of terminals, usually 10, are linked to one systems unit. This is much cheaper for the schools, three of which were striving and grappling to be under this phase in 1997. However, the number increased to 25 in 2011 and 41 in 2012. The schools register for Cambridge 0417 ICT syllabus, with four private schools in the group. The national schools tend to jump in and drop out because of the very low pass rate, as low as 6.45% in 2010 and 23.04% in 2011(MoET, 2012).

1.7 RESEARCH QUESTIONS FOR THE STUDY

The study was guided by the following research questions:

What is the status of ICT integration in Swaziland schools?

What possible factors could explain the pedagogical use of ICT?

1.8 CONCEPT CLARIFICATION

The following concepts used in this study are described below:

CONCEPT	CLARIFICATION
DIGITAL DIVIDE	Disadvantages, constraints (mostly educational, technological and financial) and increased disparity between individuals who have the means to access information and those who do not. (Fluck, 2003).
DOABLE	What is possible and can be done.
ICT	Electronic and digital technologies for the storing, processing, transferring of information and communication (Hodgkinson-Williams, C. 2006).
INTEGRATION	The pedagogical use of ICT for Learner Centred Education (Howie, S.J., Muller, A. & Paterson, A.2005).
RURAL DIVIDE	Disadvantages and constraints faced by rural people and rural segments of society which excludes them from accessing appropriate and timely information and communication technologies services (Voogt & Knezek, 2008).

1.9 CHAPTER SUMMARY AND CONCLUSIONS

This chapter has shown that the study was carried out in Swaziland, a small landlocked Kingdom whose neighbours are Mozambique and South Africa. The background has explained the context, introduced the research rationale and the statement of the problem which tells a sad story of low levels of ICT literacy experienced in Swaziland (Mashwama, 2007) even though teachers and students have access to ICT resources and computers donated to schools by the Swazi government, the Computer Education Trust, the *Coca-Cola Foundation* and other corporate donors. (MoET, 2010).

The rationale for the study and focal point has been laid out to be the integration of ICT in Mathematics and Science classrooms as case studies around the world have shown that the integration of ICT in Science learning can enable innovative classroom practices (Webb, 2008) and can benefit learners in at least two important ways: firstly, by providing an opportunity to learn useful ICT skills and, secondly, by making it possible for learners to become creators of knowledge in their own right (Howie, Muller & Paterson, 2005).

In this chapter the work done on ICT education by the Computer Education Trust has been put on the map. This started with the distribution of second hand computers to 130 Swaziland schools, followed by replenishing computers in 77 schools, helping 20 schools in the rural areas by converting a classroom into a computer laboratory and lately offering affordable broad band wireless Internet to schools through the TVWS technology, a standard for wireless regional area network in the television frequency spectrum (MoET, 2012).

While trying to understand what possible factors could explain ICT integration in Swaziland, this chapter has summarised three phases of pedagogical use (introduction, implementation and integration) which traces a pattern similar to neighbouring South Africa as illustrated by Blignaut and Howie (2009).

1.10 OUTLINE OF CHAPTERS

This dissertation is organised into six chapters. Chapter one has presented the background, introduced the problem, rationalised the study, set and contextualised the research and posed the research questions. Chapter two reviews the literature and presents the topical issues, followed by chapter three which explains the research methods, procedures of data collection and analysis. Chapter four presents the status of ICT integration, and chapter five reports on the factors that characterise ICT integration. Chapter six, as a concluding chapter, summarises the findings and presents a compilation of recommendations and reflections by the researcher.

CHAPTER TWO

The review of the literature

2.1 INTRODUCTION

Chapter 2 provides a review of relevant literature on the integration of ICT in the Swaziland Mathematics and Science classrooms. This review puts the study into international perspective by looking at SITES 2006 in section 2.2, whilst section 2.3 examines the status of ICT integration in the classroom in four countries. The obstacles to ICT integration are presented in section 2.7, followed in section 2.8 by a juxtaposition of ICT integration frameworks. Finally, section 2.9 presents the conceptual framework of the study, the Kennisnet Model.

2.2 RELEVANCE OF SITES 2006 TO SWAZILAND

Although many studies have been conducted on ICT in education, the International Association for the Evaluation of Educational Achievement has conducted the Second Information and Technology Education Study (SITES) several times. SITES – M1 was conducted in 1997 – 1999, SITES – M2 in 1999-2003, and SITES 2006 in 2004-2008. The third of these was a comparative study in schools around the world, including South Africa, and the findings are relevant as the education system of Swaziland is continuously being reviewed, built, influenced, and perfected through borrowing and fetching ideas from educational policies and practices of South Africa, England, the United States of America (USA) and Canada. Therefore, the main course of this review shall draw on the SITES findings and their influence to the Swazi education system. SITES 2006 in particular is an ordinance datum for this study on the integration of ICT in the Swazi Mathematics and Science classrooms, in that the four instruments used in this study were adopted and adapted from SITES 2006.

The following aspects make SITES 2006 important to Swaziland:

SCOPE – SITES 2006, as an international study, covered about 37 countries
AIMS (i) SITES examined the extent of ICT integration in teaching and learning
(ii) SITES identified the factors for ICT integration
DESIGN – SITES instrument design process was collaborative
CONCEPTUAL FRAMEWORK – focused on ICT use in classroom
CONTEXT – Southern African context was covered
SAMPLING – properly selected samples were used
QUESTIONNAIRES – covered the concepts of infrastructure, pedagogical practice, vision, staff development, support, organisation and management.
RESULTS – provides a set of snapshots of the teaching and learning contexts.

2.3 SITES 2006 THEMATIC AREAS FOR ICT INTEGRATION

The SITES 2006 survey (Law, Pelgrum & Plomp, 2008), after studying both classrooms and schools on pedagogy and ICT usage, came with up with the following findings as major thematic areas in the integration of ICT in the classroom:

Student to computer ratio
Software availability
Years of experience with ICT
Student to Internet computer ratio
Technical support
Pedagogical support
Requirements for teacher training
Leadership development priorities
ICT vision for lifelong learning
Vision connectedness
Vision for lifelong learning
Existence of lifelong learning pedagogy

The SITES module 2006 emphasises that the sustainable innovative use of ICT in the classroom depends on curriculum, content, goals, practicability, complexity, clarity, relevance, needs, teacher practice and student practice. These are to be aligned and added in order to achieve ICT integration (Kozma, 2003), including patterns of working together, team teaching and collaboration among teachers, student research, information management, outside communication, product creation and tutorial projects, using the tools of email, word-processing, drills and practice software, spreadsheets and database programmes, to sustain the innovative use of ICT in the classroom (Ainley, Enger & Searle, 2008).

The aim of this review is to find out what Swaziland can learn from South Africa, England, the USA and Canada, and what the country had already borrowed and infused in the education system from the educational policies and practices of the these four countries to achieve the integration of ICT in classrooms.

2.3.1 South African ICT integration status

The summary of findings reflected that the student: computer ratio was found to be 123 and 185.7 in 1998 and 2006 respectively. The number of schools without online computers was found to be 230 out of 488, the average available at schools being 7.00, and the average number of years of ICT experience in schools found to be 1.76. The Internet connection ratio was found to be 0.13.

The major thematic areas in the integration of ICT were as follows:

Online school connectivity - Gauteng online pilot project
Implementation and use of ICT to support the education system - School Net project
Transforming learning and teaching through ICT – Nepad E schools
Collaborative team teaching- SCOPE Project
Student centred pedagogies – Meraka institute
Raising the level of ICT literacy of educators – *Microsoft Partners in Learning.*

Blignaut and Howie (2009) have shown that the integration of ICT in South Africa is conceptualised in three phases, namely readiness to use ICT, system-wide ICT integration and integration of ICT at all levels.

SITES also revealed that the e-education policy framework for South Africa supported four key elements regarding the use of ICT for teaching and learning, namely: equity to ICT, infrastructure, capacity building, and norms and standards.

There are similarities in terms of approach to integration between South Africa and Swaziland, both being structured in three phases. In terms of the e-education policy Swaziland is working on an e-governance policy.

2.3.2 England ICT integration status

SITES 2006 found that computers were introduced into English schools on voluntary basis (Cox, 2009), as in Swaziland through the voluntary efforts of CET. Some of the key thematic areas under ICT integration in England included harnessing technology in schools, promoting the use of computers for university teaching, laptops for teachers, building schools for the future, use of thin clients / N computing and use of web 2.0 facilities. England, however, is experiencing growing conflict between using ICT and teaching ICT as a subject. This has caused problems for ICT experts, coordinators and head teachers arising from the fact that as some head teachers concentrate on finding more personnel for the ICT department the ICT experts concentrate on the resources. Setting ordered priorities is a problem between the ICT personnel and the head teachers, as is the problem of information overload whereby there is unlimited access to excessive information, such that teachers may spend several months teaching one topic (Cox, 2009),.

2.3.3 United States of America ICT integration status

In the case of the USA, the President's Educational Technology Initiative Plan provides e-rate subsidy or federal grants to K-12 education, which caters for the technology requirement of schools. This programme was not sustainable as the federal government ceased to provide software support and as a result private donations and special fundraising were made to purchase software, leaving schools to bear more of the cost of software (Anderson & Dexter, 2009).

SITES 2006 has found that there is no separate national curriculum for ICT education in USA, but it evolves from teaching other subjects. Technology integration requires teachers of several non-ICT subjects to share responsibility for teaching basic computing skills to students. To update their knowledge the teachers combine some voluntary participation with classes offered at district and regional level. Most have a computer coordinator to oversee the management of computer equipment, teach a computer class, and provide technical and instructional support to the teachers.

Swaziland can learn from the USA on how to integrate ICT in the curriculum and to address the challenge of finding skilled personnel and making use of the available teachers from the non-ICT subjects. The area of software and digital materials is another one in which Swaziland can learn valuable lessons from the American experience. The cost of software requires strategic thinking and planning if the integration of ICT into Mathematics and Science classrooms to be realised.

Anderson and Dexter (2009) have revealed the following thematic areas that cover integration in the USA:

Reducing the digital divide by funding low-income schools on hardware and Internet requirements
Funding research software, instructional support and ICT support for teaching and learning
Ethical issues of piracy and intellectual property rights
Ubiquitous technology and one-to-one laptop structure for students
Distance education, e-learning or online learning
Use of *Web 2.0* software and tools
New learning environments and virtual worlds
Collaborative publishing using *wikis*.

2.3.4 Canada ICT integration status

In the mid-1980s, formal ICT policy in Canada emphasised computer-related skills but now the focus is on using ICT to support and improve learning through integration with the curriculum. This process is guided by the policy document, FOCUS ON ICT, with four thematic areas:

Development of technical skills
Supplementing learning models
Improving existing learning models
Extending learning beyond the classroom.

Rich (2009) has shown that ICT in Canada enhances learning, delivery, knowledge and skill acquisition, learning system management and innovation. The Canadian approach also shows that ICT skills should not be learned in isolation but through infusion into core courses and programmes. The student : computer ratio in Canada is 5:1, with each school having an average of 72 computers, and over 50% of teachers using them for instructional purposes. Access to high speed Internet has proved to be a challenge for many rural schools, but ICT has not led to substantial changes in the Canadian education system because it has not been accompanied by changes in instructional methods. ICT is used within a conventional pedagogical format.

Swaziland can learn from Canada that curriculum and instructional design improvements are needed, with more funding, continued teacher professional development, and evidence-based approach supported by research, if there is to be transformation in education.

2.4 CONCLUSION

In conclusion, the following ten thematic areas and strategic issues should be aligned (Draper, 2010; Howie, 2010; Kozma, 2008; Tiyla, 2008) to achieve ICT integration in the classrooms:

Infrastructure development
Teacher training
Technical support
Pedagogical and curriculum change
Content development
Policy alignment
Distributed policies
Private-public partnerships
Outcome-oriented policies, programmes and evaluation
Resources.

2.5 ICT INTEGRATION IN THE CLASSROOM

Technology plays an important role in modern business and everyday living. It is associated with an efficient modern society. In education the advent of the computer has been hailed as comparable to the printing press in the global world (Watson, 2001). In the classroom, the integration of ICT has many direct and indirect benefits, seen increasingly as a powerful tool to enhance students' abilities to think, learn, communicate, use the brain creatively and logically, and provides the means to search out vast stores of up-to-date and archive information (Imison & Taylor, 2001). The Integration of ICT in the classroom is also associated with enthusiasm and motivation (Tanakachane, 2005).

2.5.1 Integration in the classroom

Imison and Taylor (2001) argue that ICT is an increasingly powerful means to enhance ability to think, learn, to communicate, use the brain creatively and logically, and provide the means by which one can *search* (my emphasis) out vast stores of up-to-date, relevant as well as archive information. This highlights the main advantages of using ICT in the classroom, providing teachers with a tool for research and communication, and increased productivity and problem-solving in their classrooms (Barron, Kemker, Harmes & Kalaydjian, 2003). The benefits include the promotion of thinking and learning, reduction of teachers' workload, virtual communication for a community of practice (CoP) and learning environment (VLE), and facilitation of desktop research.

2.5.2 Promotion of thinking

Apart from ICT being useful both to mediate and transform learning, it gives students the opportunity to think critically when using computers. Higher cognitive tasks are achievable by exploiting the creative uses of ICT in multi-context learning environments (Barron, Kemker, Harmes & Kalaydjian, 2003), in which learners acquire new knowledge and understanding, deploy critical thinking skills and develop new forms of creativity (John, 2005:479). The transformative potential is made possible by interactive whiteboards which make presentations more interesting, sharper and gripping, with better illustrations. Hyperlinks make teaching more powerful because the properties of the technology reinforce a way of teaching, whilst *PowerPoint*, email and the Internet provide a multi-modal medium.

2.5.3 Reduction of teachers' workload

Another benefit of integrating ICT into the classroom is the reduced workload for teachers, directly impacting on a number of areas:

- Creation of reusable teaching materials, thus saving preparation time
- The sharing of teaching materials and lesson plans via the Intranet, also saving preparation time and sharing ideas or good practice

- Student access to materials out of hours via the Intranet helps to deliver support to the individual learners when needed
- The production of better quality (multi-media) materials with more explanatory power and/or higher presentational clarity or visual appeal (teachers would not otherwise have time to produce these)
- Creation of interactive and engaging lessons that would motivate disaffected students
- Monitoring attendance, progress and performance and alerting teachers, parents and students to the need for intervention or support.

The multi-context environment helps teachers concentrate on teaching and worry less about timetables, planning and finance (Barron, Kemker, Harmes & Kalaydjian, 2003).

2.5.4 Promotion of learning

There are a number of ways through which ICT enhances learning as a cross-curricular tool. Students use the computer to prepare curriculum vitaes, résumés, and debate speeches. They also learn to work co-operatively (Imison & Taylor, 2001). When ICT integration involves the use of computer programs such as *Netops*, it provides remote accessing and hosting facilities, delivers learning resources for students, provide demonstrations for students without going to their work stations and makes the ICT facility into the whole learning environment. It also provides learning materials and acts as a tutor and assessor (Webb, 2002). ICT integration improves learning when it has been embedded in the context of other subjects (Loveless, 2003), helping to bridge gulf the gap between school and the outside world, whereby teachers continue to teach subject matter not children (Watson, 2001).

2.5.5 Creation of a community of practice and virtual learning environment

Digital projectors and interactive whiteboards installed in a classroom can be used for virtual meetings and the establishment of a community of practice (CoP) (Barron, Kemker, Harmes & Kalaydjian, 2003), that is a space in which a process of social learning occurs between people with a common interest (Kirschmer, Webb, 2008). The virtual meetings in a CoP are enhanced by internal communication in the form of internal emails and an electronic noticeboard, which also produce a virtual learning environment (VLE) (Barron, Kemker, Harmes & Kalaydjian, 2003; Simpson, Payne & Condie, 2002).

2.5.6 Facilitation of desktop research

The availability of the Internet in the classroom helps learners with their assignments and research, whilst teachers can download curricular materials from the World Wide Web (Barron et al*.,* 2003).

2.6 FACTORS AFFECTING ICT INTEGRATION

Factors, as groups of variables or components that influence the integration of ICT into teaching, may be either positive or negative. Positive factors include internal support from the teachers themselves and external support provided by educational institutes or colleagues to assist and encourage teachers to integrate ICT into their teaching. Negative factors include internal problems, for example lack of confidence, and external problems, such as heavy teaching load and lack of technical support, that reduce or block the integration of ICT into teaching (Tanakachane, 2005).

Factors affecting ICT integration may also be either exogenous or endogenous. The exogenous factors include such variables as age and gender, computer experience and internal support structure, while endogenous factors are determined by cluster variables that have a direct influence on personal entrepreneurship (Drent, 2005). These factors could be summarised as *learner* factors, relating to the skills of the learners; *workload* factors, which relate to the level of teaching, whether primary or secondary school; *financial* factors, which determine availability of ICT devices for the learning process, support and ICT competencies; *educational institute* factors, which relate to the readiness of the school to integrate; and *personal opinion* factors, which revolve around motivation and attitudes of teachers towards computers (age and teaching experience). For instance, research has shown that male teachers have more self-confidence in integrating ICT into teaching than females, whilst secondary teachers are better placed to integrate ICT than the primary teachers, because of workload (Tanakachane, 2005).

A crucial factor is the teacher factor (T.factor), variables which are summarised as demographics, teaching philosophy, vision and reason for ICT use. The other factors are school factors, system factors, student characteristics, pedagogical practice and ICT use. ICT use involves frequency, depth, confidence and innovative use, the last being the most important, and defined as the use of ICT applications (introduction, information processing, data processing and presenting) to support educational objectives aligned to acquisition of knowledge (Drent, 2005). Innovative use of ICT has six patterns, notably tool use, student collaborative use, information management, outside communication, product creation and tutorial projects (Ainley, Enger & Searle, 2008).

Innovative use of ICT is directed by a number of paths that are necessary preconditions for ICT competence, attitude toward ICT, personal entrepreneurship, perceived change and pedagogical approach (Drent, 2005). In this connection it is not possible therefore to have ICT integration without the innovative use of ICT. Innovative pedagogical practices cover four main components in a school milieu: a) time-space configurations; b) students c) teachers; and d) the curriculum. To be innovative the roles of the students and teachers are espoused as to assimilate, translate and transform the pedagogical use of ICT for learning (Nachmais, Mioduser & Baruch, 2008).

2.7 OBSTACLES TO THE INTEGRATION OF ICT IN SCHOOLS

Studies have shown that when infrastructure is available, for pedagogical use of ICT and integration to be attained there have to be sufficient funding, appropriate knowledge and skills, efficient leadership, proficient teachers and competent students. However, the attainment of pedagogical use of ICT and integration depend on the absence of barriers, obstacles, impediments and the formulation of visionary policies to promote cooperation and support at all levels. As such, the obstacles to ICT integration can emanate from a lack of several factors, including teacher confidence, teacher competence, access to ICT resources, technical support and resources, time and effective training. Resistance to change and negative attitudes towards it are also significant (Bingimilas, 2009).

Researchers have shown that the integration of ICT into teaching and learning is a dauntingly complex and taxing process when school management is among the obstacles. School management has to respond to a wide range of government initiatives with regard to equipment, staff training and the curriculum, liaising with local authorities and engaging with suppliers of computer-related goods and services in a difficult and fast-moving market (Goodison, 2003). The question of attitude, especially that of teachers, is another obstacle. Teachers with bad attitude wonder why they should abandon the safety and comfort of recognised subject pedagogy for the uncertainties and complexities that surround the use of ICT (John, 2005).

The curriculum orientation could also harbour a number of obstacles to the integration of ICT in schools, hinging on the curriculum due to the lack of curriculum documents such as the syllabus, policy documents on classroom infusion of ICT and the varying levels of resistance displayed by teachers and the subject sub-cultures in which they practice. These impediments to computer integrated education are difficult to deal with because they are embedded in a particular setting, labelled a “Trojan Horse” (John, 2005). Financial constraints (insufficient number of computers), lack of computer literacy among teachers, lack of training regarding the integration of computers into different learning areas, and the absence of a properly developed curriculum for teaching computer skills have been listed as constrains to ICT integration (Lundall & Howell, in Howie et al., 2005).

The school ICT infrastructure, professional activities and organisational features within secondary schools are major obstacles to integration of ICT, and as Simpson, Payne and Condie (2005) have found, these major obstacles are exacerbated by approach. They argue that the bottom-up approach is preferable to the top-down approach, as schools should look for the technology rather than it being imposed upon them, which breeds resistance to ICT practice in secondary schools (Mlambo, 2007), and raises practical issues around availability of hardware, appropriate software and affordable connectivity, sufficient technical support, training, and policy-related issues at national and school level (Hodgkinson-Williams, Sieborger & Terzoli, 2007). In such settings, visionary principal leadership and availability of champion teachers, as well as ongoing Teacher Professional Development (TPD) coupled with a willingness to change, is important. Moreover, teachers need to adapt to change if they are to survive and keep pace with ICT.

In line with the media debate between Clark and Kozma (Clark, 1994), the Swazi situation may confirm fears that computers in schools may be a waste of money. Negative factors include reports of frequent power failures, lack of ICT infrastructure, no Internet connection, lack of school ICT policy, corrupt websites, educators' computer illiteracy or lack of knowledge and computer skills, the high price of computers, sporadic changes of software, poverty, priority issues and channelling of resources, cognitive de-skilling, poor ergonomics, poor socialisation and development of linear logical thought process in children.

2.8 COMPARISON OF ICT INTEGRATION FRAMEWORKS

ICT integration frameworks are categorised into achievement, cognitive, cross-curricula tool, software, technology, pedagogical and evolutionary (Twinning, 2008). Under each framework a school may adopt ICT for administrative purposes, curriculum integration, student use and teacher use, depending on a number of factors, such as technical support, policies, attitude, knowledge, skills, cooperation, leadership, vision, training, available technology and ICT infrastructure (Kennisnet, 2006). Table 2.1 (below) shows the juxtaposition of the three phases of ICT use in Swaziland with the various ICT integration frameworks.

The oldest of these frameworks is the cognitive framework, widely known as Blooms' taxonomy, which has been revised to include levels of remembering, comprehension, application, analysis, evaluation and synthesis. The learning theories translate into four models, namely the behaviourist or transmission model, participative or cooperative learning model, learner-centred model and individual learning or integrated model (Kirschner, Wubbels & Brekelmans, 2008). Another framework is the instructional technology framework, related to the transmission model as a participative, learner-centred model and integrated model. The transmission model advocates a behaviourist-empiricist perspective. In this learning environment information is transmitted to students and there may be opportunities to practice and individualise feedback (Bottino, 2004).

Table 2.1: Comparison of ICT integration frameworks

SWAZI THREE PHASE FRAMEWORK	ACHIEVEMENT FRAMEWORK (MILLERS MODEL)	INSTRUCTIONAL TECHNOLOGY FRAMEWORK	EVOLUTIONERY FRAMEWORK (ACOT)	SOFTWARE FRAMEWORK	PEDAGOGICAL FRAMEWORK	CROSS CURRICULAR TOOL FRAMEWORK	COGNITIVE FRAMEWORK (BLOOM)	TECHNOLOGY FRAMEWORK
INTRODUCTION PHASE	Social rationale /**Introduction**	Transmission model	Entry stage	Emerging Stage/ Topicality	Active use	Productivity Tool	Behaviourism theory & **Remembering**	CAI/ Computer Assisted Instruction development
IMPLEMENT-ATION PHASE	**Entry**	Participative model	Adoption stage	Applying Stage / Surrogacy	Collaborative use	Cognitive Tool	Cognitive theory & **Comprehension**	MM/ Multimedia Learning development
	Vocational rationale **/Intermediate**		Adaptation stage		Innovative use	Communication Tool	Objectivism theory & **Applying**	IT/ Information & Internet development
INTEGRATION PHASE	Pedagogical rationale **/Penultimate**	Learner centred model	Appropriation stage	Infusing Stage / Progression	Creative use	Problem solving Tool	Constructivism theory & **Analysing**	LMS / Learning management system development
	Catalytic rationale **/Creation**	Integrated model	Invention stage	Transforming stage / Pedagogic evolution	Integrative use	Research Tool	Performance support theory & **Synthesis**	CIE / Computer Integrated Education E-Learning / live online learning development
	Cost effective rationale				Evaluative use	Reflective Tool	**Evaluation**	DE –Ubiquitous / Distance learning development
PROPONENTS	Pam Miller	R. Bottino	David Dwyer	UNESCO Stephen Hepell	J.M.Voogt W.J.Pelgrum	Barron, Kemker, Harmes & Kalaydjian	John Keller Robert Kozma Richard Clark David Merril Bloom Robert Gagne' Jean Piaget Lev Vygotsky	Seymour Papert Badrul Khan Tim Bernes Lee

An example of an evolutionary framework is the five phase model of teacher development, in which teachers go through five stages of instructional evolution of thought and practice when adopting ICT. The model is based on the Apple Classrooms of Tomorrow (ACOT) research, which explains the changes as they happen in a traditional classroom until there is purposeful radical change. The software framework is represented by Heppell's four-stage model, which runs from topicality to surrogacy, through progression to pedagogic evolution. These stages show the aspects of emerging, application, adaptation, appropriation and, finally, invention (Twining, 2008).

In terms of the technology framework, the pedagogical use of ICT for learning has revolved around storage devices, such as the CD-ROM, interactive video, and plug-in memory cards (1987 – 1990). Between 1990 and 1995 laptops were introduced, together with *Bluetooth* technology and infrared, wireless networks and video conferencing. Between 1996 and 1999 the interactive whiteboard (IWB) and personal digital assistants (PDAs) were the latest innovation. The development of the World Wide Web by Tim Bernes Lee marked the beginning of virtual learning environments *web2, wikis, N.computing* (Cox, 2008).

The migration to N computing has made it possible for ICT to become a whole learning environment as it provides learning materials and can be used in assessment and tutoring (Webb, 2002). This learning environment is what Kirschner, Wubbels & Brekelmans (2008). call a learning management system (LMS), comprising a set of software tools for delivering, tracking and managing online training and education. Lee, Teo, Chai, Choy, Tan and Seah (2007) argue that as society has become increasingly technology-rich, the education landscape has simultaneously gone through changes, catalysed by LMSs, that make online distance education a reality. Use of the most popular LMSs is shown in Figure 2.1 (below), namely *Moodle* (Modular Object-Oriented Dynamic Learning Environment), which is learner-centred, followed by *Blackboard*, a piece of teacher-centred course management software.

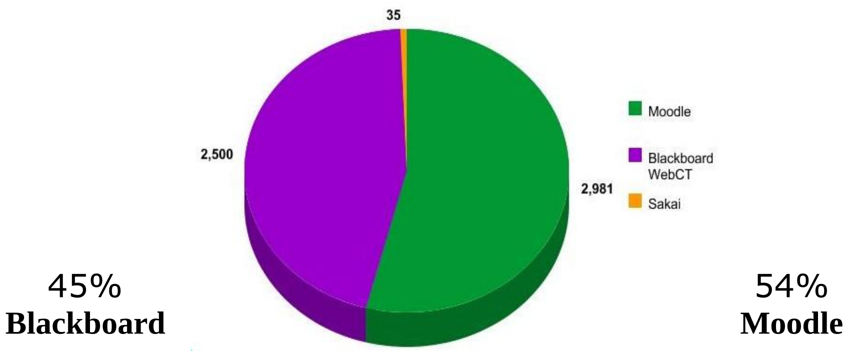

Figure 2.1: The usage of two most popular Learning Management Systems
Source: Zacker.org; Educause Study (www.educause.edu/ecar)2003

These systems are popular because they perform learner registration, track learner progress, record test scores, indicate course completion, and allow instructors or trainers to assess the performance of their learners (Dekeyser, de Byl & de Raadt, 2003). LMSs and advances in technology have made the incorporation of live online instructional materials possible (MacPhee, 2011), and this has led to the continued growth of distance education. It is characterised by frequent use of existing and emerging technologies for the delivery of the curriculum, such as webcams and *Bluetooth* technology to monitor and advise students live while teaching in the classroom. Also on the increase is frequent use of the Internet, voice over Internet protocol (VoIP), *PowerPoint* units with voiceover on Learn wise and CD-ROM (Harrington & Reasons, 2005).

The cross-curricular tool framework of ICT can be a productivity tool, research tool, communication tool and mind tool, whilst studies have shown that teachers are implementing technology as a tool for research, communication, productivity, and problem-solving in their classrooms (Twinning, 2008). The most relevant framework under this cover is pedagogical, as it related to reasons teachers have not integrated new technologies into teaching and learning methods and what can be done to alter this (Roblyer, 2008). This framework focuses on the actual use of ICT by the teacher or pedagogue, from active to collaborative, then from innovative to creative, followed by integrative and finally evaluative use. This and Blooms' taxonomy are the only frameworks that culminate in evaluation.

This framework also argues that the pedagogical use of ICT is also influenced by the learning theory implemented. While in the behaviourist perspective ICT is used for drill and practice, from the cognitive perspective ICT is used in developing reasoning and problem-solving skills, and from the constructivist perspective for the construction of new knowledge and deepening understanding (Voogt, 2008). In a similar manner, computers and appropriate software can provide scaffolding to support children and allow them to perform in their zone of proximal development (ZPD) (Vygotsky,1978; Scoter, 2008). Most of the frameworks have four to six rationales, models, stages, uses, tools, taxonomies, levels and eras to bring about ICT integration, yet the Swazi three-phase model is simplistic, as it defines, explains and expects ICT integration to be achieved in three processes, namely introduction, implementation and integration.

2.9 CONCEPTUAL FRAMEWORK OF THE STUDY - THE KENNISNET MODEL

The conceptual framework for the study was adapted from the “Four in Balance” Dutch model (see Figure 2.2, below), which reflects a scientifically researched vision for the implementation of ICT in schools. The monitor provides data collected by the educational inspectorate on the approach taken by schools in integrating ICT into their education (Kennisnet, 2006).

“Kennisnet ICT op skool**”** provides an up to-date overview of ICT developments in primary and secondary education. It assists in implementing ICT in schools in a balanced and lasting way, with inter-school comparisons (Kennisnet, 2006). Key to the Kennisnet Model as a conceptual framework is that for pedagogical use of ICT to take place there have to be certain structures in place.

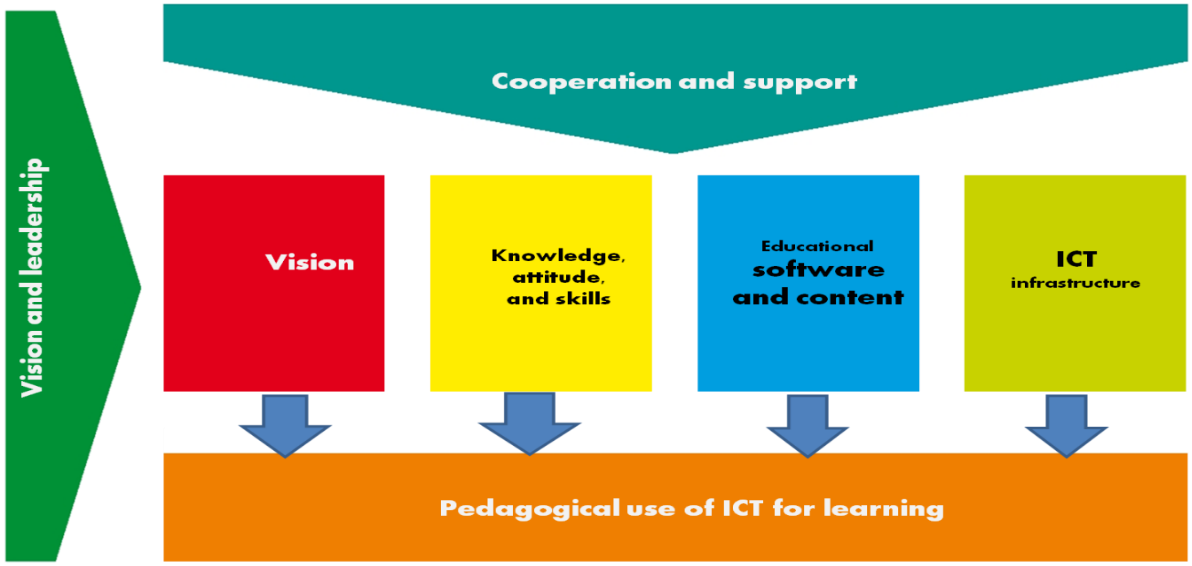

Figure 2.2: The Kennisnet Model

Source: Kennisnet -http://www.ictopschool.net

Firstly, there should be a clear national vision which has a sound leadership structure to head the process of integrating ICT in schools. Thereafter, at system level, within government departments there has to be cooperation and support for both leadership and schools. Involved in the process are nongovernmental organisations (NGOs), whose support and co-operation is vital. Finally, at school level, a balance needs to be created between the school vision, the acquisition and development of knowledge, attitudes and skills, the necessary educational software and content (ICT curriculum framework) and appropriate ICT infrastructure.

The Kennisnet model as a framework represents a set of broad ideas and principles to guide and structure the study (Smyth, 2004). It also shows the direction of the study and relationships of the different constructs to be investigated (Liehr & Smith, 1999). Within this framework the study covers the four key elements of content, teacher, learner and infrastructure (Voogt & Knezek, 2008), while grouping and clustering the policies into strategic policy for Educational ICT at system level and operational policies at school level (Kozma, 2008).

The core idea when employing the Kennisnet model as a conceptual framework is that the use of ICT for educational purposes is a matter of well-balanced deployment of four building blocks: vision on education; knowledge, attitude and skills; educational software and content and ICT infrastructure. However, the deployment of the above key building blocks at school level alone does not guarantee the integration of ICT in the curriculum, as much is dependent on two constructs at system level: vision and leadership and cooperation and support.

2.9.1 Vision and leadership

Vision and leadership are required to help shape ICT policy in schools (Kennisnet 2007). Whereas the national vision on education in Swaziland also guides the choices in respect of the use of ICT in the curriculum, the integration of ICT at school level starts with a vision. Howie (2010) has aligned the model with Kozma's policy alignment, intellectual resources and distributed policies.

2.9.2 Cooperation and support

In terms of the model, the cooperation and support provides the social building blocks to a learning process. Cooperation and support has been aligned to Kozma's private-public partnership (Howie, 2010), which in Swazi schools, at macro level (Hinostroza, Labbe, Lopez & Lost, 2008), refers to the support schools receive from the government, major corporations and donors, such as the *Coca-Cola foundation* and the CET. With the present research questions, using the Kennisnet model in the Swazi context, this study investigated inter- and intra-cooperation and support between principal, parents, inspectors, teachers, students, curriculum designers, examiners, associations, unions, NGOs, tertiary institutions, private organisations and ministries. This means that all forms of cooperation and support by parties, whether at macro level, meso level and micro level, were investigated. The parties are collectively involved in bringing about the pedagogical use of ICTs for learning.

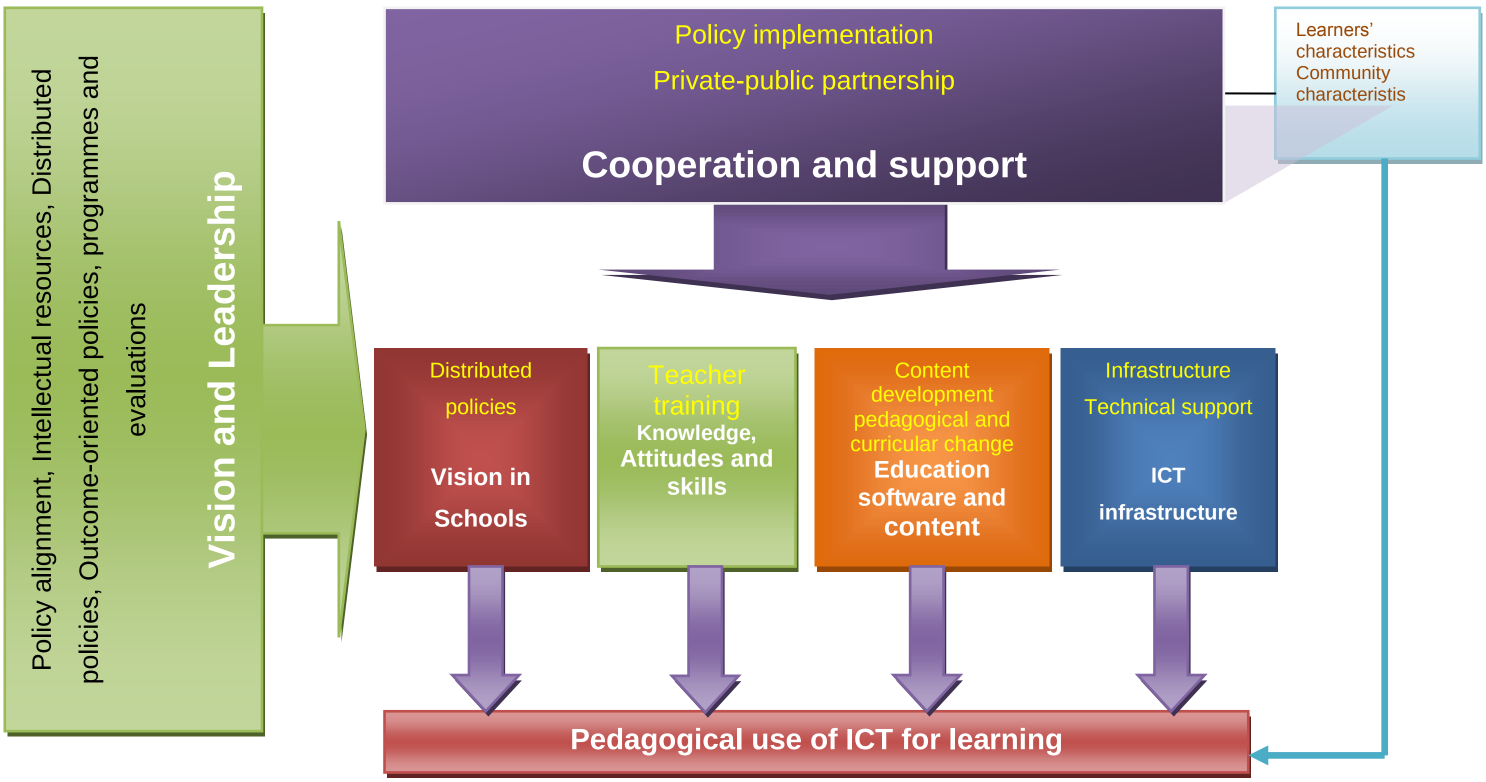

Figure 2.3: Factors related to pedagogical use of ICT by Howie (2010)

2.9.3 The building blocks

The model presents four building blocks to support the integration of ICT in education, namely: school vision, knowledge, attitudes and skills, parameters such as hardware and educational software, content and ICT infrastructure. These building blocks should be in tandem for a balanced and long-term integration of ICT to take place (Kennisnet, 2007). Featuring mainly at this level are the learners and teachers, while the infrastructure deals with the physical learning environment / learning management system, including the learning materials (Voogt & Knezek, 2008). The 'Four-in Balance model links to Kozma's four elements, as illustrated in Figure 2.3: vision links to distributed policies, knowledge, attitude and skills links to teacher training, education software and content links to content development, pedagogical and curriculum change and ICT infrastructure links to infrastructure technical support. The dominant role that community characteristics (context) and learner characteristics (learner profile or cultural capital) can play in the integration of ICT in the curriculum is also revealed.

2.10 CHAPTER SUMMARY AND CONCLUSIONS

This literature review has shown that the Kennisnet model makes it clear that there has to be a balanced push from the two fronts for the process of integration to succeed. On the horizontal plane, from left to right, there has to be vision and leadership while from the top downwards there has to be cooperation and support. This model does not suggest a top-down approach (Mlambo, 2007; Simpson, Payne & Condie, 2005) to the integration of ICT, as shown by the way the vision at the system level flows, from right to left rather than from top down.

To understand what possible factors could explain ICT integration this review has drawn from the "Howie alignment model" (Figure 2.3) on the alignment of factors related to pedagogical use of ICT. This 2010 model by Howie was helpful in the analysis of the thematic areas to achieve ICT integration in the classrooms (Draper, 2010; Howie, 2010; Kozma, 2008; Tiyla, 2008).

CHAPTER THREE

The research design and methods

3.1 INTRODUCTION

The research design and methods of the study are explained in this chapter. Section 3.2 discusses the research design, section 3.3 explains the research methods used, section 3.4 presents arguments on methodological norms and section 3.5 summarises the ethical considerations.

3.2 RESEARCH DESIGN

A survey design was undertaken and the study was therefore descriptive in nature, using central tendency and multi-dimensional measurement analysis procedures (Cohen, Manion & Morrison, 2005). The study investigated the integration of ICT in Swaziland schools and thus focused on such aspects as the availability of computers (number, type, configuration), where in the school they were located, who was using them and for what purpose, and whether any training on their use was offered (to whom, when and how). The study was also exploratory, looking at individuals, groups, institutions, methods and materials in order to describe, compare, contrast, classify, analyse and interpret the entities and events that constitute the field of inquiry (Creswell, 2005).

As summarised in Table A1 in the appendix, Mathematics and Science teachers were the major participants and the point of reference, as well as the principals and ICT teachers. Mathematics and Science are core subjects in Swaziland and case studies around the world have shown that the integration of ICT in Science learning can enable innovative classroom practices (Webb, 2008) and effectively support teaching and learning. Studies have also shown that the actual integration of computers in classrooms remains limited (Kozma, 2008). Mofokeng and Mji (2010) have also found that most Mathematics and Science teachers in the Gauteng province of South Africa do not integrate computers in their teaching of the subjects. As Drent (2005) has observed, the integration of ICT in education is not a simple process.

3.3 RESEARCH METHODS

The research methods used in the study were quantitative (Creswell, 2008), in the form of self-administered questionnaires. The preliminary activities of this inquiry included desktop research and document analysis, exploration of ICT materials from government and policy statements, interviews and content analysis of publications. Data was gathered from policy documents, teachers and principals, in line with the Kennisnet model.

3.3.1 Instruments

The SITES 2006 South African instruments were used in this study, following a request made through the Centre for Evaluation and Assessment (CEA) to use the module. There were four questionnaires, as shown in Table 3.1, first adapted before usage to collect data.

Table 3.1: Research instruments

QUESTIONNAIRE	RESPONDENTS
Technical or ICT infrastructure questionnaire	ICT teacher
Mathematics teacher questionnaire	Form 4 Mathematics teacher
Science teacher questionnaire	Form 4 Science teacher
Principal / head teacher questionnaire	The head of school

The SITES 2006 instruments that were developed through a stepwise procedure, aligned from concepts to indicators and from there to four separate instruments (Kozma, 2008).

3.3.2 Sample

The sampling frame in this study was 43 schools in the Manzini region. The up-to-date list of schools was provided by the Education Management Information Services (EMIS) in the MoET on Wednesday, June 8, 2011. They had a laboratory, an ICT teacher and computers that were either purchased by the school, donated by the *Coca Cola Foundation*, CET or the government through the MoET. A sample was drawn up that included research participants in four groups, relevant to the operational research questions, namely the ICT teachers, Mathematics teachers, Science teachers, and their principals. These are tabulated below.

Table 3.2: Research participants

RESPONDENTS	ROLE
ICT teacher	Responsible for school computer laboratories and providing the support for teachers to integrate ICT in their teaching practice.
Mathematics teacher	Responsible for integrating ICT in their teaching practice to achieve the pedagogical use of ICT for learning.
Science teacher	Responsible for integrating ICT in their teaching practice to achieve the pedagogical use of ICT.
Principal / head teacher	Responsible for making administrative decisions in a school to facilitate the pedagogical use of ICT.

3.3.3 Data collection

The self-administered questionnaires were delivered and collected from the schools using a research-tracking form, the response rate being 149 (87%), as shown in Table 3.3 below.

Table 3.3: Actual number of respondents

Teacher Category	Intended	Actual
Principal / head teachers	43	33 (77%)
Technical / ICT teachers	43	40 (93%)
Mathematics teachers	43	39 (91%)
Science teachers	43	37 (86%)
Totals	**172**	**149 (87%)**

All collected questionnaires were usable. Non-respondents were followed up telephonically. Some received transfers to other schools, mostly on a promotional basis, whilst others had died.

3.3.4 Data analysis

The Statistical Package for Social Sciences (SPSS) was used in the analysis of data, which was coded and analysed to derive meaning . Descriptive and inferential statistics in the form of factor analysis were used to factor out the principal components. The data was analysed in accordance with the framework as shown in Table A1 in the appendix. The findings were mostly presented in tables, graphics and narrative form to address the study research questions.

RQ1: What is the status of ICT integration in Swaziland schools?

This research investigated the status of school vision (school ICT policy), knowledge, attitudes and skills of stakeholders (principal, ICT teachers, Mathematics and Science teachers and students), funding, budget priorities, availability of educational software and content (books, programs and syllabus), what types of computer hardware were available, by whom it was being used and for what purpose, and how Internet access was provided and related ICT obstacles and barriers. This question was addressed through questionnaires to the schools and measures of central tendency were generated from baseline data.

RQ 2: What possible factors could explain the pedagogical use of ICT?

Once again the theoretical orientation taken in this study (as illustrated in Figure appendix) describes the layout and units of analysis. The mind map shows all thematic areas studied for a holistic investigation to present meaningful findings on what possible factors could explain the pedagogical use of ICT. There were three constructs, namely ICT infrastructure, ICT integration and ICT obstacles.

The overall factor analysis of the data by the researcher, while drawing from the conceptual framework, produced the thematic areas on the integration of ICT in the Mathematics and Science classrooms.

Steps followed in the factor analysis:

The following steps by field (2005) were followed in the analysis:

a) Data cleaning and screening - The aim was to remove outliers, identify missing data and look for any variables that did not correlate or correlate with many variables.

b) Sample validation - The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used, which is an index for comparing the magnitude of the observed correlation coefficients to the magnitude of the partial correlation coefficients. The acceptable sample sizes to yield reliable factors were those with a KMO measure closer to 1. These indicated a sizeable sampling adequacy. The values of KMO accepted were above 0.5 (0.8 and higher are great, 0.7 was acceptable, 0.6 was considered mediocre and less than 0.5 was unacceptable). A priori level (0.001) was set in accordance with the Kaiser criterion (Field, 2005).

c) The Bartlett's Test of Sphericity (BToS): The considered cases were those where $p < 0.001$. These were regarded to be significant correlations between items which were sufficiently large for principal component analysis (Field, 2005).

d) Running the analysis: The analysis proceeded in four steps (Khelifa, 2008):

the correlation matrix for all variables is computed
factor extraction
factor rotation
make final decisions about the number of underlying factors

Factors with Eigen values greater than 1 were considered. The Chronbach's Alpha was also considered. An alpha of 0.60 or higher was the minimum acceptable level. Preferred alpha was 0.70 or higher.

3.4 METHODOLOGICAL NORMS

The questionnaires had to pass the test of validity and reliability. While validity refers to how well the answer to a question corresponds with the true value for the construct that is being measured, reliability measures how well a question performs (Fowler & Cosenza, 2008). Miller (2000) advises that instruments be described in terms of:

Validity - Does the instrument or technique measure what it purports to measure with this group?
Reliability - Whatever the instrument or technique measures does it do so consistently with this group?
Suitability - Utility must be high for subjects to whom it is administered.

3.4.1. Validity

The concept of validity is multifaceted and according to Cohen, Manion and Morrison (2005), the instrument was validated as follows:

Construct validity

Construct validity measures the degree to which an instrument functions the way it does. The instrument should show that it fairly and comprehensively covers the domain or items that it purports to cover.

The questionnaire audit framework ensured that the instrument covered all the research questions and these were aligned to the conceptual framework.

Face validity

This measures the extent to which an instrument measures what it is purported to measure at face value. A panel of experts validated the adapted instrument.

Content validity

Content validity assures that the instrument provides adequate questions for the variables to be measured.

Criterion validity

The SITES 2006 modules provided a basis on which to address the aspect of criterion validity. This compared the current findings with past research to give a more valid and objective result. A relevant and reliable criterion was selected in order to validate the instrument. The relevant criteria covered the aspects of scope, aims, design, conceptual framework, context, sampling results and instrumentation.

Inferential validity

Inferential statistics in the form of factor analysis were used in the study to investigate the possible factors that could explain the pedagogical use of ICT.

3.4.2 Reliability and suitability

According to Cohen et al. (2005), reliability is a synonym for consistency and replicability over time, over instruments and over groups of respondents. As a measure of consistency, reliability is concerned with precision and accuracy. The instrument was thus pilot tested and field tested in the country's four geographical regions in July 2011 through a PPS sample of 16 schools obtained nationwide by applying probability proportional to size sampling technique (McGinn, 2004).

Table 3.4: Computer schools by region

Geographical regions	Computer schools by region	# of schools in PPS sample
Manzini	43	5
Shiselweni	43	4
Hhohho	40	4
Lubombo	34	3
Total	**160**	**16**

The reliability was calculated in SPSS and Chronbach Alpha was found to be very high for all the instruments, as shown in Table 3.5 (below). The technical and Science teacher questionnaire had the highest reliability, while the principal questionnaire and Mathematics questionnaire had the lowest coefficients.

Table 3.5: Reliability coefficients

Questionnaire	Chronbach Alpha
Principal questionnaire	0.77
Technical questionnaire	0.82
Mathematics questionnaire	0.76
Science questionnaire	0.83
Average	**0.80**

3.5 ETHICAL CONSIDERATIONS

As many people have become suspicious of surveys that the information may be used wrongly (Fowler & Cosenza, 2008), the researcher subscribed to the principles of ethical research as enshrined in the University of Pretoria, Faculty of Education guidelines for ethical clearance by the ethics committee. In the initial stages of the research an appointment was made with the Chief Inspector of schools, the Director of Education and the Regional Education officer to request permission to research the schools. This was provided and such letters of permission are attached in Appendix B. The respondents were individual adults whose rights and freedoms were respected.

A declaration was made in the cover pages of the research question to explain the dimensions of the research, including fair explanation of procedures, an offer to answer inquiries through a given email address and a notice that the respondents were free to withdraw consent and discontinue participation at any time.

Informed consent means obtaining the consent and co-operation of the research participants (Cohen et al., 2005). Letters of introduction were first sent to schools prior to the data collection and telephone calls were made to ascertain if the school principals and teachers were willing to be part of the process. Their contact details were requested and all confidential information was kept safely in a research tracking form. Confidentiality and anonymity of human respondents was guaranteed and ensured by the researcher, in that no individual school or person was referred to by name, but rather, unique codes were used to identify and differentiate the participants at all times for protection of individual identities.

3.6 CHAPTER SUMMARY AND CONCLUSIONS

The chapter presented a survey as design using four questionnaires that were adapted from SITES 2006 module. A Probability Proportional to Size Sampling technique was employed during the pilot and field testing of the instruments. Data was analysed through descriptive statistics and exploratory factor analysis reduced the data and use of loadings, Eigen values, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's Test of Sphericity (BToS) determined significant correlations between items (Field, 2011).

The results from the analysis are presented in chapter four entitled the ICT integration status and chapter five presents the thematic areas for ICT integration.

CHAPTER FOUR

The status of ICT integration in Swaziland schools

4.1 INTRODUCTION

The aim of this chapter is to describe the status of ICT integration, beginning with a description of the research participants by job category, gender, age, highest education qualification, and experience and ICT status.

4.2 DESCRIPTION OF RESEARCH PARTICIPANTS

The total number of respondents was 149, from four departments in 43 schools. The numbers of research participants by job category are shown in figure 4.1.

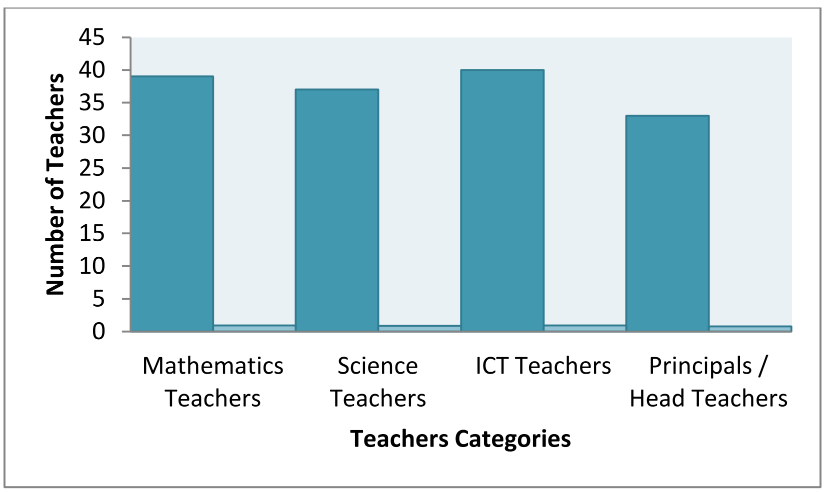

Figure 4.1: Research participants by job category

There were 39 Mathematics teachers, 38 Science teachers, 33 head teachers and 40 ICT teachers who participated in the research. The smallest group of respondents were the head teachers, because they were too busy to respond to the questionnaire, or admitted to having misplaced it. The highest group of respondents was the ICT teachers. Figure 4.1 indicates that 40 ICT teachers participated. The research participants profile is described in terms of gender.

Table 4.1 (below) shows that most of the principals and ICT teachers were male, yet most of the Mathematics and Science teachers were female.

Table 4.1: Gender of teachers by category

Gender	Principal	Science	Mathematics	ICT
Female	11	24	28	15
Male	22	12	8	25

Table 4.2 (below) indicates that most of the principals were in the age bracket of 41-50, most of the ICT teachers were in the age bracket of 21-30, and most of the Mathematics and Science teachers were in the age bracket of 31-40. They were older than the ICT teachers and younger than the principals. There was no principal below 30 years old and no ICT teacher above 51 years old.

Table 4.2: Age of respondents

Age	Principal	Science	Mathematics	ICT
21-30 years	0	7	2	25
31-40 years	8	15	23	11
41-50 years	20	11	8	2
51-60 years	5	2	1	0

As exhibited in Table 4.3 (below), the principals were the most experienced and the ICT teachers the least. Of significance is that only two ICT teachers had more than 11 years experience.

Table 4.3: Experience of teachers

Experience	Principal	ICT
0-3 years	11	21
4-7 years	5	9
8-11years	7	4

It is evident from Table 4.4 (below) that most of the ICT teachers were diploma holders and most of the Mathematics and Science teachers had no ICT qualification. Very few ICT teachers held a degree.

Table 4.4: Qualification of teachers

	Qualification	Science	Mathematics	ICT
Highest Qualification	High School	0	2	3
	Diploma	6	8	12
	Degree	26	23	8
	Honours	1	1	0
	Masters	2	2	0
ICT Qualification	None	28	26	5
	Certificate	7	5	6
	Diploma	1	1	22
	Degree	0	4	2

It is clear from Table 4.5 (below) that most of the ICT teachers and about half the principals used a computer daily, yet only two of the Mathematics and Science teachers did so. The computers were used for schoolwork and browsing the Internet.

Table 4.5: Respondents ICT status

ICT status	Principal	Science	Mathematics	ICT
Home computer access	22	15	18	32
Home computer used for school work	19	12	15	31
Home computer Used for Internet	16	13	16	24
Daily computer usage	11	2	2	36

4.3 ICT STATUS OF SCHOOLS

Table 4.6 (below) shows that the average number of computers per school was 29.

Table 4.6: Available infrastructure

Infrastructure	N	Mean	Standard Deviation
Available computers	1038	29	16.58
Broken computers	294	9	10.90
Available laptops	57	1	7.36
Broken laptops	3	0	0.28
Available printers	30	1	0.49
Broken printers	32	2	3.32
Maintained laboratories	24	21.5	8.40
Unmaintained laboratories	16	10.0	9.81

Table 4.7: Description of computer laboratories

Status of laboratory	Purpose built computer laboratory	Converted classroom
Type of laboratory	N=40	N=40
Period of use	21	17
0-2 years	7	4
3-5 years	5	4
>6 years	7	9
Have written ICT policy	4	5
Networked computers	7	8
Available Internet access	9	10
White board installed	14	12
Two printers installed	16	10
Air-conditioned	7	8
Designed for future expansion	7	6
Security alarm installed	10	7
Backup power available	0	1
Burglar proofed	21	17

The ICT laboratories were built in the previous three to five years, and whereas some of the schools used converted classrooms some had no ICT policy, no network, no Internet access, no printers, no security alarm, badly designed computer laboratory, no power backup, and no burglar proofing, all obstacles to ICT integration. As shown in Table 4.7 more than half the schools had up-to-standard computer laboratories.

The study has also shown in Table 4.8 that there are more female teachers than male teachers in the schools. There are however more boys than girls in the schools which is due to the gender parity on gross enrolment rates (EMIS, 2010). On the contrary there are more male computer teachers than females. The same arrangement applies with the principals as there are more male principals than females.

Table 4.8: Comparison of gender in schools

Gender Class	N	Mean	
Boys	6574	275	183.68
Girls	6421	259	146.36
Male teachers	448	14	7.34
Female teachers	501	16	7.02

The total number of students is 12,995 and the number of teachers is 949. This translates to a teacher to student ratio of 1: 14 while the student to computer teacher ratio was found to be 325:1. This indicates that there is one computer teacher per school whereas other subjects like Mathematics and Science have more than twice the number of teachers. The student computer ratio (SCR) was also calculated as total number of students at the school divided by the total number of computers available to students. The computer to student ratio was found to be 13:1.

The subject fee is as low as E20 and as high as E390 as exhibited in Table 4.9. The proposed subject fees for 2013 ranges from E70 to E404. As for the pay the lowest paid ICT teacher pockets E1400 a month and the highest paid goes home with E13200.

Table 4.9: Subject fees and payment for ICT teachers

Financial Profile	N	Mean	Standard Deviation
Highest ICT subject fee for 2012	E390	E203	119.00
Lowest ICT subject fee for 2012	E20	E203	119.00
Highest subject fee for 2013	E404	E231	110.04
Lowest subject fee for 2013	E70	E231	110.04
Highest salary for ICT teacher	E13200	E3826	2,527.09
Lowest salary for ICT teacher	E1400	E3826	2,527.09
Highest expected pay by ICT teachers	E15000	E6776	3,166.63
Lowest expected pay by ICT teachers	E2800	E6776	3,166.63

4.4 ICT INTEGRATION STATUS OF SCHOOLS

A number of factors impacted on ICT integration in schools.

4.4.1 Vision and leadership

The study has shown that the Student Computer Ratio (SCR) is very high, as is the student to ICT teacher ratio, though not commensurate. Vision and leadership are needed in this area to enable ICT integration. Table 4.7 (above) shows slightly over half of the schools had up-to-standard computer laboratories. There were many converted classroom laboratories which were not up to standard and a very small number of the purpose-built or converted classroom laboratories had an ICT policy. It was also a finding of this research that some schools did have computers but no computer laboratory, with other space being used. Computers were still in their packaging in a storeroom or room that may not have been burglar proofed, such as the Home Economics storeroom. The same Table 4.7 (above) also shows that few of the schools had computer laboratories that were properly designed for future expansion.

4.4.2 Support and cooperation

As shown in Table 4.10, most head teachers indicated that in terms of budget priority the procurement of ICT equipment (toners, modems) was rated low, together with addressing the problems of frequent power cuts and addressing the obstacles emanating from the curriculum being too strict. The budget priority level was found to be high on developing learners ICT skills, improving access to ICT outside the school to establish and enhance online learning support platform, and improving its management. Similarly, priority was given to issues of pressure of standardised tests, out-of-date computers, increasing numbers of computers connected to the Internet, and decreasing number of learners per computer. This would require cooperation among stakeholders.

4.4.3 School vision

Table 4.7 showed that most of the schools indicated they had no written ICT policy, yet this is a vital tool to manage and maintain the ICT infrastructure. As a matter of vision at school level, Table 4.10 reflects that the head teachers' budget did not prioritise computer ratio, Internet, resources, E learning, skills, use of ICT, competence, ICT skills, or teachers' ICT use.

4.4.4 ICT infrastructure

In terms of the availability of infrastructure, as Table 4.6 showed, the computers were classified as old and insufficient. The maintenance of ICT infrastructure was also found to be lacking. In terms of maintenance of ICT infrastructure, it was also a disturbing finding of this research that the average number of broken computers per school was found to be nine. This confirms that maintenance was lacking. As evident from Table 4.7 the computers were not maintained by the schools, government or the Computer Education Trust. About half of the schools maintained their computers, and there were 16 schools with unmaintained laboratories.

4.4.5 Knowledge, skills and attitude

The research has revealed that about half of the head teachers considered teachers' lack of ICT skills as an obstacle, two thirds indicated that a fraction of the learners were computer literate, just half indicated that a section of teachers were computer literate, and less than half of the Mathematics teachers and Science teachers admitted that they had not attended an introductory course for Internet and general applications (e.g., word-processing, spreadsheets, databases). These teachers indicated that they would like to attend such professional development courses, as shown in Table 4.11.

4.4.6 Teachers' general use of ICT

Table 4.10 below indicates that the software that is commonly used by most Science teachers is word-processing, spreadsheet and database software, while most of the Mathematics teachers commonly use word-processing software, application of multimedia and data-logging tools. The research revealed that about a quarter of the Science and Mathematics teachers indicated that they were confident in using a word-processing program to produce a letter, while a few indicated that they had little confidence with email, photographs, folders, spreadsheets, Internet, animations and online purchases. In comparison, the study has shown that both Science and Mathematics teachers mostly use word processing software, while the graphic calculator was used less by the two groups of teachers than database, spreadsheet, presentation, application of multimedia, email, Internet software and data logging tools.

4.4.7 Learners' skills

The Science teachers indicated that a majority of their Form four learners had word-processing, database and spreadsheet operation skills, whilst a section had database and spreadsheet operation skills. The study has shown that some Science learners had competence in using the Internet, application of multimedia, email, and graphic calculators. At the same time, the Mathematics teachers, as indicated in Table 4.10, said a majority of learners in Form four had word-processing and spreadsheet operation skills.. By comparison, the Science learners had more operation skills.

Table 4.10: Comparison of general use of ICT by teachers and learners of Science and Mathematics

ICT used	Count (No. of teachers) Science teachers		Count (No. of teachers) Mathematics teachers		Count (No. of teachers) Science learners		Count (No. of teachers) Mathematics learners	
	A little	Somewhat	A little	Somewhat	Some learners	Majority of learners	Some learners	Majority of learners
Word processing	4	**9**	2	**10**	2	**11**	**9**	**9**
Database software	3	**7**	**4**	5	6	**7**	5	**5**
Spreadsheet	**5**	**7**	**4**	5	7	**9**	3	**9**
Presentation software	3	6	2	6	7	2	6	2
Application of multimedia	4	5	1	**7**	**12**	3	7	4
Email	4	6	2	6	**10**	5	**12**	3
Internet	**5**	6	3	6	**10**	3	**11**	**5**
Graphic calculator	**6**	6	**5**	2	**12**	1	7	1
Data-logging tools	**5**	6	2	**7**	8	3	4	3

4.4.8 Comparisons of teachers and learners use of ICT

Table 4.10 juxtaposes general computer use of teachers' and learners' operational skills. Whereas the majority of Science learners have operational skills in word-processing, database software, spreadsheets and email, the Science teachers use word-processing, database software and spreadsheets. Mathematics teachers use word-processing, application of multimedia and data logging tools, while the majority of their learners have operational skills in word-processing, database software spreadsheets and the Internet.

4.4.9 Teachers' pedagogical use of ICT

Table 4.11 (below) presents the pedagogical use of ICT and teachers' professional development courses. The results indicate that most of Mathematics and Science teachers can find useful curriculum resources on the Internet and use ICT for collaboration with others. While the Science teachers have knowledge on which teaching/learning situations are suitable for ICT use, the Mathematics teachers can use the Internet (e.g., select suitable web sites, user groups / discussion forums) to support learner learning and also install educational software.

4.4.10 Teachers' professional development courses

A majority of the Science and Mathematics teachers indicated that they had attended a an introductory course for Internet use and general applications (e.g., basic word-processing spreadsheets and databases), yet 19 had not attended a course in the following:

Technical course for operating and maintaining computer systems.
Advanced course for applications/standard tools (e.g., advanced word- processing, complex relational database).
Advanced course for Internet use (e.g., creating websites / developing home pages, advanced use of the Internet, video conferencing).
Course on pedagogical issues related to integrating ICT into teaching.

Subject-specific training with learning software for specific content course on multimedia operations (e.g., using digital video and/or audio equipment).

Of significance in Table 4.11 is that 30 Mathematics and Science teachers expressed interest in attending an advanced applications course.

4.4.11 Educational software / digital materials

Table 4.11 revealed that most of the Mathematics and Science teachers saw lack of digital learning resources as an obstacle to using ICT in their teaching. Few of the head teachers consider digital learning resources related to the curriculum to be of high priority in the school ICT budget. It was also worth noting that most Mathematics teachers could install educational software, whereas few Science teachers could. The relevant course necessary to equip teachers with this skill is the course on subject-specific training with learning software for specific content. Evidence in Table 4.11 suggests that most of the teachers who attended this course were Mathematics teachers, more than twice the number of Science teachers who attended.

Table 4.11: Comparison of pedagogical use of ICT and teachers' professional development courses

ICT use	Teachers Pedagogical use of ICT				Teachers Professional development			
	Count (No. of teachers) **Science teachers**		Count (No. of teachers) **Mathematics teachers**		Count (No. of teachers) **Science teachers**		Count (No. of teachers) **Mathematics teachers**	
	A little N= 38	Somewhat	A little	Somewhat N=39	No, will attend	Yes, attended	No, will attend	Yes, attended
I can prepare lessons that involve the use of ICT by learners / (**Introduction course)**	6	6	4	3	17	17	16	**19**
I know which teaching/learning situations are suitable for ICT use / (**Integrating ICT course)**	<u>3</u>	**8**	4	5	28	4	**30**	<u>5</u>
I can find useful curriculum resources on the Internet / (**advanced Internet course)**	4	**8**	<u>0</u>	**10**	28	4	29	6
I can use ICT for monitoring learners' progress and evaluating learning outcomes / (**advanced applications course**)	4	5	4	4	**30**	<u>2</u>	**30**	6
I can use ICT to give effective presentations/explanations (**Multimedia operations course**)	5	6	<u>2</u>	6	**29**	<u>3</u>	25	10
I can use ICT for collaboration with others / (**Multimedia operations course**)	4	**7**	3	**7**	28	4	25	10
I can install educational software on my computer **/ (technical course)**	4	5	<u>1</u>	**7**	28	4	24	10
I can use the Internet (e.g., select suitable web sites, user groups / discussion forums) to support learner learning/ **(advanced Internet course)**	6	6	<u>2</u>	**8**	17	17	29	6

4.5 OBSTACLES TO ICT INTEGRATION IN SCHOOLS

There were major and minor crosscutting obstacles to ICT integration in the schools.

4.5.1 Major crosscutting obstacle

As shown in Table 4., the major crosscutting obstacle in the study was found to be insufficient digital resources, for instance digital learning materials in the form of learning objects, electronic content, syllabus, encyclopaedias and subject-enrichment CDs, video CDs and DVDs.

4.5.1.1 Head teachers' obstacles

Head teachers linked the insufficient number of online computers as a major obstacle. The bandwidth was also considered a major obstacle, followed by teachers' lack of ICT skills and insufficient confidence. In terms of budget priority, learners' ICT skill was highly prioritized, yet the issue of curricula being too strict was given low priority.

4.5.1.2 Science teachers' obstacles

In the case of the Science teachers, the major obstacles to pedagogical use of ICT were lack of ICT tools such as printers, scanners, dongles and digital cameras.

4.5.1.3 Mathematics teachers' obstacles

Most of the Mathematics and Science teachers pointed out as a major obstacle insufficient ICT equipment and ICT tools, such as servers, computers, scanners. The issues of access to the required tools, insufficient confidence and school policies were not seen as obstacles to ICT Integration by this cohort.

4.5.1.4 ICT teachers' obstacles

The ICT teachers listed insufficiency of computers linked to the Internet, access to ICT outside the school and learners ICT skills as major obstacles. Frequent power cuts, the age and model of computers were mentioned as obstacles to ICT integration by this group of teachers.

Table 4.12: Obstacles to using ICT integration in schools

Obstacles	Count (No. of teachers) Science teachers		Count (No. of teachers) Mathematics teachers		Count (No. of teachers) ICT teachers		Count (No. of teachers) Head teachers		Count (No. of teachers) Budget priority	
	No	Yes	No	Yes	Somewhat	Great extent	Somewhat	A lot	Low	High
Insufficient qualified personnel	21	15	21	15	5	12	5	16	3	17
Insufficient on Internet computers	**24**	12	19	18	3	**24**	2	**24**	3	**18**
Insufficient Internet bandwidth	22	14	19	18	4	20	3	**19**	6	15
Lack of special ICT equipment	**24**	12	**24**	13	3	9	3	8	4	16
Insufficient ICT equipment	**24**	12	11	**26**	9	19	9	15	9	11
Computers are out of date	**24**	12	19	18	**11**	12	3	11	3	**18**
Insufficient digital resources	8	**27**	7	**30**	6	**22**	**10**	**18**	4	16
Lack of ICT tools	10	**26**	11	**26**	9	21	**12**	13	3	14
Teachers' lack of ICT skills	21	15	23	13	7	8	5	**19**	3	17
Insufficient time for teachers	16	20	18	19	7	15	**7**	17	1	**18**
Curricula are too strict	17	19	22	15	5	5	3	5	**10**	12
Insufficient space for integration	17	19	21	15	9	10	6	6	3	14
Insufficient budget	8	**27**	19	18	10	10	5	8	3	**18**
School goal anti integration	20	16	**26**	11	5	9	2	4	3	14
Frequent power outages	17	17	19	18	**11**	9	3	8	9	11
Learners ICT skills	19	15	19	18	**11**	10	3	8	1	**25**
Access to ICT outside the school	22	14	19	18	3	**24**	3	**19**	1	**18**
Pressure of standardized tests	20	16	20	17	9	10	3	5	1	**18**
Insufficient confidence	18	18	**25**	12	7	8	5	**19**	3	17
Access to the required ICT tools	**24**	12	**24**	13	9	19	9	15	4	16

4.5.2 Minor crosscutting obstacles

As shown in Table 4.10, nearly all the Science, Mathematics, ICT and head teachers considered lack of special ICT equipment and access to the required ICT tools as a minor obstacle or no obstacle to ICT integration.

4.5.2.1 Head teachers' obstacles

This group also regarded frequent power cuts as an obstacle. The obstacle of using ICT for teaching and/or learning is not a goal of the school, and insufficient space for integration were regarded as a non-obstacle.

4.5.2.2 Science teachers' obstacles

The Science teachers did not consider as obstacles the number of computers linked to the Internet, special ICT equipment such as joysticks and pads, model and year of computers or access to the required ICT tools. Access to ICT outside the school and lack of knowhow in identifying which ICT tools were also considered a non-obstacle by the Science teachers.

4.5.2.3 Mathematics teachers' obstacles

The obstacle captured as using ICT for teaching and or learning is not a goal of the school, and access to ICT outside the school was not counted as obstacles by the Mathematics teachers.

4.5.2.4 ICT teachers' obstacles

The issue of the prescribed curricula being too strict was not considered as an obstacle by this group of teachers. This is true because currently there is no localised syllabus and there is a certain degree of freedom.

4.6 CHAPTER SUMMARY AND CONCLUSIONS

In summary, the head teachers who were part of this study were mostly male, 41-50 years, with no to three years' experience as head teachers. There were 22 with access to a home computer, and 11 with access to computers daily for some of the schoolwork and accessing the Internet. The majority of the ICT teachers were males, aged between 21 and 30 years, with no to three years' experience as ICT teachers, and using the computer daily to do schoolwork. They were holders of diploma qualifications. In the case of Mathematics, most of the teachers were female, with ages ranging between 31 and 40 years, degree holders, with no certificate in ICT, using the computer mostly to teach and access the Internet. Once again, the majority of the Science teachers were also female, with ages ranging from 31 to 40 years, using the computer to teach and access the Internet.

Although more than half of the schools had up-to-standard computer laboratories, the study found that the students: computer ratio (14:1) to be very high. This was lower than neighbouring South Africa, which was found to be 123 and 185.7 (Blignaut & Howie, 2009). Although comfortable with word processing, the Mathematics and Science teachers lacked general ICT skills and as such the pedagogical use of ICT was very limited. Most said they would like to attend a professional development course in ICT or effective training (Bingimilas, 2009).

Lundall and Howell (in Howie et al., 2005) pointed to financial constraints (lack of or insufficient numbers of computers); lack of computer literacy among teachers; lack of training regarding the integration of computers into different learning areas; and the absence of a properly developed curriculum for teaching computer skills as constraints to implementing ICT. In this study the obstacles were insufficient digital resources, insufficient number of Internet computers, lack of ICT tools, insufficient ICT equipment, lack of access to ICT outside the school, and learners ICT skills. As another obstacle, most schools had no written ICT policy.

CHAPTER FIVE

Factors explaining ICT integration in Mathematics and Science classrooms

5.1 INTRODUCTION

The aim of this chapter is to identify the possible factors that could explain ICT integration in Mathematics and Science classrooms. It describes the variables and the constructs in the study, using factor analysis to highlight the thematic areas.

5.1.1 Variables and constructs in the study

As shown in Figure 5.1 (below), when infrastructure is available for pedagogical use and ICT integration, there have to be sufficient funding, appropriate knowledge and skills, efficient leadership, proficient teachers and competent students, however, the attainment of pedagogical use and ICT integration depends on the absence of barriers and the formulation of visionary policies to promote cooperation and support at all levels.

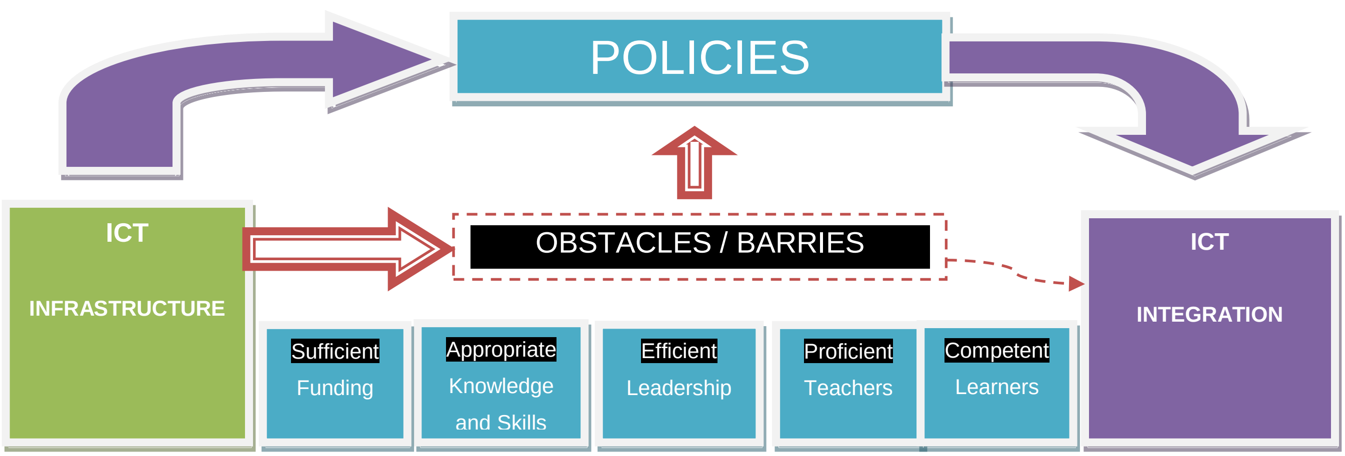

Figure 5.1: Constructs in the study

The exploratory factor analysis method in SPSS (Field, 2011) was used. The goal was to explore the factors for three constructs among the 361 variables in the study. The existence of these factors was inferred rather than observed, as the exploratory factor analysis started from observed data to identify unobservable and underlying factors, unknown to the researcher but expected to exist from theory (DeCoster, 1998).

Table 5.1: Variables in the study

Questionnaire	Constructs	Domains	Factors	Variables
TECHNICAL questionnaire	ICT Infrastructure	4	4	40
	ICT Obstacles	4	8	27
	ICT Integration	1	2	5
MATHEMATICS questionnaire	ICT Infrastructure	1	5	13
	ICT Obstacles	3	8	24
	ICT Integration	7	21	84
SCIENCE questionnaire	ICT Infrastructure	1	4	13
	ICT Obstacles	3	9	24
	ICT Integration	7	15	84
PRINCIPAL questionnaire	ICT Infrastructure	1	3	10
	ICT Obstacles	6	9	31
	ICT Integration	1	3	6
Totals	**3**	**39**	**91**	**361**

The total number of variables in the study as shown in Table 5.1 (above) was 361, and through data reduction the factor analysis came up with 91 factors for the three constructs of ICT infrastructure, ICT obstacles and ICT integration.

5.2. FACTORS UNDER ICT INFRASTRUCTURE

Table A2 in the appendix shows five factors that explain the ICT infrastructure, namely laboratory conditions, resource materials, budget priorities, available computers and maintenance. In total, 15 components loaded, however, as summarised in Figure **5.2**, there were nine components that had relatively high loadings and whose Eigen values were greater than 1 when using the varimax method. Out of the nine components eight were significant. The school computer laboratory essentials as a component were not significant in terms of the Bartlett' test of Spherecity (BToS), and as such were classified as having an unacceptable sample size to yield reliable factors. Funding is one thematic area, which could possibly explain the availability of ICT infrastructure. This is addressed under three thematic areas of donor funding, school funding and head teachers' budget priorities. The type of infrastructure is explained under four thematic areas: teaching resources; digital resources; ICT tools and networks; and availability of computers, laptops, printers and PDAs.

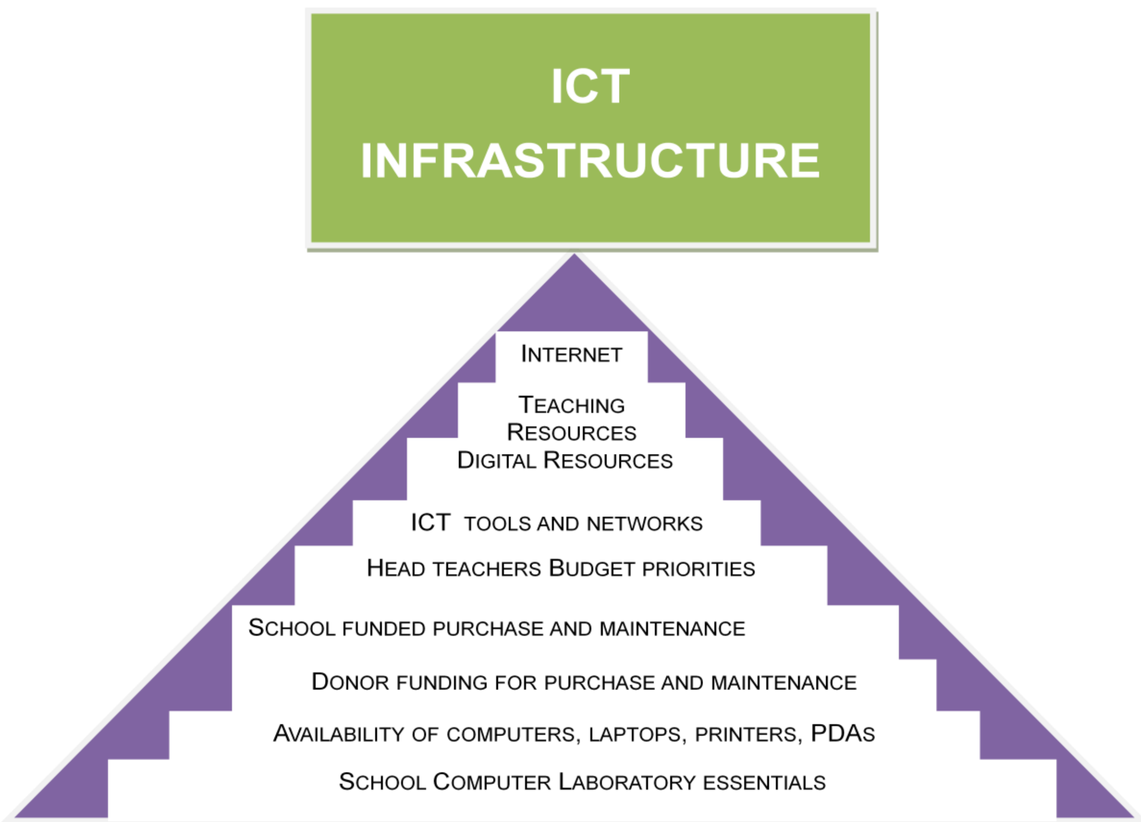

Figure 5.2: Significant components and thematic areas under ICT infrastructure

5.3 FACTORS UNDER ICT OBSTACLES

In total there were 35 loading components under ICT obstacles, as captured in Table A3 in the appendix, and as summarised in Figure 5.3 (below) there were 18 of the components that were significant. Curriculum orientation in the schools rendered the subjects to be classified as basic (loading 0.86) and common (loading 0.74). Social studies, Siswati and ICT as a subject loaded amongst common subjects. This indicates that ICT is not taken seriously as a subject. The main reason could be that ICT teachers are not paid by government but by the parents. Generally, the necessity for ICT integration has not been realised and the government is not employing an ICT teacher for every school. Worth noting is that the lack of ICT policy has loaded as an obstacle in the "ICT world" of all the teachers except in the "ICT world" of the principal. It did load as a component but was not significant in terms of sample adequacy, and the reliability was very low.

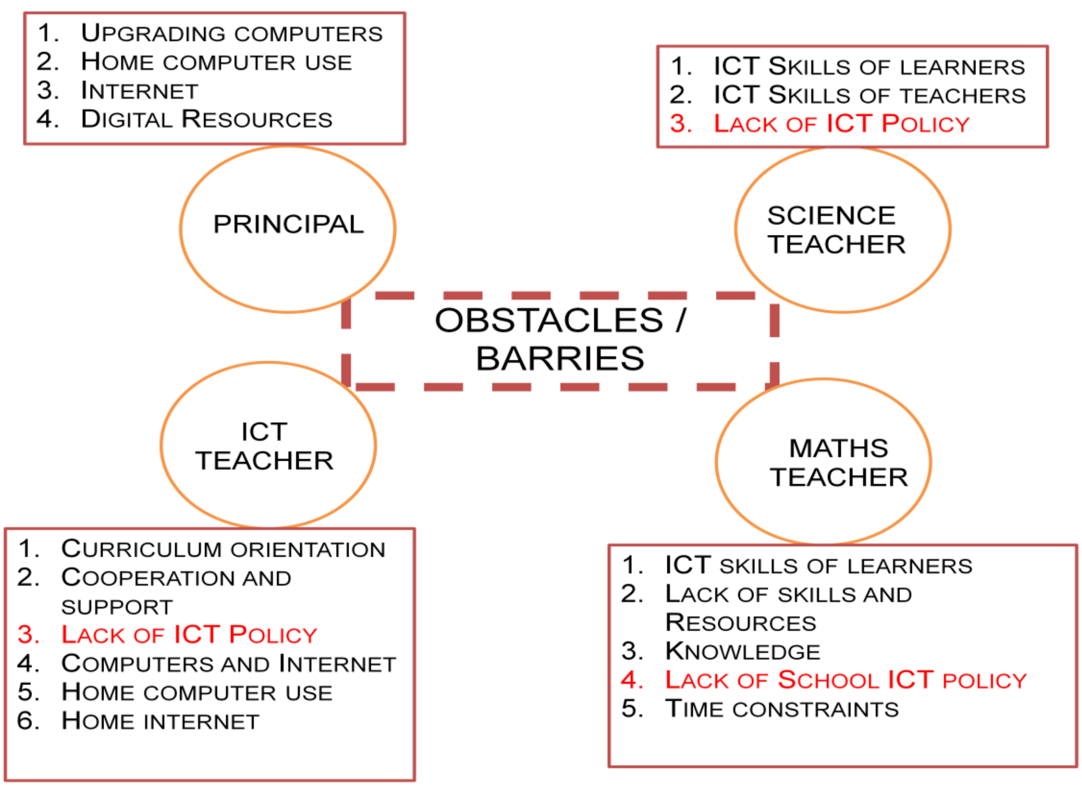

Figure 5.3: Obstacles in teachers' "ICT worlds"

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5.4 FACTORS UNDER ICT INTEGRATION

In total there were 41 loading components under ICT integration, as captured in Table A4 in the appendix. As shown in Figure 5.4 (below) there were also nine components that were significant, compared to 41. Significantly, the Science teachers as one group were most likely to easily integrate ICT in their classrooms. However, under innovative ICT use it was the Mathematics teachers who had covered more ground, in that their innovative ICT use loaded under four components, namely learners' activities (loading 0.80); teachers' activities (loading 0.86); learners' assessment (loading 0.78); and remediation activities (loading 0.81). This group was the most prepared to integrate ICT, which could explain the nature of the subject, teaching methodologies, paradigms and the curriculum orientation adopted.

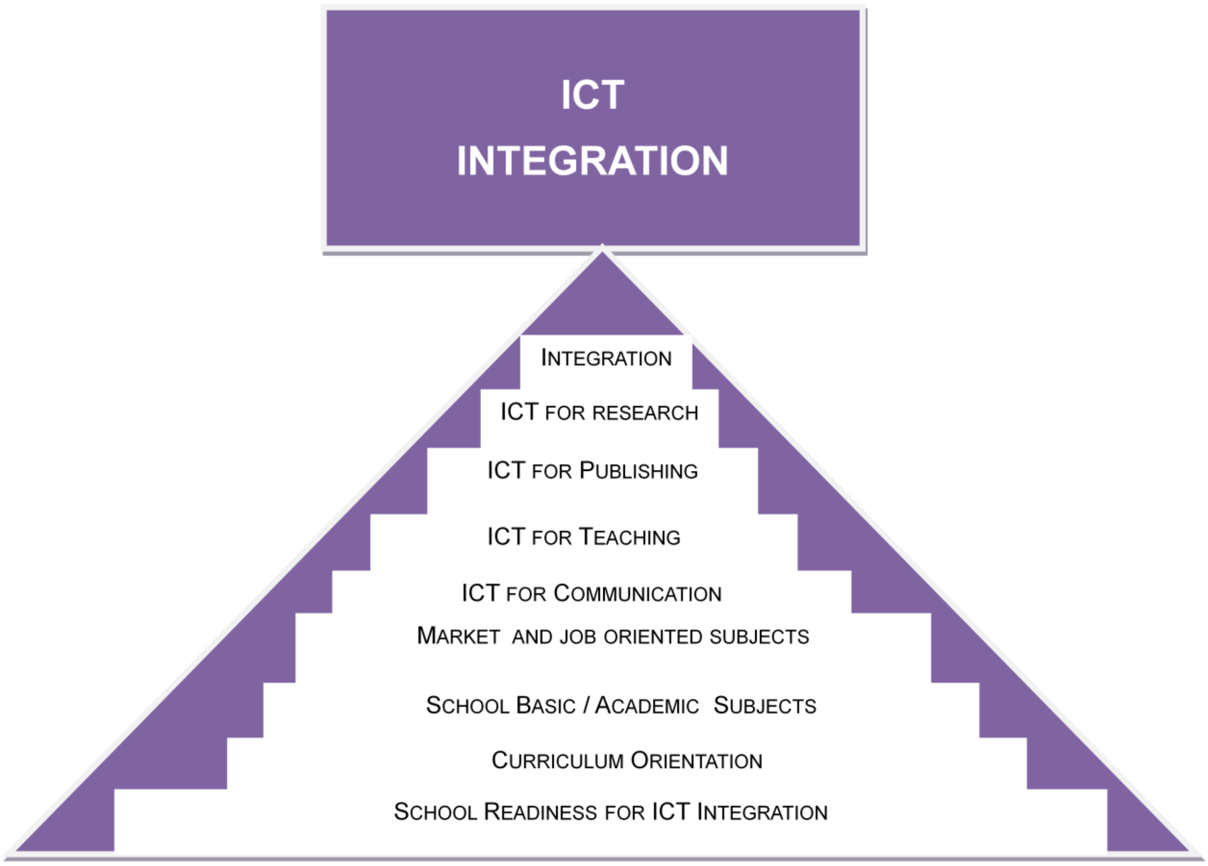

Figure 5.4: Thematic areas under ICT integration

5.5. FACTORS UNDER SOCIAL BUILDING BLOCKS

In terms of the Kennisnet model, the social building blocks had to be in tandem (Kennisnet, 2007). True to the model the study focused on thematic areas that balanced the four building blocks. An analogy of levers was employed to look at how each block could be balanced, a principle that is not alien to the world of Mathematics and Science teachers. The principle, as shown in Figure 5.5 (below), works through balancing objects on a fulcrum. To maintain balance each object is placed on one side of the fulcrum, as shown below.

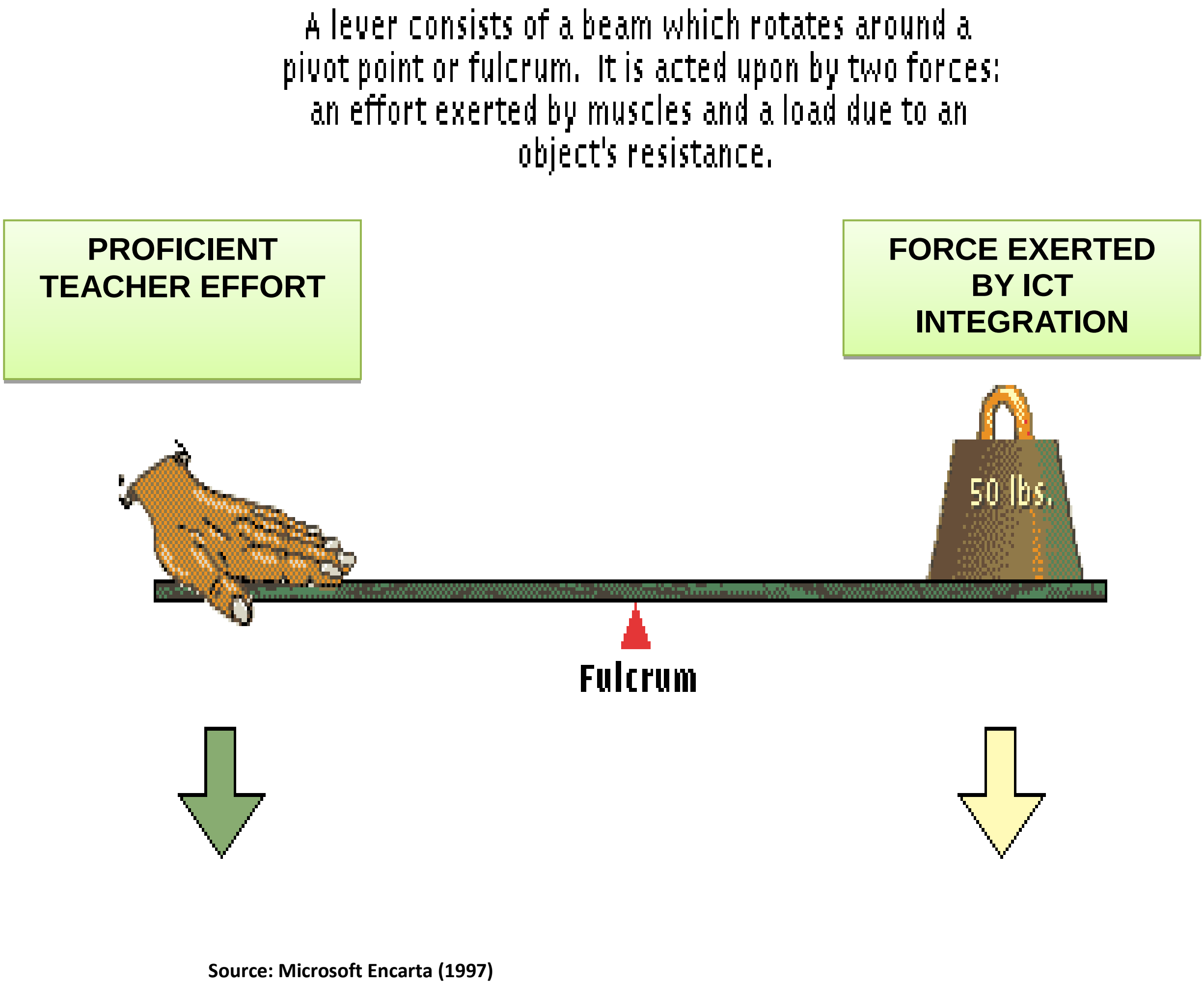

Figure 5.5: Proficient teacher effort to balance the demands of ICT Integration

In line with the principle of levers, with load balanced against a human, each social building block for ICT integration is to be in tandem with each other, and each had to be balanced against a standard, which in this case was ICT integration. The factors of each block were balanced against the factors of ICT Integration.

5.5.1 Appropriate knowledge and skills

Figure 5.6 (below) illustrates the eight components that had significant loadings. These were the eight thematic areas with some effort needs to be applied to ensure appropriate attitude, knowledge and skills. It was interesting that the courses arose as two groups, which were then labelled as *introductory* and *advanced* ICT courses. Depth of ICT use, innovative ICT use, confidence of ICT use and research arose as the five thematic areas that could explain appropriate attitude, knowledge and skills.

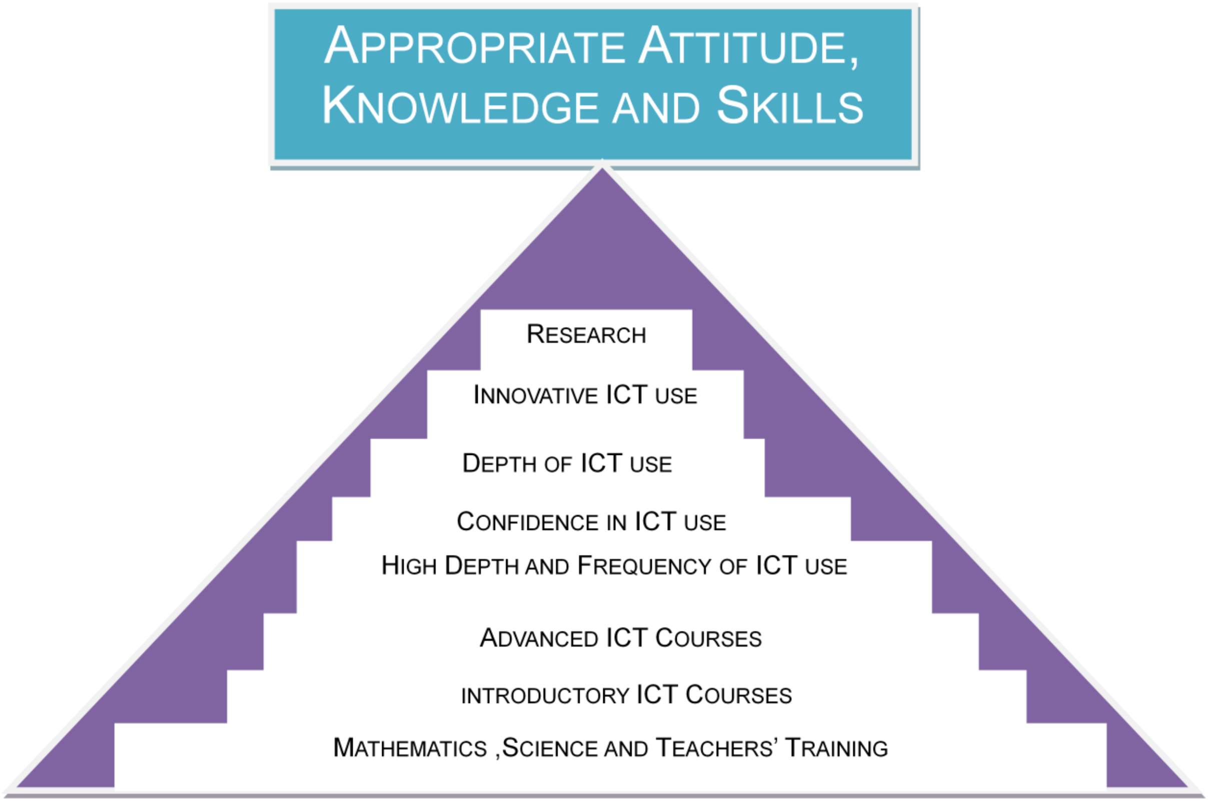

Figure 5.6: Thematic areas under appropriate attitude, knowledge and skills

5.5.2 Sufficient funding

To attain sufficient funding for ICT integration, the results in Figure 5.7 (below) shows the seven components loadings that was high and significant. This implies that there are seven thematic areas to consider in ensuring sufficient funding for ICT integration, namely partnerships, government payment of salaries, budget priorities', subject fees and school ICT budget.

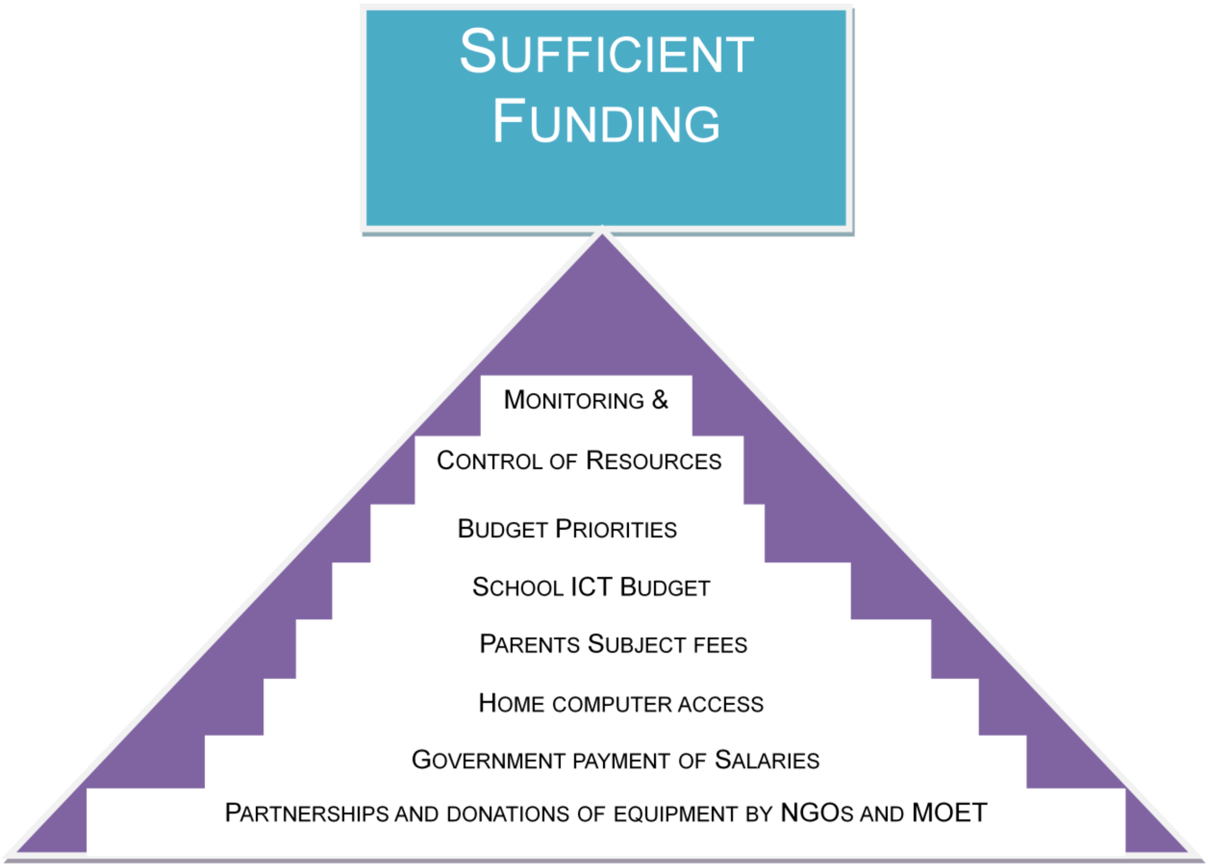

Figure 5.7: Thematic areas under sufficient funding

5.5.3 Proficient Mathematics, Science and ICT teachers

There were eight significant components that loaded under this factor, which mainly summarises the teacher profile factor. All the profiles of the three groups of teachers are shown in Figure 5.8 (below). The components presented eight areas in which teachers need to apply effort to be proficient and bring about ICT integration. It was interesting to note that a teacher being a member of an ICT community of practice emerged as a thematic area, that could explain proficiency in the pedagogical use of ICT.

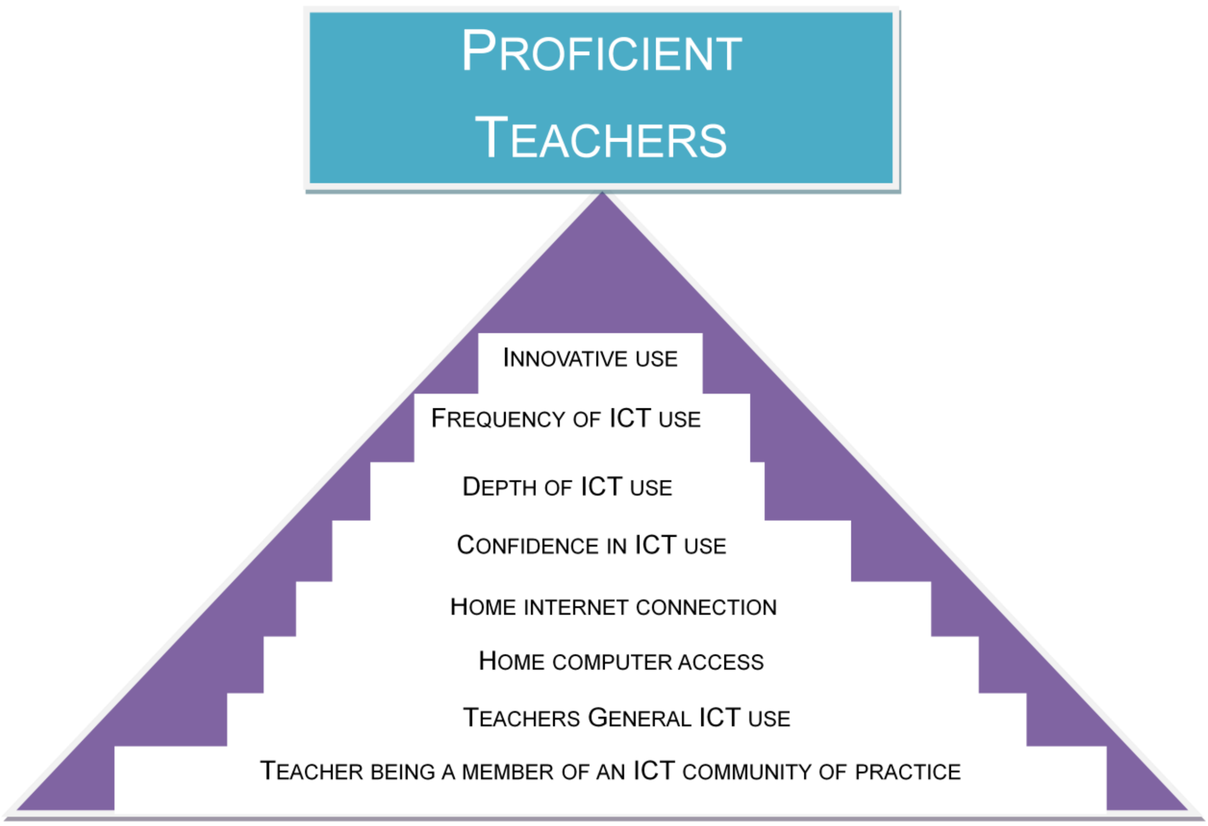

Figure 5.8: Thematic areas for proficient teachers

5.5.4 Efficient Leadership

As shown in Figure 5.9 (below), there were five components with relatively high loadings which were considered significant. The crafting of the ICT policy also emerged as another thematic area under efficient leadership. It is once again noted that the lack of it loaded as a bearer in the “ICT worlds” of the ICT teacher, Mathematics teacher and Science teacher.

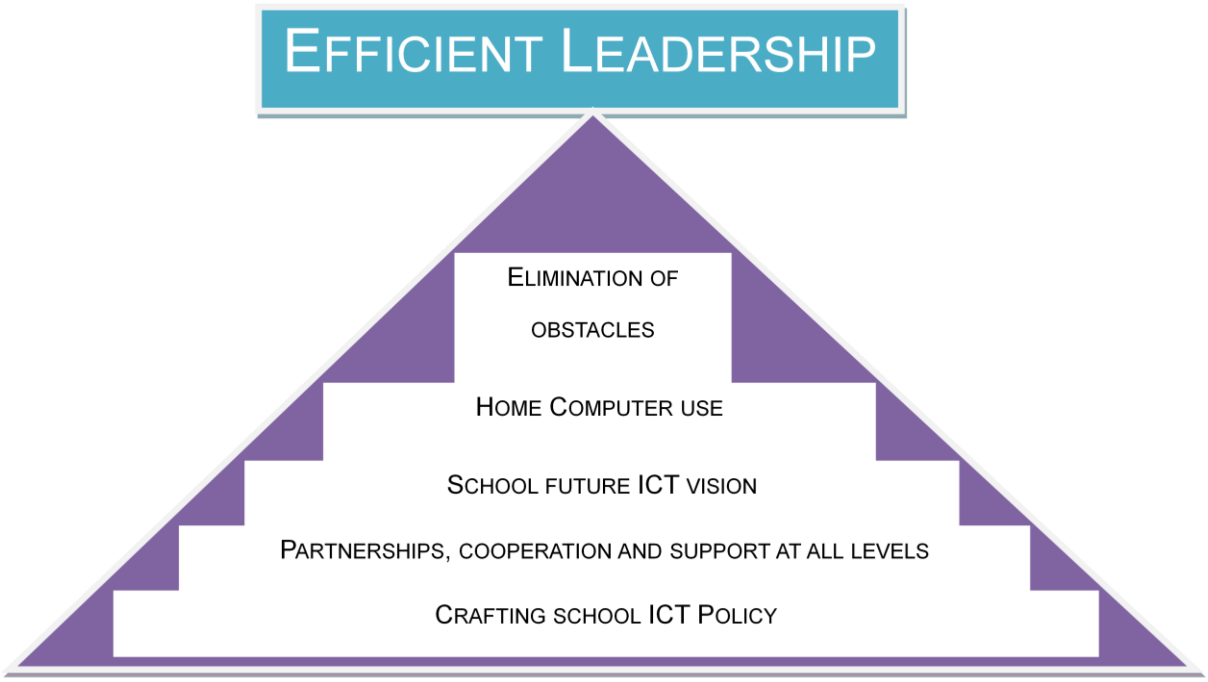

Figure 5.9: Thematic areas under efficient leadership

5.5.5 Competent learners

Figure 5.10 (below) indicates six competent learner thematic areas. These revolve around skills, availability of computers and learners activities. The ICT skills of Science and Mathematics learners loaded under the components of general skills and popular skills. These popular skills could be the finger tip skills learners possess that are self-taught, learnt on the move, and speedily learnt from friends, such as writing and burning CDs, downloading films, loading *Opera Mini*, using *What's App* and social networking, which are currently ICT skills much in demand by the youth.

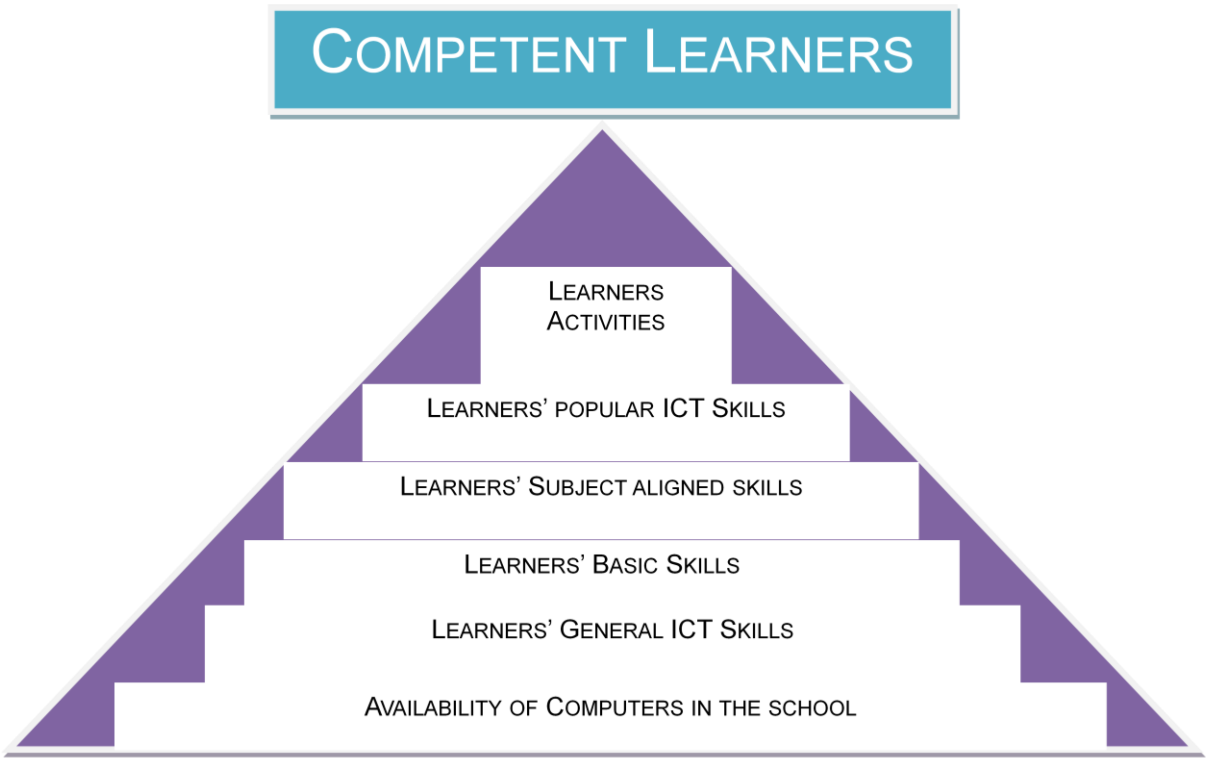

Figure 5.10: Thematic areas for competent learners

5.6 CHAPTER SUMMARY AND CONCLUSIONS

Whereas Kozma (2008), after studying both classrooms and schools on pedagogy and ICT use, came up with 12 major thematic areas in the integration of ICT in the classroom, in this study five major thematic areas emerged in the Swazi context:

Sufficient funding
Appropriate knowledge and skills
Efficient leadership
Proficient teachers
Competent learners.

These are the social building blocks (Kennisnet, 2006) that should be brought together to bring about an enabling environment for the integration of ICT. The creation of this enabling environment depends on the establishment and alignment of distributed policies (Draper, 2010; Howie, 2010; Kozma, 2008; Tiyla, 2008). These policies can eliminate obstacles.

As shown in Figure 5.3, the major obstacle (Bingimilas, 2009) in the "ICT world" of the all the teachers in the school is lack of ICT policy (Hodgkinson-Williams, Sieborger & Terzoli, 2007). This suggests that Swaziland remains in the readiness phase, compared to the South African situation (Blignaut & Howie 2009).

CHAPTER SIX

Conclusions, recommendations and reflections

6.1 INTRODUCTION

This chapter presents a summary, reflections, conclusions, and recommendations of the study to integrate ICT in the Mathematics and Science classrooms. The sections covered are: research in summary; summary of findings; reflections on conceptual framework, methodology and constructs. The conclusions and recommendations on policy, practice and further research were covered in the last section.

6.2 SUMMARY

The purpose of the study was to investigate the integration of ICT in the Swaziland Mathematics and Science classrooms. Mathematics and Science are core subjects in Swaziland and case studies around the world have shown that the integration of ICT in Science learning can enable innovative classroom practices (Webb, 2008). The study was guided by the following research questions:

> What is the status of ICT integration in Swaziland schools?
> What possible factors could explain the pedagogical use of ICT?

This study began by investigating the status of ICT integration in Swaziland (see chapter 4) and chapter 5 presented the factors characterising ICT integration. The following basic specific questions were addressed: what has been done, what should be done and what is “doable” in the integration of ICT in the Mathematics and Science classrooms to transform the country to an information society (Voogt, 2009) and bridge the digital divide which exists between Swaziland and the first world.

The design of the study was a survey using central tendency and multi-dimensional measurement analysis procedures (Cohen et al., 2005). A total of 43 schools from Manzini region were studied. The schools studied (sampling frame) had a laboratory, an ICT teacher and computers that were either purchased by the school, donated by the *Coca-Cola Foundation*, CET, or the government through the MoET. Data was collected using self-administered questionnaires delivered to Mathematics teachers, Science teachers, ICT teachers and principals. The response rate was 149 (87%), with all collected questionnaires usable. Non-response was mainly caused by factors such as death and transfers to other schools on a promotional basis. The SPSS was used in analysis of data. Descriptive statistics were used to present data and inferential statistics in the form factor and scale analysis were used. The findings were presented in tabular, graphic and narrative format.

6.3 SUMMARY OF FINDINGS

The findings to the research questions were as follows:

6.3.1 Research question one

In terms of the status quo of ICT integration in Swaziland schools the findings revealed that the head teachers and ICT teachers were mainly male (67% and 63% respectively), whereas the majority of Mathematics and Science teachers were mostly female (72% and 67% respectively). The age range was 46 to 55 years for head teachers, 21-35 years for ICT teachers, and 30-39 years for both Mathematics and Science teachers. In terms of ICT literacy, 67% of the ICT teachers were diploma holders, whereas 72% of the Mathematics and 78% of the Science teachers had no ICT qualification.

The SCR was found to be 13: 1. The students had to share a computer, and the average number of operational computers per school was found to be 29 for a statutory class size of 45. This meant that 16 learners shared computers, and by calculation only 13 had access to computers to learn, practice and perfect their computer skills.

On the same theme, 65% of the schools had no ICT policy, no network, no Internet, no printers, no laptops, no security alarm, badly designed computer laboratory, no power backup, and no burglar proofing. In most of the schools the computers were found to be old and out of date.

The maintenance of ICT infrastructure was found to be lacking. It was a disturbing finding of this research (see Table 4.6) that the average number of broken computers per school was nine. The percentage of schools that had access to the Internet was 17.9%, with 64% of the schools indicating that they had a whiteboard.

The major crosscutting obstacle in the study was found to be insufficient digital resources, that is digital learning materials in the form of learning objects, electronic content, localised syllabus, encyclopaedias and subject enrichment CDs, video CDs and DVDs.

6.3.2 Research question two

Regarding possible factors that explain the pedagogical use of ICT in Mathematics and Science classrooms, the study arrived at the following findings:

The total number of variables in the study, as shown in Table 5.1, was 361, and data reduction in factor analysis brought up 91 factors for the three constructs, ICT infrastructure, ICT obstacles and ICT integration

There were nine components under ICT infrastructure that had relatively high loadings and whose Eigen values were greater than 1 when using the varimax method. Out of the nine components eight were significant. The school computer laboratory as essential component was not significant. These significant components translated to eight thematic areas (Tilya, 2008) under ICT Infrastructure.

The major loading obstacles in Mathematics, Science and ICT teachers' "ICT worlds" were lack of ICT policy as the main thematic area to be addressed for the successful integration of ICT (see Figure 5.3). There were nine thematic areas under ICT Integration, including school readiness and curriculum orientation.

In the course of the study five social building blocks emerged with their thematic areas to ICT integration as possible and relevant social building blocks in the Swazi context. These were sufficient funding, appropriate knowledge and skills, proficient Mathematics, Science and ICT teachers, efficient leadership and competent learners.

6.4 REFLECTIONS

The following reflections arose from the study:

6.4.1 Conceptual framework

The Kennisnet model as a framework was helpful in that it presented a set of broad ideas and principles to guide and structure the study (Smyth, 2004). It gave the required direction to the study on the different constructs investigated (Liehr & Smith, 1999). It was during the factor analysis that it became apparent that the nature of the data in the Swazi context was different from that of the Netherlands, where the Kennisnet was developed. The model therefore had to go through a paradigm shift and was rearranged, reorganised and rephrased, as in chapter 5 (Figure 5.1). Nor did the Kennisnet model give the desired attention to learners' characteristics, as one issue with which the teachers were concerned. It became necessary to refer to Figure 2.3, and Howie's (2010) alignment of the Kennisnet 'Four-in Balance' model to Kozma's four elements.

6.4.2 Methodology

A survey was employed in the study. Four questionnaires were used to collect the data, as an adapted version of the SITES 2006 module. The adaptation eliminated aspects that were not relevant to the Swazi context. The units of analysis included the Mathematics teachers, Science teachers, principals of schools and ICT teachers. These international questions for SITES 2006 under the auspices of IEA (International association for Evaluation and Assessment) and the PPS (Probability Proportional to Size Sampling) technique (McGinn, 2004) proved useful in the study (see chapter 3). Regarding the exploratory factor analysis, this technique simplified the phenomenon and reduced the data and use of loadings, Eigen values, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's Test of Sphericity (BToS) to determine significant correlations between items (Field, 2011), thus triangulating the analysis and improving the transferability of findings.

In carrying out a nationwide survey, the instrument should further be reduced to include those sections which appear relevant and can be identified through a nominal group technique (NGT) (Cohen et al., 2005). This could also help to determine whether there are other constructs apart from the three in the study (ICT infrastructure, ICT obstacles and ICT integration). These three constructs that should be maintained and the NGT should decide which variables make up the constructs, so that the latent factors that exist but cannot be directly measured (DeCoster, 1998) can be summarised into thematic areas and grouped into domains to increase the reliability of items.

6.5 CONCLUSIONS

Having investigated the integration of ICT in the Swaziland Mathematics and Science classrooms, and based on the findings, the following two main conclusions have been drawn.

6.5.1 Conclusion 1

The ICT integration status of ICT in Swaziland Mathematics and Science classrooms is at the initial stage of readiness to use ICT stage when compared to the South African three phases of ICT integration.

At this stage the physical, financial and human resources are not adequate to support the integration of ICT in Mathematics and Science classrooms. In Chapter 4 it was established that the basic ICT infrastructure is inadequate to support the integration of ICT in Mathematics and Science classrooms, the subject teachers are not proficient (do not possess the required knowledge and skills), and the learners are not competent. Here the Mathematics and Science teachers have shown that they doubt the operational skills of the students, albeit the Student Computer Ratio (14:1) is very high. By the same token, the latest analysis highlights that ICT illiteracy rate in the country could have moved from an all-time high of 98% (James, Hesselmark & Sibiya, 2002) to 90.4%. This figure is also still high.

The thematic areas under efficient leadership and sufficient funding have also revealed that head teachers are not comfortable with the financial demands of the programme.

The ICT teachers, as shown in Chapter 4, are also not comfortable with the budget priorities of the head teachers. Under physical preparations they have not built classrooms that comply with ICT integration. Chapter 5, under the theme of area school computer laboratory essentials, registered the need for some effort in this area. The same chapter indicated lack of precursory factors for ICT integration in Mathematics and Science classrooms, which include general ICT use of, depth of, frequency of and confidence in ICT use, especially innovative use. Innovative use of ICT is a key element in ICT entrepreneurial skills (Drent, 2008). Nor is government helping, with the majority of the ICT teachers being paid by parents. Table 4.4 indicated the number of ICT teachers being paid by government to be only 2 in the Manzini region, a mere 6%.

6.5.2 Conclusion 2

The lack of school ICT policy has emerged as a major possible factor that could affect the integration of ICT in Mathematics and Science classrooms.

The obstacles of the teachers, including the head teachers, covered 18 thematic areas, with the lack of ICT policy emerging as a topical issue (See Figure 5.3). This is a problem even in South African schools, where the Gauteng online project became “Gauteng offline” (Draper, 2010). In Zimbabwe "lack of an ICT policy" at both Ministry and school level has contributed to the non-use of ICT. Coupled with this was a top down management structure in which school heads, teachers and students were used to operate on directives. The schools expected a directive in the form of a Ministry ICT policy, but this was absent. In turn, school ICT polices were not in place to direct the way ICT infrastructures in schools could be used optimally. Thus, while some teachers expected to have their subject timetabled for the laboratory to use computers this was not the case in the schools (Mlambo, 2007).

6.6 RECOMMENDATIONS

The following recommendations have been informed by the study findings, professional experience and the emancipatory interest of the researcher.

6.6.1 Policy and practice

The Swazi government has to set up an education task force to focus on ICT education thematic areas (Tiyla, 2008). Once in place, this should look at the relevance of the 2012 education sector policy, with an aim of aligning it to the country's ICT policy (MICT, 2010). This could create an enabling environment for distributed policies (Draper, 2010; Howie, 2010; Kozma, 2008; Tiyla, 2008). These policies, once implemented, should promote cooperation and support and eliminate a number of obstacles; ensure sufficient funding, appropriate knowledge and skills, efficient leadership, proficient teachers and competent students, and thereby give impetus to ICT integration in Mathematics and Science classrooms.

6.6.2 For future research

In the preliminary investigations of this research a three-phase model which presents itself as a pattern of how ICT integration has been conceptualised in the country emerged. This model is an undocumented model but is structured along the South African pattern. Research in this field will help to refute or support the claim of the Swazi three phase model. Particularly, studies are encouraged to study and document this model as it was an initiative by private-public partnership.

It would be interesting to find out if this model is classified under evolutionary, achievement, cognitive, cross curricula tool, software, and technology or pedagogical frameworks. Such findings would help to structure and address a number of problems faced by ICT professionals in the country.

6.6.3 A last word

In this research the student computer ratio (SCR) was found to be 13:1 and yet the average number of broken computers per school is 9; and with the Computer Education Trust having given a notice in 2011 that the computer distribution programme has come to an end and they will now be focusing on providing Internet to schools a vacuum has been created. This brings up a number of unanswered questions such as:

How will schools get computers?
Who will service the second hand computers CET donated to schools?
How will donor agencies liaise with schools?
What is the future of the computer laboratories?
Where will schools get digital materials?
Who will address the issues of software licensing in schools?
Are the schools computer laboratories ready for the Internet service?
How will the schools (mostly primary schools) that were not reached by the CET get assistance?
Has the work done by the CET been evaluated?
What lessons have been learned from the work done by CET in schools?

The above questions clearly point out that there is a big vacancy that the CET will leave behind. Therefore, it is against this background that I strongly recommend the establishment of a Swaziland Schools Media Centre as an outlet or an ICT centre to recycle and distribute information and communication technologies, digital materials, software and especially open source software to schools.

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APPENDIX A

TABLES AND FIGURES

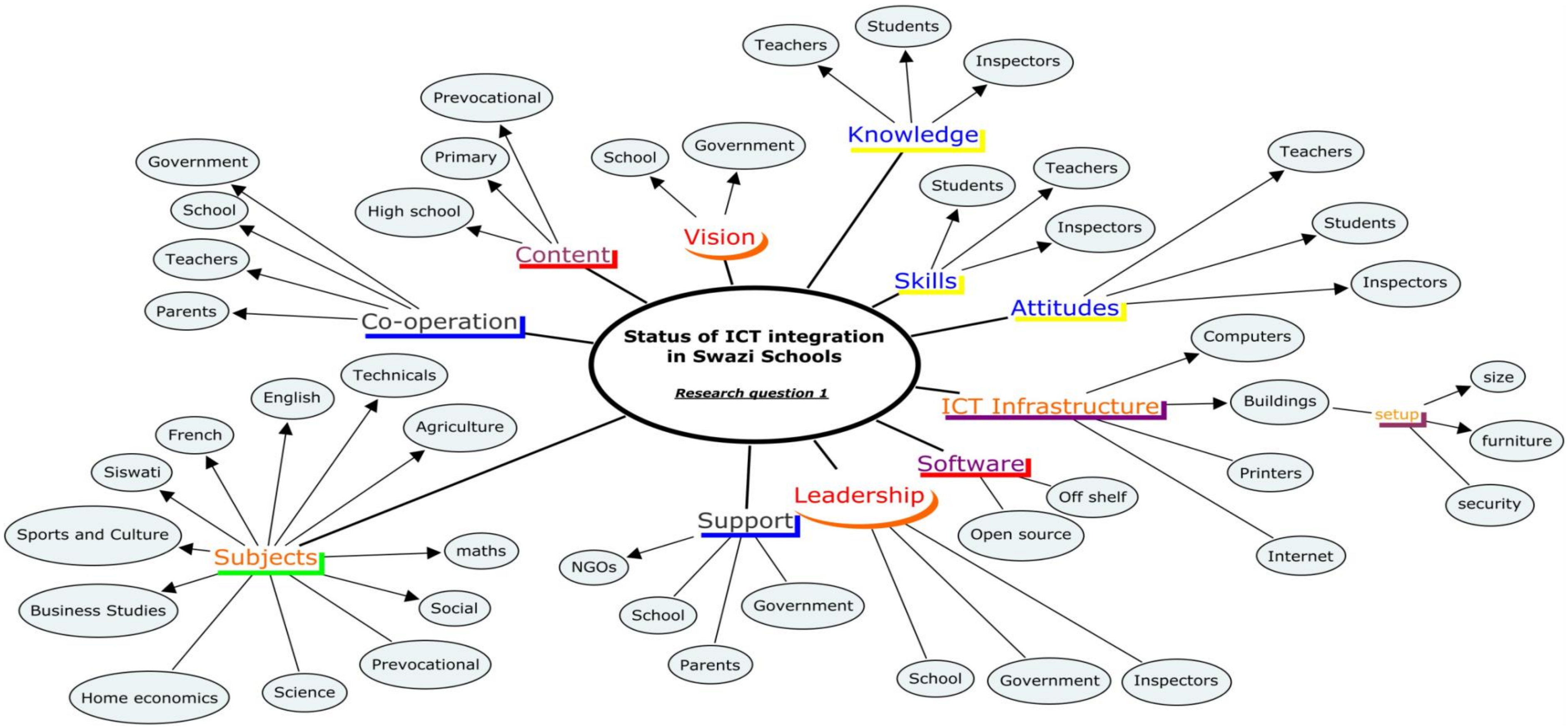

Figure A1: Theoretical base of the study

Table A1: Research design framework and questionnaire audit table

Kennisnet model based data level questions	Technical / Infrastructure Questionnaire (ICT teacher)	Teacher Questionnaire (Mathematics and Science)	Principal Questionnaire
Use of ICT in education / Pedagogical use of ICT for learning			
1.1 How many teachers use ICT in their lessons?			Section D ,Q10; Section B ,Q3,Q4;
1.2 How often is ICT actually used?	Section A Q6	Section A Q2; Section F, Q17; Section B ,Q3; Section C ,Q4	Section E, Q18
1.3 What is ICT used for?	Section A ,Q4B,C,E.	Section A ,Q1	Section B ,Q3,Q4; Section E Q20
1.4 Is there use of ICT by teachers?	Section A,Q5B,C,	Section D ,Q5; Section C, Q4; Section F, Q18	Section B ,Q4; Section E Q20
1.5 How much ICT is used?	Section B, Q7	Section E, Q8; Section A ,Q1	Section D, Q14; Section E Q20
Vision / Distributed policies			
2.1 Is there an ICT Policy?	Section A, Q4A.		Section A ,Q1,
2.2 What is the size of the school ICT	Section D,M.		Section A Q2; Section D

budget?			,Q6,12;
2.3 What is the school vision about ICT?	Section A ,Q5; Section D, Q12N	Section E, Q8; Section D ,Q6	Section A ,Q1
2.4 What are the obstacles where the vision need support from stakeholders?	Section D, Q12	Section E, Q8	Section C ,Q5
Expertise / knowledge, attitude and skills / training plan			
3.1 is there familiarity with the possibilities opened up by ICT?	Section B, Q7	Section A ,Q1; Section B ,Q3; Section C ,Q4; Section D ,Q6; Section E ,Q8;	Section B ,Q3
3.2 Are Teachers' ICT skills adequate for integration?	Section D, Q12I	Section A Q2; Section E, Q7,Q9,Q16; Section E, Q8C,D,E,I.	Section B, Q4
3.3 Are Pupils' skills adequate for integration?	Section A ,Q6	Section A ,Q1;Section B,Q3; Section E8F	
Digital learning materials / educational software and content			
4.1 Is the proportion of digital learning materials adequate?	Section B ,Q12	Section C ,Q4	
4.2 What digital learning materials are used most frequently?	Section B Q12	Section C, Q4	

4.3 Have priorities been set for integration?	Section A ,Q4	Section D, Q6	
4.4 Are digital learning materials adequate?	Section B ,Q12	Section E, Q8J	
ICT infrastructure / Infrastructure Technical support			
5.1 Are the Computers / ICT infrastructure adequate?	Section C, Q8,910;Section D, Q12	Section E, Q8B,J,L	
5.2 Is there a plan to replace obsolete computers?	Section C ,Q11		Section D ,Q11
5.3 Is there an Internet connection?	Section AQ4C; Section D, Q12B,C. Section E, Q18	Section E, Q12	Section E, Q20
5.4 Which types of whiteboards are available?	Section B, Q7J	Section C, Q4J	
5.5 Is there equipment for using web video?		Section C, Q4D	
5.6 Is the management and maintenance of computer facilities satisfactory?	Section C ,Q11		Section C, Q5
5.7 Are ICT facilities adequate?		Section A ,Q1; Section E, Q9B,J,L.	Section A ,Q1

Table A2: ICT infrastructure

Factors	Description	Variables presented For factor analysis	Response Options	Loading Components Labels (Correlations Varimax)	Chronbach's Alpha KMO)	Variables per component	Eigen values	BToS X^2(df)
1.Laboratory Condition	ICT lab status functional condition	10	1-No 2-Yes	*Laboratory Essentials (0.88)*	0.70(0.5)**	2	1.5	11.8(1)
2.Resource materials	Technology applications on ICT infrastructure	12	1-Available 2-Needed but not 1 3-Not needed not 1	*E. Learning Resources (0.74)*		4	3.6	
				Communication Resources (0.73)	0.70(0.63)**	4	2.3	188.2(78)*
				Digital resources (0.72)		2	1.4	
				Teaching Resources(0.67)		2	1.4	
3. Budget Priorities	School fees that goes towards ICT infrastructure	11	1-Not at all 2-Low priority 3-Medium priority 4- High priority	*E. Learning Budget(0.77)*		4	4.3	
				Skill development Budget (0.74)	0.81(0.61)**	4	1.6	144.7(66)*
4. Available Computers	Explains the quantities of available ICT infrastructure	12	Actual numbers	*Available to all (0.73)*		4	4.0	
				Available to learners(0.85)	0.74(0.45)	3	2.0	211.4(78)*
				Available to staff (0.91)		2	1.7	
				Available to none (0.76)		2	1.0	
5.Maintenance	Explains the type of maintenance and technical support available to ICT infrastructure.	6	1-No 2-Yes	*Donorfunded maintenance (0.85)*		2	2.0	
				School funded maintenance(0.57)	ˉ0.32(0.51)**	2	1.6	22.5(15)

p* < 0.001 significant correlations between items were sufficiently large for principle component analysis

Acceptable *sample size to yield reliable factors.*

Table A3: ICT obstacles

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X^2(df)
1.Finance	Subject fee.	2	Actual numbers	*Computer fees (0.99)*	*0.97*(0.5)**	2	1.9	42.6(1)*
2.Head teacher Profile	Computer usage by the Head teacher	3	1-No 2-Yes	*Home computer use (0.76)*	*0.38*(0.5)**	2	1.2	1.3(1)
3. ICT teacher Profile	Computer usage by the ICT teachers	3	1-No 2-Yes	*Home Internet available (0.83)*	*0.47*(0.5)**	2	1.4	4.9(1)
4. Science Teacher Profile	Computer usage by the Science teachers	3	1-No 2-Yes	*Home computer use (0.87)*	¯*0.61*(0.6)**	2	1.3	5.0(28)
5. Mathematics Teacher Profile	Computer usage by Mathematics teachers	3	1-No 2-Yes	*Home computer use (0.87)*	*0.40*(0.5)	2	1.5	5.5(3)
6. Science Learners Profile	ICT competences of Learners	9	1-Nearly none 2-Some learners 3-Majority of learners 4-Nearly all learners	*General skills (0.73)* *Popular skills (0.76)*	*0.89*(0.7)	5 4	4.8 1.1	169.3(36)*
7. Mathematics Learners Profile	ICT competences of Learners	9	1-Nearly none 2-Some learners 3-Majority of learners 4-Nearly all learners	*General skills (0.77)* *Popular skills (0.77)*	*0.97*(0.8)**	5 4	5.0 1.3	189(36)*
8.Curriculum orientation	The teaching style and paradigms in the various subjects	9	1-Never 2-Sometimes 3-Often 4- Always	*Basic subjects (0.86)* *Common subjects(0.74)*	*0.90*(0.7)**	5 3	5.2 1.4	173.2(36)*

**p < 0.001 significant correlations between items were sufficiently large for principle component analysis*

** Acceptable *sample size to yield reliable factors.*

Table A3: ICT obstacles factors continued

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X^2(df)
9.Policies	ICT policies provide for the vision.	11	1-No 2-Yes	*Lack of School ICT Policy(0.12)*	*0.55*(0.5)**	2	1.4	6(1)
10. Head teacher Obstacles	Explains the usage of computers by the ICT teachers	15	1-Not at all 2-Very little 3-Somewhat 4-To a great extent 5-Not applicable	*Upgrading Computers (0.69)*		2	4.5	
				Internet Connection(0.89)	*0.80*(0.5)**	2	2.3	204.1(105)*
				Digital Resources (0.71)		3	1.7	
11. ICT Teacher Obstacles	Explains the usage of computers by the Science teachers	15	1-Not at all 2-Very little 3-Somewhat 4-To a great extent 5-Not applicable	*Curriculum Orientation (0.71)*		6	5.6	
				Cooperation and Support (0.81)	*0.87*(0.6)**	4	3.0	366.7(105)*
				Lack of School ICT policy(0.77)		2	1.5	
				Computers and Internet(0.77)		2	1.1	
12. Science Teacher Obstacles	Explains the usage of computer by the Mathematics teachers	12	1-No 2-Yes	*Learners and Teachers ICT skills*(0.73)		4	3.3	
				Lack of School ICT policy(0.75)	*0.70*(0.5)**	3	1.6	119.6(66)*
13. Mathematics Teacher Obstacles	Explains the ICT competes of Learners	12	1-No 2-Yes	*Lack of skills and Resources(0.65)*		5	3.6	
				Knowledge(0.77)		2	1.8	
				Lack of School ICT policy(0.69)	*0.7*(0.6)**	3	1.3	120.9(66)*
				Time constraints(0.82)		1	1.0	

**p* < 0.001 significant correlations between items were sufficiently large for principle component analysis*

** Acceptable *sample size to yield reliable factors.*

Table A4: ICT integration factors

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X^2(df)
1.Science Teachers Confidence in General ICT Use	**Application of basic** ICT knowledge	8	1-Not at all 2-A little 3-Somewhat	*ICT for Communication*(0.85) *ICT for Desktop publishing*(0.78)	*0.92*(0.5)**	3 4	4.7 1.0	*31.6(*11)
2. Mathematics Teachers Confidence in General ICT Use	**Application of basic** ICT knowledge	8	1-Not at all 2-A little 3-Somewhat	*ICT for Desktop publishing(0.86)* *ICT for Communication(0.85)*	*0.9*(0.7)**	5 2	4.4 1.6	*55.7(28)**
3.Science Teachers Innovative ICT Use	**ICT driven learner** centred activities requiring modelling, instructional designing, development and innovative thinking and creative ideas.	20	1-No 2-Yes	*Innovative ICT Use*(0.83)	*0.83*(0.5)**	20	4.4	*2.9(*24)*
4. Mathematics Teachers Innovative ICT Use	I**CT driven learner** centred activities requiring modelling, instructional designing, development and innovative thinking and creative ideas.	20	1-No 2-Yes	*Learners Activities(0.80)* *Teachers Activities(0.86)* *Learners Assessment0.78()* *Remediation activities(0.81)*	*0.9*(0.6)**	7 4 6 3	12.3 2.2 1.8 1.1	*55.4(28)**

**p < 0.001 significant correlations between items were sufficiently large for principle component analysis*
** Acceptable *sample size to yield reliable factors.*

Table A4: ICT Integration factors continued

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X^2(df)
5. Science Teachers ICT Training	**Professional** development activities that teachers have participated in.		1-No, I do not wish to attend 2-No, I would like to attend 3-Yes, I have attended	*ICT training(0.86)*	*0.89*(0.7)**	6	4.7	*7.5(34)**
6. Mathematics Teacher ICT Training	**Professional** development activities that teachers have participated in.	7	1-No, I do not wish to attend 2-No, I would like to attend 3-Yes, I have attended	*Advanced Course*(0.78)	*0.90*(0.8)**	6	4.2	*150.5(21)**
7. Science Teachers Depth of ICT Use	**Knowledge and** accomplishments to indicate extent of ICT use by teachers.	12	1-Not at all 2-A little 3-Somewhat 4. A lot	*High ICT use* (0.91)	*0.84*(0.6)**	6	6.3	5.1(3)
				ModerateICT use(0.92)		2	3.0	
8. Mathematics Teachers Depth of ICT Use	**Knowledge and** accomplishments to indicate extent of ICT use by teachers.	12	1-Not at all 2-A little 3-Somewhat 4. A lot	*High ICT use* (0.87)	*0.81*(0.6)**	5	15.4	*185.4(46)**
				Moderate ICT use(0.88)		4	4.5	
				Low ICT use(0.73)		2	1.8	
9. Science Teachers Frequency of ICT Use	**How often teachers** incorporate ICT in practice	12	1-Never 2-Sometimes 3-Often 4- Nearly always	*High Integration*(0.78)	*0.70*(0.7)**	3	3.8	*181.4(66)**
				Moderate Integration(0.87)		2	2.1	
				Low Integration(0.81)				
				Unlimited Integration(0.81)		2	1.2	
10. Mathematics Teachers Frequency of ICT Use	**How often teachers** incorporate ICT in practice	12	1-Never 2-Sometimes 3-Often 4- Nearly always	*Very High Integration*(0.78)	*0.84*(0.5)**	3	5.3	*140.3(66)**
				High Integration(0.78)		3	3.5	
				Moderate Integration(0.72)		2	2.4	

**p* < 0.001 *significant correlations between items were sufficiently large for principle component analysis*

** Acceptable *sample size to yield reliable factors.*

Table A4: ICT integration factors continued

Factors	Description	Variables presented for F.A.	Response Options	Loading Components labels (Correlations Varimax)	Chronbach's Alpha (KMO)	Variables per component	Eigen values	BToS X^2(df)
11. School Readiness to integrate ICT	Preparations for ICT Integration.	6	1-No 2-Yes	*Preparing ICT infrastructure* (0.79) *Preparing Pedagogical approaches*(0.77)	*0.48(0.40)*	2 2	1.5 1.4	17.5(15)
12. School ICT Integration	Usage of ICT in the school as a community of practice	5	1-Strongly disagree 2-Disagree 3-Agree 4- Strongly Agree	*Present Status*(0.86)	*¯0.99(0.5)***	2	1.8	29.5(10)*
13. Science Teachers Pedagogical Use of ICT	Classroom use of ICT to enhance the teaching and learning process	8	1-Not at all 2-A little 3-Somewhat	*Teaching and learning* (0.78) *Pedagogical support* (0.85)	*0.92(0.7)***	4 3	4.6 1.0	70.1(21)*
14. Mathematics Teachers Pedagogical Use of ICT	Classroom use of ICT to enhance the teaching and learning process	8	1-Not at all 2-A little 3-Somewhat	*Pedagogical support* (0.85) *Teaching and learning*(0.83)	*0.94(0.6)***	4 4	5.6 1.0	88.9(28)*

**p < 0.001 significant correlations between items were sufficiently large for principle component analysis*

** Acceptable *sample size to yield reliable factors.*

APPENDIX B

PERMISSION LETTERS