The Pedagogical Use of ICTs for Teaching and Learning within Grade Eight Mathematics in South African Schools

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Abstract

Information and communication technology (ICT) has become part of education as it has, in many cases, become the mode of choice of communication with people in all spheres of life. It provides teachers with the opportunity to access information from a vast array of resources that assists them in their teaching practices. Education in South Africa is constantly transforming to new requirements from the National Department of Education (NDoE). The fundamentals of Outcomes Based Education are lifelong learning and the development of 21st century skills that allow learners to use information for different contexts. ICT enables teachers and learners to access computer systems to develop skills, interact with their peers, colleagues, and the global society. Even though teachers know the value of ICT in teaching and learning, the pedagogical use of ICT in South African schools remains limited. In the SITES 2006, South African teachers acknowledged that they were enthusiastic to explore new ways to make teaching and learning more interesting, but that they encountered many barriers that hinder the pedagogical use of ICT for mathematics. This research has determined that the teachers' ICT pedagogical knowledge contributed towards more effective teaching and learning practices of mathematics in South African schools. The study also describes how insufficient ICT pedagogical knowledge affected teachers' confidence to explore ICT tools. This study followed a secondary data analysis (SDA) of the Second International Information Technology in Education Study of 2006 (SITES 2006) data from the 640 participating mathematics teachers in South Africa. The correlated data describes the technological pedagogical content knowledge (TPCK) of mathematics teachers while making use of ICT. Continuous professional teacher development is required to focus on the attainment of information technology pedagogical knowledge to further the use of ICT on the teaching of Mathematics. The study also indicates that South Africa lags far behind the other 22 countries that participated in SITES 2006.

Keywords:

Mathematics education; information and communication technology; technological pedagogical content knowledge (TPCK); SITES 2006; e-Education policy; continuous professional teacher development (CPTD); secondary data analysis (SDA).

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List of Acronyms

ANOVA	Analysis of variance
CD	Compact disk
CK	Content knowledge
DVD	Digital video disk
CD-ROM	Compact disk, read only memory
CPTD	Continuous Professional Teacher Development
FET	Further Education and Training
GET	General Education and Training
HOTS	Higher Order Thinking Skills
ICT	Information and Communication Technology
IEA	International Association for the Evaluation of Educational Achievement
ISAD	Information Society and Development
IT	Information Technology
KHANYA	Western Cape Educational Department Technology in Education Project
NAPTOSA	National Professional Teachers' Organisation of South Africa
NCS	National Curriculum Statement
NDoE	National Department of Education
NEPAD	New Partnership for African Development
NRC	National Research Coordinator
OBE	Outcomes Based Education
ODC	Online data collection
OfSTED	The Officer for Standards in Education
OLSET	Open Learning Systems Educational Trust
PC	Pedagogical content
PCK	Pedagogical content knowledge
PK	Pedagogical knowledge
PIRLS	Progress in International Reading Literacy Study
PNC	Presidential Commission on Information Society and Development
PCA	Problem-Centered Approach
SAR	Hong Kong Special Administrative Regions
SABC	South African Broadcasting Cooperation
SDA	Secondary data analysis
SITES	Second International Information Technology in Education Study
SMME	Small, medium and micro enterprises
SMT	Senior Management Team
TIMMS	Trends in International Mathematics and Science Study

TK	Technological knowledge
TCK	Technological content knowledge
TPK	Technological pedagogical knowledge
TPCK	Technological pedagogical content knowledge
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VSAT	Very Small Aperture Terminal

Chapter One

Introduction to the Study

1.1 Introduction

The technological era demands that learners develop higher order thinking skills (HOTS) in school education. Mathematics is an indispensable part of the curriculum and has an important role in the development of HOTS to accomplish the tasks relevant to achieving the outcomes and developing skills like conceptualising, abstraction, generalisation, problem solving and information-processing (Nieuwoudt, 2006: 150-155). The South African education system should adapt to the change and use information and communication technology (ICTs) to enhance the development of HOTS through integrated ICT teaching and learning (South Africa, 2004b: 4).

The Second International Information Technology in Education Study (SITES 2006) was a large scale comparative survey that provided an extended view on the pedagogical practices of ICT across the world (Pelgrum *et al.*, 2008: 10, 16) (Chapter 3). The study constructed three questionnaires that were administered to school principals, ICT coordinators at schools, and mathematics and science teachers in a probabilistic sample of more than 400 schools per country or education system. SITES 2006 focused on the role ICT can play in the teaching and learning of mathematics in schools and examined how it can contribute towards the development of 21st century skills. They include conceptualising, abstraction, generalisation, problem solving and information processing. From these results, South Africa ranked the lowest ICT use for teaching and learning mathematics. Findings indicate that other factors besides policy and school level conditions contribute to the insufficient ICT use in teaching and learning (IEA, 2007: 2).

This chapter provides an overview of the background of the study, the purpose of the research, the clarification of relevant terminology, as well as an outline of the following chapters.

1.2 Background and problem statement

The pedagogical use of ICTs consists of two main components, namely the application of pedagogy and the use of ICTs. Mishra (2008) refers to the importance of having a sound technological pedagogical content knowledge (TPCK) to ensure the effective integration of ICTs in schools. Pedagogy is an active method of teaching with confidence using certain techniques, strategies and technologies to attain pedagogical goals within a specific environment, as well as assisting learners through interaction and activity in the ongoing academic and social events of the classroom (BlogSpot, 2008; Farlex, 2009: online; Martinet *et al.*, 2001: 43-50). It is also known as the study or scientific method of teaching where the teacher has to acquire relevant pedagogical knowledge and techniques to be able to teach competently and confidently (BlogSpot, 2008: online). Besides having adequate pedagogical knowledge, teachers should be knowledgeable about the content of their subject (content knowledge) as well. The third important element in the TPCK is technological knowledge. Technological knowledge is the ability to use the ICTs in teaching and learning of content knowledge to learners. ICTs are characterised as artificial and symbolical technologies implemented in schools to facilitate the teaching and learning process (Bosco, 2004: 266). Technological tools such as graphing calculators, geometric software, multimedia tools and the Internet are useful tools in teaching and learning mathematics (Jarred, 1998: 8). According to the *White Paper on e-Education (South Africa, 2004b: 14)*, ICTs represent the convergence of information technology and communication technology and the combination of networks, hardware and software, as well as the means of electronic communication. The pedagogical use of ICTs refers to the methods and practices involved in using ICTs for teaching and learning processes (Law *et al.*, 2008e: 5). While pedagogy has a broad usage, for the purpose of this investigation the ICT pedagogical practices of teachers relating to the methods, techniques and strategies of ICT use in classrooms will be investigated (South Africa, 2002: 8).

The *National Curriculum Statements for grades R*-9 (South Africa, 2002), the South African education system is based on progressive, learner-centered, outcomes-based education, with an integrated approach to knowledge. Both *The Need for an e-Education Initiative* (South Africa, 2007b: 81) and the National Curriculum Statement (South Africa, 2002: 8) for grades R-9, encourage the use of ICTs for teaching and learning, especially in learning areas not traditionally taught through these tools. This encouragement is manifested in the critical outcomes, which among others, require learners to use science and technology to solve problems and communicate (South Africa, 2007a: 57-58). Some of the most effective methods of teaching mathematics can be applied by means of certain electronic devices and technologies (South Africa, 2007a: 5). Technology can be used to effectively master routine elements of measuring, calculating, tabulating and graphing, which are some of the basic mathematics processes learners have to master in grade 8 (Ruthven *et al.*, 2002: 50).

Learning with ICTs is a powerful way to support learners to achieve NCS goals (South Africa, 2007a: 19). However, the South African results from international surveys and studies on the use of ICTs do not reflect the vision stated within the policy documents. South Africa also participated in other large scale studies: the international reading literacy levels (PIRLS), Trends in learner achievement in mathematics and science (TIMMS) and SITES through the International Association for the Evaluation of Achievement (IEA). South Africa performed poorly in all these studies compared to the other participating education systems. Though ICT can add value to the teaching and learning of mathematics, it is only effective when the three main components of the learning environment are used simultaneously: (i) the content (subject matter), (ii) the pedagogy (means of teaching) and, (iii) the technology (Mishra *et al.*, 2006a: 1019). This implies a sound pedagogical content knowledge on the use of ICTs. This study will, through secondary data analysis of the SITES 2006 data, investigate teachers' pedagogical use of ICTs for teaching and learning of mathematics in South African schools.

Mathematical pedagogy is based on the philosophy of mathematics. Many view mathematics as a set of rules, while others regard mathematics as a combination of deductive and inductive processes (Huetinck *et al.*, 2000: 12). The teacher should be in charge of relevant mathematical knowledge, skills, attitudes and values that the learners should achieve in order to facilitate learners in a specific context. Therefore, effective mathematics teaching is not only about the personal attributes of the teacher, but also about the contextual perspective of teaching and learning mathematics. Learners with different learning styles should be challenged and supported to meet the expectations and reach the logical and analytical outcomes required from a formal science subject like mathematics (Goldsmith *et al.*, 1993a: 124-131). The teachers questionnaire of the SITES 2006 study (International Association for the Evaluation of Educational Achievement, 2006) investigated, amongst others things, how and to what extend ICTs foster learners' ability and readiness to set their own learning goals and to plan, monitor and evaluate their own progress, as well as to what extent ICTs impact problem-solving skills, self-directed learning skills, collaborative skills, etc.

The problem-centred approach (PCA), which is also a socio-constructivist approach is proposed as the best practice for mathematics education at school level (Nieuwoudt, 2006: 33; Ridlon, 2004: 2). Through PCA activities mathematics is not based on drill and practice exercises, but relates to the active engagement of learners in mathematical problems and activities relating to their immediate environments. Two cornerstones of PCA are problem-solving contexts and social interaction (Nieuwoudt, 2006: 36). According to Murray *et al*. (1998: 171) social interaction creates opportunities for learners to talk about their own thinking which is essential for meta-cognition and reflective thinking. Reflective thinking is an important requirement for effective learning (Du Plessis *et al.*, 2008: 16). Learners learn from the knowledge they construct during social interaction with their peers. Meaningful problem solving and HOTS occur within learner-learner and teacher-learner relationships which develop during such social constructivist interaction: "Technology's greatest impact on learning is in the area of problem solving and higher order thinking and when technology is integrated into the core curriculum it can be an exceptionally powerful teaching and learning tool" (Jarred, 1998: 5).

Teachers who experience difficulties in developing learners' understanding of mathematics, could make use of ICTs to provide visual and dynamic representations of abstract ideas (Kennewell, 2004: 61). Teachers can, amongst others, obtain pedagogical support through a variety of technological means: downloading teaching materials from the Internet, improving their pedagogical knowledge though professional development, coping with curriculum changes through peer support, as well as developing insight and obtaining advice from other online mathematics teachers. ICTs can assist teachers in providing individual tuition and support to learners, especially learners with special needs. Also, teachers can use ICTs to assist in electronic assessments, to keep record of marks and outcomes, to report results, as well as to do many other repetitive administrative tasks (Oldknow *et al.*, 2003: 241). ICTs can provide opportunities to learners to apply mathematical skills in extended projects (Way *et al.*, 2007: 20). According to the *Need for an e-Education Initiative* (South Africa, 2007a: 104), ICTs make unique pedagogical contributions to the development of learners' mathematical skills when they connect within and across areas of mathematics. Examples are relational symbolical functions, computation of set values, and graphical representations generated of a mathematical situation. Some key elements of the *National Curriculum Statement for grade R-9* (South Africa, 2002) cannot be successfully accomplished without the use of ICTs.

The effective use of ICTs can challenge current pedagogical practices, as they facilitate efficient and reliable communication between teachers (Tirosh *et al.*, 2003: 653). According to the *White Paper on e-Education* (South Africa, 2004b: 6&41), ICTs are obligatory to the changes taking place throughout the world. Furthermore, the e-Education policy intends that all teachers should have integrated ICTs into their classrooms by 2013. The percentage of South African schools with computers only increased from 18% during the 1998 study to about 38% during the 2006 study, despite South Africa's enormous development leap during this period (Pelgrum, 2008a: 74). Considering the above stated 2013 objectives of the White Paper of e-Education and the fact that PCA is currently proposed as best practice for mathematics education at school level (Nieuwoudt, 2006: 33), it is important that ICTs should link to the basic requirements of PCA for the effective teaching and learning of mathematics. ICTs can support PCA and at the same time add value to the teaching and learning of mathematics (Law *et al.*, 2008e). With proper equipment and training, teachers can easily use ICTs to compose and facilitate assessments. One of the most widely used ICT in mathematics is the calculator. While many learners in rural areas share calculators in groups because of poverty in the community, the greater majority of learners do get the opportunity to use calculators in mathematic classrooms and at home. Computer facilities are increasingly being implemented at schools in South Africa, and it is therefore expected that mathematical computer software will be used by more schools in the future.

From the above, it becomes evident that ICTs offer benefits for the teaching and learning of mathematics. However, only 8% of grade 8 South African mathematics teachers that participated in the SITES 2006 studies (2008: online) reported that they made use of ICTs in their teaching of mathematics (Law *et al.*, 2008e: 159). Many respondents from the SITES 2006 indicated that the real benefit of ICTs only becomes evident when teachers are both competent and confident to use ICTs. Ruthven and Hennessy (2000: 43-88) and Law *et al*. (2008e), ICTs have the potential to change the way mathematics is taught, but only when teachers are confident to use ICTs effectively in front of their learners, who are often more ICT competent than them. Competent teachers plan effectively with clear goals and specific instructional objectives, act with confidence, and reflect on how they teach (Department of Education, 2002; Eison, 1990: 21). Such teachers tend to be more open towards change relating to their teaching practices when they realise the value of ICTs for mathematics teaching.

All Singapore's learners had access to ICTs since 1998 and were the best performers in TIMMS 2003 still identified a number of barriers preventing teachers from using ICTs in teaching and learning (Law *et al.*, 2008e). Some of their teachers were not confident to use ICTs due to intrinsic and extrinsic reasons. Extrinsic barriers related to the inability to change, the lack of control over access to ICTs, insufficient time to plan instruction, inadequate technical skills, insufficient training to support teachers with the ICT integration processes, as well as pressure from management for learner achievement (Lim *et al.*, 2006: 100). An additional extrinsic barrier important to the South African context is the unavailability of guidelines for the integration of ICTs in mathematics teaching and learning (Department of Education, 2007: 229). Intrinsic barriers relate to teachers' low appreciation of the benefits of ICTs in the learning process, their beliefs about what constitutes good teaching, the teaching practices at the specific schools, the role of ICTs in teachers' lives, teachers' reluctance to change, and technophobia (Law *et al.*, 2008e). Large scale quantitative data of South Africa's participation in SITES 2006 (Law *et al.*, 2008e) provide a valuable opportunity to explore different intrinsic and extrinsic barriers of ICT use for pedagogical purposes in grade 8 mathematics in South Africa.

Both the intrinsic and extrinsic barriers to teaching and learning with ICTs can be managed. Extrinsic barriers can be managed through professional teacher development to assist in the ICT integration process. Also, effective management of time and schedules assist teachers to plan their ICT pedagogical integration, and also support them in the selection and use of educational software (Lim *et al.*, 2006: 103). When teachers focus on resolving their intrinsic barriers, their confidence and competencies increase and they become more open to change. Therefore, both extrinsic and intrinsic barriers should be addressed in order to facilitate effective change in schools (Drent *et al.*, 2007: 189).

From the above exposition, the following research questions arise: What is the pedagogical use of ICTs for the teaching and learning of grade 8 mathematics in South African schools? To what extend can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?

1.3 Purpose of the research

The aim of this study is to determine:

(i) what teachers' pedagogical use of ICTs is within the teaching and learning of grade 8 mathematics in South African schools

(ii) to what extend knowledge of the pedagogical use of ICTs in grade 8 mathematics contributes toward more effective mathematics teaching in schools

Conducting this research will give the National Department of Education (NDoE) some insight to the progress of ICT integration in schools in collaboration with the aims set by the e-Education policy in the three phase plan (South Africa, 2004b: 22-23) (Chapter 6), the extent of the pedagogical use of ICT by teachers in mathematics classroom in South Africa, and the areas at system, school and teacher level that need to be addressed in order to achieve those aims.

1.4 Research design and methodology

The study will follow a basic secondary data analysis (SDA) methodology that includes a scholarly review of the literature, as well as analyses of the South African data of SITES 2006 (Smith, 2008: 4). The central theme of the SITES group of studies was to understand how ICTs affect the way learners learn in schools. For the purpose of this investigation, only the South African dataset for 640 grade 8 mathematics teachers who completed the teachers' questionnaire was used for the SDA to gain insight in the pedagogical use of ICTs in mathematics in South Africa.

1.5 Clarification of important terminology

The important terminology for this study is:

- ***Pedagogical use*** of ICT in education refers to the science or profession of teaching, which includes how the teaching occurs, the approach to teaching and learning, the way the content is delivered and what the learners learn as result of the process (Oakland, 2010: 1). The use of ICT in mathematics is an example of an approach to deliver the subject content or the classroom pedagogy (Law *et al.*, 2008e). Technological pedagogical content knowledge (TPCK) links the pedagogy, content and knowledge and is central to effective teaching and learning with ICT (Chapter 2).
- ***Mathematics education*** focuses on engaging learners in problem solving situations, requiring reasoning, discovering, inventing and communication of ideas and ultimately critically evaluating the results and reflecting on the whole teaching and learning process (Thompson, 1988: 128)
- ***The International Evaluation for the Educational Achievement*** (IEA) started work in 1967 when a group of scholars, educational psychologist, sociologist and psychometricians met at the UNESCO Institute for Education in Hamburg to voice their concern regarding problems in school and education. Since then they have used educational systems across the world to experiment, using a variety of research methods to get results for many questions concerning education and the meaningful contribution towards the development of educational outcomes (IEA, 2007: 1).
- ***The Second International Information Technology in Education Study*** (SITES 2006) is an international comparative research study conducted under the support of the IEA to research the use of ICT in education. The study does not focus on the learner performance and abilities, but on the pedagogical practices with ICT and the availability and integration of ICT in schools (Pelgrum *et al.*, 2008: 2).

1.6 Layout of the chapters

Chapter 1 provides an overview of the research study and addresses the introduction to the research, the statement of the problem for the research, background to the study, the purpose of the research, and clarification of terminology used throughout the study.

Chapter 2 links the relevant literature and underpinning philosophy of teaching and learning to pedagogical practices of mathematics education in schools, resources available for teaching and learning mathematics, the pedagogical use of ICT and how ICT can contribute to the effective teaching and learning of grade 8 mathematics. The existing ICT-related policy model in South Africa is discussed and how it relates to some other systems. The barriers experienced to implementing ICT in South African schools are discussed and how these barriers can be overcome. The management of ICT at system, school and classroom level is also addressed. The professional development status in South Africa, the strategies implemented at system and school level, as well as the importance thereof is discussed.

Chapter 3 provides an overview of the all the SITES Modules since the commencement of the research by the IEA, specifically focussing on the purpose of the research, the research design and methodology of all SITES research conducted, the findings from SITES M1 conducted between 1997and 1999, SITES M2 conducted from 2000 and 2002, and SITES 2006 which started in 2004 until 2006, and the recommendations made for future research.

Chapter 4 describes the research design and methodology of the SDA of the 504 South African participating computer and non-computer schools; the nature of the dataset; the ethical consideration; the variables that were identified for correlation SDA; and the statistical analysis procedures in this SDA.

Chapter 5 analyses the results of the pedagogical use of ICT in grade 8 mathematics in South African schools and the SDA conducted to answer the research question: whether the knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools.

Chapter 6 summarises the findings which have affected the three phase plan of the e-Education policy in South Africa, the ICT integration process in schools, and recommendations at system, school and teacher level to have ICT into all schools in South Africa by 2013 specifically in the teaching and learning of all learning areas (subjects) (South Africa, 2004b).

Chapter Two

Literature Review

2.1 Introduction

This chapter describes the ICT use in mathematics education in South African schools. Firstly, it refers to philosophical views of mathematical teachers and how these views underpin the teaching and learning of mathematics in schools. This chapter also obtains information from the e-Education policy (South Africa, 2004b), the National Curriculum Statement (NCS) for mathematics (South Africa, 2002), and how these policies compare to those from other educational systems. This chapter outlines the South African e-Education implementation model developed by the NDoE and reviews the current implementation status of ICT in South African schools. The chapter also describes the multiple resources available for teaching mathematics in schools, the availability of ICT infrastructure in South African schools, as well as how ICTs benefit mathematics teaching and learning. It is necessary to take note of the barriers that hinder the implementation of ICT in South African schools and other systems worldwide, and possible solutions to overcome these barriers are speculated on. The chapter concludes with the need for continuous professional teacher development (CPTD) and how the current status of CPTD influences ICT use in South African schools.

2.2 Philosophy of mathematics education

Mathematics has a unique place within the every education system. It has been debated since the early Greek philosophers Plato and Aristotle, as well as Thompson (1988) and in modern times . Teachers' patterns of behaviour and instruction methods are manifested in their notions, beliefs, and preferences. All teaching therefore will be influenced by these conceptions (Thompson, 1984: 173). The NCS grades R-7 (South Africa, 2002: 4) mathematics is a human activity that involves observing, representing, investigating patterns and quantitative relationships in physical and social phenomena and relationships between mathematical objects themselves. Mathematics has unique symbols to describe the multiple patterns, geometrical and graphical relationships. Mathematics is a form of symbolic language which allows humans to think about, record and communicate ideas in relation to quantities. It is a universal method of communicating with numbers irrelevant to the race, language or social background of individuals. Gates and Vistro-Yu (2003: 31-32) add that mathematics is a discipline by which individuals make sense of the world through communication of information, ideas, and solving a range of real life tasks and problems.

2.2.1 Mathematics education in South Africa

The Constitution of the Republic of South Africa in Act 108 of 1996 (South Africa, 2002: 1) provides a foundation for curriculum transformation and development to enable education to move forward as one nation and not according to previous colour margins . Mathematics aims to heal the divisions of the past by having an education system used in all school throughout the nine provinces in South Africa, create a society based on democratic values, improve the quality of life for all citizens, develop the potential of all people, and build a united and democratic South Africa (South Africa, 2002: 1). Education and the curriculum are fundamental in realising these aims. A new curriculum, the outcomes-based curriculum (OBE), was developed to enable learners to reach their maximum potential.

2.2.2 The link between the philosophical views and mathematics education

Philosophy has multiple meanings: it refers to the academic study devoted to the systematic examination of concepts such as truth, existence, reality, causality, and freedom. It also denotes a particular system of thought or a set of principles or concepts underlying a particular sphere of knowledge. Broadly, philosophy refers to beliefs, aims, precepts, or principles that underpin practices, conducts, restraints, resignations, tranquillity or rationality in the behaviour or response of people to events (Barnhart *et al.*, 1990a: 1565).

Mathematicians in South Africa have different philosophical views on what mathematics entails. Every mathematics teacher has an opinion, a judgment and a particular way of interpreting or thinking about something. This is especially true of how mathematics should be used in specific situations. While many philosophers view mathematics as a set of rules, others regard it as deductive and inductive processes (Huetinck *et al.*, 2000: 12). Disagreements about what constitutes good mathematics teaching prevail. One should address the nature of mathematics to resolve these issues (Marang, 2006; Thompson, 1988: 132). Mathematics education in South Africa promotes OBE as philosophy, but various other philosophical viewpoints are still dominant in classrooms.

The realist formalists view mathematics as absolute truths bound together through logic. Intrinsic meanings then form the basis of mathematics teaching. This eclectic view often involves the more gifted learners (Nieuwoudt, 2006: 11) and strongly links to the traditional method of mathematics teaching. From this perspective, the mathematics teacher plays the central role in the teaching and learning where learners have become passive recipients of knowledge.

From a relativist perspective, Aristotle believed that mathematics constantly develops in the human mind, expands through human creation and invention while generated patterns are distilled into knowledge. He believed that learners should engage in mathematical activities from a problem-centred approach while they enquire to get to know (Nieuwoudt, 2006: 11; Stanford Encyclopedia of

Philosopy, 2004; Stumpf, 1993: 80-107). Therefore, the role of teachers is to present learners with problems which they engage in and solve. Activities from this philosophical perspective are aimed at the highest cognitive domains and require that learners plan, generate, produce, formulate, design and construct knowledge (Gunter *et al.*, 2003: 27).

The instrumentalists view mathematics teaching as content organised according to a hierarchy of skills and concepts (Thompson, 1988: 136). Therefore, mathematics teaching becomes a set of unrelated, but utilitarian rules and facts to be taught and learnt (Ernest, 1989: 13-33; Nieuwoudt, 2006: 12). This perspective of mathematics results in a product-directed method of teaching. The role of the teacher is to demonstrate, explain and define the material, and present it in an expository style. This method of teaching has dominated mathematics classrooms. It overarches many teachers' perspective of good mathematics teaching as teachers' philosophical views determine their methods and classroom practices of mathematics teachings (Setati, 2004; Thompson, 1988: 136).

The OBE viewpoint, which forms the basis of the NCS is rooted in the functionalist or socio-constructivist paradigm (Burrel *et al.*, 1979). Mathematics teaching and learning should be objective and qualitatively focused on the development of unique individuals through life-long learning, who are confident and independent, literate, numerate, and multi-skilled, compassionate, respectful of the environment, and will participate in society as a critical and active citizen (South Africa, 2002: 8).

Nieuwoudt (2000: 7) maintains that teaching and learning of Mathematics should be discussed from an ontological-contextual perspective consisting of six inter-related aspects: the teacher, learner, content, intention, live interaction and the context, which coherently enable learners to perform learning tasks. Teachers, who use learning facilitation as a teaching strategy, should have a clear goal about what they want to achieve during learning interventions. The teacher should be in charge of relevant mathematical knowledge, skills, attitudes and values that learners should achieve in order to facilitate learners in a specific context. Therefore, effective mathematics teaching is not only about the personal attributes of the teacher, but also about the ontological-contextual perspective of teaching and learning mathematics. Learners of different types of learning styles should be challenged and supported to meet the set expectations and to reach the logical and analytical outcomes required from a formal science subject like mathematics (Goldsmith *et al.*, 1993a: 124-131).

The problem-centred approach (PCA) represents a socio-constructivist approach like OBE. It is currently proposed as a best practice for mathematics education at school level (Nieuwoudt, 2006: 33; Ridlon, 2004: 2). Conducting PCA mathematics activities is not based on drill and practice exercises, but relates to the active engagement of learners in mathematical problems and activities relating to their immediate environments. Two cornerstones of PCA are problem-solving contexts and social interaction (Nieuwoudt, 2006: 36). According to Murray *et al*. (1998: 171) social interaction creates opportunities for learners to talk about their own thinking, essential for meta-cognition and reflective thinking.

After research in nine secondary schools, Wilson, Cooney and Stinton (2005: 83) state that good mathematics teaching comprises:

- teachers who have a comprehensive knowledge of mathematics
- teachers who promote mathematical understanding
- learners engaged and motivated to learn mathematics
- teachers who manage the teaching and learning process effectively
- guidelines to ensure good mathematics education
- a mathematics curriculum policy that ensures that learners obtain appropriate knowledge and skills.

When all these components are presents good mathematics teaching and learning will take place.

2.2.3 Mathematics teaching and learning

In this section the following aspects of mathematics education will be discussed: mathematics policy and the standing of South African mathematics towards other systems.

2.2.3.1 Mathematics policy

For the General Education and Training (GET) band eight learning area statements were developed: languages, mathematics, natural sciences, social sciences, arts and culture, life orientation, economic and management science, and technology. The learning area statement and the national policy on assessment form the foundation for teaching and learning in each learning area (subject). Included in the learning area statements are the critical outcomes, which relate to the long term goals for education in South Africa. One of the critical outcomes is to use science and technology effectively and critically. Within each learning area are learning outcomes and assessment standards which learners should be achieved before progressing to the next learning outcome. For mathematics the leaning outcomes are: numbers, operations and relationships; patterns, functions and algebra; space and shape; measurement; and data handling. The teaching and learning of mathematics comprises the mastering of the learning outcomes in alliance with the critical outcomes. Teaching mathematics with technology is part of the critical outcomes: use science and technology effectively and critically, showing responsibility towards the environment and the health of other (South Africa, 2002: 1).

2.2.3.2 The standing of South African mathematics towards other systems

South Africa was one of 49 countries across the world who participated in the Trends in International Mathematics and Science Study (TIMMS) in 2003. The aim of TIMMS 2003 was to provide policy makers and curriculum designers with data about learners' achievements in mathematics and science in relation to different types of curricula, instructional practices and school environments. Fundamentally all systems want their learners to be able to compete in a global society and therefore it is important for each system to improve the teaching and learning of mathematics and science and address the areas for improvement (Mullis *et al.*, 2004: 13).

For TIMMS 2003 four different points as international benchmarks were used to represent the range of performance of learners. The advanced benchmark was 625, the high benchmark was 550, the intermediate benchmark was 475, and the low benchmark was 400. The best performing countries were Singapore, Chinese Taipei, Korea, and Hong Kong Special Administrative Regions (SAR) had about one-third or more of their learners reaching the advanced benchmark, about two-thirds to three-fourths reaching the high benchmark, around 90% reaching the intermediate benchmark, and almost all (96 to 99%) reaching the low benchmark. In South Africa, none of the learners at grade 8 could reach the advanced benchmark which focussed on the ability to organise information and make generalisations to solve non routine mathematical problems. Only 2% of the grade 8 learners could apply their understanding and knowledge in a wide variety of complex situations, and only 6% of the grade 8 learners could apply basic mathematical knowledge in uncomplicated questions. The highest score was reached in the low international benchmark at 10% of grade 8 learners in South Africa, with having a basic mathematical knowledge (Mullis *et al.*, 2004: 62-64).

The results from the TIMMS 2003 study indicate that South Africa was one of the poor performing countries and were, at that stage, not able to compete in a global society. Policymakers, curriculum designers, and teachers have a huge task to raise the level of teaching and learning of mathematics in South African schools. It will contribute to increase the results in mathematics if all the role players are provided with the necessary resources and training.

2.2.4 Resources for mathematics

Miller (2003: 2) identifies four important principles for successful mathematics teaching: let it make sense, remember the goals, know your tools, and live and love mathematics. These four principles also should be central to the teaching and learning of any mathematics class. Teachers should strive to ensure that the concepts they teach are understood. The goals that mathematics teachers aim for their learners to achieve are: to survive in the modern world, understand the information surrounding them, prepare for further education and training, to teach logical reasoning, and appreciate the beauty of mathematics.

To meet these mathematical principles and goals, teachers should know the mathematical tools available to them. However, some of these tools can be intimidating. Miller (2003: 2) reminds about the basic rules of mathematical tools: quantity does not equal quality. Using fewer tools effectively is more useful than using more tools ineffectively. Mathematical resources and tools can be categorised in two groups: basic tools and extras. The basic tools consist of: the blackboard, chalk and books to write in; the mathematics curriculum; and manipulatives (concrete objects like the abacus, place value cubes, fraction, and cardboard models, and geometry and measuring tools). Many extra tools are available: games for drill and practice exercises, games relevant to certain topics, mathematical software, and an online library of technology tools, lessons, activities, and support materials.

2.3 ICT as a mode of instruction

The White Paper on e-Education (South Africa, 2004b) defines ICT as representing a body of information technology and communication technology. Galloway (2007: 1) states that the use of the term ICT is unique to the field of education. Others refer to this concept as information technology (IT), which includes a wide range of equipment such as computers, cables, the Internet, wireless connections, handheld devices, mobile phones, digital cameras, DVD and CD players, television, radio and microwave installations. The IT range of tools for educational purposes includes data-capturing tools, multimedia software, information systems, publishing and presentation tools, digital recording equipment, computer projection technology and computer-controlled microscopes for science (Osborne *et al.*, 2003: 4). The communication aspect linked to IT mainly focuses on the communication of learners and teachers by through the use of word-processing, electronic mail, video conferencing and web searching and communication. Additionally, the term ICT is also used when information technological equipment is used to perform an educational task focusing on achieving the learning outcomes and assessment standards set by the curriculum. Therefore, ICT is not merely beneficial for learners in terms of ongoing support, but also increases cognitive engagement with Mathematics by means of providing mathematical contexts, enabling learners to visualize mathematical concepts and aiding them in communicating with mathematical forms independent from the mathematical formulas.

2.3.1 Pedagogical use of ICT

All of our lives are influenced by new technologies. This is especially true for ICT in teaching and learning in schools. In the past, many tasks have been performed without using ICT, and the question arises: of what is the value ICT brings the pedagogy? Ertmer *et al*. (1999: 47) maintains that ICT can supplement, support and facilitate the entire curriculum.

However, merely introducing ICT into teaching and learning is not sufficient. Teachers should be skilled and knowledgeable in order to appropriately incorporate ICT into their teaching and learning practices (Mishra *et al.*, 2006b: 1018). Shulman (2004: 201) in *The Wisdom of Practice* discusses three categories of knowledge that facilitate effective teaching: content knowledge, pedagogical knowledge, and pedagogical content knowledge. *Content knowledge* (CK) refers to the quality and organisation of knowledge in the thought processes of teachers. Mathematics teachers should have appropriate content knowledge to be able to teach the subject successfully (Ball *et al.*, 2008: 395; Mishra *et al.*, 2006b: 1026). *Pedagogical knowledge* (PK) refers to the expertise of teachers in selecting appropriate methods of teaching the content to learners. Ball *et al*., (2008: 395) maintain that mathematics teaching starts with showing therefore mathematical concepts must be taught using visual aids so that learners can see the objects in their natural form. *Pedagogical content knowledge* (PCK) is a combination of subject and pedagogical knowledge, or referred to as specialised content knowledge (Shulman, 2004: 188). PCK is evident when teachers have the ability to build on learners' prior knowledge and adapt their teaching strategies to best transfer the new content to learners (Mishra *et al.*, 2006b: 1027).

With the introduction of ICT into teaching and learning, Mishra and Koehler (2006b: 1026) and Ball *et al.,* (2008: 396) acknowledge Shulman's theory by extending the framework to the Technological Pedagogical Content Knowledge (TPCK) that describes the effective integration of ICT in teaching and learning. In order for technology to bring value to teaching, it cannot be regarded as context-free and it must be linked to the pedagogy and content. Figure 2.1 represents the framework TPCK and shows the impact when content, pedagogy and technology are integrated.

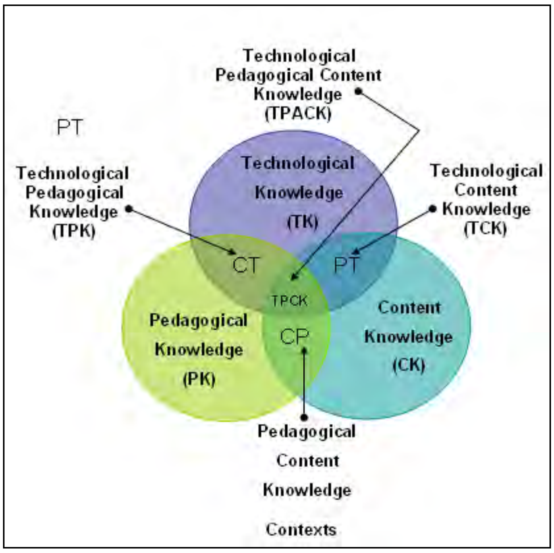

Figure 2.1 The Technological Pedagogical Content Knowledge Framework (Mishra, 2008)

Besides content knowledge (CK), pedagogical content knowledge (PCK), and technology knowledge (TK) are important dimensions of effective teaching. Technology knowledge (TK) refers to ability and skills to use the variety of technology like books, chalk, blackboard and more advanced technologies like computers, Internet and digital resources to teach the learners the required content. Where the content and technology link, technological content knowledge (TCK) comes into play and refers to how content and technology are related and used so that the content is taught through the use of technology. Technological pedagogical knowledge (TPK) is where the technology and the pedagogy are linked. This knowledge base is where the teaching and learning occurs due to the existence, components and capabilities of the various technologies. With TPK teachers will select a specific teaching strategy and the most appropriate technology to teach the content to the learners.

The central dimension where all these technology will meet are known as *Technological Pedagogical Content Knowledge* (TPCK) which is not merely a basis of technology, pedagogy and content. Mishra and Koehler (2006b: 1029) maintains that TPCK is the basis of teaching with technology which requires:

- an understanding of the representation of concepts with technology
- pedagogical techniques that use technologies in constructive ways to teach content
- knowledge of what makes concepts difficult or easy to learn and how technologies can redress the problems learners are facing
- knowledge of learners' prior knowledge and theories of teachers' nature of their philosophy
- knowledge of how technology can be used to build on their existing knowledge and build on new philosophies.

When ICT is embedded in the teaching and learning (TPCK), many activities are available to learners to research, create and communicate using ICTs to enhance their learning. ICT specifically enhances both the theoretical and practical aspects of teaching and learning. Examples are: speeding up and enhancing work production, linking school content with reality, supporting exploration and experimentation and providing immediate feedback, focusing attention on over arching issues, increasing relevant and underlying abstract objects and improving motivation and engagement (Osborne *et al.*, 2003: 4). More importantly, these activities will not be effective if the learners cannot use the technological devices. It is the teacher's responsibility to teach the use of these devices while simultaneously focusing on skills development, acknowledge acquisition and collaboration (Galloway, 2007: 2).

2.3.2 ICT infrastructure

Infrastructure refers to the essential hardware elements that form the basis of a system or structure (Barnhart *et al.*, 1990b: 1084). Supplying schools with the necessary ICT infrastructure is the first step towards ICT integration in education. The basic ICT infrastructure includes: a basic computer, an advanced computer, a refurbished computer, a basic laptop, a server and a basic printer. In 2005 the ICT infrastructure status for teaching and learning in South Africa was: Eastern Cape 7.89% out of 6 239 schools were equipped with the basic infrastructure; 25,9% out of 1 842 schools in the Free State, 78.81% out of 1 897 schools in Gauteng, 11.98% out of 5 653 schools in Kwazulu-Natal were equipped, 16.32% out of 1 863 schools in Mpumulanga, 60.43% out of 422 schools in the Northern Cape, 8.74% out of 4187 schools in Limpopo, 29.73% out of 2 025 schools in the North West, and 76.55% out of 1 454 schools in the Western Cape. The national status for ICT infrastructure for teaching and learning was 22.59% out of the 25 582 schools in South Africa (South Africa, 2007b: 57-58).

The SITES 2006 data on the availability of ICT resources of the participating schools through the technical questionnaire indicate that South Africa has the lowest infrastructure at 17%, Thailand following at 40%, Chile and the Russian Federation at 47% and the remaining system above 60% (Pelgrum, 2008b: 81). A shortfall of infrastructure will influence the implementation process, professional development and the ICT status in comparison with other educational systems worldwide. South Africa faces many challenges regarding integration of ICT in schools, eventually making it impossible to compete with other systems in all areas relating to education (Els *et al.*, 2009: 2).

2.3.3 Benefits of ICT in mathematics teaching and learning

A benefit is an advantage which has a good effect and promotes well-being (Barnhart *et al.*, 1990b: 188). ICT cross-curriculum use can be an advantage for teachers, learners, schools, as well as the wider education system. How can each sector in education benefit by ICT cross-curriculum use?

In their study of *How Information Technology Enable 21st Century Schools,* Kolderie and Mc Donald (2009: 1) maintains that the national and provincial departments benefit by gaining competent learners and teachers who could compete in a global society. This comparative study indicate that ICT cross-curriculum schools are more effective and achieve better results in assessment when compared to schools that did not use ICT. In an European study, Balanskat et al., (2006: 1) noticed that learners' marks in their various subjects increased, their motivation increased, their cognitive processing developed, and they were able to work independently. The initial cost of installing the ICT infrastructure is high, but ultimately the institutions will be cutting on costs, especially with regard to resources like books, copying, and postage.

Schools benefit in many aspects from using ICT. Firstly, learning and teaching materials are available in one central location, ensuring easy access for both teachers and learners. Teaching aids are also made available by means of email and websites, and new stimulating lessons are readily accessible to all learners. Learners can communicate and share information with one another, as well as with teachers, even after the end of the normal school day. Although machines cannot replace the human interaction between teachers and learners, they can be used to enhance the relationship between the various role players within the system of education (Bramald *et al.*, 2000: 6). Role players in the learner's school career, e.g. parents, have easy access to important information on the homepage, which saves time and money, and ensures that all role players receive relevant news (Becta, 2006: 3). Assessment marks are also recorded electronically and parents can monitor their children's performance without making an appointment with the class teacher. Additionally learners can have access to their marks at all times to pace their performance as well (Twiner *et al.*, 2007: 141). This indicates that the computer-generated classroom allows a multi-faceted teaching and learning experience (Becta, 2010: 2).

Ward (2003: 9) states that teachers have mixed opinions on the benefits of ICT, but according to Kolderie and McDonald (2009: 7), teachers can benefit in various ways, including reconstructing and improving the method of presenting, planning, advising and evaluating their work, as well as their teaching practice in general. Teachers who make use of ICT realise its value through engaging with ICT when teaching their learners. Their attitudes change as they realise the value it brings and many make a paradigm shift when they embrace the concept of teaching and learning by means of technology (Balanskat *et al.*, 2006: 2). Learners also benefit from teachers using ICT. Learners' individual needs are catered for, as they are able to engage in creating their own knowledge and play an active role in their own learning. Learners also become the centre of learning and they can work at their own pace without feeling pressured. Enrichment exercises can also be done after they have finished their tasks, which will ensure that the learners feel more motivated to learn. A vital aspect of OBE is that the individual needs can be catered for by creating activities according to the level of the abilities of each learner. Learners can complete tasks at their own pace without feeling pressured by the rest of the group. They engage in creating their own knowledge through exploring with multiple tools at their disposal. By engaging with the various tools and software, they are actively involved in learning. Additionally, teachers can engage with the more competent learners in enrichment exercises (Kolderie *et al.*, 2009: 1-7). Some learners love playing with numbers, but find mathematics difficult or just boring. Edutainment software can make learning mathematics fun—or at least a lot less painful—by incorporating solid mathematics practices work into multimedia by combining animations, problem-solving exercises, learning games, and adventure plots. Educational specialists agree that much learning takes place through the interactivity of play (Cooper *et al.*, 1996: 34-36).

Galloway (2007: 64) believes that ICT significantly supports the teaching of mathematics through shareable tools on interactive whiteboards. They include games and activities specifically designed for the learning of mathematics. Examples are drill and practice type activities, during which learners use ICT to practice concepts and calculate their sums. Some of these activities are designed to assist the whole class, and others are suitable to support the individual learner.

Surveys, counting work and fractions in bars are some of the spreadsheet activities for the foundation phase, while ratio, percentages, estimation, currency converters, and travel budgets for the intermediate and senior phase are some of the activities addressing the outcomes for mathematics. Spreadsheets are easily accessible tools for teachers without schools having to purchase additional software (Ozgun-Koca, 2000). Spreadsheets create platforms where abstract concepts in mathematics can be communicated through pictures, coloured squares, number lines, number charts and pictographs. They also serve classrooms with diverse learning styles (Goldsmith *et al.*, 1993b: 124-131). Dynamic software (e.g. spreadsheets, Geometeris™, Sketchpad™, GeoGebra™) cater for learners who learn visually as they use colour and patterns to shade areas to visualise addition and subtraction. According to Bloom (1976) and Gardner (1986), developing higher order thinking and problem solving skills are some of the critical outcomes learners have to develop in order to survive in the world of work. Using the formulas allows them to focus on the mathematical reasoning and helps them to shift between a wider range of representations of modelling approaches embedded in spreadsheets. Dynamic spreadsheets and spreadsheets provide learners with the opportunity to organise their ideas using charts and graphs from existing records, and present the relevant information to analyse, interpret and add meaning to the information. By using ICT in teaching mathematics, curriculum outcomes can be addressed through various activities, particularly spreadsheet activities ranging from foundation phase to senior phase (Lewis, 2001) Spreadsheets also contribute to learner motivation. The computer is a judgement free environment where learners can be motivated to play, complete tasks, correct their mistakes and add some personal touches to their work (Lewis, 2001; Ozgun-Koca, 2000).

The interactive whiteboard and other multimedia tools can be used to explain mathematical concepts to groups or to the whole class. The built-in computer performs difficult calculations like long additions, multiplications, divisions and subtractions, which saves time and provides the teachers the opportunity to focus on more important activities at hand.(Gillespie, 2006: 99). Various integrated learning systems are available which adjust automatically according to the learner's performance. These integrated systems record the learners' results which then assist the teachers in assessment.

Additionally, ICT develops the skills, concepts and the ability to perform mathematical procedures through drill and practice (Galloway, 2007: 67). According to Gillespie (2006: 94), computers support and heighten the learning process as ICT mediated learning supports weaker learners by permitting them to learn at an appropriate pace (Lim, 2006: 84).

2.4 Policies on ICT

A policy is defined as a course of action, a program of actions adopted by a person, government or the set of principles on which they are based (Barnhart *et al.*, 1990a: 1613). It is a prerequisite for all educational systems to have a national ICT policy. Policymakers are responsible for implementing this policy successfully. Embedded within the policy must be a vision—an idea perceived vividly in the wisdom of planning. According to *The Need for an e-Education Initiative in South Africa* (South Africa, 2007b: 7) the vision of South Africa is that all its people will have access to lifelong learning, education and training opportunities, which will ultimately contribute towards improving the quality of life. However, the reality is that South Africa faces many barriers to the implementation of ICTs in schools.

2.4.1 e-Education White Paper

The NDoE has a responsibility towards ensuring the implementation of ICT in schools. In 2004, the former Minister of Education, Naledi Pandor, introduced the Draft White Paper on e-Education after consultations within the Presidential Commission on Information Society and Development (PNC on ISAD) since 2001. An advisory team consisted of representatives from the public as well as the private sectors. In September 2002 three focus areas, education, health and small, medium, and micro enterprises were identified by an additional council made up of executive officers from large international companies and professionals working in the field of ICT (South Africa, 2004b: 8). The

ICT policy development in South Africa lags behind other countries. In the late 1990s, the Danish Ministry of Education introduced an ICT integrated achievement plan; Italy's program for the Development of Educational Technologies was implemented during 1997-2000; the *e-Japan strategy* was introduced in 2001; and *Masterplan for IT in Education* for Singapore has existed since 1997 (Anderson *et al.*, 2008: 57-63).

The ICT policy in South Africa holistically organises important aspects relating to ICT to ensure effective implemented (South Africa, 2004b: 8&22-23). The national policy is a framework that relates to equity, access to ICT infrastructure, capacity building and norms and standards to ensure that educational institutions, teachers and learners are engaging in creative, problem-centred and innovative activities. In alignment with the national policy all ICT schools should have an active ICT policy to monitor the functioning and equipment within the laboratory. Each school should develop its individual ICT policy within context specifically keeping in mind the motivation, the pedagogies and technological infrastructure (Way *et al.*, 2007: 16). The purpose of the school ICT policy is to address the different elements needed to regulate the daily activities within the laboratory as well as the duties of the different ICT committee members (Pacaltsdorp, 2009: 1).

2.4.1.1 e-Education White Paper recommendations

Singapore made policy recommendations after conducting research on the effective integration of ICT in Singapore schools (Lim, 2006: 112-113). These include: developing strategies for learners' ICT competency in government and subsidised schools, setting standards for teachers and learners, and re-assessing methods of assessment currently used. It was agreed that the vision statement for ICT integration has to be clear and the whole school community should share this vision. A framework should be designed where teachers can work collaboratively on ICT-mediated lessons, allowing every teacher within the same department to create ICT mediated lessons and distribute the available resources and lesson preparations. Regular workshops were held to showcase examples of ICT mediated lessons, and to provide learners and teachers with incentives as a motivating mechanism.

According to Childs *et al*., (2005: 30) the NDoE should have the authorisation to set ICT related policies, outcomes and curriculum guidelines to support e-learning. Strategic planning for e-learning integration at national and regional level must be in place. A committed team of managers, technical staff and teachers is needed to promote the policies for ICT integration. Unenthusiastic managers and teachers should be replaced. The ICT integration learning programs have to be flexible in structure, methods and time allocation, and these have to be easily accessible to accelerate the teaching and learning process.

2.5 Implementation of ICT

In the following sections the implementation of ICT is discussed under the headings of South African implementation models, implementation status of ICT in South African Schools, and barriers to ICT implementation.

2.5.1 South African implementation models

In accordance with the NDoE obligation to deliver on public expectation and growth as well as the assurance that every learner in the General Education and Training (GET) and Further Education and Training (FET) band will be ICT literate by 2013, a three phase implementation model with specific priorities and actions, was created in alignment with the capacity and national educational budget . Phase I (2004-2007) focussed on the enhancement of system-wide and institutional readiness to use ICT in teaching and learning. In Phase II (2007-2010) the focus has been on the system-wide integration of ICT's into teaching and learning. Phase III (2010-2013) ICT's will be integrated at all levels of the education system—management, teaching, learning and administration (South Africa, 2004b: 22-23).

2.5.2 Implementation status of ICT in South African schools

According to *The Need for an e-Education Initiative in South Africa* (South Africa, 2007b), referring to system-wide readiness to use ICTs for learning, teaching and administration, the lowest percentages were seen in the Limpopo Province where only 50% of regional offices were connected, less than three percent (2.09%) of schools were connected for administrative purposes, and less than two percent (1.24%) of schools were connected for teaching and learning purposes. The Western Cape was the only province with a 99% availability of computers for administrative purposes. Nationally in South Africa in 2005, less than thirty percent (22.59%) of schools had computers for teaching and learning.

Other initiatives that support ICT implementation in South Africa are Mindset, the Learning Channel and OLSET (Open Learning Systems Educational Trust) who were active in developing content applicable for the South African curriculum. Mindset has developed more than two hundred hours of educational content in video, print, computer-based format and multimedia including both primary and high schools. The basic functionality of OLSET includes: to provide teachers with learner-centred pedagogy, qualitative audio and print support materials, design, produce and broadcast radio instruction programs on SABC (South African Broadcast Cooperation), and use ICT to deliver the curriculum in rural schools. Gulati (2008: 12) agrees that the printed materials, radio and television are more useful and available in rural schools. In August 2006, 18 535 content resources were available via Thutong Portal relating to the National Curriculum Statement (South Africa, 2007b: 62). Unfortunately, these provisions are not adequate to address the shortcomings at system level.

2.5.3 Barriers to ICT implementation

A barrier refers to an obstruction, or something which separates one place from another; often a stumbling block obstructing success (Microsoft Corporation, 2006). It can also be something that causes problems or makes it impossible for something to happen (Burgess, 2002: 51). According to Barnhart and Barnhart (1990b: 166) a barrier is something which hinders progress. There are many ICT-related barriers that affect teachers, managers, learners and the broader education sectors. They ultimately have an effect on the success of ICT implementation in schools and may prevent the successful integration of ICT in schools, or prevent schools from realising their pedagogical goals. These can be divided into barriers with extrinsic and intrinsic qualities. Lim and Khine (2006: 91-96) focus on extrinsic as well as intrinsic barriers hindering the implementation of ICT, whereas Pelgrum (2008b: 85) mainly looks at extrinsic barriers teachers experienced during SITES 2006.

2.5.3.1 Extrinsic barriers

Poverty, insufficient social and educational infrastructures and cultural issues are examples of extrinsic barriers which restrict developing countries and widen the gap between the privileged and deprived groups. In China, more than 70 000 schools with computers and more than ten million learners have mastered basic computer skills. Most of these schools are in cities. Rural and poorer communities are continually being deprived of investment, infrastructure and skilled teachers. Technology has done little to help deprived groups gain access to educational opportunities (Gulati, 2008: 1-12). This seems to be much the same situation in South Africa (Pelgrum, 2008b: 86).

The pedagogical barriers from the SITES 2006 were: insufficient Internet-enabled computers, a scarcity of ICT equipment for learners with special needs, unsatisfactory ICT equipment for teaching, outdated computers, shortage of digital equipment for instruction, and lack of ICT science tools for laboratory work (Pelgrum, 2008b: 85). These aspects act as barriers as they prevent successful integration of ICT from taking place. All the equipment, if easily accessible for teachers and used correctly, will allow teachers to achieve the learning outcomes in the best possible manner.

Several substantial issues were raised regarding the ICT integration and effectiveness in England, Singapore, Canada, New England, and Australia (Bramald *et al.*, 2000: 2; Granger *et al.*, 2002: 485; Lim *et al.*, 2006: 99; Richardson, 2000: 12; Ward, 2003: 2). An important aspect was the amount of time available to teachers to devote to the learners who are working on the computers as there is often only one or two computers available per class. It takes much time to teach learners even the most basic word-processing skills in such cases. The amount of time it takes teachers to acquire skills to use high-level and complicated software is also a problem as they do not have the knowledge and skills to interact with the software on a high level. Insufficient and immediate technical support is also problematic.

2.5.3.2 Intrinsic barriers

The intrinsic barriers are those essential aspects that hinder change of teachers towards ICT integration (Ertmer *et al.*, 1999: 55). These barriers are of a personal nature and much more difficult to overcome (Lim *et al.*, 2006: 100). According to Greenberg *et al(*1998*:* 300*)*, Handal (2004: 8) and Ward (2003: 8)the fact that teachers do not believe in the ability of ICT to enhance learning, have confidence in their learners and the contexts of schools, and their reluctance to change their deep-rooted teaching methods will require much effort to change. Ward (2003: 9) reveals that teachers disliked the ongoing development and the requirement of changing their teaching practices.

Every new curriculum development will encompass barriers that should be addressed. However, they are not impossible to overcome. Ignoring the barriers that prevent the use of ICT in the teaching and learning process is not the route any stakeholder in education will follow. Bramald *et al.* (2000: 3), suggested that once barriers have been overcome, the development gains momentum and overcomes the issues of limited teachers' skills. Confidence increases and implementation spreads. In the past barriers were addressed in isolation, but Thornburn (2004: 2) envisages the importance of dealing with these barriers as a whole.

2.5.3.3 Managing of barriers

Managing of barriers relate to overcoming defeat or to control something successfully (Burgess, 2002: 459). For the implementation of ICT to be successful, educational institutions, managers, technical staff and teachers should overcome barriers. Every new curriculum development comprises barriers that should be addressed. Although the previous education system was not developed to adjust to any changes within the system (Kolderie *et al.*, 2009: 10), it is not impossible to overcome the barriers of ICT implementation in schools. Strategies should in place to speed the process of addressing barriers (Lim *et al.*, 2006: 100).

Employing strategies for solving the extrinsic barriers seems to be straightforward. The failure to complete activities within a specific timeslot could be overcome by allocating appropriate timeslots to each subject. ICT-mediated lessons have to be pre-tested before the learners participate in the activity to ensure that all technical glitches are addressed. A supply of CD-ROM courseware should be available to assist the teachers in their teaching. Teachers should allow learners to progress at their own pace, and not at that of the teacher. The frustration that outdated computers and insufficient computers cause should be rectified by the school management team and local education department. Schools should be supplied with adequate computers to optimally mediate an ICT learning environment (Lim *et al.*, 2006: 109-113).

Addressing the intrinsic barriers requires much more effort as teachers' beliefs of teaching and learning with ICT should be changed. Teachers need ongoing motivation and they should be willing to make a mind shift and gain confidence in their ability to change. Getting teachers to not only make use of ICT in their traditional methods, e.g. using drill and practice exercises, but also to engage in CPTD activities to develop their skills and knowledge on the use of ICT in teaching and learning, is extremely important. Teachers should be encouraged to participate in seminars, workshops and demonstration sessions where the focus is on the pedagogical aspect of ICT use. They should reflect on what they have learnt, as well as areas that still need assistance to increase their confidence (Lim *et al.*, 2006: 114-119). Motivating teachers and learners with incentives like flexibility in achieving the ICT-related outcomes is a method to develop positive attitudes towards ICT in teaching and learning (Lim *et al.*, 2006: 121).

2.6 Managing of ICT

The ICT managerial duties are not solely the responsibility of the NDoE and provincial departments of education, but all that of stakeholders, including the school, the community, and teachers.

2.6.1 System management

The Ministry of Education is first and foremost responsible for development and integration of ICTs in schools. Managing ICT at system level is a big responsibility. Quebec, Canada, is one of the world leaders in ICT integration in education and they have measures in place to ensure a high level of ICT curriculum content available that is accessible to teachers. They continually evaluate ICT tools, curriculum content, assessment practices, and CPTD. Teachers have access to online networks from which they download relevant documents and communicate with each other. Quebec has a budget of about $2 million for computer and telecommunications infrastructure, as well as a separate grant for content development, and for maintenance. Finland, which is considered the leader in ICT implementation, has 90% of their primary and 95% of high schools connected to the Internet. They have an annual budget of €50.5 million, to further their ICT strategy. Schools in Finland are supported by the Ministry of Education through infrastructure, strategic planning, support services, and the development of learning materials. Israel was one of the first countries to have an ICT integration program ready in the early nineties. The Ministry of Education and the national lottery have provided funds since1994 for the development of new curricula, alternative assessment methods, CPTD, and infrastructure that provides schools with ICT infrastructure and Internet broadband (Richardson, 2000: 5-19). The NDoE of South Africa has a set three phase plan for ICT integration into teaching and learning to ensure the process are managed and integrated according to the targets set within the plan (South Africa, 2004b: 22-23). Unfortunately the implementation of the phase plan is not as effective as visualized.

2.6.2 School management

Managing a school is foremost the responsibility of the principal or school leader. Leadership is the condition of the ability to lead and give guidance and direction (Barnhart *et al.*, 1990a: 1191). It is imperative for all educational institutions to have leaders that guide ICT innovations in schools. The school leader in collaboration with its leadership team is central in supporting teachers to participate in innovative practices (Scrimshaw, 2004: 5). The principal, with one or two deputy principals and the heads of departments, constitutes the leadership team known in South Africa as the Senior Management Team (SMT) (Knapp *et al.*, 1996: 9). The SMT is responsible for the strategic planning and management of the school which includes strategic direction and development of the school, teaching and learning, leading and management staff, efficient and effective deployment of staff and resources and accountability. Strategic direction, which relates to the continuous development of ICT administration and development, is needed to ensure the effective functioning of the school. The SMT should determine to what extent the ICT curriculum should be taught, and the relevant teacher training required for the ICT-related needs to be met. Members of the SMT have leadership and managerial responsibilities. Adequate resources should be distributed at the school according to the strategic plan for ICT curriculum integrating. Learning areas should be allocated to the most suitable staff member for each specific area. SMT members are accountable to the parents, governing body and the NDoE (Becta, 2002: 1-2).

In addition, the SMT has specific ICT-related obligations including the planning and arranging of the ICT CPTD plan, ICT purchasing, ICT planning, ICT numeracy and literacy targets, understanding and ensuring integration of ICT into the teaching and learning. Managing ICT and guaranteeing ICT are integrated into the curriculum (Becta, 2002: 2). School managers should regularly monitor the integration process to ensure that ICT targets are met.

Unfortunately, many SMT's experience many challenges which hinder the strategic planning and management of schools. The annual technology budget of the school is an important aspect central to the future ICT innovation. SITES 2006 indicated that more than forty percent (47.71%) of principals did not even have enough funds for non-ICT supplies. Principals should be aware of the factors that influence the effective use of ICT in their schools to be able to facilitate the eradication of inadequacies in their schools (Vallance, 2008: 1).

2.6.3 Classroom management

It is crucial for ICT to be managed appropriately within the classroom to ensure that the pedagogical use of ICT within teaching and learning is in line with achieving the 21st century skills.

Lim (2006: 110-111) states that, in order to effectively integrate ICT in the classroom, a favourable environment should be created. Firstly, the educational institution needs to address the classroom management issues which create a barrier for successful ICT pedagogical use. During a study by Lim (2006) for *Effective integration of ICT in Singapore schools*, a couple of important issues concerning classroom management were identified. The availability of ICT tools, the creation of disciplinary rules and procedures, and the distribution of labour among teachers, technical assistants and learners is important to ensure smooth functionality of the ICT laboratory and that maximum learning will take place for the time learners have access to the facilities. Classroom activities should be designed to engage learners in high-order thinking. It must also acknowledge the role of the teacher in creating suitable activities and achieve high-order thinking. The teacher should keep the outcomes of each lesson in mind and make use of scaffolding where learners must unpack the information in order to solve the problem. Learners should also be trained in ICT skills to ensure the activities will be performed without wasting time.

2.7 ICT training and professional development of teachers

ICT professional development of teachers is fundamental in ensuring that teachers will integrate ICT into their teaching and learning practices. The development of teachers must be based on the TPCK model to teach new concepts to the learners.

2.7.1 Professional teacher development

Profession refers to an occupation that needs a high level of training or education (Burgess, 2002: 506). According to Barnhart *et al.* (1990b: 572), development is the process of growth and expansion. Burgess (2002: 182) states that it is the practice of becoming better in your job. *The Need for an e-Education Initiative* (South Africa, 2007b: 25) describes professional development as the provision of access for teachers to resources, tools and services designed to facilitate the teaching and learning process. Ongoing professional development forms an integral part of education enhancement. Providing teachers with adequate resources, tools, training and opportunities to develop their ICT skills is essential in ultimately achieving successful pedagogical use of ICT (Reynolds *et al.*, 2003: 159). Childs *et al*. (2005: 30) and Zucker (2008: 132) acknowledge that continuous professional teacher development (CPTD) is an essential though costly element in ensuring the integration of ICT in teaching and learning. If CPTD is inadequate, barriers will affect ICT integration (Becta, 2006: 2).

2.7.2 Required teacher professional development for the implementation of ICT

The quality of CPTD ensures that teachers make a paradigm shift and become innovative and adventurous in their teaching practices (Ward, 2003: 12). CPTD should occur in all sectors of education, including leadership development, teacher development, supporting staff development and technical staff development (Becta, 2008a; Becta, 2008b: 1). A detailed training program for each staff member, depending on the role they fulfil at the school, should be implemented, ensuring that teachers are not only experts users of computers, but are at least skilled in using ICT to teach learners (Ward, 2003: 11). The CPTD must engage teachers in continuous, life-long training that will ensure that they are constantly gaining new insight regarding technological and curriculum developments (Thornburn, 2004: 3). Therefore, CPTD must ensure that all teachers have a sound technological pedagogical content knowledge (TPCK), not merely teaching using ICT, but knowing how to teach the content using ICT.

A CPTD program that focuses on skills training, as well as on the design, development and provision of ICT integration is needed. Technical staff should be supplied with the technical and administrative equipment necessary for learner support. The ICT tools have to be in good condition to ensure that effective teaching and learning with ICT can take place (Childs *et al.*, 2005: 30). Apart from the basic training for ICT integration, a CPTD program in the form of workshops, courses and other in-service programs is essential to keep teachers motivated and equipped for new trends. Zucker (2008: 132) and Granger *et al.*,(2002: 483) maintain that teachers' successful implementation of ICT in should be 'just-in time' collaborative learning where teachers learn from their colleagues as well as from the learners. A balance between formal and informal training is vital to ensure that ongoing CPTD takes place. All schools are responsible for maintaining a guaranteed high standard of CPTD to promote the attainment of the learning outcomes (Zucker, 2008: 132).

2.7.3 Current status of ICT CPTD in South African schools

Reynolds, Treharne and Tripp (2003: 159) report that in 2002 that only six out of every ten high school teachers were trained in ICT use, and half of teachers in primary schools in South Africa never had any ICT training. SITES 2006 indicated that only 26% of the participating mathematics teachers in South Africa had ICT training for Internet and general applications like word-processing, spreadsheet and data processing. Nine percent of mathematics teachers attended a pedagogical ICT course, but 87% indicated that they would have liked to attend a similar course. Education systems like Alberta Province, Canada, Chile, Finland, Israel, Italy, Japan, France, Norway and Thailand also indicated that their educational institutions have insufficient ICT integrated courses (Pelgrum, 2008b: 97). *The Need of an e-Education Initiative in South Africa* (South Africa, 2007b: 216) states that CPTD will be monitored through a provincial development model. The program will focus on improving teachers' competence in using ICT for their administrative tasks, as well as in their classrooms. It declares that ICT training will form an integral part of continuous CPTD.

ICT training in South African schools is an area of concern. During SITES 2006 the technical coordinators indicated that 32% of teachers attended introductory courses (word-processing, spreadsheet, databases), 19% received training for technical courseware relating to operating and maintaining computer systems, 16% attended advanced courses for application or standard tools (advanced word-processing, relational databases, etc.), 15% had training in advanced courses for Internet use, 17% in learning area specific training and 13% on multimedia use (Pelgrum, 2008b: 100-

101). These findings indicate that the majority of teachers in South African schools have received insufficient training to ensure the smooth integration of ICT into administration, managing, and teaching and learning. According to *The Need for an e-Education Initiative in South Africa* (South Africa, 2007b: 38) all learners in the GET and FET will be ICT capable by 2013. When considering the backlog regarding the ICT training of teachers in 2006, we should realise that the strategic goal of the NDoE may not be achieved.

Depending only on private initiatives like *Microsoft Partners in Learning* to collaboratively work with the various Departments of Education will not solve the lack of ICT pedagogical training within the broader education system. It will also not accommodate the magnitude of teachers who still need training. There are other pathways which can be explored to maximise the output of CPTD. According to Blignaut *et al*. (2009: 6), technical coordinators at schools can assist and promote CPTD programs which are currently not functioning to their potential.

The school and the Ministry of Education are responsible for CPTD to ensure successful ICT integration in schools (Vallance, 2008: 14). A professional learning community where all staff and learners participate in continuous training is important for personal growth to ensure that a high standard of education is maintained (Becta, 2008b: 3). To achieve a positive climate for CPTD at schools, regular training must form part of the teacher training program at school. Competent and confident teachers will raise the standard of education at schools in South Africa and enable teachers and learners to compete globally with leading ICT countries like Singapore and Finland.

2.8 Strategies for supporting professional teacher development

Every education system and school needs a structured plan to ensure the level of CPTD on ICT integration in teaching and learning to be at an acceptable standard. In 2001, Finnish schools had a strategy for ICT CPTD at school and further education and training level (Richardson, 2000: 15). In Lithuania, more than ninety percent (92%) of the participating school teachers in SITES 2006 indicated that they have been trained for pedagogical use of integrating ICT, as well as subject-specific training with learning software (Pelgrum, 2008b: 101). Unfortunately, it is not always possible to address the shortage of CPTD at national and provincial levels. Schools in all systems as well as in South Africa should contribute to the CPTD of ICT integration in teaching and learning.

2.8.1 External enabling strategies

External aspects such as support and guidance from the NDoE and the various provincial education departments can often be the most frustrating part of ICT implementation and usage, and can make managers and teachers very despondent. This is especially true with regard to something as this 'new' as ICT, especially since it can have such a great influence on the general approach to teaching and learning in schools. Several external strategies are recommended and can be put in place to achieve less frustration during ICT integration.

Community involvement can help schools to move further towards a learner-centred approach of ICT integration by supplying schools with computers through fundraising, use the existing facilities to further training, and allowing learners to make use of the ICT facilities after school under the supervision of a governing body member. Through community involvement, ICT integration will benefit from such an approach and the integration of ICT will become more contextualised. Promoting a working relationship with neighbouring schools, teachers can exchange ideas and information to integrate ICT into pedagogical practices. Skills training sessions can be arranged for teachers to enable them to become more confident about using ICT use in their classes. Participating in the national ICT initiatives like ICT-based projects can also cultivate a beneficial positive attitude. Managers can have access to valuable information and training if they actively participate in these projects and initiatives. Teachers can communicate with other teachers via email, blogs, wiki's and webcams to share ideas and information. Using these multiple methods will ensure that ICT CPTD development will take place (Childs *et al.*, 2005; Scrimshaw, 2004: 6).

2.8.2 School-enabling strategies

There are many ways in which schools can move ahead without any external support to enable ICT use in schools. The role of the principal is essential in enabling teachers to engage in innovative practice (Gibson, 2002). Planning the ICT implementation process is central to any success. There are three aspects of planning which should be taken into consideration: (i) the creation of a vision that is an important driving force behind the success of any project; (ii) the importance of needs assessment; (iii) the need for a school development plan. The following three aspects are important: to assess the current status of ICT in the school, to determine what the shortcomings are, and establish the methods by which those shortcomings will be addressed (Becta ICT Research, 2006).

Any success should have a clear goal to attain the end product. All role players within the school should be involved with ICT integration and sharing of resources, information, ideas and planning of the integration process. CPTD at school level can take place where a variety of approaches may be used depending on the level of staff abilities and current skills at their disposal. In Finland it is compulsory that 10% of all teaching staff members at a school should be competent in ICT curriculum content, professional applications, creating digital resources, and the ability to assist in ICT management and training (Richardson, 2000: 16). Many schools have skilled staff members who can assist and train the other staff members to assist them in utilising the basic skills required to use ICT in classrooms. Schools should appoint reliable technical support to assist in the basic technical requirements of implementing the ICT program (Scrimshaw, 2004: 5). The materials and equipment should be easily accessible—preferably all at a central location where all teachers can access these (Becta, 2006: 2).

2.8.3 Teacher strategies

Bramald *et al*.,(2000: 5) identifies four factors at teacher level that affect teachers' engagement with ICT. They are confidence, time, access to quality resources and adequate CPTD. If teachers are not confident in using ICT, they are less likely to experience the positive effect it has on the quantity and quality of the learners' work. Reynolds *et al*., (2003: 159) and (Ward, 2003: 8) observed that the teachers' confidence as well as their abilities has an influence on the extent of ICT use in their classrooms and also on the effectiveness of it. The teachers' level of confidence has a noticeable effect on the outcomes learners achieve (Bramald *et al.*, 2000: 5). During a quantitative study in Queensland schools, mathematics teachers were asked to indicate whether they are confident to use technology while teaching mathematics, and of the 483 participants, 59% indicated a high level of confidence, 33% indicated moderately confident and only 18% said that they were not confident. SITES 2006 indicated that 70 % of Mathematics teachers indicated that they had little or no confidence with regard to using ICT in teaching and learning situations (SITES, 2006a: 64) and Proctor-Jamieson *et al.* (2006: 2-4) also acknowledge that lack of confidence in teachers is a global problem which many educational institutions experience which can be a reason why many teachers shy away from communication due to the fact that they lack confidence.

Granger *et al.* (2002: 487) maintains that attitudes, philosophies and communication are also important factors that influence ICT implementation. Attitudes such as resistance and to change teachers' philosophical view can prevent the successful integration of ICT in teaching and learning, especially when teachers have not realised the advantages of using technology in their teaching practices.

In contrast to the adaptability and acceptance required from the teachers in terms of valuing ICT as effective tools in schools, many educational departments do not acknowledge the critical role the teachers play in creating the conditions for ICT-supported learning. Teachers are of great importance in this project as they are required to select and evaluate appropriate resources, as well as to design structure and sequence a set of learning activities (Osborne *et al.*, 2003: 4).

2.9 Summary

Mathematics teaching in South Africa starts first and foremost with the policy (NCS) (South Africa, 2002: 2) and the most suitable philosophical viewpoint to promote the achieving of the outcomes within the policy. OBE still forms the basis for teaching and learning in South African schools, even though many teachers struggle in adapting to this transformation, and though the policy will be changed in the near future. Embedded in the critical outcomes are the promotion of ICT and the importance of using technology effectively and critically. In alignment with the critical outcomes, an e-Education policy (South Africa, 2004b) has been introduced with a three phase implementation plan to ensure South Africa will compete with other systems worldwide.

Effective mathematics teaching entails that teachers should have a good comprehensive knowledge of mathematics; they should promote mathematical understanding; learners should be engaged and motivated; and teachers should manage teaching and learning effectively. In addition, the goals mathematics teachers want their learners to achieve should be met. These goals include: to guide their learners in the modern society to survive in the world, to understand the information around them, to prepare learners for further education and training, to teach logical reasoning and to promote the beauty of mathematics. Ensuring that these mathematical principles adhere to the envisaged goals, teachers should have a sound knowledge of the content and pedagogy; know the mathematical tools available to them and when to use them. There are numerous mathematical tools available to teachers to assist them when teaching: the traditional tools like the textbooks, blackboard, chalk, abacus, etc. and the more recent ICT tools.

Having these tools available is unfortunately not enough. In order for any of these tools to add value to the teaching and learning of mathematics a sound Technological Pedagogical Content Knowledge (TPCK) is required. The TPCK model developed by (Mishra, 2008) addresses the various aspects in teaching and learning which must be in place and used collaboratively to achieve effective results: technological knowledge, content knowledge, and pedagogical knowledge. Teachers therefore must know the subject content, know how best to teach it to the learners and use technology at their disposal effectively to assist them in their teaching and learning practices.

Even though the NDoE has an ICT integration plan, the implementation of ICT into teaching and learning remains a major challenge. SITES 2006 indicated that only 26% of teachers in South African schools received basic training and only 8% ICT integration training. Therefore South Africa should invest much more time and resources to raise the ICT competence level of teachers and extend their existing CPTD program.

Managing ICT is not solely the responsibility of the NDoE, but at school level the SMT and the local community can also make an effort to contribute to promoting ICT integration in teaching and learning. It can be made compulsory that a percentage of all teaching staff members at a school should be competent in ICT relating to curriculum content, professional applications and creating digital resources, and have the ability to assist in ICT management and training.

SITES 2006 indicated that of the participating schools more than forty percent (47.71%) of principals indicated that they did not even have enough funds for non-ICT supplies. It is clear that South Africa is faced with many barriers that deter teachers from integrating ICT into teaching and learning. Some of the barriers identified in SITES 2006 were: shortage of Internet accessed computers, a scarcity of ICT equipment for learners with special needs, unsatisfactory ICT equipment for teaching, outdated computers, shortage of digital equipment for instruction, and lack of ICT tools for teaching and learning.

The barriers of ICT integration in teaching and learning will be overcome only when the NDoE, the provincial departments and SMT's of schools invest in the necessary funds for the professional development of teachers, focussing on developing a sound knowledge base for curriculum ICT integration and for supplying schools with the ICT infrastructure.

Chapter Three

Overview of the SITES Modules

3.1 Introduction

Since its commencement in 1958, the IEA has conducted more than 23 research studies on cross national achievement of trends in international reading literacy levels (PIRLS), trends in learner achievement in mathematics and science (TIMMS) and SITES (Second International Technology in Education Study). PIRLS is conducted on a five year cycle (2001, 2006 and 2011) and twenty six countries participate to measure the trends in grade 4 childrens' reading literacy achievement and the policy and practices related to literacy. The trends in grades 4 and 8 achievement in mathematics and science are measured by TIMMS for learners in more than sixty countries (IEA, 2007).

The SITES modules are the only studies of which the main focus is not on learner achievement. The SITES modules focus on the educational aspects from a teacher and school perspective. SITES Module 1 (1997-1999) was a survey to principals and technology coordinators; SITES Module 2 (1999-2003) was an in-depth study of innovative teaching practices in schools (Plomp *et al.*, 2009: 7). SITES 2006 built on the findings from the previous SITES modules to obtain an extended overview on the effectiveness of ICT integrated pedagogical practices in all the participating educational systems (Pelgrum *et al.*, 2008: 10, 16).

3.2 SITES Module 1

SITES Module 1 was a quantitative international comparative study that took place between 1997 and 1999. The purpose of this study was to determine the status of each of the twenty six participating education system on the availability of ICT infrastructure in schools relative to the status of the other participating countries. The study also provides a benchmark for subsequent studies, and assists national policy-makers in the planning of their educational strategies. The data collection took place between November 1998 and February 1999 (Pelgrum *et al.*, 2008: 3).

3.2.1 Study design and methodology

The battery of surveys consisted of a questionnaire to school principals and to the technology co-coordinators. In South Africa, the representative sample involved only computer-using schools from primary, lower secondary and upper secondary schools. Twenty four countries from the northern hemisphere and two countries from the southern hemisphere (Chile and South Africa) participated in the module. The coordinator and director of the module was Dr. Willem J Pelgrum from the University of Twente in the Netherlands and Prof. Ronald E Anderson assisted in the representation of the findings (Pelgrum *et al.*, 2008: 4).

3.2.2 Conceptual framework and research questions

Four elements were predominant in the SITES M1 namely: curriculum (main element), infrastructure, staff development, management and organisation. The curriculum aspects included the existing pedagogical practices by the participating teachers in primary; lower secondary and upper secondary schools. ICT infrastructure included the availability of both hardware and software. The ICT competence of teachers and ICT related training of teachers formed the basis for staff development aspect of the questionnaire. Managing and organising ICT in schools specifically focussed on the initiatives relating to infrastructure, creating a positive view towards ICT use, and implementation of ICT related policies (Howie, 2005: 21). Table 3.1 lists the four elements included in SITES M1 and the questions addressed to the participating systems.

Table 3.1 Four elements of SITES M1 and research questions *

Focus element	Research question
Curriculum	• What are the ICT-related objectives and pedagogical practices that schools have adopted? • Which ICT-related opportunities are schools offering to learners?
Infrastructure	• What ICT facilities are available in schools?
Staff Development	• How do schools help staff become more able at applying ICT? • What incentives are offered to teachers to acquire ICT-related skills and which training facilities are available for teachers?
Management and organisation	• What policies and other actions are taken by school management to facilitate ICT use? • Which support facilities are made available in schools? • To what extent are school principals in favour of ICT? • What financial arrangements are in place?

* (Howie, 2005: 22)

The questions in Table 3.1 were identified as the core components needed to be addressed to get an overview on the integration process of ICT the participating systems.

3.2.3 Design of the survey instruments

In order to gain relevant information to answer the research questions a survey methodology was considered the most appropriate method. A survey of principals and technology co-ordinators in primary, lower secondary and upper secondary schools formed the basis for SITES M1. A random sample of 251 school for lower secondary and 247 school for upper secondary computer using schools in South Africa was drawn for this study (Howie, 2005: 26).

3.2.4 Findings

The results from the survey were given according to the four elements addressed in the survey namely: curriculum and pedagogy, infrastructure, staff development, and management and organisation.

3.2.4.1 Curriculum and pedagogy

The survey made a division between the school-intended or emerging curriculum (the curriculum the schools intend to realise) and the implemented curriculum (practices by learners and teachers currently existing in schools) (Pelgrum, 2001a: 88). The curriculum and pedagogy part of the survey additionally addressed the ICT-related skills practised or needed in the three phases, the use of email or the Internet for teaching purposes, and ICT relating opportunities regarding the emerging and traditional pedagogical opportunities.

In the lower secondary schools word-processing was seen as the most important ICT-related skill learners needed to practise and in the upper secondary schools word-processing and Spreadsheets was equally important. Using the email or Internet for teaching purposes was high in the upper secondary schools and not so important to the lower secondary schools. Only in Finland, Luxembourg, New Zealand, and Norway did more than 50% of schools use email or the Internet for teaching purposes. In South Africa about 30% of lower secondary schools and about 45% of upper secondary schools made use of the email or Internet for teaching purposes. For ICT-related opportunities regarding the emerging pedagogical practices, learning to search for information and learning by doing were the indicated activities where ICT contributed to a large effect. The traditional pedagogical practices were still dominant in most primary schools, especially in Cyprus and Singapore, and only in Italy and Japan the emerging pedagogical practices were preferred to the traditional. In the lower secondary schools somewhat 50% of schools indicated traditionally important ICT-related opportunities and in the upper secondary there were medium to low percentage values for traditionally important ICT-related opportunities. The systems which indicated high percentages for emerging pedagogical practices were the schools which had a low learner: computer ratio meaning they had access to more hardware than the other systems (Pelgrum, 2001a: 102-116).

3.2.4.2 Infrastructure

The infrastructure data collected focussed on the available infrastructure in the participating systems at the end of 1998. It included: the learner: computer ratio for teaching and learning purposes, the quality of available equipment, availability of computer related equipment, access to the Internet, availability of software, and the problems relating to hardware and software, and the expenditure for school budgets.

To determine the learner computer ratio the total number of learners attending the specific school was divided by the number of computers available for teaching and learning purposes. Canada, Finland, Iceland, Israel, New Zealand, Norway and Singapore were the primary schools which had a low learner computer ratio. In the lower secondary schools, Canada and New Zealand had fewer than ten learners per computer, but in Lithuania and the Russian Federation more than fifty learners had to share one computer. China Hong Kong, Iceland, Luxembourg, and Singapore had more advantageous computer availability in the lower secondary and in the primary schools. Availability in the upper secondary schools was more promising. In South Africa 60% of the lower secondary schools and (45%) of the upper secondary schools had Windows 95 or 98, WinNT MacOS 7,5^{+} processors. This standard of equipment was the same in the majority of the participating systems. In China Hong Kong, the majority of schools; primary 91%, lower secondary 84%, and upper secondary had Intel Pent^{+} Mac 103^{+} higher standard of equipment.

In 1998 nearly 60% lower and upper secondary schools in South Africa were connected to local networks. Iceland indicated the highest level for connectedness at more than 70% in primary, more than 80% in lower secondary, and more than 90% in upper secondary schools. Table 3.2, indicates the percentages of computers that were not in use during the survey in South Africa. More than fifty percent (56% of the computers in the lower secondary, and 57% in the upper secondary schools) were broken. High percentages of computers were outdated: 62% in the lower secondary and (69%) in the upper secondary. More than fifty percent (56% of the total amount) of computers in the lower secondary were not in use and 35% in the upper secondary

Table 3.2 Percentage frequencies of computers not in use in South Africa *

Lower secondary	%	Upper secondary	%
Not in use	56	Not in use	35
Outdated	62	Outdated	69
Not compatible	20	Not compatible	22
Broken	56	Broken	57
Do not know how to use	8	Do not know how to use	7

* (Pelgrum, 2001b: 136)

The computer related equipment most commonly found in all the participating systems were laser printers, CD-Rom drives, colour printers and scanners.

Communications facilities for teaching and learning purposes were the highest in the upper secondary schools and less in the primary and lower secondary schools. The highest access to the Internet was 80% in Canada, China Hong Kong, Chinese Taipei, Denmark, Finland, Iceland, Lithuania, New Zealand, Norway, Singapore and Slovenia. Low Internet access was experienced in Bulgaria, Cyprus and Thailand. Of the participating schools in South Africa more than 50% had access in the lower secondary and more than 60% in the upper secondary schools (Pelgrum, 2001b: 119-140).

Mathematical software was most commonly found available in most of the participating systems. Budget expenditure on software was a lot less compared to that on hardware. In Finland the educational department spent US $50 and in Italy only US $15 per learner on educational software.

One of the barriers identified relating to hardware and software for educational purposes were the lack of copies of the educational software. A vast difference between countries regarding ICT infrastructure in schools and the availability thereof to learners was the most significant finding in the SITES M1 (Pelgrum, 2001b: 149-152).

3.2.4.3 Staff development

The training of teachers to integrate ICT within teaching and learning is an integral part of achieving the 21st century skills. For many teachers it is a complex innovation and they experience difficulties in making the necessary adjustment to their teaching and learning practices. The aspect relating to staff development, addressed in SITES M1 to school principals and ICT coordinators, was to what extent they experienced lack of qualifications as a problem, specifically relating to lack of knowledge and training. In primary schools and lower secondary schools lack of knowledge was identified as a major barrier. The Teachers quality of training was the most significant barrier, especially in Canada, New Zealand, Slovenia and South Africa, in the upper secondary schools (Pelgrum, 2001c: 157-159).

All the participating systems indicated that the training of teachers was a policy goal in their schools. In the participating schools in South Africa, more than 20% of teachers in the lower secondary schools were compelled to undergo training, but 40% of the teachers had undergone training. In the upper secondary schools 40% were compelled and more than 60% had undergone training. Only 20% of the training courses were informal and less than 10% of the courses were done by external agencies. More than 80% of teachers in lower and more than 70% of teachers in upper secondary schools in South Africa received general ICT training, and just above 30% in both lower and upper secondary schools received ICT training (Pelgrum, 2001c: 160-171).

3.2.4.4 Management and organisation

The aspects addressed in this part of the survey dealt with: the principals' attitudes towards ICT, school adopted ICT policies, the extent to which ICT was being used to monitor learners' progress and administrative work of teachers and the organisational problems experienced with the introduction of ICT. In general principals from primary schools, lower secondary and upper secondary schools had a positive attitude towards the use of ICT in schools. More than 80% of principals in South Africa indicated a positive attitude towards the use of ICT in schools.

Despite the positive attitude towards ICT in schools, less than 50% of lower and upper secondary schools in many systems, including South Africa, had an ICT related school policy. Between 40-60%

of primary schools did not make use of ICT to track the learners' performance, 40% of lower secondary schools did make use of ICT to track learners' performance, and in the upper secondary schools ICT was used more frequently for this purpose.

The problems identified in all systems that prevented the realising of ICT-related goals were: insufficient time to prepare ICT lessons, difficulty to integrate ICT in classroom instruction, scheduling enough time to get learners to use the facilities, no time to schedule time for learners to use the Internet and not enough time to explore the opportunities of the Internet (Bos *et al.*, 2001: 181-200).

Regardless of the availability of computers at schools and access to the Internet, in many educational systems significant problems were identified which may have an influence on subsequent projects. The problem most often mentioned was the insufficient number of computers and their inability to have access to the Internet. Teachers had insufficient knowledge and skills regarding ICT and the integration of ICT from a pedagogical perspective show a large difference between systems. Policy goals regarding ICT training for teachers were not realised because only the minority of the schools achieved these (Pelgrum *et al.*, 2008: 4). The relationship between ICT and innovative pedagogical use thereof was also addressed in the SITES Module 2.

3.3 SITES Module 2

SITES Module 2 took place between 1999 and 2002 and comprised both quantitative and qualitative components. It was an international comparative study of innovative pedagogical practices of using ICT in schools, the role that ICT played in these practices and the contextual factors that influenced and supported them. The study provided an opportunity for all the stakeholders in the educational system to get an overview of the current status, and for innovations regarding the implementation and adaptations of ICT in their systems. It also provided policy makers with information that will help them in their ICT initiative, and provided teachers with new ideas for ICT use in classrooms, and identified contributing factors for the successful use of ICT in classrooms (IEA, 2007: 1).

3.3.1 Study design and methodology

A common set of case study methods collected data from 28 educational systems from the Northern and Southern hemispheres. Chile and South Africa were again the only two countries from the Southern hemisphere. Data from 174 case studies between 2000 and 2001 described innovative pedagogical practices using ICT (IEA, 2007). The rationale for using more qualitative research methods was to provide more detailed information relating to the participating people and systems. Due to the large number of cases the quantitative analyses were used to identify the major trends between systems (Kosma, 2003b: 21).

3.3.2 Conceptual framework and research questions

SITES Module 2 was a qualitative, analytical, and not a theory-validation study. Embedded in the framework was a set of factors and general relationships to steer the creation of the instruments, data collection protocols and analyses. Overall the framework focussed on three levels of the education system: micro level (classroom), meso level (school or the local community), and macro level (state, national and international entities) (Kosma, 2003a: 13-15).

At micro level the prime focus was to determine how innovative pedagogical practices can be enabled and constrained by the capabilities of computer-based technologies and capabilities related to representation, generation, storage, processing, and communication of information. All the factors relative to school support and community involvement formed the base for research at meso level. Technology coordinators and principals were interviewed by the research teams about the availability of resources and ICT policies to support teachers' attempts at ICT use in schools. The national and local policies regarding ICT integration were examined at macro level (Kosma, 2003a: 13-15). The factors addressed at the different levels were included in a set of research questions divided into four different areas as indicated in Table 3.3.

Table 3.3 SITES Module 2 research areas and questions *

Areas	Key concepts of the research questions
ICT and innovative classroom practices	• ICT based pedagogical practices • Innovative practices specifically similarities and differences between countries • New teacher and learner roles • Change effect on classroom practices • Affect the patterns of teacher-learners and learner-learner interaction • ICT change the organisation of classroom • Capabilities of the applied technologies support pedagogical practices
ICT and the curriculum	• Practices change curriculum content and goals • Impact on learners' competencies, attitudes and other outcomes • Have they changed learners' knowledge and what teachers need to learn
ICT in the schools	• Contextual factors associated with innovations • Factors present across different innovative pedagogical practices • Implications relating to sustainability and transferability of innovations • Barriers and overcoming of barriers even with limited resources
ICT policies	• Local policies relating to staff development, learner computer fees, facilities, technical support etc. in supporting ICT innovations • National telecommunications policies relating to Internet access, equipment purchase, training and ICT effective for innovations

* (Kosma, 2003a: 16)

Illustrated in Table 3.1 are the core questions included in each of the areas addressed to ultimately answer the main research question.

3.3.3 Findings

Some key findings from this study indicated that ICT supported significant changes in the teaching and learning process. It also pointed out quite a number of similarities on how ICT is being used in constructivist activities in classrooms across educational systems (Pelgrum *et al.*, 2008: 7). In order to interpret the data the 174 cases were organised into 27 themes and 143 codes (Kosma *et al.*, 2003: 47).

3.3.3.1 ICT and innovative classroom practices

Many similarities were found between systems regarding the innovative practices of ICT. The teacher's role was more that of advisor or guide in the learning process and learners became more actively involved in the learning process. The differences between systems were that some systems used ICT to support the advancement of collaboration skills and teamwork while other systems focussed on the improvement of creative thinking skills and learner-centred pedagogy (Kosma *et al.*, 2003: 77-78).

Visible changes were observed in the general organisation of the classroom: group work and teachers and learners actively communicated with peers and others outside their schools to search for information. The most commonly used ICT's was the productivity tools, email and the Web, and not the innovative technologies as was expected (Kosma *et al.*, 2003: 79).

3.3.3.2 ICT and the curriculum

The primary focus of this part of the study was to determine whether the changes within the policy documents warranted the introduction of ICT in schools. Of the 174 cases only 27% portrayed new content, 37% adjusted their goals according to the economic and social changes within their systems, and only 18% indicated that ICT contributed to curriculum change which will ultimately achieve educational reform. All the cases were categorised into three patterns namely: Single-Subject Curricular focus, Thematic Curricular focus, and School-wide Curricular focus. Table 3.4 provides a summary of the trends, findings on ICT, and the curriculum across the three patterns identified in the 174 cases (Voogt *et al.*, 2003: 119).

Table 3.4 Three categorised patterns in ICT and curriculum *

	Single-Subject Curricular	Thematic Curricular	School-wide Curricular
Content goals	• More depth in current content	• New goals important for information society • Content delivered in different ways and cross-curricular approaches and thematic approaches	• New goals important. • Learners responsible for own learning • Independent learning work and subject-related work
Curriculum activities and organisation	• Learners create products and carry out research projects • Learners collaborate and search for information • Tasks requiring problem solving • Teachers advise and guide learners	• Learners create products and carry out research projects • Learners collaborate and search for information • Learners publish and present results • Teachers advise and guide learners	• Learners create products and carried out research projects • Learners collaborate and search for information. • Learners publish and present results • Learners pick their

	Single-Subject Curricular	Thematic Curricular	School-wide Curricular
	• Teachers mediate content and prepared materials		own task • Learners participate in innovation the entire school day • Teachers advise and guide learners • Collaborate regularly
Assessment practices	• More emphasis on formative than on summative assessment • Learners assess their own and peers' work. • More product assessment than tests	• More emphasis on formative than on summative assessment • Learners assess their own and peers' work • More product assessment than tests	Formative and summative assessment are integrated and in some cases supported by ICT
Learner and teacher outcomes	• Learners positive about and motivated by innovations, • Acquisition of ICT skills • Skills not learned separately from the context • Acquisition of collaboration skills. • Teachers develop positive attitude towards innovation • Subject matter knowledge important • Information handling skills important for lifelong learning	• Learners positive about and motivated by innovations • Skills not learned separately from the context • Acquisition of collaboration skills • Teachers develop positive attitude towards innovation • Information handling skills important for lifelong learning	• Learners positive about and motivated by innovations, • Acquisition of ICT skills • Skills not learned separately from the context • Acquisition of collaboration skills • Teachers develop positive attitude towards innovation • Subject matter in compliance with national curriculum requirements. • Information handling skills important for lifelong learning
Added value of ICT	• Specialised software and Subject-specific Web environments. • In-depth coverage of curriculum	• Educational reform related to societal change where learners master new goals. • Productivity tools and digital resources	• Educational reform where ICT was integrated throughout the curriculum
ICT-supported curriculum change	• Innovative pedagogical practices did not involve curriculum change	• Innovative pedagogical practices did not involve curriculum change	• Innovative pedagogical practices did not involve curriculum change

* (Voogt *et al.*, 2003: 120-124)

At all levels remarkable changes occurred with the implementation of ICT in the curriculum, learners were more confident, teachers developed a positive attitude, and educational reform occurred where ICT was used across the curriculum.

3.3.3.3 School context, sustainability and transferability of innovation

The overall results indicated three categories of factors that had an influence on maintaining innovation: characteristics of change, local characteristics and external factors. The characteristics of change were: the needs of the schools to make teachers comfortable with pedagogical approaches used in innovation, teachers' ability to believe that their learners will benefit from the innovations, and the recognition of the value of innovation as a motivating mechanism for teachers. The local characteristics of sustaining innovation are the teachers, principal and school, the districts, as well as the broader community. Teachers' support and professional development was identified as essential components. Professional development not merely to enhance the technical skills of teachers, but also innovative practices teachers need to participate in. Principals need to improve the status of innovation within their schools and provide ongoing support to learners. Some of the external factors identified which had an influence on ICT innovation were ICT policy and plans and the lack of partnerships with universities and private sectors. Numerous barriers were recognised: 62% of the cases lacked of equipment and resources, 41% named teacher-related concerns such as an overworked schedule or limited computer skills, 36% involved learner-related concerns such as inability to make use of the Internet or email, and 30% of the cases indicated a shortage of technical support (Owston, 2003: 159-160).

3.3.3.4 Local and national ICT policies

Several change factors were addressed in national policies: the method to which ICT can change education (Singapore and Finland), the enhancement of learner achievement (United States), ICT-related goals as to the development of ICT capacity and skills in teachers and learners (Denmark), and the goals relating to the performance of learners (England). In several countries the national policy supported the expansion of educational software for curriculum purposes.

The local policies differed relatively between cases. Local policies mainly focussed on the practices that occurred in classrooms. Some cases emphasised the enhancement of higher-order thinking and problem solving skills while others used technologies to change the teaching and learning methodologies. More than fifty percent of the cases (54%) acknowledged that innovation was connected to both the national and local ICT policies (Jones, 2003: 188-191).

Kosmo (2003c: 232-233) agrees that in order for policy makers to achieve effective results regarding ICT innovation, they need to administer several changes within their systems. Firstly, they have to incorporate skills relating to information management, knowledge creation, investigation and collaboration. Constant professional development of teachers and principals need to take place to ensure the implementation of policies and classroom activities. Lastly, they have to revise their assessment methods to incorporate new goals and content, such as information management, problem solving, communication and collaborative skills.

3.4 SITES 2006

Twenty-two countries participated in SITES 2006 (Table 3.4). As indicated, fifteen of these countries also participated in SITES Module 1 and Module 2. SITES 2006 was designed as a survey of schools and teachers—specifically mathematics and science teachers for grade 8. The focus of the study was the pedagogical practices adopted by grade 8 teachers in all the participating systems, and the use of ICT in these practices. A sample of about four hundred schools and four teachers per system was compulsory. The bulk of the data were collected via an Online Data Collection (ODC) specifically designed for this study. The study started in October 2004 and the main collection process took place in 2006. In 2005, the necessary modifications and translations to the piloting instruments were made to make them more accessible to the broader community and the project staff were trained to conduct the process to avoid unnecessary mistakes during the study (Law *et al.*, 2005; Law *et al.*, 2008c: 2-9).

Table 3.5 Education systems that participated in the three SITES modules *

Education system	SITES M1	SITES M2	SITES 2006	Education System	SITES M1	SITES M2	SITES 2006
Alberta Province, Canada				Japan			
Catalonia, Spain				Lithuania			
Chile				Moscow, Russian Federation			
Chinese Taipei				Norway			
Denmark				Ontario Province, Canada			
Estonia				Russian Federation			
Finland				Singapore			
France				Slovak Republic			
Hong Kong				Slovenia			
Israel				South Africa			
Italy				Thailand			

* (Law *et al.*, 2008e: 294)

3.4.1 Study design and methodology

Despite vast socio-economic, political, ICT access and curriculum differences between educational systems around the world, many schools share common views regarding classroom practices and the positive effect the integration of ICT can have on the teaching and learning process. SITES 2006 vision was to build on the findings from previous SITES Modules and to identify factors that contributed mostly to the effective integration of ICT into the teaching and learning process. SITES 2006 consisted of a survey of teachers, principals and ICT coordinators (Law *et al.*, 2008d: 16).

3.4.2 Conceptual framework and research questions

The focus of SITES 2006 was to determine the classroom practices most commonly used, the different types of activities learners engage in and whether ICT has been used in any of these activities. In order to achieve satisfactory results the assumption was that ICT-using practices are part of the teachers' daily pedagogical practices. The overall conceptual framework developed for this study includes all the factors namely school factors, system factors, teacher and learner characteristics, overall pedagogical practices using ICT and learning outcomes that have to interrelate in order to achieve quality pedagogical practices using ICT (Law *et al.*, 2008d: 19). According to Ten

Brummelhuis (1995: 91), successful implementation of ICT is not dependent on the presence or absence of one factor but is determined during a dynamic process of linking all the factors. The findings and results from the previous modules helped to determine the relevant factors that should to be included in the overall conceptual framework for SITES 2006 (Law *et al.*, 2005: 7) . The three research questions were based on the conceptual framework for the study to ensure that all the facets within the framework were included within the research process, of which the first two questions focussed on the pedagogical aspects and the third concentrated more on the contextual factors that can be influential on the pedagogical practices of ICT in schools.

Research question 1: *What are the pedagogical practices adopted in schools and how is ICT used in them?*

This question aimed to determine what the key pedagogical approaches were and which practices were adopted by teachers in their teaching, the importance of ICT use in realising these different approaches and practices, and the perceived impact of ICT on learners.

Research question 2: *What ICT and how is ICT used in specific situations where ICT has been used relatively extensively within a pedagogical practice?*

This question aimed to gather descriptions from teachers of their satisfying experiences in their use of ICT in teaching. They were asked to describe one experience where ICT had been used to support learning and teaching, and they had to report on the contributions of ICT in practice to learner outcomes and teaching practice.

Research question 3: *What are the teacher, school, community and system factors that are associated with different pedagogical approaches and ICT?*

This question aimed to explore the current status of these factors within the different educational systems, how these may be related to different characteristics of pedagogical practices and ICT use, and whether there were systematic differences across countries in relation to the explanatory models identified (Law *et al.*, 2008d: 20).

3.4.3 Design of the survey instruments

In order to gain the relevant information to answer the research questions, a survey methodology was considered the most appropriate method of gathering data to realise the aim and the current status of pedagogical practices and ICT use in all the participating educational systems. The survey consisted of three questionnaires: a teacher questionnaire (core component), a principal questionnaire and a technical questionnaire. An additional context questionnaire was distributed to the National Research Coordinators to gather contextual information at system level (Law *et al.*, 2008d: 20).

3.4.4 General information

The first part of the questionnaire comprised questions relating to the target class: the gender, learner ratio per class, curriculum track of the class, absenteeism, language of instruction (whether it was the learners' native language) and time spent teaching mathematics and science. The data gathered were used to gather information at system level and not for analyses due to the fact that it was not part of the main aspects addressed within the conceptual design (Pelgrum *et al.*, 2008: 22-23).

3.4.5 The teachers' questionnaire

The teacher questionnaire was the core component of SITES 2006**.** The questionnaires were distributed to grade 8 Mathematics and Science teachers, and the main purpose was to answer questions regarding the factors that influence the pedagogical practices and ICT. The questionnaire comprised eight parts: Information about the Target Class; Curriculum Goals; Teacher Practice; Learner Practice; Learning Resources and Technology Infrastructure; Impact of ICT Use; Information about You and Your School and Specific Pedagogical Practices that Use ICT. Three sets of core indicators on pedagogical orientation were developed: the curriculum goal orientation, teacher's role orientation, learners' role orientation as well as the ICT pedagogical orientations of mathematics and science teachers (SITES, 2006c).

3.4.5.1 Information about the target class

The first part of the teachers' questionnaire required certain information regarding the target class specifically focusing on the gender, the curriculum track, absentees on that specific day, the language of instruction and the scheduled class time they have available for Mathematics and Science. This information was used to get a clear focus on the class when answering the rest of the questions within the questionnaire and not to be used for analyses purposes. Law et al., (2008d: 23) believe that this information could have provided some insights, different perspectives, or changed perceptions regarding some aspects of the study.

3.4.5.2 Curriculum goal orientation

Several aspects were extensively addressed in the questionnaire, and Table 3.6, provides an overview of the curriculum goal orientation included in the questionnaire. This was included to get an idea of the curriculum goal orientation in all the participating systems. In general, the traditional goal orientation was the highest for all the participating systems and the connectedness was the lowest. The only countries where lifelong learning goal orientation was high were Ontario Province, Canada, Estonia and Norway (see Table 3.5). Denmark and France were the only two countries where the traditional and lifelong learning curriculum goal orientations were equally important (Law *et al.*, 2008a: 122-125).

Table 3.6 Summary of number frequencies of the core indicators on curriculum goal orientations for grade 8 mathematics in South Africa *

	Curriculum Goal Orientation	Not at all	A little	Somewhat	A lot
A	Prepare learners for work	13	46	110	488
B	Prepare learners for secondary education	6	15	75	563
C	Provide for to learn peers and experts	43	85	175	354
D	Provide activities to incorporate real world	10	55	148	443
E	Improve learner performance assessment	3	14	64	578
F	Increase learning motivation	4	11	77	567
G	Individualise learner learning experiences	6	54	208	386
H	Learners plan, monitor or evaluate progress	10	74	189	384
I	Foster collaborative or organisation skills	8	69	178	401
J	Communication skills face to face or online	22	78	185	368
K	Satisfy parents or community expectations	14	45	174	417
L	Prepare learners for competent ICT use	150	102	117	273

* (SITES, 2006a)

South African grade 8 mathematics teachers indicated that to prepare learners for upper secondary education and beyond, to improve learners' performance in assessment and examinations, and to increase learning motivation were the most important aspects in curriculum goal orientation. To prepare learners for competent ICT use and for responsible Internet use was not a top priority to them. South African teachers and the teachers from all the other participating systems indicated that the traditional goal orientations are important to them (SITES, 2006c).

3.4.5.3 Pedagogical practice orientations

Table 3.7 provides an overview of the pedagogical orientations addressed within the teacher's questionnaire and the South African data for grade 8 mathematics. A four-point scale (1 = Never, 2 = Sometimes, 3 = Often, 4 = Nearly Always) was used and Figure 3.1 indicated whether teachers in South Africa made use of ICT's when practising these activities. Teachers in grade 8 mathematics preferred to make use of teacher lectures and exercises to practice skills and procedures. Overall, the learners played a more passive role and the teachers were more likely to engage in pedagogical activities. The traditional method of teaching and learning still dominates South African grade 8 mathematics classrooms (Law *et al.*, 2008a: 124-132).

Table 3.7 Number frequencies of the core indicators on pedagogical practice orientations in South African schools*

	Teacher Practice	Never	Sometimes	Often	Nearly Always
A	Extended projects	120	342	130	38
B	Short- tasks projects	54	219	246	114
C	Product creation	109	324	132	64
D	Self- assessed courses	74	242	202	107
E	Scientific Investigations	129	285	152	61
F	Field Study activities	201	258	120	43
G	Teacher lectures	69	122	202	229
H	Exercises to practice skills and procedures	34	116	222	253
I	Laboratory experiments clear instructions	360	132	77	51
J	Discovering Mathematics principles concepts	34	135	234	228
K	Studying natural phenomena	153	236	168	63
L	Looking up ideas and information	46	220	205	162
M	Processing and analysing data	89	197	206	136

* (SITES, 2006a: 15-21)

The pedagogical practice orientations in South Africa rated the highest among all the participating systems were exercises to practice skills and procedures, teacher lectures, and discovering mathematics principals and concepts, and conducting extended projects, laboratory experiments with clear instructions and product creation were the lowest. Despite the high scores for lifelong learning goal orientations in Ontario Canada, Estonia and Norway the pedagogical orientations for lifelong learning were remarkably low, which means that, even though they aspire to achieve lifelong goal orientations, they do not practice it in their classroom (Law *et al.*, 2008a: 128-129).

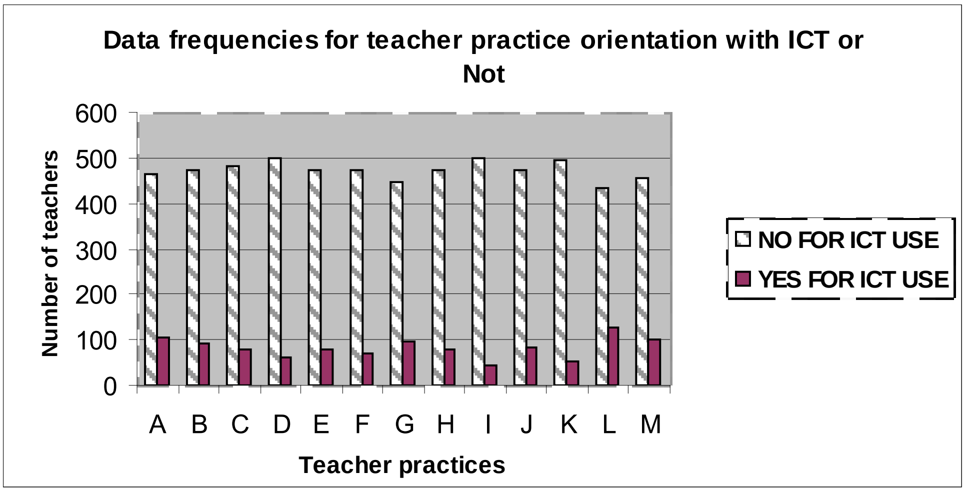

Figure 3.1 Data frequencies for teacher practice orientations with ICT or not

Figure 3.1 gives an overview of the use of ICT within the teacher practice activities in Table 3.7when teaching grade 8 mathematics in South African schools. On the x-axis the teacher practice-orientations are indicated and on the y-axis are indicated whether teachers made use of ICT (Yes or No) in their teacher practices orientations. The teachers mainly made use of ICT when doing research. With regard to the rest of the teacher practice activities, the majority of the grade 8 mathematics teachers did not make use of ICT. Addressing these core components enabled the researcher to get in-depth results regarding the main aspects that had to be researched and to obtain detailed results regarding the main aspects of the research (Law *et al.*, 2008a: 124-132). The teachers still preferred to be involved in traditional activities where the learners play a more passive role in the classroom and they do not participate in lifelong learning activities like searching for information, and processing and analysing data. Teachers and learners only made use of ICT when engaging in traditional pedagogical practices and activities. Finland was the only participating system where the teacher practice indicator was the highest for connectedness.

3.4.5.4 Learner Practice Orientations

The learner practice-orientation focus on how often teachers engage their learners in the various activities displayed in Table 3.8 e.g. exploring, observing and monitoring, teambuilding and collaboration which are some examples of lifelong learning activities (SITES, 2006a: 22-32).

These activities, which enable learners to function effectively in society and require them to engage metacognitively, the act where learners set their own goals, plan their learning activities and monitor their level of mastery and understanding (Kosma, 2003a: 13), tend to be neglected. Despite the fact that teachers have to promote learner engagement within the teaching and learning process in order to promote the attainment of 21st century skills, which include creativity and innovation, critical thinking and problem solving, and communication and collaboration (Partnership for the 21st Century skills, 2004: 2), the traditional methods of completing activities and tasks still prevail in classrooms. The mathematics teachers more frequently engaged their learners in completing worksheets or exercises in most of the systems, and science teachers reported a higher connectedness than mathematics teachers (Law *et al.*, 2008a: 136). Table 3.8, gives a summary of the number frequencies of the learners' practice orientations in grade 8 mathematics in South Africa and Figure 3.2 gives an indication whether ICT were used or not when conducting these activities. These numbers indicate that the majority of the learners participated often or nearly always in completed worksheets, activities and answer tests and responded to evaluations using ICT. The learners mostly practised traditional classroom activities, and activities requiring communication, collaboration, determining own goals and learning at own pace, were less popular.

Table 3.8 Summary of the number frequencies of the core indicators on learners' practice orientations in grade 8 mathematics in South Africa *

	Learner Practice	Never	Sometimes	Often	Nearly Always
A	Learners working on the same learning materials at the same pace	36	204	236	165
B	Learners learning and working during lesson at own pace	19	207	260	156
C	Complete worksheets, exercises	14	106	219	303
D	Give presentations	85	281	170	103
E	Determine own content goals for learning	167	274	133	66
F	Explain and discuss own ideas with teachers and peers	35	243	243	123
G	Collaborate with peers form other schools within or outside the country	276	240	83	41
H	Answer tests or respond to evaluations	6	89	252	292
I	Self or peer evaluation	49	238	220	134
J	Reflect on own learning experiences and review or adjust learning strategy	130	268	167	70
K	Communicate with outside parties	225	268	103	43
L	Contribute to community through own learning experiences	257	257	92	35

* (SITES, 2006a: 22-32)

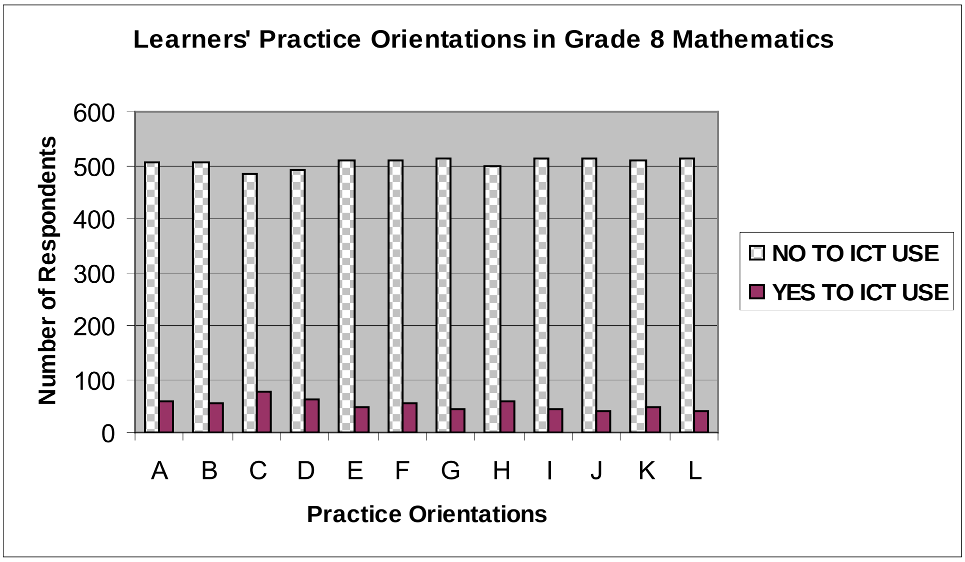

Figure 3.2 South African learners' practice orientation grade 8 mathematics

Figure 3.2 presents the data recorded for the use of ICT in learner practice orientation in grade 8 mathematics in South Africa. On the x-axis the learners' practice-orientations are indicated and whether learners made use of ICT (Yes or No) in their practices orientations are indicated on the y-axis. The majority of South African learners do not make use of ICT when learning. ICT was most frequently used to complete worksheets and exercises (SITES, 2006a: 22-32).

The traditional orientation dominates in all three sets of core indicators on pedagogical orientation. Change needs to occur in the pedagogical practices in all systems that participated in SITES 2006.

Pedagogical innovations need to occur within curriculum goal orientation, teacher practice orientation and learner orientation in order to develop lifelong learning abilities and skills (Law *et al.*, 2008a: 136).

3.4.5.5 Learning resources

Teachers used a variety of resources during the teaching and learning process, depending on the outcomes to be achieved. They were supplied with a list of tools and resources and asked to indicate how often they made use of these during teaching and learning in their mathematics and science classes. Results indicate that the majority of teachers still prefer to use *conventional equipment* and *hands-on materials* rather than any other resources, closely followed by the *general Office Suite* that was used by both Mathematics and Science teachers. Science teachers generally made use of a variety of resources and Mathematics teachers more frequently made use of tutorial or exercise software. In many of the systems ICT usage levels were high, but teachers still tend to avoid more sophisticated and advanced equipment such as mobile devices and smart boards. A strong link exists between the learning management systems (e.g. web-based learning environments) and time and space, due to the fact that those teachers who indicated a low level of learning management system use also indicated the lowest level of separation in time and space. When learning management systems are high in use and planned, like in Chile, the low level of separation in space will not have an influence on the activities learner will participate in (Law *et al.*, 2008a: 158-161).

3.4.5.6 Outcomes assessment and ICT use

Assessment forms an integral part of the teaching and learning process. Applying formative and summative outcome-based assessment strategies allows teachers to measure their learners' performance according to the learning outcomes and assessment standards for that specific grade. A variety of assessment methods are available to measure the learners' performance depending on the teaching and learning strategies. Teachers were given a list of eight different assessment methods and were asked whether they made use of these strategies during their academic year, and if they made use of ICT to perform these assessment tasks. The types of assessment were grouped as traditionally important (written tests or examinations, written tasks or exercises), learning products (individual and oral presentations, oral and written group presentations, project report and multimedia products) and reflection or collaborative (learner peer evaluation, portfolio and learning log, assessment of group performance on collaborative tasks). Similarities and differences across systems were evident from the results received. Many teachers still preferred the traditional methods of assessment, but in Thailand and South Africa, teachers indicated an 80% and above average for learning products, reflection or collaboration. The majority of systems, with the exception of Chinese Taipei and Finland, had a mean percentage use for Science which is higher than 50% for learning products in assessment. Catalonia, Chinese Taipei, Finland, Israel, Japan and Slovenia were the only participating systems that did not have higher than 50% for learning products in mathematics (Law *et al.*, 2008a: 150-154).

The adoption of ICT during assessment varied greatly across systems. Mathematics teachers mostly made use of ICT in assessment of traditionally important tasks and not during the other forms of assessment, but it was still less than 50%. Mathematics and Science teachers in Hong Kong, Ontario and Singapore more frequently made use of ICT in learning products than during traditionally important tasks (Law *et al.*, 2008a: 161-165).

3.4.5.7 ICT using pedagogical orientations of mathematics and science teachers

Additional information was collected regarding specific aspects which included the pedagogical activities, types of learning resources used, methods of assessment and whether ICT has been used in any of these activities. The results indicate that the pedagogical activities which have been practised by teachers for many years (e.g. teacher lectures, discovering mathematics principles and concepts) tend to be the most popular and the majority of teachers make use of ICT when engaging their learners in these activities. The least frequently practised activities were studying natural phenomena, field study activities and lab experiments. Some of the most popular ICT resources were tutorial and exercise software, general office suite, conventional equipment and hands on materials. Data logging tools, simulations, data modelling, digital games, mobile devices and smart boards are the least popular of all the ICT resources. The majority of teachers used the traditional methods of assessment in all of the systems. Thailand and South Africa had an average of about 80% for the use for learning products, specifically individual oral presentations, group presentations (oral or written), project reports and multimedia presentations. Assessment of collaborative tasks, and learners' self and peer evaluations were the least popular methods of assessment (Law *et al.*, 2008a: 161-165).

3.4.5.8 Extent and perceived impact of ICT on teaching and learning

ICT usage in general in grade 8 encountered the lowest usage level in South Africa, which was only 18% for mathematics and 15.9% for science. South Africa was the only participating system which did not have100% ICT access and availability in schools. An average of 80% of teachers in schools in Singapore and Hong Kong make use of ICT in teaching and learning. Despite the high usage level of ICT in teaching and learning, pedagogically ICT is not used to its full potential. Teachers make use of ICT for administrative tasks, to empower their teaching and develop their ICT skills. Unfortunately, teachers do not make use of ICT when monitoring learners and when giving feedback on their progress. Ontario Canada had the highest percentage of ICT use for teaching and learning purposes (Law *et al.*, 2008a: 175).

3.4.5.9 Teachers' perceived impact of ICT on self

Teachers' acceptance of the value and use of ICT within the teaching and learning of mathematics and science will determine the impact ICT will have on their personal growth and development. Figure 3.3 indicates the number frequencies of the teachers ICT use or lack of ICT when teaching mathematics in grade 8 in South African schools.

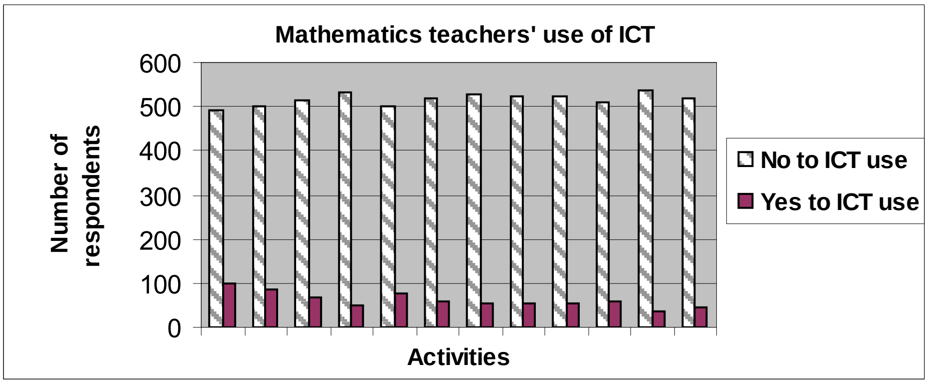

Figure 3.3 South African grade 8 mathematics teachers' use of ICT (SITES, 2006a: 24-32)

Israel reported that only 22.3% of their grade 8 mathematics teachers make use of ICT when teaching and learning but the perceived the impact of ICT as being very high. Ontario Canada reported the highest percentage of teachers using ICT when teaching and learning. Unfortunately, the ICT usage level for mathematics teachers in South Africa was very low. Figure 3.3 presents the South African mathematics teachers' response on the use of ICT. On the x-axis the teacher practices are indicated and on the y-axis is indicated whether ICT had an impact (Yes or No) in their teacher practices. An average of 86% of mathematics teachers in grade 8 reported that they do not make use of ICT to present information, give class instruction or provide enrichment instruction to learners. More than 90% of mathematics teachers do not make use of ICT to help learners in exploratory and inquiry activities, to organise, observe or monitor learner-led whole-class discussions, demonstrations, presentations, to provide feedback to learners, for classroom management, to organise, monitor and support teambuilding among learners, to collaborate with learners and peers within or outside the school and for counselling to learners. The use of ICT for teachers in grade 8 mathematics in South Africa is still not accepted and valued as an integral part of personal growth and enrichment.

Figure 3.4 presents the data for South African grade 8 mathematics teachers' confidence in using ICT and the impact of ICT use has on them.

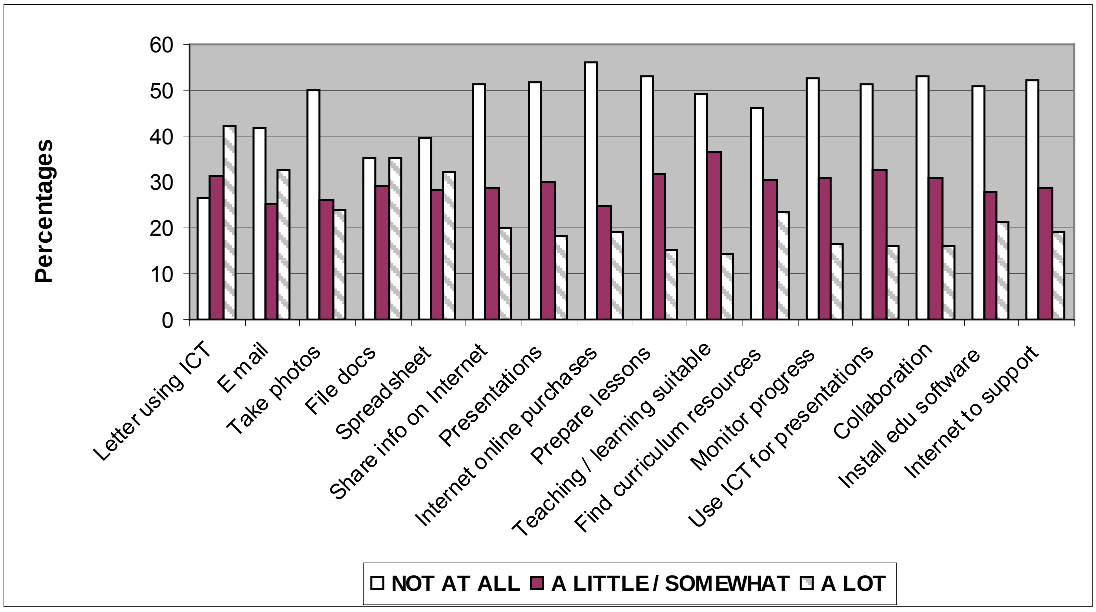

Figure 3.4 South African grade 8 mathematics teachers' confidence in using ICT (SITES, 2006a: 61-66)

Teachers who regularly make use of ICT in teaching and learning have the opportunities to explore and experiment with a variety of teaching and learning methods. Using ICT will eventually increase teachers' confidence as the regular interaction with a variety of software will show them that ICT can be of great value when used in teaching and learning (Osborne *et al.*, 2003: 4). Across all the participating systems teachers generally have a positive perception of ICT itself, although a vast number of teachers admit to not being confident using ICT in broader educational systems, specifically the pedagogical use of ICT in grade 8 mathematics and Science (Law *et al.*, 2008a: 174). The South African data frequencies indicate that the majority of South African mathematics and science teachers in grade 8 are not confident in performing some of the most basic ICT functions. An average of 26% of grade 8 mathematics teachers in South Africa does not even make use of ICT to write a letter. Only 18% of grade 8 mathematics teachers in South Africa are confident in making PowerPoint presentations with simple animation, 46% of respondents had no knowledge of how find curriculum resources on the Internet, 53% do not know how to collaborate with other colleagues via email and an average of 49% of them do not know in which teaching and learning situations to use ICT. Professional development needs to take place, starting with training teachers in basic ICT skills and then advancing to more advanced skills. This can aid teachers in accepting ICT as part of their daily teaching practices and realising the value ICT can bring to their teaching and learning. Teachers' access to education content to integrate ICT in the curriculum for 2006-7 was 50% for teachers in the Eastern Cape, Gauteng, Limpopo, North West and the Western Cape .(South Africa, 2007b: 69)

3.4.5.10 Teachers' perceived impact of ICT use on learners

The teachers who indicated they made use of ICT when teaching and learning were asked to indicate the extent to which the use of ICT impacted on their learners in 15 different areas of education. A five-point Likert scale was used (1 = decreased a lot, 2 = decreased a little, 3 = no impact, 4 = increased a little and 5 = increased a lot) so that they could indicate each as either positive or negative (Law *et al.*, 2008a: 173). Table 3.9 displays the eight types of impacts perceived by South African grade 8 mathematics teachers that participated in this question. The number of participants in this question gives us an idea of the low usage of ICT in teaching and learning of grade 8 mathematics. Figure 3.4 shows that the teachers who make use of ICT acknowledged that there was a general increase in all the aspects mentioned. Those teachers who indicated a decrease in impact within the different aspects were only a small percentage of those who participated.

Table 3.9 Frequencies of South African teachers' perceived impact of ICT use on learners*

	Impact on learners	Decreased a lot	Decreased a little	No Impact	Increased a little	Increased a lot
A	Subject matter knowledge	6	5	52	66	37
B	Learning motivation	6	5	50	57	47
C	Information handling skills	7	7	54	56	40
D	Problem-solving skills	4	10	53	58	37
E	Self-directed learning skills	8	8	56	56	35
F	Collaborative skills	6	10	51	68	28
G	Communication skills	5	9	46	58	45
H	ICT skills	13	3	57	59	32
I	Learn at own pace	9	7	50	60	35
J	Self esteem	8	4	50	61	41
L	Time spent on learning	12	12	51	58	29
M	School attendance	10	8	67	35	43
N	Assessment	8	6	56	61	32
O	Digital Divide	12	15	71	42	25

* (SITES, 2006a)

Even though some teachers indicated that there was some decrease to learners' ICT skills when using it within their learning activities the majority of teachers indicated that the use of ICT had little or a lot of impact on their learners' when conducting activities with the use of ICT's.

3.4.6 Additional component to the teacher's questionnaire

This component was used as an extension on information received from SITES Module 1 and SITES Module 2. In SITES Module 1 the principals were asked to describe the most satisfying example of ICT in their school, and in SITES Module 2 teachers were asked to describe the new and creative exemplars of ICT using pedagogical practices in their country. Based on the findings from previous modules, an additional component for SITES 2006 was developed. Firstly, teachers were asked to describe in detail the pedagogical practices, the ICT used and the content used in a maximum of twenty words, after which three multiple questions were added to get unambiguous results (Law *et al.*, 2008d: 24).

3.4.6.1 Pedagogical practices, ICT and content

The teachers' questionnaire where teachers had to indicate whether they made use of ICT in their teaching practices, many teachers did not adhere to the requirements for the descriptive question. The majority of the mathematics teachers in South Africa did not answer this part of the question (SITES, 2006a: 90-99). An extensive range of descriptions were received: some were very short and briefly mentioned ICT used, while others were rich in description and informative regarding the pedagogy, ICT applications and content used. Data were acquired online, and the limited space available obstructed the ability to have a complete and clear answer. A selection of the more informative descriptions was used to gather the results for this part of the questionnaire. The first five complete mathematics and science examples were selected from the database of every participating system. NRC's from all the systems translated the descriptions in English and only the NRC from Chinese Taipei did not submit results. In Alberta Province Canada, Chile, Italy, Ontario, Hong Kong (only for Science) and Russian Federation (only for mathematics) ICT is used on a weekly basis. In six of the participating systems some of the science teachers and more in mathematics do not make use of ICT in pedagogical activities. Only four of the 22 participating systems are moving towards a lifelong learning approach and coping with the demands of the 21 st century (Voogt, 2008: 226-229).

3.4.6.2 Pedagogical practices with ICT use contributed to changes in learners' outcomes

The grade 8 mathematics and science teachers were asked whether the pedagogical practice with ICT contributed towards changes in the learners' outcomes. Many of the mathematics and science teachers reported that learner outcomes had increased on everything but the achievement gap among learners. Teachers that use ICT on a regular basis were certain those learners' ICT skills, learning motivation, ability to learn at their own pace, communication skills, problem solving skills and self-esteem had increased. Table 3.10, gives a summary of the South African data gathered and the response of the participating teachers. Many of the teachers indicated that the learner outcomes had increased in all the relevant areas. Only 26% of all the participating teachers in grade 8 mathematics in South Africa completed this part of the questionnaire; thus the pedagogical practices with ICT are still largely untapped (Voogt, 2008: 232).

Teachers of grade 8 mathematics and science were asked to indicate whether the use of ICT in the pedagogical practices contributed to changes in their teaching practices. Table 3.10, indicates that many of the teachers reported that they were able to adapt to the learners' individual needs and better the quality of classroom instruction. An overall increase in collaboration among learners and teachers was achieved and teachers had more resources and content at their disposal. The only negative aspect mentioned by some teachers was that the preparation time increased, but many of the teachers did not perceive a difference from their normal routines. It was noticed by some teachers that the amount of time spent to motivate learners had decreased (Voogt, 2008: 239).

Table 3.10 Frequencies of pedagogical practices with ICT use contributed to changes in learners' outcomes *

	Learners' outcomes	Decreased	Made no difference	Increased	Total Participants
A	Subject matter knowledge mastery	11	48	98	157
B	ICT skills	12	54	90	156
C	Learning motivation	8	43	105	156
D	Ability to learn at own pace	9	58	88	155
E	Communication skills	12	43	100	155
F	Information-handling skills	9	53	94	156
G	Collaborative skills	9	63	84	156
H	Self-directed learning skills	8	63	85	156
I	Problem-solving skills	7	51	97	155
J	Achievement gap among learners	12	56	86	154
K	Self-esteem	9	50	96	155

* (SITES, 2006a)

Derived from the results in Table 3.10, the use of ICT's contributed positively to the teaching nad learning of mathematics.

Table 3.11 gives a summary of to what extend the pedagogical use of ICT use contributed to changes in teaching of grade 8 mathematics in South African schools. Many of teachers acknowledged that there was more time available to help learners that the quality of instruction and discussions increased a greater variety of learning activities and resources were used, that collaboration among learners increased, better insight into the progress of the learners was gained and their learners' confidence increased.

Table 3.11 Frequencies of pedagogical practices contributed to change in teaching *

	Pedagogical practice	Decreased	Made no difference	Increased	Total participants
A	Quality of coaching learners	9	50	100	159
B	Time available to help individual learners	14	61	85	160
C	Time needed to solve technical problems	19	60	79	158
D	Time needed for preparations	24	49	86	159
E	Quality of instruction given to the learners	11	51	93	155
F	Time needed for classroom management	20	55	83	158
G	Quality of classroom discussion	11	53	95	159
H	Collaboration between learners	7	61	91	159
I	Communication with the outside world	17	62	80	159
J	Availability of new learning content	9	51	99	159
K	Variety of learning resources or materials	14	53	91	158
L	Variety of learning activities	12	49	97	158
M	Adaptation to individual needs of learners	13	61	84	158
N	Amount of effort needed to motivate learners	15	57	87	159
O	Insight into the progress of learner performance	8	56	95	159
P	Self-confidence	7	52	100	159

* (SITES, 2006a)

Grade 8 mathematics teachers from all participating systems agreed on most of the aspects mentioned in this question. Unfortunately, the opinions expressed were only some of all the participating grade 8 mathematics teachers in South Africa.

3.4.6.3 Initiating agent of teaching and learning actions

The grade 8 mathematics and science teachers were asked to indicate which party (teacher or learner) initiated actions of teaching and learning in the pedagogical practice. Different aspects of teaching and learning were included within this specific question and teachers were asked to indicate which party was responsible for initiating this aspect of the teaching and learning. The results from all the participating systems show that the teachers in all the systems were the initiators in teaching and learning activities. Demonstrating learning achievement was the only aspect where 43% of the teachers reported that the learners take initiative. Teachers who make use of ICT on a weekly basis reported that learners take the initiative in organising group work (Voogt, 2008: 247).

Table 3.12, summarises the different aspects addressed in this question and data as captured in South Africa. It shows that the grade 8 mathematics teachers in South Africa are the initiators in the planning and conducting of teaching and learning activities. Learners tend to take initiative only when demonstrating learning achievement, organising groups and providing feedback. The remaining teaching and learning activities was teacher initiated.

Table 3.12 Frequencies of initiating actors of teaching and learning aspects *

	Initiating teaching and learning activities	Teacher	Learner	NA
A	Determining content	334	10	48
B	Determining learning goals	325	27	38
C	Getting started	308	38	38
D	Organising grouping	294	61	35
E	Choosing learning materials or resources	342	16	32
F	Deciding on the location of learning	325	25	39
G	Planning of time	340	19	34
H	Deciding on the time needed for learning	324	31	36
I	Deciding on when to take a test	321	30	36
J	Demonstrating learning achievement	257	95	36
K	Monitoring progress	349	9	32
L	Providing feedback	302	52	34
M	Choosing learning activities or strategies	352	9	32

* (SITES, 2006a)

Adjusting teaching and learning strategies towards a more learner-centred approach is important in order to achieve 21st century goals, but the planning of teaching and learning activities still needs to be initiated by the teacher (Partnership for the 21st Century skills, 2004).

3.4.7 The school questionnaire

The school questionnaire, which included the principal's questionnaire as well as the technical questionnaire, focused on the infrastructure, the pedagogical practices and the status quo of lifelong learning in schools, professional development of the teachers regarding ICT training for teaching and learning, internal and external pedagogical support system and the general organisation and management of ICT in the teaching and learning at school level (Voogt, 2008: 39).

3.4.8 National context questionnaire

The National context questionnaire provided educational system level information regarding the contextual factors associated with the pedagogical practices and ICT use, and assisted with the interpretation of the results from the teachers' and school questionnaires. Four spheres of contextual factors were included within the contextual questionnaire namely demographics, educational systems, pedagogy and the effect of ICT. Figure 3.5 displays the four spheres of contextual factors included in the national context questionnaire.

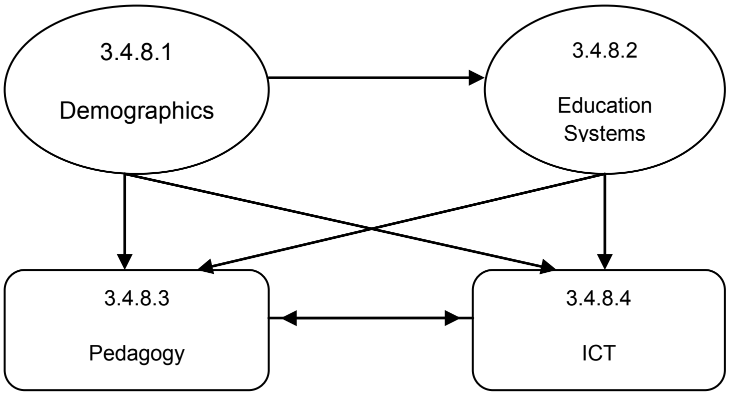

Figure 3.5 Four spheres of contextual factors

The four spheres gave valuable insight regarding the main components which need to be in place to achieve successful ICT integration with teaching and learning.

3.4.8.1 Demographics

During 2006, several demographic and educational system-wide cultural indicators were obtained from the UNDP (Human Development Report), which included population, urbanisation, income, income inequity, education level and capital investments in education. The context questionnaire explored the extent to which these indicators influence structure, pedagogy, and ICT in education. A limited number of demographic indicators were selected due to prior research that indicated that these indicators have an influence on the patterns of diffusions of ICT within education (Anderson *et al.*, 2008: 39-40).

3.4.8.2 Structure of educational systems

In addressing the structures of educational systems, four sets of indicators were identified; (1) educational systems investment and output, (2) centralisation and terms of funding sources and curriculum components, (3) professional development requirements for teachers, and (4) Mathematics and Science curriculum components (Anderson *et al.*, 2008: 40).

3.4.8.3 Pedagogy

The national research questionnaire instrument contained a number of questions for the NRC to answer with regard to prevailing styles in pedagogical practices within each system. These included aspects like teacher preparation, changes in pedagogical practices over the last five years and the new pedagogies using ICT. Table 3.13 summarises the questions addressed in teacher preparation, changes in pedagogy and new pedagogy (Anderson *et al.*, 2008: 38-50).

Thirteen of the participating systems (including South Africa) required any postgraduate degree with an additional diploma in education; four of the systems required only a post secondary diploma or a certificate in education; only teachers in France were required to have a post secondary degree; and Finland, Singapore and Italy had other requirements to teach from grade seven. In none of the participating systems were teachers required to have subject teaching knowledge with ICT; fourteen systems expected no ICT training and knowledge, two reported that they require technical knowledge, and three systems, namely Japan, Lithuania and Singapore, required ICT based pedagogy. Thirteen systems reported that their teachers were not required to undergo any of the professional development activities listed, Japan and Thailand require their teachers to undergo most of the professional development and four systems (Israel, Catalonia (Spain), Lithuania, and Ontario Province) did not list professional development activities, however most of their teachers do take part in professional development (Anderson *et al.*, 2008: 49). In most of the systems the ministry of education provides the funds for professional development that needs to take place. Twenty of the systems reported that there was a slight increase in terms of non-standard pedagogical practices over the past five years. The new pedagogies with ICT listed in Table 3.9, are some of the attributes of a learner-centred approach to teaching and learning identified as important aspects for ICT integration in schools. Only Alberta Province Canada, Norway and Thailand reported that they have a curriculum program which includes all of the five attributes. Twelve of the systems did not have a system-wide program and the remaining seven systems addressed some of these attributes.

Table 3.13 Summary of questions on teacher preparation, change in pedagogical practices and new pedagogies using ICT *

Teacher preparation
What is the normal requirement for being certified a teacher?
Are there ICT specific requirements for being certified a teacher?
Are qualified teachers in the target grade required to undertake regularly any in-service training and or professional development?
Do any government agencies subsidise in-service training or professional development courses for teachers in any of the following areas? • a. ICT skills • b. use of ICT in subjects • c. use of ICT in administration • d. use of ICT for new approaches in learning
Change in pedagogical Practices
Non- traditional practices has increased or decreased over the five years?
New pedagogies using ICT
• b. Learner-centred pedagogies • c. online learning • d. connecting with other schools and cultures • e. collaborative team learning • f. Communication and presentation

* (Anderson *et al.*, 2008: 38-50)

3.4.8.4 Use of information and communication technologies

Various aspects were included in this part of the questionnaire namely funding for ICT in education, ICT policies and practices on the use of ICT.

- **Funding**

Twenty of the systems increased their funding for ICT over the past five years. Norway, Catalonia, Spain and Finland spend vast amounts of money on ICT. South Africa was one of the countries who increased their ICT funding, but it was less than the required amount. The funding required for e-Education in South Africa in the budget plan was R 608,4 million for all provinces, but only 36% of the target was met in 2005-6, R 717 million for 2006-7 of which only 48% of the target was met and R 789,6 million required for 2007-8, but only R 394,788 (0.44%) was allocated (South Africa, 2007b: 69). The shortfall of funds, the lack of training and access to ICT for integration into the curriculum every year will ultimately create a bigger gap between South Africa and the other educational systems worldwide.

- **System-wide ICT Education Policy**

In twenty of the systems an ICT policy in education existed. Each system was asked to look at the eleven specific components: clear vision, support for the curriculum, mode of integrating ICT in teaching, minimum level of access to ICT, Internet connectivity, goal to reduce the digital divide, attempt to ensure ICT access outside school, teachers' professional development requirements, stimulation of teachers' professional development requirements on ICT, evaluation for ICT policy implementation, and funding arrangement. Estonia, Israel, Singapore and South Africa were the only four systems which had all the components in place (Anderson *et al.*, 2008: 56).

Eight of the educational systems indicated that language was an obstacle: Israel, Lithuania, Moscow, Slovak Republic, Slovenia, South Africa and Thailand. The remaining educational system did not regard language as a barrier to ICT use in grade 8.

The various educational systems were asked to indicate whether they have a system-wide program regarding the ICT related skills learners are required to have in grade 8. Chinese Taipei, France, Japan, Slovak Republic and Thailand have one or two compulsory classes in ICT and Alberta Province Canada, Chile, Denmark, Finland and Singapore implement the program policy by integrating ICT instruction within the different subject areas. Thirteen of the participating systems indicated that they had policies promoting 21st century skills.

All of the participating systems had a policy or plan in place for ICT in teaching and learning. Table 3.14 summarises the countries that had an ICT policy in place during the SITES study and what that policy entails.

Table 3.14 Participating systems and ICT policy in place *

Participating system	ICT program or policy
Alberta Province, Canada	Infuse ICT in learning of all subjects Do not promote constructivism Emphasis on individualised learning
Catalonia, Spain	Integration of ICT in teaching and learning and evaluation Learner autonomy, ICT skills and values develop in harmony
Chile	ICT skills part of secondary curriculum 21st Century skills in a set of intersecting aims within curriculum
Chinese Taipei	Emphasis that ICT should integrate on all learning areas during instruction 21st Century skills
Denmark	ICT in education focusing on learner skills in ICT Integrating new pedagogical opportunities into learning Increased integration of ICT in pre-service and in-service training
Estonia	Four cross-curriculum topics (ICT and media-education) e-learning seamlessly integrated into everyday school life 90 % teachers using ICT in learning process
Finland	2015 ICT related strategic intents, ICT linked to daily life of citizen and organisation Two cross-curriculum themes, refers to learner understanding of technology ICT related skills, versatile use of ICT and responsible use of ICT
France	2002 goals for policy on ICT use in different levels of education 2004-2006: Action plan for level in hierarchy of education
	2006: IT and Internet proficiency certificate and ICT skills development at all levels
Hong Kong (SAR)	Policy goal is to empower learners with IT Learners acquire necessary skills, values, attitudes and knowledge for lifelong learning 2004: Document on ICT in education with a learner- centred approach
Israel	National Computerisation program, 21 st Century skills with system-wide change ICT literacy and Information skills in learning processes
Japan	2001 e-Japan Strategy Aim to create a knowledge-emergent society Learners utilise ICT in all learning areas
Lithuania	Teacher training program focusing on collaborative and active learning
Moscow, Russian Federation	ICT in learning supported by hardware, software and connectivity
Norway	2004-2008 multi-year program for digital literacy Aims to smooth out digital divide through promoting digital skills Addresses the entire education system Digital literacy includes ICT skills, equivalent to reading, writing and numeracy Advance skills ensuring creative and critical use of digital tools Media including tasks such as locating and controlling information from digital sources
Ontario, Canada	Optional Grade Nine course in ICT and Business Optional Grade Ten course in Communications Technology
Russian Federation	Twenty-five years ago started a course of Computer Science and Technology ICT adopted in primary, grade 8 and 9 and different profiles in high school
Singapore	1997: launched the Master Plan for IT in Education (MPITE) Integration of ICT in education system to meet challenges of 21 st Century skills 2003: Masterplan II for IT in education with similar goals
Slovak Republic	2000 Policy for school reform "Millennium" Supported by new government in 2001
Slovenia	2010 Strategic frameworks Goal is to develop an efficient and ICT supported national system 2006-2010: national strategy for e-learning
South Africa	White Paper on e-Education Two new subjects Technology Education and Computer Application Technology

Participating system	ICT program or policy
Thailand	1999: Act B.E. 2542 identified General Provisions for development of 21 st Century skills 2007-2011: 9th National and Social Development Plan

* (Anderson *et al.*, 2008: 60-65)

Norway was one of the systems which had a detailed ICT policy plan from 2004 to 2008. Thailand had a national and social development plan from 2007 until 2011.

- **Change in pedagogical practices**

Integrating ICT into the teaching and learning practices in schools across the globe is a very important part of change and development, but a paradigm shift from the traditional practices to that of lifelong learning practices in classrooms is of equal importance. Investigating the change in pedagogical practices during SITES 2006 will provide an overview of the number of participating systems who have adapted their teaching and learning practices in grade 8 mathematics and science towards a lifelong learning method of teaching to achieve the 21st century skills (Anderson *et al.*, 2008: 54-55).

3.4.9 Perceptions of school principals about the presence of lifelong learning and pedagogy in schools

This question was addressed in both SITES Module 1 and SITES 2006. The data from 1998 were compared with those of SITES 2006. The samples for SITES Module 1 and SITES 2006 were not compatible for a number of systems, because Module 1 consisted of schools using ICT at targeted grade ranges, while SITES 2006 schools were sampled from a total population of lower secondary schools. During SITES Module 1 there were a few of the systems which did not use ICT yet, but in 2006 ICT use was in nearly 100% of the systems. In South Africa in 1998 only 18% of schools were using ICT and in 2006 it was (38%) of the schools. Several aspects regarding pedagogical approaches were included, and Table 3.15 shows the most significant changes within each system from 1998 to 2006 (Pelgrum, 2008b: 108-114).

Table 3.15 Changes within systems *

Country	% in 1998	% in 2006	Change within the system
Chinese Taipei	22	40	Higher emphasis on Information Handling
Denmark	58	78	Information Handling
	45	29	Decrease in independent learning
	28	19	Decrease learning at own pace
	56	44	Co-operative and project-based learning
France	36	47	Information Handling
	20	8	Decrease in independent learning
Hong Kong	7	48	Information Handling
	3	22	Increase in independent learning
	13	42	Co-operative and project-based learning
Israel	26	48	Information Handling
	14	43	Co-operative and project-based learning
Italy	14	45	Increase in learning at own pace
	14	43	Co-operative and project-based learning
Japan	6	29	Information Handling
	6	30	Co-operative and project-based learning
Norway	28	38	Co-operative and project-based learning
	61	34	Decrease in independent learning
Russian Federation	11	20	Co-operative and project-based learning
	28	36	Increase in independent learning
	43	25	Decrease learning at own pace
Singapore	24	40	Information Handling
	15	39	Co-operative and project-based learning
Slovenia	37	13	Learner controlling their own learning processes
	33	9	Decrease learning at own pace
South Africa	12	26	Increase in learning at own pace
	22	36	Co-operative and project-based learning
	31	19	Decrease in independent learning
	39	22	Decrease in information handling
Thailand	32	56	Increase in learning at own pace

* (Pelgrum, 2008b: 72-77)

The most significant change in all of the systems was that of an increase in information handling.

3.4.10 Conditions at school level

The conditions at school level refer to the circumstances and the availability of resources which influence the integration of ICT at school. These conditions were discussed under the following five domains: vision, infrastructure, technical and pedagogical support, staff development, leadership development priorities and organisation and management.

3.4.10.1 Vision

School principals play an important role in promoting the vision on pedagogical and general use of ICT, and in general the pedagogical visions across systems were very highly rated. Many systems indicated that they promote visions with regard to traditional, lifelong learning. Connectedness related to pedagogical goals was lower than lifelong learning, which was high in Chile and Thailand and low in

Denmark, Finland and Norway. Even though lifelong learning is low in these countries, more of the lifelong pedagogical practices exist in these countries. Principals in all twenty two participating systems indicated that they do encourage teachers to prepare the learners for responsible Internet use even though about 20% of principals in Israel, South Africa and the Russian Federation did not pay attention to this matter. In France and Japan the lifelong learning pedagogical practices were very low. There is no comparison between the vision of the principals and the pedagogical practices of teachers (Pelgrum, 2008b: 69).

The question regarding the lifelong learning orientated practices were addressed to both the teachers and the principals and relative high scores of Chile and Thailand in comparison to the low scores of Catalonia, France, Japan and South Africa the, but the indicators were convergent and therefore further investigation is necessary in future analyses (Pelgrum, 2008b: 72-74). Chile and Thailand both indicate within their policy they focus a lot on the development of the 21st century skills.

3.4.10.2 Infrastructure

Schools need adequate infrastructure (hardware and software) to support teachers in achieving their pedagogical goals. South Africa had the lowest availability of infrastructure at 38% in 2006. All the other participating systems had an availability of 95% to 100%.

There was a vast difference between education systems in terms of ICT-infrastructural conditions. The learner-computer ratio refers to the number of computers available to learners for teaching and learning at each school, and for access to ICT this varied quite significantly. The number of computers available at the school was expressed as a ratio to the number of learners and the results were given as percentages. In some systems like Alberta Province, Canada and Norway the ratio was less than five (at least one computer for every five learners), which is quite satisfactory, and in other systems like Denmark, Finland, France, Japan, Hong Kong, Ontario and Singapore it is still satisfactory with a ratio of less than ten at least one computer for every ten learners). In Italy, the Russian Federation, Slovak Republic, South Africa and Thailand hardly any schools had a ratio of less than ten (Pelgrum, 2008b: 74-76).

- **Tools and facilities available**

The availability of tools and facilities form an integral part of the teaching and learning process with ICT. ICT equipment was available in most of the systems, but in Chile at 47%, Thailand at 41% and South Africa the lowest at 17%, the availability of ICT equipment poses a real problem. Most of the systems had adequate tutorial software, except Thailand at 17% and South Africa at 10%. The access to general purpose software was only a problem in South Africa and Thailand and only 13% of teachers in South Africa and 11% of teachers in Thailand had mail accounts. These two countries were also the only which did not have any communication software (Pelgrum, 2008b: 80).

- **Needs for ICT tools and facilities**

There was a general increase in the number of PCs and Internet availability in schools, but whether it is sufficient to realise the pedagogical goals for schools needs to be investigated. Most of the systems were satisfied with the amount of PCs in their schools as well as the Internet availability. South Africa's needs were the highest of all the participating systems:

- Equipment 83%
- Tutorial software 88%
- General Software 54%
- Multimedia 91%
- Data-logging 86%
- Simulation 93%
- Communication Software 83%
- Digital Resources 80%
- Mobile Devices 79%
- Smart Boards 88%
- LMS 89%
- Mail accounts for teachers 83%
- Mail accounts for learners 84%.

Many teachers, through their technology co-coordinators, identified various barriers that prevent them from achieving their pedagogical goals. Insufficient ICT tools for science laboratory work, was a barrier in most of the systems. Chile, Russian Federation, South Africa and Thailand did not even have a sufficient budget for basic equipment like pencils and paper, thus ICT tools are not a priority for teachers in these systems (Pelgrum, 2008b: 83):

- **Location of Computers in schools.** In 2006, only 1% of classrooms in South Africa had computers, only 3% had computers in some classes, 48% had computer laboratories, 9% had computers in their libraries and 12% had computers elsewhere on the school premises. All of the other participating systems had an average of 78% to 100% computer laboratories (Pelgrum, 2008b: 88-89).
- **Maintenance of computers at schools.** Almost all of the systems' school staff took care of the general maintenance of the IT equipment. The lowest rate of staff maintenance was in Singapore at 49% and South Africa at 42% (Pelgrum, 2008b: 88-90).

3.4.10.3 Technical and pedagogical support

The presence of technical and pedagogical support is a very important condition when implementing ICT into the teaching and learning process. Two questions were posed to the principals:

- Who is providing ICT support to teachers and how much time is spent on these activities per week?
- To what extent is technical support available for teachers who use ICT for new forms of teaching and learning?

The technical support in nearly all of the systems was adequate and teachers knew that there was a good support system in place. Many teachers and technical staff were efficiently trained to see to some of the basic maintenance of the IT equipment. In South Africa, 41% of the technical support came from the computer coordinators, 24% of teachers indicated that other ICT staff members assisted them, 4% indicated that the school administrative staff helped them, 28% of the teachers said that their colleagues supported them, 14% of the teachers got help from their learners, 3% were assisted by external companies and 4% of the teachers indicated that other people assisted them. The ICT equipment was available for a total of thirteen hours per week and each learner only had one minute access time per week. The pedagogical support was not discussed in detail by the researcher, but the pedagogical support for teachers in South Africa was less than 85% (Pelgrum, 2008b: 90-94)

3.4.10.4 Staff development

Professional development for teachers is an important part of enhancing the quality of education in schools. It is an ongoing process, whereby the education department can ensure that quality teaching and learning will take place (Reynolds *et al.*, 2003: 159). During Sites 2006 the principals, as well as the technology coordinators, were asked to list fifteen barriers preventing the school from realising its pedagogical goals. The obstacle that dominated in all the systems was that teachers did not have efficient ICT skills. Most education systems did not require their teachers to be trained for the integrating of ICT in any form of teaching and learning. In Chinese Taipei, Denmark, Estonia, Hong Kong, Lithuania, Moscow, Singapore and Slovenia courses on pedagogical issues relating to the integration of ICT were available. Education systems like Alberta province, Canada, Chile, Finland, Israel, Italy, Japan, Norway, South Africa and Thailand did not have access to pedagogical courses relating to ICT integration. Many school principals did have ICT integration training and school leaders should be competent handling educational innovations in schools (Pelgrum, 2008b: 95-101). Staff development across all systems needs to take place in order to achieve the 21st Century skills.

3.4.10.5 Leadership development priorities

School principals must be equipped with the relevant academic knowledge and skills, management skills as well as competencies regarding the use of ICT to ensure that the institution functions properly and works toward achieving the 21st Century skills. Principals play an important role in managing and initiating changes and growth within the school, and are solely responsible for creating a positive school climate (Becta, 2002: 1-2). Unfortunately, many school principals do not have the sufficient qualifications to perform the tasks to the best of their ability. Many school principals indicated the acquisition of certain ICT skills as a high priority. In Chile more than 90% of the school principals indicated that they would like to attend the necessary ICT training, but in Japan only 20% of school principals were interested in attending ICT training.

Table 3.16 summarises the type of training school principals can attend. School principals in Chile are more eager to attend ICT training than school principals in South Africa. Organising cooperation with other schools regarding the development of materials and ICT based teaching and learning takes a higher priority in South Africa (Blignaut *et al.*, 2009).

Table 3.16 Type of training for school principals *

	Type of training for school principals
A	Developing a common pedagogical vision
B	Managing the pedagogical innovation at school
C	Explaining to teachers the relevance of encouraging learners to be responsible for own learning
D	Identifying best practices that exist outside the school regarding the integration of ICT into learning
E	Promoting collaboration between teachers of different subjects
F	Managing the adoption of ICT -supported methods for assessing learner progress
G	Organising cooperation with other schools regarding the development of materials
H	Organising cooperation with other schools regarding the development of ICT based teaching and learning
I	Promoting the integration of ICT in the teaching and learning of traditional subjects
J	Developing a strategic plan for integrating ICT use in teaching and learning

* (Pelgrum, 2008b: 102-103)

Figure 3.6 compares the percentages of school principals in Chile and South Africa, which were two of the systems with the highest scores of all the participating systems and the only two participating systems within the Southern Hemisphere.

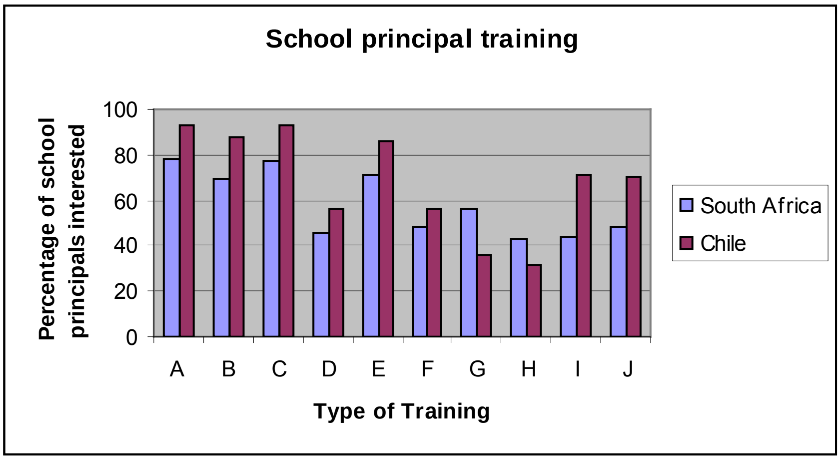

Figure 3.6 Percentages of school principals in Chile and South Africa interested in training (Pelgrum, 2008b: 98-99)

Many school principals in Chile undergone training to develop a common pedagogical vision, to manage the pedagogical innovation at school, to explain the relevance of encouraging learners to be responsible for their own learning and promoting collaboration, which shows that they are implementing their ICT policy and plan (Pelgrum, 2008b: 72-77&98-99).

3.4.10.6 Organisation and management of ICT in schools

The organisational and management aspects regarding the infrastructure and pedagogical use of ICT are an integral part in ensuring the implementation and the development of ICT in the teaching and learning as well as the wider school spectrum. Funds, academic programs, timetables, access to resources and Websites, planning of activities, and training programs are some of the important facets of the organisation and management of schools. Unfortunately the bulk of the 2010 South African budget which amounted to R 165 billion with an additional R 2.7 billion, was allocated towards Numeracy, Literacy and development and training of teachers, and not for ICT infrastructure and resources (South Africa, 2010). The NDoE in South Africa has a structural academic program referred to as the NCS from grade R to twelve, as well as an additional ICT policy known as the White Paper on e-Education which all schools must adhered to, depending on the availability of infrastructure and resources. All schools are required to develop timetables within the requirements set by the NDoE. All schools and communities need to have access to websites. The training of teachers and the broader community to raise the standard of educational is essential. Schools must plan ICT collaboration activities well in advance to ensure the optimum time for activities is utilised and teachers can monitor the whole implementation process. Providing all teachers with laptops is a dream many systems would like to achieve, unfortunately not a realistic vision for many systems. A laptop initiative was launched for teachers in South Africa in 2008, but in a recent notice by NAPTOSA (National Professional Teachers' Organisation of South Africa) there has been no notification of the purchasing of laptops and training program. Regardless of the lack of ICT infrastructure and the declaration of the laptop initiative the basic requirements regarding the organisational and management are vital in ensuring effective functionality of the educational program and ICT integration.

School principals were given a list of eleven measures relating organization action: re-allocate workload for collaborative planning, re-allocate workload for technical support, organizing demo-workshops, review pedagogical approach of teachers, monitor implementation of change, new teacher teams, change class schedules, incentive schemes, teacher collaboration with external experts, new instructional methods to school newspaper and parents' involvement in ICT related activites.

Re-allocating workload to allow for collaborative planning took place in more than 80% of schools in Chile, Norway, Singapore and Thailand, but fewer were implemented in Estonia at only 43%, Finland 47% and France 30%. The results indicate that there were vast differences among education systems for the remaining ten measures (Pelgrum, 2008b: 104-107). Many principals do not realise that the organisation and management of ICT infrastructure and pedagogy will determine the quality and success of ICT implementation in schools.

3.4.11 School principals' perceptions of lifelong learning pedagogy

During SITES Module 1 the school principals were asked to indicate whether the learners had developed the ability to undertake independent learning, search for, process and present information; can control their own learning processes, work at their own pace, are involved in cooperative or project-based learning, and if they have the ability to determine when they are ready to take a test. This question was addressed again to the principals in SITES 2006 in order to compare the previous results with the current situation in schools across the participating systems (Pelgrum, 2008b: 108-114).

Many systems showed a substantial increase over the period of eight years in some of the pedagogical practices while other pedagogical practices showed no relevant changes. There was more emphasis on information-handling in most of the systems.

Table 3.17 provides an overview of the relevant changes in pedagogical practices from 1998 to 2006. No relevant changes occurred in Finland. Lithuania and Thailand showed relevant increases (from 32% to 56%) in all of the pedagogical practices between 1998 and 2006. Independent learning experienced declines in some systems and increases in other the systems.

The question arises whether the principals' vision regarding pedagogical-related lifelong-learning had an influence on the perception that these pedagogical practices occur in their schools. Results indicate that there is some co-variation between the vision and the perceptions of school principals. Results indicated that Norway, Finland and Denmark lifelong-learning pedagogical practices were used regularly (Pelgrum, 2008b: 108-114).

Table 3.17 Changes in pedagogical practices *

Country	Information Handling	Independent Learning	Learning at own pace	Controlling own learning Process
Chinese Taipei	+18%			
Denmark	+20%	-16%	-11%	
France	+11%	-12%		
Hong Kong	+39%	+19%	29%	
Israel	+22%	+27%		
Italy			+31%	
Japan	+23%		24%	
Norway		-27%		
Russian Federation		+8%	-18%	
Singapore	+16%			
Slovenia		-24%	-24%	-24%

* (Pelgrum, 2008b: 110)

3.4.12 Conclusion and reflections on South Africa's ICT pedagogical status

SITES 2006' main purpose was to examine the pedagogical practices adopted by grade 8 teachers in all the participating systems and the use of ICT in these practices. Contextual aspects incorporated within the teaching and learning process were built into the different research tools in order to get a global picture concerning general practices in schools, and whether adjustments within the systems were made in order to promote 21st century skills. Most importantly, SITES 2006 wanted us to understand the status of pedagogy, and the ICT-use in mathematics and science classrooms in all the participating systems, and how these practices compare and differ across systems. Additionally, the status of the different contextual factors at work in school and system-levels was addressed. It also allowed the researchers to build models aimed at explaining how these different contextual factors contribute or restrain the pedagogical use of ICT by teachers (Law, 2008: 263).

South Africa's participation in this study gave all the role-players within the educational system an opportunity to measure the countries' status of pedagogy, the ICT-use in mathematics and science classes, the contextual factors at school and system level compared to the rest of the participating systems.

Even though the world is striving towards educational reform, many schools do not have the equipment and the infrastructure to compete with the global society. The conditions at school level in South Africa is one of the aspects that need to be addressed in order achieve equality with the rest of the participating systems, especially those system that performed well in SITES 2006. South Africa had the lowest availability of infrastructure at 38% in 2006 whereas other participating systems had computer laboratories, 9% had computers in their libraries and (12%) had computers elsewhere on the school premises. South Africa was the only participating system which did not have 100% access and availability to ICT in schools.

Pedagogical and the technical support are definitely areas of concern as well. In South Africa, the technical support came mainly from the computer coordinators at 41%, while 24% indicated that other ICT staff members assisted them, 4% indicated that the school administrative staff helped them, 28% of the teachers said that their colleagues supported them, 14% of the teachers got help from their learners, 3% were assisted by external companies and 4% of the teachers indicated that other people assisted them. Pedagogical support for teachers in South Africa was less than 85% (Pelgrum, 2008b: 90-94).

Staff development opportunities did not exist for training of ICT integration into the teaching and learning process. Organising cooperation with other schools regarding the development of materials and ICT based teaching and learning takes a higher priority in South Africa than in other countries, and school principals were more eager to attend ICT training than the remaining participating systems.

In general, teachers in South Africa do not welcome change. The majority of teachers indicated that they still prefer to use the traditional method of teaching as well as traditional goal orientations. Many teachers only made use of ICT search for information. In South Africa in 1998 only 18% of schools were using ICT and in 2006 it was 38% of the schools. Teachers in grade 8 Mathematics preferred to make use of teacher lectures and exercises to practice skills and procedures. Even though a variety of resources were available in many schools, mathematics teachers more frequently made use of tutorial or exercise software. Even though there are many infrastructural shortages, the South African teachers indicated an 80% and above average for learning products, reflection or collaboration, which was higher than all the other participating systems.

The teachers mainly made use of ICT when they were looking up ideas and information, and for extended projects. Regarding the rest of the teacher practice activities, the majority of the grade 8 Mathematics teachers did not make use of ICT. Many schools do have efficient ICT and infrastructure, but they indicated a low level of confidence due to the fact that they did not know in which teaching and learning situations to use ICT effectively. ICT usage in general in grade 8 encountered the lowest usage level in South Africa, which was only 18% for mathematics and 15.9% for science.

Even though South Africa has an ICT policy in place and acknowledges that certain changes within the systems need to take place, reform needs to starts at the foundation of education where teachers play a fundamental role in the change and development process.

Chapter Four

Research Design and Methodology

4.1 Introduction

The study followed a basic secondary data analysis (SDA) using the data of the stratified sample of the 504 computer using and non-computer using schools in South Africa which participated in SITES 2006; specifically the data from the mathematics teachers' questionnaire. This chapter outlines the SDA research design and methodology used in this study, the nature of the dataset, ethical considerations, the variables that were identified for correlation within SDA, and the statistical analysis procedures in this SDA. SDA refers to the empirical exercise that uses original research questions and data for the analyses of further questions in order to address specific research questions, using either the same or different statistical procedures (Smith, 2008: 4). SDA aims at reanalysing such data in order to test hypotheses or to validate models (Mouton, 2001: 153).

4.2 Secondary data analysis

The National Research Coordinators (NRC) (Law *et al.*, 2008e: 289-293) from all participating education systems in SITES 2006 used survey methodology as their approach to the international comparative study. Three survey instruments: a teacher questionnaire (Addendum 4.1), a principal questionnaire, and a technical questionnaire were developed in cooperation with the participating countries. An additional national context questionnaire collected data on the policies that prevailed in each country. The target population was grade 8 mathematics and science teachers, the school principal and the ICT co-ordinator of randomly selected schools. In South Africa, a stratified sample of 504 non-computer using and computer using schools comprised the final sample prepared by the Data Processing Centre, Hamburg, Germany (Law *et al.*, 2008e: 26).

This investigation followed a basic SDA methodology that includes a scholarly review of the literature (Smith, 2008: 4), as well as analyses of the South African data of SITES 2006. According to Barrett (2006; 406), secondary data have already been collected by another organisation and the researcher was not involved in the data collecting process. SDA focuses on specific problems through analysis of existing data which were originally collected for another purpose (Glaser, 1963: 11; Mouton, 2001: 153), and uses original research questions and either numeric or non-numeric data for the analyses of further questions in order to address specific research questions distinct from that dataset (Hewson, 2006: 274). It can use the same statistical procedures as the original study, or different ones. The numeric empirical data can include population census, government surveys, other large scale surveys, cohort and other longitudinal studies, other regular or continuous surveys and administrative records (Smith, 2008: 4).

Conducting SDA are not always more objective than the data received using qualitative research methods and mistakes which might have been visible in the original data can not be traced (Smith, 2008: 64-70).

The reason why many researchers choose SDA as the method of research is that there are significant benefits of using SDA. Using SDA saves time and money, and allows an increased sample size from the existing high quality primary data that are available from the organisation (Barrett, 2006: 406). The researcher saves time in the designing process and no primary data need to be gathered. The SITES 2006 dataset is readily available and is considered of high quality. The SITES 2006 dataset (Addendum 4.2) allows the researcher to explore different themes and correlations between variables that were not calculated and reported by the main study, without any further data collection or expenditure beyond SDA consultation services.

4.3 Study population for this secondary data analysis

The international SITES 2006 dataset comprises the combined data collected from the teachers' questionnaire, technical questionnaire and a principals' questionnaire of the 22 participating countries and educational systems. For the purpose of this investigation, only the South African dataset for grade 8 mathematics teachers who completed the teachers' questionnaire will be used for the SDA. This dataset comprises a total of 640 South African grade eight mathematics teachers (Howie *et al.*, 2009: 8). The gender distribution of the participating grade 8 mathematics teachers in South Africa was well-balanced with 306 male and 334 female teachers (SITES, 2006a: 86).

4.4 Ethical consideration for SDA

The questionnaires and dataset of SITES 2006 are available in the public domain. Therefore, this study acknowledges the source of data, as well as respect for the integrity of the dataset. No identifiable information is available on the teachers or schools that participated in the main study and therefore the research will adhere to all ethics of research already obtained during the main study. No further ethical clearance was necessary.

4.5 Variables

A variable is any quality or characteristic in a research investigation that has two or more possible values (Leedy *et al.*, 2005: 218). For this study, the variables constituted the pedagogical use of ICTs in the teaching and learning of mathematics. After intensive review of the questions in the teachers' questionnaire, the researcher, in cooperation with the statistical consultation services of the North-West University, will attempt to answer the second research question: to determine whether knowledge of the pedagogical use of ICTs in grade 8 mathematics contributes towards more effective mathematics teaching in schools, Question 21 J (from Part VII of the SITES 2006 Teachers' questionnaire on the pedagogical use of ICT (I know in which teaching and learning situation to use ICT). This research will be used as the main variable, then correlated with as many possible other variables within the same teachers' questionnaire, to answer the research question: *To what extend can knowledge of the pedagogical use of ICT's in grade eight mathematics contribute towards more effective mathematics teaching in schools?*

4.6 Statistical procedures for SDA

In order to address the first research question: *What is the pedagogical use of ICTs for the teaching and learning of grade eight mathematics in South African schools?,* the frequency tables of the dataset for mathematics teachers (Addendum 4.2) were used to identify how grade 8 mathematics teachers use ICTs for teaching and learning. First of all, the dataset is used to analyse the mathematics teachers' general use of ICT and use of ICTs, i.e. word-processing, e-mail, electronic filing, spreadsheet use for budgeting and administration, the use of Power Point presentations, ICT for lesson planning and learner monitoring, ICTs to practise skills and procedures, ICTs to look up ideas and information and process data, and how ICTs in general are used to reach curriculum goals. Thereafter, the proportion of learners' skills in mathematics classrooms in word-processing, database software, spreadsheet, presentation software, application of multi-media, email, Internet, graphic calculator and data-logging tools is analysed. Thirdly, the impact of ICT use is analysed, and fourthly the obstacles of ICT use for teaching and learning are evaluated.

In order to address the second research question: *To what extend can knowledge of the pedagogical use of ICT's in grade eight mathematics contribute toward more effective mathematics teaching in schools?,* descriptive statistics and cross tabulations are calculated. In many cases it is important to know whether there is a relationship (correlation) between two variables. As already pointed out in Section 4.5, to determine to what extend whether knowledge of the pedagogical use of ICTs in grade 8 mathematics contributes towards more effective mathematics teaching in schools (SITES 2006 Teachers' Questionnaire, (Addendum 4.1) Part VII, Item 21J), is the main variable that is correlated with other variables in order to answer the second research question. For random sampling, statistical relationships (correlations) between variables are determined with Chi-square tests and effect sizes, but what is imperative is whether the relationship is large enough to be important (Ellis *et al.*, 2003: 4). In such cases the statistical significance tests (e.g. Chi-square tests) are used to show that the result is practically statistically significant. Chi-square X^2 is a sampling distribution that gives probabilities about frequencies (Spatz, 2008: 295). The kind of data is the characteristic that distinguishes Chi-square from other techniques. For t-tests and ANOVA (analysis of variance), the data consist of a set of scores such Intelligence Quotients (IQs), attitudes, time, errors, etc. Each subject has one quantitative score. With Chi-square, however, the data are *frequency counts* in categories. Each subject is observed and placed in one category. The frequencies of observations in categories are counted and the Chi-square test is calculated from the frequency counts. Chi-square analysis compares the observed frequencies of a category to frequencies that will be expected if the null hypothesis is true (Spatz, 2008: 295). There is an effect size index for Chi-square problems that have more than one degree of freedom. Both phi coefficient and Cramer' v can be considered as effect sizes. It was proposed by Harald Cramér and is referred to as Cramér ø, or Cramér V. A Cramér V < 0.3 is considered a small effect with no or very little practically significant correlation; 0.3≤ Cramér V ≤ 0.4 is considered a medium effect that tends towards practically significant correlation; and Cramér V ≥ 0.5 is considered a large effect with practically significant correlation. The Statistical Consultation Services of the North-West University assist in the cross tabulation analysis using SPSS® 16.0 for Windows (SPSS, 2007: 141).

4.7 Summary

This is an SDA of the South African dataset for the grade 8 mathematics teachers who completed the teachers' questionnaire. A total of 666 South African grade 8 mathematics teachers, 49.4% male and 50.6% female, completed the teachers questionnaire (Howie *et al.*, 2009: 8). No ethical clearance was necessary because this is an SDA. In order to address the first research aim and to answer the first research question: *What is the pedagogical use of ICTs for the teaching and learning of grade 8 mathematics in South African schools?;* the frequency tables of the dataset for mathematics teachers are used to identify how grade eight mathematics teachers use ICTs for the teaching and learning. In order to answer the second research question: *To what extend can knowledge of the pedagogical use of ICT's in grade 8 mathematics contribute toward more effective mathematics teaching in schools?;* descriptive statistics and cross tabulations are calculated. Knowledge and confidence to suit ICTs to different teaching and learning situations (SITES 2006 Teachers' Questionnaire, Part VII, Item 21J), is the main variable that is correlated with other variables using cross tabulation (Chi-square X^2) and effect size (Cramér V) in order to answer the second research question.

Chapter Five

Results and Discussion

5.1 Introduction

This chapter addresses the research questions through the calculation of frequencies of the data from the SITES 2006 mathematics Teachers' Questionnaire. First it addresses the question: *What is the pedagogical use of ICTs for the teaching and learning of grade 8 mathematics in South African schools?* This includes the extent of ICT pedagogical practices of mathematics teachers, as well as their perceptions of the value of ICT for mathematics education. In order to answer the second research question: *To what extend can knowledge of the pedagogical use of ICT's in grade 8 mathematics contribute toward more effective mathematics teaching in schools*?, descriptive statistics and cross tabulations indicate how pedagogical knowledge of ICT impacts on the curriculum goals and teacher practices. This section also includes how the availability of learning resources and technological infrastructure influences pedagogical practices.

5.2 Pedagogical use of ICT in grade 8 mathematics classrooms in South African schools

The dataset of this study relates to the South African dataset from the international SITES 2006 main study. Various frequencies were calculated to address this question. The SITES 2006 mathematics teachers' data frequencies comprised eight parts:

Part I information about the target class
Part II curriculum goals
Part III teacher practice
Part IV learner practice
Part V learning resources and technology infrastructure
Part VI impact of ICT use
Part VII information about schools
Part VIII specific pedagogical practice that use ICT (SITES, 2006c: 34-36).

To address the first research question, the results are discussed under the following themes: general use of ICT; pedagogical use of ICT; learners' competence with operating skills; impact of ICT; and barriers of ICT use for teaching and learning.

5.2.1 General use of ICT

Data on the general use of ICT resulted from Part VII, Question 21 (A-H) of the teachers' questionnaire (Addendum 4.1). Teachers responded on a four point Likert-type scale (i.e. *not at all; a little; somewhat; a lot*). For the purpose of this secondary data analysis, there is only a slight difference between two categories and the researcher combined the categories *A little* and *Somewhat* (closely related) to form three analysis criteria, i.e. (i) those who use ICTs with confidence; (ii) those who use ICTs to a certain extent (a little to somewhat); and (iii) those who do not use ICTs at all. Table 5.1 summarises the general use of ICTs in Mathematics education. The percentage frequencies that are highlighted within Table 5.1 are those teachers who are confident to make use of ICT and the teachers who have no confidence using ICT. General use of computers relate to the use of word-processors, emails, electronic filing, and spreadsheets for budgets and administration.

Table 5.1 Percentage frequencies of general use of ICTs (word-processing, email, electronic filing and spreadsheets) *

	Scale	Word-processing	email	Electronic filing	Spreadsheets for budgets and administration
General use of ICT	Do not use ICT at all	**26.55**	**41.75**	**35.29**	**39.36**
	Confidence to a certain extent	31.23	25.43	29.29	28.29
	Use ICT with confidence	**42.22**	**32.82**	**35.42**	**32.35**

* (SITES, 2006c: 61-62)

The teachers' level of confidence influences the extent of their ICT, as well as the effectiveness thereof (Bramald *et al.*, 2000: 5). If teachers are confident of their ability to use computers, the level of use increases and they have access to a variety of resources to enhance their teaching and learning. Table 5.1 indicates that 26.55% of the participating teachers indicated that they do not use word-processing at all, while 42.22% indicated that they use word-processors with confidence. At another level of computer use, 41.75% indicated that they do not feel confident at all to create an email with attachments, while only about a third of the respondents (32.82%) expressed confidence in using email. Nearly the same number of respondents (35.29%) indicated that they do not know how to electronically file documents in folders and subfolders as opposed to those who did not (35.42%). A computer literacy assessment of post-graduate learners' readiness for higher education found practically significant correlations between electronic file management skills and other comperacy criteria (Blignaut *et al.*, 2010: 107). This indicates that electronic file management can be used as a reliable predictor of general computer literacy. The SITES 2006 data also indicated low levels of electronic file management and other general computer skills. The majority of the respondents (39.36%) indicated that they had insufficient confidence to use spreadsheets for budget managements and administration purposes, while 32.35% indicated that they use spreadsheets with confidence. With the implementation of ICT in schools, the NDoE (via their service providers) ensures that the majority of teachers have access to computers and they receive training to specifically perform administrative tasks with ease. In the Western Cape more than twenty thousand (25,724) teachers have received ICT training for administration and curriculum delivery (Western Cape Education Department, 2008). Spreadsheets are valuable tools for compiling class schedules, recording assessment results and creating report cards at the end of each term. From a pedagogical viewpoint, spreadsheets can also be used to create graphs for data handling in mathematics (Ozgun-Koca, 2000: 1).

5.2.1.2 Summary of general use of ICT

From the discussion of results as summarised in Table 5.1, the following issues on mathematics teachers' general use of ICT:

- 42.86% of grade 8 mathematics teachers who participated in this study use word-processing with confidence. However, the total group is less confident in the use of emails, electronic filing, and spreadsheets.
- A growing number of teachers use word-processing to create documents (e.g. tests and exam papers). In SITES M1 only a fifth of primary and lower secondary teachers and a sixth of upper secondary schools made use of word-processing. Eleven percent of mathematics teachers in primary and lower secondary and ten percent of upper secondary mathematics teachers used ICT (Voogt, 2008: 211-212). SITES M2 revealed that 41.70% of the cases used ICT for tutorials (Kosma, 2003d: 281) whereas in SITES 2006 42.22% of mathematics teachers used word-processing with confidence..
- Many teachers (39.86%) still do not feel confident using spreadsheets and for budget and general administration purposes. It seems that the NDoE and its training providers favour word-processing skills above other skills such as electronic filing and spreadsheets.
- During the introduction stages of ICT at schools various departments responsible for the installation e.g. KHANYA in the Western Cape, provide basic training for all teaching staff at the particular school. To extend the training program, the offices of the Premier made additional training facilities available where teachers could attend ICT integrated training after school for a period of six months, or three day workshops, or one week workshops. During 2009 the Premier Offices of the Western Cape Education Department provided training to a large number of teachers from the Foundation Phase to the Further Education and Training phase in basic ICT skills, Web-based projects and Internet teach. Recent communication with the offices of the Premier confirmed that all training programs for 2010 were cancelled due to insufficient funds (Western Cape Education Department, 2008). Recommendations should be made to the Department of Education to promote the training of teachers and they must realise the value of all training relevant to teaching and learning in South African schools, especially spreadsheet and electronic filing skills training for teachers.
- Only 13% of teachers who participated in SITES 2006 had school email accounts at the time of assessment, and that only 67% of the schools had computers with Internet connection available

for teachers. Insufficient access may account for the mathematics teachers' low confidence and skill in email use (SITES, 2006d).

5.2.2 The pedagogical use of ICT

The pedagogical use of ICT for mathematics teachers relates to Part VII Question 21 (I-P) of the teachers' questionnaire from SITES 2006 (Addendum 4.1). Teachers responded on a four point Likert-type scale (i.e. *not at all; a little; somewhat; a lot*). Again, the researcher combined the categories as there is not a noticeable difference between the two categories: *A little* and *Somewhat* (closely related) to form three analysis criteria, i.e (i) those who use ICTs with confidence (a lot); (ii) those who use ICTs to a certain extent (a little to somewhat); and (iii) those who do not use ICTs at all. Table 5.2 shows the grade 8 mathematics teachers' confidence about their pedagogical use of ICTs. The percentage frequencies highlighted indicate how many teachers lacked confidence to make use of ICT's for some of the basic ICT skills for teaching and learning and the small percentage of teachers who can use ICT's with confidence.

Table 5.2 Percentage frequencies confidence for the pedagogical use of ICTs *

Pedagogical use of ICT: Knowledge of …	Not at all (%)	Sometimes (%)	A lot (%)
Preparing lesson using ICT	52.87	31.82	**15.31**
Using ICT in teaching and learning	48.96	36.67	**14.37**
Finding curriculum resources (via Internet)	**46.02**	30.30	**23.67**
Monitoring learners' progress with ICT	**52.59**	30.86	16.54
Using ICT for effective presentations or demonstrations	51.18	32.60	**16.22**
Using ICT for collaboration with others	**53.00**	31.07	**15.93**
Installing educational software	**51.06**	27.68	21.27
Using the Internet to support learners' learning	**52.21**	28.55	**19.23**

***** (SITES, 2006a: 64-66)

Lesson preparation is a daily chore for all teachers and using a word-processor saves much time. Although only 42.22% grade 8 mathematics teachers from the study use word-processing with confidence (Table 5.1), the majority (52.87%) indicated that they were unable to use ICTs in the preparation of lessons (Table 5.2). Only 15.31% teachers indicated that they used ICTs with confidence to prepare lessons with confidence (SITES, 2006a: 64-66).

Almost half of the respondents (48.96%) indicated that they have no confidence to assess the principal use of ICTs in different teaching and learning scenarios. It is unfortunate that only 14.37% of the respondents have the confidence and knowledge to integrate ICTs in different learning situations. The Internet provides many curriculum resources for teachers to support their pedagogical practices. Examples of valuable Internet resources for grade 8 mathematics include: Think Quest (real life geometry), Building Big (interactive laboratories and challenges of building big and figuring out how geometry is used in building big structures), Symmetry and Pattern (the art of oriental carpets) and Dr Maths (mathematics practices and games as well and online tutor facilities) (Ittechno, 2010). However, 46.02% of the respondents indicated that they do not know where to find curriculum resources using ICTs (e.g. via the Internet); while a mere 23.67% indicated that they are confident to search for curriculum resources on the Internet, despite the fact that free curriculum-based resources (e.g. the NDoE, Thutong Portal, available at http://www.thutong.doe.gov.za) are available to teachers. Only 27.72% of the mathematics teachers indicated that they had already completed an introductory course for Internet use and general applications (e.g. basic word-processing, spreadsheets, etc.), while only 8.26% indicated they had completed an advanced course in Internet use and web-development (SITES, 2006a).

The National Policy on Assessment and Qualifications for Schools in the General Education and Training Band (South Africa, 2004a: 9) states that reporting should take place at least once a term, and informal or daily assessment should be done through observations, discussions and informal classroom discussions (South Africa, 2004a: 7). Regular electronic monitoring of learners' progress will assist teachers when they finalise assessments at the end of each term. Table 5.1 indicates that about 39.36% of teachers do not make use of spreadsheets for administrative purposes, while Table 5.2 shows that more than half of the respondents (52.59%) do not use ICTs to monitor their learners' progress with readily available tools such as spreadsheets. This indicates that many teachers still record their marks manually and do not make use of electronic tools for planning. They waste a lot of time by repeating the same tasks instead of creating interesting lessons for their learners. Many existing spreadsheet templates are available that can be easily adapted. The use of macros accelerates the compilation of graphs that illustrate and monitor learners' progress (Ozgun-Koca, 2000).

It is essential to use visual aids in the transfer of certain mathematical concepts, e.g. mathematical patterns to illustrate certain patterns in nature (Galloway, 2007: 66). More than half of the respondents (52.59%) were unable to create effective presentations with ICT's. Only 16.22% of the respondents indicated that they were able to use ICTs for effective presentational and explanatory purposes. In addition, installing simple educational software on computers posed difficulties for more than half of the respondents (51.06%). Subject specific educational software is often necessary to complement and enhance presentations to augment difficult concepts. Teachers who cannot install educational software cannot expose their learners to optimal learning opportunities to achieve the learning outcomes best.

Teachers should communicate with their peers, share information and ideas on teaching mathematical concepts or clearing away uncertainties. More than half of the respondents (53.00%) could not use ICT to collaborate with their colleagues at their schools, or schools in their districts. It is disheartening that only 15.93% of teachers were able to communicate via ICTs as email has become the business communication method of choice. One should consider that only 13% of teachers who participated in the SITES 2006 had e-mail accounts at their schools, and that only 67% of the schools had computers with an Internet connection (SITES, 2006d). Insufficient ICT infrastructure and professional training, as well as technophobia, possibly accounts for why only 15.93% of mathematics teachers use e-mails for communication and networking (Els *et al.*, 2009).

Teachers should have a variety of resources at their disposal to create a rich and authentic learning environment. However, the majority of the respondents (52.21%) did not use the Internet to support their learners' learning. Only 19.23% were confident to use the Internet to search for resources to assist their learners in their learning. This indicates that teachers struggle to provide rich learning environment, especially in the light of the demise of school libraries. Outcomes-Based Education's (OBE) principal focus is quality education where learners will engage in lifelong learning experiences, be numerate and be successful at the end of each learning activity. ICTs can greatly assist in this regard (South Africa, 2008: 2).

5.2.2.1 Summary of the confident pedagogical use of ICT

From the discussion of results as summarised in Table 5.2 the following issues on the pedagogical use of ICT:

- The majority of grade 8 mathematics teachers have no confidence knowing in which teaching and learning situation to use ICT. They reflect insufficient confidence to use ICT to prepare lessons adequately.
- Finding curriculum resources on the Internet, monitoring learners' progresses, as well as the ability to do presentations and explanations with ICTs, are problematic.
- The majority of the respondents were not confident in the pedagogical use of ICT and only a small percentage of them make use of ICTs in planning, monitoring, supporting and conducting pedagogical activities.

5.2.3 Learners' competence with operating skills

Issues regarding learners' basic operating skills were addressed in Part I Question 7 (A-I) of the teachers' questionnaire, which used a five point Likert-type response (i.e. *nearly none; some learners; majority of the learners; nearly all the learners; don't know*). For the purpose of this secondary data analysis the researcher combined the frequencies for *the majority of the learners* and *nearly all learners* because they are closely related and there is no noticeable difference between these two indicators. Table 5.3 summarises the learners' competence in operating the computer. The highlighted percentages indicate how many learners has no basic ICT skills and the small percentages of learners possessing basic ICT skills.

Table 5.3 Percentage frequencies of learners' competence in operating skills *

Learners' competence in operating skills	Nearly none	Some learners	Majority - nearly all	Don't know
Word processing	**44.59**	21.91	14.01	19.48
Database software	**54.71**	16.09	**5.21**	24.07
Spreadsheet	**56.03**	14.73	4.97	24.38
Presentation Software	**56.01**	13.79	**5.62**	24.57
Application of multimedia	**52.47**	16.91	6.67	23.96
Email	**56.31**	13.79	6.71	23.19
Internet	**54.87**	14.35	**8.36**	22.42
Graphic calculator	**54.27**	14.42	7.20	24.12
Data-logging tools	**60.62**	9.77	1.80	27.81

* (SITES, 2006a: 6-9)

Born within a technological advanced era, many learners have the advantage of being exposed to technological advices from an early age. They have the ability to master electronic devices without much effort. In spite of this statement, Table 5.3 shows that 44.59% of the mathematics teachers indicated that almost none of their learners are competent in word-processing. According to *The Need for an e-Education Initiative in South Africa* (South Africa, 2007b: 48-50) only 17% of schools in South Africa have ICT equipment in their schools, and only 8% of their learners have email accounts. Email accounts are considered a luxury for most. These figures are realistic as more than twenty percent (22.90%) of schools in South Africa did not have access to electricity. In 2006 the most basic of infrastructure, sanitation, was often lacking: 5.20% of schools had no toilets and 11.5% of schools had no water sources. Sanitation, access to water and electricity are fundamental in creating a basic learning environment (South Africa, 2007: 48-(South Africa, 2007b: 48-50). It is understandable that only 14.01% of the teachers indicated that the majority of their learners were competent users of word-processors. The fact that only 15.31% of the teachers use word-processing to prepare for lessons (Table 5.2) shows that most of the teachers are not able to take the lead to introduce word-processing to their learners and prepare them for 21st century skills.

Database applications enable learners to capture and retrieve information. However, only 5.12% of the teacher respondents indicated that their learners were competent to access database software (SITES, 2006a: 7). The majority of the respondents (54.71%) indicated that their learners were not able to use database software (Table 5.3).

Mathematical calculations (e.g. percentages and averages) can be done effectively with spreadsheets (Lewis, 2001). According to the teachers, more than a half of the learners (56.03%) do not have the knowledge and skills to use spreadsheet for learning activities. Table 5.2 shows that 52.59% of the teachers cannot monitor their learners' progress using spreadsheets. A variety of mathematical spreadsheet activities are available to enrich the learners' learning experience. Determining ratio, percentages, estimation, currency converters, and travel budgets for the intermediate and senior phase are some of the activities addressing the outcomes for mathematics (Lewis, 2001).

Presentation software can be used to address many learning outcomes and assessment standards in mathematics, e.g. concepts relating to shapes and space. Learners can use the presentation software to demonstrate how various shapes can be used to create a structure (Cooper *et al.*, 1996: 34-36). Despite the value that presentation software can add to teaching and learning, only 5.62% of the respondents indicated that their learners have the ability and opportunity to use presentation software for activities and projects. More than fifty percent of the respondents (56.01%) indicated that none of the learners are competent to use presentation software (SITES, 2006a: 8). In addition, Table 5.2 indicates that only 16.22% of the mathematics teachers are able to use presentation software for teaching and learning purposes themselves. Learners will not be exposed to presentational software and gain new skills as long as teachers are incompetent and afraid to use presentational software for pedagogy. This indicates that even though presentational software can enhance the teaching and learning of mathematics many teachers and learners do not have the skills to take advantage of the equipment at their disposal.

Email is one of the most affordable methods of communication outside the classroom for teachers and learners. The NDoE informs teachers, learners and principals on any changes and future events via email. At the time of data collection, a little more than fifty percent (56.31%) of the respondents indicated that nearly none of their learners were competent in email use; and only 8.36% indicated that most of their learners were competent in emails (Table 5.3).

Intel® Teach (SchoolNet, 2008), an initiative by SchoolNet South Africa, is used by many education systems throughout the world. It is mostly project based teaching in collaboration with the Internet to search for information regarding the topic. Additionally, Wiki's and Blogs support communication between teachers and learners. Information regarding their projects will be in the Wiki especially created by the teacher for that specific project. Learners can access the project blog if they have any questions regarding their project. In most schools Internet access is available for teachers and learners (under supervision) when they search information for projects. Unfortunately, 54.87% of the mathematics teachers indicated that nearly none of their learners are competent in operating the Internet and only 8.36% indicated that most of their learners could use the Internet competently.

The graphic calculator is a mathematical tool that can be attached to computers to assist learners in calculating difficult sums and concepts like quadrants, *x* and *y* ratios (Jarred, 1998: 19). However, in Table 5.3 only 7.20% of the respondents indicated nearly all of their learners were competent in using graphic calculator tools, and 54.27% of the respondents indicated that nearly none of their learners could use graphical calculators. In addition, more than half of the respondents (60.62%) in Table 5.3 indicated that nearly none of their learners were competent in operating data-logging tools, and only 1.80% indicated that nearly all of their learners were competent to operate data-logging tools (Els *et al.*, 2009). For the above exposition of the SITES data, it can be concluded that most South African learners are not ready for 21st century learning skills where the use of ICT tools assists higher order thinking skills.

5.2.3.1 Summary of competence with operating skills

From the discussion of the results as summarised in Table 5.3, the following issues on the learners' competence with ICTs:

- few learners were competent in using word-processors
- a small percentage of learners were competent to access database software
- few learners were competent in operating data-logging tools.

Derived from the results it is evident that many learners' were not competent with using ICT's.

5.2.4 Impact of ICT

The mathematics teachers who indicated in Part VI Question 18 that they made use of ICT when teaching grade 8 were asked to indicate in Part VI Question 19 (A-L) of the teachers' questionnaire according to four point Likert-type scale (*not at all; a little; somewhat; a lot*) whether the use of ICT had an impact on them. For the purpose of this secondary data analysis the researcher combined the categories *A little* and *Somewhat* (closely related) to form three analysis criteria, i.e. (i) no at all; (ii) a little to somewhat; and (iii) a lot (Table 5.4).

Changes within the education systems mostly affect the teachers and learners. The complicated school environment plays an important role in the method of teaching occurring in schools (Ward, 2003: 2-7). It is a well-known fact that learners are more adaptable to change, but teachers often struggle to change their philosophical views and methods of teaching. Only 93 of the participating mathematics teachers indicated that they made use of ICTs for teaching grade 8 mathematics, and 414 indicated that they do not make use of ICT at all for teaching and learning purposes (IEA, 2006: 50). Table 5.4 summarises the impact of ICTs on teachers' pedagogical practices. The highlighted percentages are some of the basic ICT teaching and learning practices.

Table 5.4 Percentage frequencies for the impact of ICT on teachers' pedagogical practices *

Impact of ICT	Not at all	A little – somewhat	A lot
On teachers' ICT skills	**39.21**	39.06	**21.73**
Incorporating ICT teaching methods	**31.00**	40.80	**28.20**
Individualised feedback using ICT	30.20	41.08	**28.72**
Incorporate new ways organising learners' learning	**27.44**	49.53	**23.03**
Monitor more easily learners' learning	32.70	41.62	25.68
Access more diverse and quality learning resources	33.41	45.25	21.34
Collaborate more with colleagues within my school	28.58	41.14	**30.29**
Collaborate with peers and experts outside my school	**34.70**	46.20	**19.10**
Complete my administrative tasks more easily	**26.50**	42.81	**30.69**
My workload has increased	**32.82**	37.66	**29.51**
Increased in work pressure	**33.97**	41.20	**24.84**
I become less effective as a teacher	**61.57**	31.68	6.75

* (SITES, 2006a: 50-54)

Mastering the use of ICT equipment will occur when one constantly explores its functions and abilities (Kolderie *et al.*, 2009: 7). Teachers' ICT skills will improve if they optimally make use of ICTs for teaching and learning. As shown in Table 5.4, about a fifth (21.73%) of the respondents indicated a change within their ICT skills, but 39.21% indicated no transformation in their abilities to operate ICTs.

When teachers start integrating ICT into their teaching and learning, they have insufficient confidence and knowledge. However, multiple mathematics software is available to assist them with the integration process (Cooper *et al.*, 1996: 34). About the same number of teachers indicated that they do not use ICTs to incorporate new teaching methods (31%) as those who tried ICTs in collaboration with various new instruction methods (28.20%).

Providing learners with individualised feedback regarding their progress will give them an indication in which areas they needs to improve. Using ICT to give progress reports to the learners will allow them to access their results at any convenient time. Only 28.72% of the respondents indicated that they made use of ICT to provide feedback to their learners. As indicated in Table 5.2 more than fifty percent (52.59%) of the respondents did not make use of ICT to monitor their learners' progress, therefore the chances of them providing individualised feedback to their learners are slim. Changes in teaching practices can be overwhelming if not done systematically (Jarred, 1998: 6). According to Table 5.4, 49.53% of the mathematics teachers indicated that they started to use ICT to incorporate new ways to organise their learners' learning. Unfortunately, only 23.03% regularly made use of ICT to incorporate various methods to organise their learners' learning. Even though 27.44% of the respondents indicated that ICT did not have an impact on the way in which they organised their learners learning, many are starting to use ICT (SITES, 2006a: 50-54).

Many teachers are faced with a massive workload and extramural activities each day. Therefore, it is not always possible for teachers to regularly communicate with their colleagues. Using ICT to keep in touch and share ideas would be the most convenient alternative method of communication for teachers (Bramald *et al.*, 2000: 6). A total of 30.29% of the respondents indicated that ICTs impact on collaboration with colleagues within their schools. About forty percent of the respondents (41.14%) said that they also make use of ICT to communicate with their colleagues to a certain extent. Teachers are less likely to interact with people outside their schools than with those they have built a working relationship with over a long time. Therefore, the decline in communication with peers outside their school is understandable. Only 19.10% of the respondents indicated they regularly share ideas and information with peers outside their schools, while 34.70% indicated that they never communicate with peers outside their own schools (SITES, 2006b). Building networks with other teachers within the same district will help teachers develop their ICT knowledge and increase their confidence.

Administration is an integrated part of teaching and the less time spent on doing these time consuming tasks the more time could be spent on actually teaching and preparing learners to take their rightful place within society. Teachers spend many hours on administrative duties as the last review of curricula showed (Twiner *et al.*, 2007: 141). Repetition occurs when teachers initially do their work manually, and afterwards convey it to a computer. Nearly thirty percent (26.50%) of the respondents indicated that ICT did not impact on their administrative tasks, while 30.69% indicated that ICT had a massive impact on their ability to complete their administrative tasks more easily.

About thirty percent of the mathematics teachers indicated that their workload has not increased (32.89%) after they started to make use of ICTs; and 33.97% indicated that the use of ICTs has not increased their work pressure. A total of 29.51% of the respondents indicated that the use of ICTs has increased their workload much; and 24.84% indicated that the use of ICTs has had a negative impact on the amount of pressure at work. It is important that only small portions of the new curriculum be tackled and mastered at once. About sixty percent of respondents (61.57%) indicated that ICTs had no impact on them becoming less effective as a teacher.

5.2.4.1 Summary of the impact of ICTs on teachers

The following issues regarding the impact of ICTs on teachers were evident from the discussion in Table 5.4:

- many teachers indicated no change to their abilities to operate ICTs
- teachers still lack confidence and knowledge with regard to integrating ICT into their teaching and learning even though many kinds of mathematics software are available (e.g. edutainment software) to assist them with the integration process (Cooper *et al.*, 1996: 34)
- more than fifty percent of the respondents did not make use of ICT to monitor their learners' progress
- ICTs had no impact on them becoming less effective as teachers, therefore they acknowledge that ICT had no negative effect on their teaching
- few teachers regularly shared ideas and information with peers outside their schools.

The integration of ICT's in the teaching and learning of mathematics holds many challenges for teachers and implementing ICT's will have an impact on the teachers' use thereof.

5.2.5 Barriers of ICT use for teaching and learning

The barriers mathematics teachers experienced were addressed in the teachers' questionnaire Part VII question 23 (A-L). Teachers were asked to answer *yes* or *no* to specific statements. Table 5.5 shows the many barriers teachers are faced with when integrating ICTs in the teaching and learning process. The percentage frequencies highlighted are some most important findings regarding the barriers relating to teaching practices in schools.

Table 5.5 Percentage frequencies of barriers of ICT use for teaching and learning *

Barriers of ICT use for teaching and learning	Yes (% frequencies)	No (% frequencies)
Usefulness of ICT in schools	**74.17**	25.83
Availability of ICT in schools	34.05	**65.95**
ICT related skills	42.77	57.23
Pedagogical ICT-related skills	36.60	**63.40**
Confidence to try new approaches	41.25	**58.75**
Learners' required ICT skills	73.94	26.06
Teachers' time to develop and implement activities	41.30	**58.70**
Identifying ICT useful tools	55.20	44.80
School lacks digital resources	**77.91**	22.09
Flexibility to make own decisions	51.41	48.59
Access to ICT outside school	52.13	47.87

* (SITES, 2006a: 71-75)

There are many systems, school and teacher related barriers preventing the integration of ICT in schools (Granger *et al.*, 2002: 485; Richardson, 2000: 12; Ward, 2003: 2). The extrinsic barriers are those not within the teachers' ability to change. The extrinsic barrier experienced by many teachers (Table 5.5) preventing ICT integration was 77.91% insufficient digital resources. Sixty six percent (65.95%) of the respondents indicated they did not have ICT infrastructure available within their schools. Additionally, professional development of teachers is not keeping up with the ICT integration process. In 2006 only 9% of participating mathematics teachers attended an ICT pedagogically related course (Pelgrum, 2008b: 97). Sixty three percent (63.40%) of the respondents did not have ICT related pedagogical skills. Fortunately, many teachers (74.17%) realise that ICT could be useful. If extrinsic barriers could be overcome, ICT could have a positive effect on teaching and learning practices.

It is within teachers' ability to overcome intrinsic barriers (Bramald *et al.*, 2000: 3). Many of these could be overcome without much effort and with the help of colleagues and the technology coordinator at school. Having the support from colleagues would prevent teachers spending too much time to develop the ICT related activities. Due to insufficient assistance, nearly sixty percent of the respondents (58.70%) indicated that they did not have sufficient time to develop and implement ICT related activities. More than fifty percent of the respondents (55.20%) were able to identify ICT useful tools, but due to their lack of confidence to try new approaches more teachers (58.75%) did not make use of ICT when teaching.

It can be concluded that ICT related barriers have a negative influence on the integration of ICTs within teaching and learning, which ultimately influences the development of 21^{st} century skills among both teachers and learners.

5.2.5.1 Summary of the barriers

From the discussion in Table 5.5 the following barriers regarding integrating ICTs in the teaching and learning practices in grade 8 mathematics classes were identified:

- teachers did not have ICT related pedagogical skills
- teachers did not have sufficient time to develop and implement ICT related activities
- Insufficient assistance for teachers to develop ICT related activities
- teachers had insufficient confidence to try out new approaches.

There are many barriers that hinder the integration of ICT's into the teaching and learning of mathematics and only when these barriers are dealt with will the integration process be successful.

5.3 Knowledge of the pedagogical use of ICTs in grade 8 mathematics

In order to answer the second research question: *Can knowledge of the pedagogical use of ICT contribute towards more effective mathematics teaching in schools?* various questions arose from the dataset from the SITES 2006 mathematics teachers' data frequencies which comprised eight parts:

Part I information about the target class
Part II curriculum goals
Part III teacher practice
Part IV learner practice
Part V learning resources and technology infrastructure
Part VI impact of ICT use
Part VII information about schools
Part VIII specific pedagogical practices that use ICT (SITES, 2006c) were correlated with Item 21 J: *I know which teaching or learning situations are suitable for ICT use* (Part VII of the SITES 2006 Teachers' Questionnaire).

The analysis also investigated whether curriculum goals, teacher practices, impact of ICT, impact of ICT on learners, confidence in the pedagogical use of ICT's, enhancing ICT in teaching and learning, barriers in using ICT, and teaching related activities had an influence on the practices in grade 8 mathematics classrooms. For the purpose of this secondary data analysis, there is only a slight difference between the two categories and the researcher combined the categories *A little* and *Somewhat* (closely related) to form three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot).

The frequency tables of the dataset for mathematics teachers in South Africa were correlated using cross-tabulations. For random sampling, statistically and practically significant correlations were determined between variables using Chi-square tests and effect sizes (Ellis *et al.*, 2003: 4). Chi-square X^2 is a sampling distribution that gives probabilities about frequencies (Spatz, 2008: 295). . The Chi-square analysis compares the observed frequencies of a category to frequencies that would be expected if the null hypothesis was true (Spatz, 2008: 295). An effect size index for Chi-square problems that have more than one degree of freedom was proposed by Harald Cramér and is referred to as Cramér effect size (Cramér ø or Cramér V) (Ellis *et al.*, 2003). An effect size $V \leq 0.2$ is considered a small effect with no or very little significance. An effect size $0.3 \leq V \leq 0.4$ is considered a medium effect that tends towards a practically significant correlation. For the purpose of this investigation, an effect size $V \geq 0.5$ (preferably $V \geq 0.8$) is considered a large effect which indicates a practically significant correlation. In order to complete the SDA for the second research question, the Statistical Consultation Service of the North-West University assisted in the cross tabulation analysis using SPSS® 16.0 for Windows (SPSS, 2007: online). Only medium and large effect sizes (Phi and V values ≥ 0.3) are reported. Both phi coefficient and Cramer' v can be considered as effect sizes (Ellis *et al.*, 2003)

5.3.1 Correlation with Curriculum goals

The main variable (i.e. *I know which teaching or learning situations are suitable for ICT use*) was correlated with several questions regarding Curriculum Goals (Part II of the Teachers' Questionnaire) in order to help answer the second research question. All the questions used from this part of the questionnaire are listed in Addendum 4.1. Because no practically significant correlation was calculated between the main variable and any of the Curriculum Goal items (V values ≤ 0.1), none are reported.

5.3.2 Correlation with teacher practices

The main variable (*I know which teaching or learning situations are suitable for ICT use*) was correlated with several items concerning Teacher Practices (Teachers' Questionnaire, Part III, items 9A-C, 9G-H, 9J and 9M), as well as with Teacher Practices in the Target Class (14A-L) in order to help address the second research question. The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations.

5.3.2.1 Correlations with extended projects

As illustrated in Table 5.6, 88.70% of the respondents indicated that they were not knowledgeable about teaching and learning situations that demanded the use of ICTs, and they also did not use ICT for extended projects. It is clear that if teachers have insufficient knowledge on the profitable use of ICTs, they are also less inclined to make use of ICT.

Table 5.6 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and teacher use of ICT for extended projects *

		for Extended Projects	
		Yes	No
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	11.30%	**88.70%**
	ICT knowledge to a certain extent	30.50%	69.50%
	Adequate ICT knowledge	**35.70%**	**64.30%**

* (SITES, 2006a)

As shown in Table 5.6, 35.70% of respondents who use ICT for extended projects are knowledgeable about in which teaching and learning situations to use ICTs. The respondents, who did not use ICT for extended projects (88.70%), also did not have knowledge about which teaching and learning situations to use ICT's. Various reasons can be put forward for the low use of ICTs for extended projects: insufficient infrastructure, curriculum demands, or time at their disposal or simply lack of knowledge. The 64.30% respondents who indicated that they made use of ICT for extended projects, and had the necessary knowledge of when to make use of ICT during teaching, are possibly those teachers who makes a positive contribution on the application of mathematical skills during extended projects (Way *et al.*, 2007: 20). From this cross tabulation it becomes clear that teachers should attain basic, as well as more extensive ICT skills to make a worthy difference in their teaching and learning, as well as in their schools. Therefore, if teachers were knowledgeable about the use of ICT's they would make use of it for extended projects.

Table 5.7 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and teacher use of ICT for extended projects

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.27	.27	.00

A medium effect size (V = 0.27), which tends towards a practically significant correlation, was calculated between teachers' knowledge about which teaching situations to use ICTs for, and their use of ICTs for the purposes of extended projects. This is important to mention as knowledgeable teachers relating to the pedagogical use of ICT, with the necessary support, will make use of ICT for extended projects.

5.3.2.2 Correlation with teacher lectures

As illustrated in Table 5.8, 91.40% of the respondents who indicated that they were not knowledgeable about which teaching and learning situations require the use of ICTs, also did not use ICT for their lectures.

Table 5.8 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and teacher use of ICT in teacher lectures *

		In teacher lectures	
		No	**Yes**
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**91.40%**	8.60%
	ICT knowledge to a certain extent	**76.60%**	**23.40%**
	Adequate ICT knowledge	**62.50%**	**37.50%**

* (SITES, 2006a)

Even though they did not know in which teaching and learning situations to use ICTs a small percentage (8.60%) of teachers made use of ICT for their classes Only 21.50% of the respondents who have the required knowledge about which teaching and learning situations to use ICTs for, make use of ICTs for their lectures. An interesting finding is that 62.50% of the teachers who indicated that they have knowledge about which teaching and learning situations to use ICTs for, in practice did not use ICTs for their classes.

Table 5.9 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and teacher use of ICT in teacher lectures

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.31	.31	.00

A medium effect size (V = 0.31), which tends towards a practically significant correlation, was calculated between teachers' knowledge about which teaching situations to use ICTs for, and their use of ICTs for lecturing. Even though some teachers have the knowledge about ICT use, they tend not to make use of ICT for lectures, possibly either due to philosophical beliefs or lack of ICT related infrastructure at their schools or lack of confidence with operating ICT's.

5.3.2.3 Correlations with teacher practices (model making skills and procedures, discovering principles and concepts, and processing and analyzing data) indicating no significant correlations

The main variable (i.e. *I know which teaching or learning situations are suitable for ICT use*) was correlated with Teacher Practices (items 9C, 9H, 9J, and 9M). Small effect sizes were calculated ($V \leq 0.1$) which indicate no practically significant correlation between knowledge when to use ICTs and Teacher Practices (model making. skills and procedures, discovering principals and concepts, and processing and analyzing data). These results are not reported.

5.3.2.4 Correlations with teacher practices (ICT teaching activities)

The main variable (*I know which teaching or learning situations are suitable for ICT use*) was correlated with ICT teaching activities (items 14A, 14B 14C, 14D, 14E, 14F, 14G, 14H, 14I, 14J, and 14L). The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations.

As reported in Table 5.10, the cross tabulation reveals that nearly ninety five percent (94.60%) of the respondents indicated they were not knowledgeable about teaching and learning situations that required the use of ICTs to present information or demonstrations. The results from the cross tabulations indicated that pedagogical knowledge of ICT use has an effect on the use of ICT to present information, demonstrations, or class instructions, and if grade 8 mathematics teachers had more knowledge in which teaching and learning situations to use ICT, they would use it more effectively in their classes. Only 29.90% of the respondents were knowledgeable about teaching and learning situations that are suited for ICT and had the ability to make use of ICT's to present information or demonstrations in their teaching and learning practices. Again many factors could be accountable for the insufficient use of ICT, insufficient infrastructure, curriculum aspects or time to prepare their teaching (Lim *et al.*, 2006: 91-96).

Table 5.10 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and teacher use of ICT to present information or demonstrations *

		To present information or demonstrations	
		Yes	**No**
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	5.40%	**94.60%**
	ICT knowledge to a certain extent	26.20%	73.80%
	Adequate ICT knowledge	**29.90%**	**70.10%**

* (SITES, 2006a)

Teachers, who would have multiple support methods to assist them with their teaching, would have a variety of instruction methods to help them teach more effectively. This could, in turn, contribute towards more effective teaching and learning of grade 8 mathematics (Lim *et al.*, 2006: 100).

Table 5.11 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and teacher use of ICT to present information or demonstrations and or class instructions

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.30	.30	.00

The only medium effect size (V = 0.3), which tends towards a practically significant correlation was calculated between the main variable and item 14A (Present information, demonstrations, or give class instructions). This is interesting because it shows that very few teachers have the knowledge of when to make use of ICT in teaching and learning practices. In conclusion, very few teachers have the prerequisite ICT knowledge required to do presentation and demonstrations, and many factors influence their ability to perform these tasks.

Small effect sizes ($V \leq 0.1$) were calculated between the main variable and the remaining items: 14B (Provide remedial or enrichment instruction to individual learners or small groups of learners); 14C (Help to learners in exploratory and inquiry activities); 14D (Organise, observe or monitor learner-led whole-class discussions, demonstrations, presentations); 14E (Assess learners' learning through tests or quizzes); 14F (Provide feedback to individuals or small groups of learners); 14G (Use classroom management to ensure an orderly, attentive classroom); 14H (Organise, monitor and support teambuilding and collaboration among learners); 14I (Organise or mediate communication between learners and experts or external mentors); 14J (Liaise with collaborators (within or outside school) for learner collaborative activities); and 14L (Collaborate with parents, guardians or caretakers in supporting or monitoring learners' learning or in providing counseling). Many teachers still do not make use of ICT's in the daily organisational, administrative and management tasks at schools.

5.3.3 Correlation with impact of ICT use

The main variable (*I know which teaching or learning situations are suitable for ICT use*) was correlated with correlated with items 19A-K to answer the research question: *Can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?* The respondents had to indicate whether they made use of ICT in teaching and learning, and whether ICT had an impact on them. Questions 19A-K focussed specifically on teachers that make use of ICT within the teaching and learning practices in grade 8 mathematics and the impact of ICT on different aspects within teaching, learning and planning. The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations.

5.3.3.1 Correlations with ICT skills

As can be seen from Table 5.12, 60.30% of the respondents who indicated no improvement in their ICT skills confirmed that they had no knowledge about which situations to use ICTs. More than forty percent (48.70%) who indicated that their ICT skills have improved much also indicated that they have knowledge about which situations to use ICTs. Even the 32.40% of the teachers who indicated that they have moderate knowledge (a little to somewhat) about which situations to use ICTs in, also indicated that their ICT skills have improved.

Table 5.12 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and my ICT skills have improved *

		My ICT Skills have improved		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**60.30%**	35.50%	4.40%
	ICT knowledge to a certain extent	13.50%	54.00%	**32.40%**
	Adequate ICT knowledge	2.60%	48.70%	**48.70%**

* (SITES, 2006a)

The results therefore indicate that regular interaction with ICT's when teaching and learning will ensure an increase in ICT skills.

Table 5.13 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and my ICT skills have improved

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.75	.53	.00

A practically significant correlation (V= 0.53) was calculated between teachers' knowledge about which teaching situations to use ICTs in and the improvement of ICT skills. This shows that even moderate ICT interaction improves ICT skills. It can thus be concluded that teachers who lack the knowledge about which situations to use ICTs in, tend to avoid making use of ICT therefore their skills do not improve, and neither does their confidence to interact with the ICT's to improve their skills. Therefore, it seems that pedagogical knowledge contribute towards more effective mathematics teaching, while regular interaction with ICT can develop their ICT knowledge as their skills improve and improve their confidence to use ICT's in their teaching and learning practices (Jarred, 1998: 6).

5.3.3.2 Correlations with new teaching methods

As shown in Table 5.14, 45.50% of the respondents who indicated that they incorporate new teaching methods also indicated that they know in which situations to use ICTs. Exposing learners to different methods of solving problems with the help of ICT can contribute towards more effective teaching and learning of mathematics.

Table 5.14 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and incorporate new teaching methods *

		Incorporate new teaching methods		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**60.60%**	33.30%	6.10%
	ICT knowledge to a certain extent	8.60%	62.80%	28.60%
	Adequate ICT knowledge	6.50%	48.10%	**45.50%**

* (SITES, 2006a)

More than sixty percent (60.60%) of the respondents indicated they lacked knowledge about ICT use in teaching and learning and they did not incorporate new teaching methods using the multiple ICT's at their disposal. The 45.50% of the knowledgeable respondents regularly made use of ICT's when teaching and learning mathematics.

Table 5.15 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and incorporate new teaching methods

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.66	.47	.00

A practically significant correlation (V = 0.47) was calculated between teachers' knowledge about which situations to use ICTs and the incorporation of new teaching methods. These results indicate that if teachers had the necessary knowledge of the pedagogical uses of ICT they would be more confident to experiment with new teaching methods, and ultimately, it can contribute towards more effective mathematics teaching as a variety of methods will be used to convey the mathematical concepts to learners.

5.3.3.3 Correlations with individualised feedback

As indicated in Table 5.16, 38.20% of the respondents indicated that they that are able to use ICTs to provide individual feedback to learners indicated that they had the required knowledge about what teaching and learning situations are best suited for ICT use. In this context, learners will have access to their performance so they can monitor their results and access areas where they need to improve. Learners will constantly be able to evaluate their improvement and areas where they need to work harder.

Table 5.16 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and provide more individualised feedback using ICT *

		Provide more individualised feedback using ICT		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**56.90%**	29.20%	13.80%
	ICT knowledge to a certain extent	11.40%	51.40%	37.10%
	Adequate ICT knowledge	7.90%	23.90%	**38.20%**

* (SITES, 2006a)

In Table 5.16 of the respondents 56.90% had insufficient knowledge in which teaching and learning situations to make use of ICT's will not be confident and able to communicate with their learners using ICT. Nearly forty percent (38.20%) of the respondent had adequate knowledge to use ICT and made use of ICT to provide individualised feedback to the learners. Table 5.17 gives the effect sizes of the correlations in Table 5.16.

Table 5.17 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and provide individualised feedback to learners using ICT

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.53	.37	.00

A medium effect (V = 0.37), which tends towards a practically significant correlation, was calculated between teachers' knowledge about which teaching situations to use ICTs and their ability to provide individualised feedback to learners. From thus results it can be said that teachers who do not know how to use ICTs in various situations seem to find it difficult to give individual feedback to their learners, and those who use ICTs with comfort seem to be able to provide individual feedback to learners more easily.

5.3.3.4 Correlations with incorporating new ways of organising learners' learning

As illustrated in Table 5.18, only 36.50% of the respondents who indicated that they regularly used ICTs to incorporate new ways of organising learners' learning in grade 8 mathematics had adequate knowledge about which teaching and learning situations to use ICTs.

Table 5.18 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and incorporate new ways of organising learners' learning using ICT *

		Incorporate new ways of organising learners' learning		
		Not at all	A little -Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**58.50%**	30.70%	10.80%
	ICT knowledge to a certain extent	11.40%	51.40%	**37.10%**
	Adequate ICT knowledge	2.70%	60.80%	**36.50%**

* (SITES, 2006a)

It seems that knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching with new ways to get learners to learn. Teachers that make use of different methods to organise their learners' learning will explore new ways of teaching and learning, therefore they will contribute towards the teaching and learning of mathematics in grade eight. Even the 37.10% of teachers who incorporate new ways of organising learners' learning had moderate (little to somewhat) knowledge about which situations to use ICT for pedagogical purposes. However, the 58.50% of teachers who do not incorporate new ways of organising learners' learning lacked knowledge about ICT use in different situations. A possible reason for the absence of ICT use for incorporating new ways to organise learners' learning can be due to the lack of exploring with ICTs to develop new methods to transfer the knowledge to their learners. Table 5.19 indicates the effect sizes of the correlations done in Table 5.18.

Table 5.19 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and incorporate new ways to organising learners' learning using ICT

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.60	.43	.00

A medium effect (V = 0.43), which tends towards a practically significant correlation, was found between teachers' knowledge about ICT use in different situations, and the ability to incorporate new ways of organising learners' learning. ICT use therefore seems to promote new ways of organising the learning process.

5.3.3.5 Correlations with monitoring learners' learning

As reported in Table 5.20, the 46.70% of teachers who monitor their learners' learning progress more easily; also know what ICTs to use in different situations.

Table 5.20 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and monitoring learners' progress with ICT *

		Monitor more easily learners' learning progress		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**59.40%**	31.30%	9.40%
	ICT knowledge to a certain extent	8.60%	64.30%	**37.10%**
	Adequate ICT knowledge	4.00%	50.20%	**46.70%**

* (SITES, 2006a)

Likewise, the 37.10% of teachers who monitor their learners' learning progress have moderate (a little to somewhat) knowledge of ICT use in various situations. These results show that many teachers realised the value of ICTs and how ICTs can simplify their administrative work and avoid repetition of work. However, 59.4% of the teachers who do not know how to use ICTs for different pedagogical purposes also do not make use of ICT to monitor learners' learning progress. Therefore, those teachers who are knowledgeable about the pedagogical use of ICT admitted they could monitor their learners' process effortlessly. However, many teachers avoid making use of ICTs to evaluate their learners, resulting in valuable pedagogical time wasted on paper administration. In Table 5.21 the effect sizes of the correlations are displayed.

Table 5.21 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and monitor learners' progress

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.62	.44	.00

A medium effect (V = 0.44), which tends towards a practically significant correlation, was calculated between teachers' knowledge about which ICTs to use for different pedagogical situations, and their ability to monitor the progress of their learners' learning progress. This shows that teachers who have the ICT knowledge make use of ICT to monitor learners' progress effortlessly; unfortunately less than half of the mathematics teachers made use of ICT for monitoring.

5.3.3.6 Correlations with availability of resources

According to Table 5.22, 32.40% of the respondents knew how to access more diverse and high quality resources and had the knowledge which teaching and learning situations were best suited for ICT use. It is disheartening that more than sixty percent (62.50%) of the respondents indicated that they never made use of ICT to access more diverse or high-quality resources did not have the knowledge to decide which teaching and learning situations are best suited for ICT use and will not know where to search for these resources.

Table 5.22 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and access to more diverse or higher quality learning resources *

		Access diverse or high quality learning resources		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**62.50%**	34.30%	3.10%
	ICT knowledge to a certain extent	11.80%	55.90%	32.40%
	Adequate ICT knowledge	4.10%	63.50%	**32.40%**

* (SITES, 2006a)

The knowledge of the pedagogical use of ICTs will ensure that teachers access more diverse or high-quality resources, and with a variety of methods and resources at their disposal. They will be able to explore within their teaching and learning, and through that it can contribute toward more effective mathematics teaching in grade 8. The effect sizes of the cross tabulations in Table 5.22 are displays in Table 5.23.

Table 5.23 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and access more diverse or high quality learning resources

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.67	.47	.00

A practically significant correlation (V= 0.47), is found between the teachers' knowledge regarding in which teaching situations to use ICTs, and the access to more diverse or higher quality resources. This means that if teachers are able to access more resources especially for learners who struggle to visualise the different dimensions of an object.

5.3.3.7 Correlations with collaboration with colleagues

As illustrated in Table 5.24, 48.60% of the respondents who regularly communicated with their colleagues using various ICT methods of communication knew which teaching and learning situations are best suited for ICT use. They were able to support each other in completing tasks and sharing their ICT knowledge. Unfortunately more than fifty percent (56.90%) of the respondents could not communicate constructively with their peers on aspects relating to the completion of tasks and they did not have the ICT pedagogical knowledge to make use of ICT.

Table 5.24 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and more collaboration with colleagues within the school *

		I collaborate more with colleagues within my school		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**56.90%**	24.60%	18.50%
	ICT knowledge to a certain extent	5.70%	57.10%	37.10%
	Adequate ICT knowledge	5.40%	46.00%	**48.60%**

* (SITES, 2006a)

If teachers had the ICT related pedagogical knowledge they will confidently collaborate with colleagues within their school, to share ideas and information to enrich their teaching practices. Table 5.25 indicates the effect sizes of the correlations done in Table 5.24.

Table 5.25 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and more collaboration with colleagues within the school

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.60	.43	.00

A medium effect (V= 0.43), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and collaboration with colleagues within their school. This is interesting because if teachers had the necessary ICT pedagogical knowledge they will be able to communicate effectively with their peers regarding tasks and activities, and share information that will assist them to transfer knowledge more effectively (Oldknow *et al.*, 2003: 60).

5.3.3.8 Correlations with collaboration with peers outside their schools

According to Table 5.26, 53.80% of the respondents who indicated that they did not collaborate with peers and experts outside their schools had insufficient ICT-related pedagogical knowledge. Their evasion to conduct in collaborating activities is understandable as they lack the knowledge to communicate with their peers. The 41.70% of the respondents who frequently communicated with peers and experts outside their schools indicated that they had sufficient knowledge of which teaching and learning situations to use ICT in. Interacting with other teachers in their subject will enable them to get support from other teachers when they struggle to complete tasks. Those who know what to do will make use of collaboration with their peers and experts and they will ask significant questions relating to their teaching practices (Bramald *et al.*, 2000: 6).

Table 5.26 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and more collaboration with peers and experts outside my school *

		Collaborate more with peers and experts outside my school		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**53.80%**	35.40%	10.80%
	ICT knowledge to a certain extent	14.30%	54.30%	31.40%
	Adequate ICT knowledge	9.70%	48.60%	**41.70%**

* (SITES, 2006a)

The knowledge of the pedagogical use of ICTs will ensure that teachers will be confident to collaborate more with peers and colleagues outside their school. Table 5.27 shows the effect sizes of the correlations done in Table 5.26.

Table 5.27 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and more collaboration with peers and experts outside the school

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.49	.35	.00

A medium effect (V= 0.35), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and collaboration with peers and colleagues outside their school. This is important to mention as the collaboration with peers and experts outside their schools will allow teachers to broaden their knowledge and share valuable information that can contribute towards more effective teaching and learning (Bramald *et al.*, 2000: 6).

5.3.3.9 Correlations with administrative tasks

In Table 5.28, 64.40% of the respondents who indicated they make use of ICT to complete their administrative tasks had sufficient knowledge of which teaching and learning situations are best suited to ICT. The knowledge of the pedagogical use of ICTs will ensure that teachers will be confident to complete their administrative tasks more easily, and through that they will save time on the administrative work. This will, in turn, enable teachers to spend more time to enhance and increase their mathematical knowledge, and ultimately it can contribute towards more effective mathematics teaching in grade 8. The 58.10% that indicated a lack of knowledge never made use of ICT to complete their administrative tasks will not realise the value of using ICT for administrative tasks.

Table 5.28 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and completing administrative tasks *

		Complete administrative tasks more easily			
		Not at all	A little	Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**58.10%**	19.40%	11.30%	11.30%
	ICT knowledge to a certain extent	5.70%	28.60%	22.90%	42.90%
	Adequate ICT knowledge	5.50%	8.20%	21.90%	**64.40%**

* (SITES, 2006a)

They would be able to complete their administrative tasks without much fuss if they possessed efficient knowledge of the operating systems of the computer (Oldknow *et al.*, 2003: 60). Table 5.29 shows the practical significant correlations illustrated in Table 5.28.

Table 5.29 Effect size of the relationship between teacher knowledge of which teaching and learning situations are suitable for ICT use, and completing administrative task

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.67	.47	.00

A practically significant correlation (V= 0.47) is found between the teachers' knowledge regarding in which teaching situations to use ICTs and "I will complete their administrative tasks more easily." The reason for correlation was to determine whether the pedagogical knowledge of ICT had an influence on the completion of administration tasks using ICT.

5.3.3.10 Correlations with increase in workload

In Table 5.30, 56.90% of the respondents who indicated their workload did not increase making use of ICT also indicated they did not have the ICT related pedagogical knowledge. The 37.80% of respondents who admitted that their workload increased had knowledge of which teaching and learning situations are best suited the use of ICT. Therefore, it can mean that they are finding alternative methods to teach mathematics, and therefore even though their workload has increased, the use of ICT can contribute in a positive manner towards the teaching and learning of mathematics in grade 8. Of the respondents 40% admitted that their workload increased much, and also indicated they had some ICT pedagogical knowledge.

Table 5.30 **Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and increased workload with the use of ICT ***

		Workload increased with the use of ICT		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**56.90%**	29.20%	13.80%
	ICT knowledge to a certain extent	11.40%	48.60%	**40.00%**
	Adequate ICT knowledge	14.90%	47.30%	**37.80%**

* (SITES, 2006a)

In conclusion knowledge about the use of ICT in teaching and learning can increase a teachers' workload especially at the beginning of the integration process where teachers need to explore the numerous resources at their disposal. Table 5.31 shows the effect sizes of the correlations in Table 5.30.

Table 5.31 **Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and increased workload with the use of ICT**

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.49	.35	.00

A medium effect (V= 0.35), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and my workload has increased. The teachers acknowledge that their workload did increase as they tend to discover the various uses of ICT and become more creative in their teaching practices.

5.3.3.11 Correlations with work pressure

According to Table 5.32, 34.25% of the respondents admit that their work pressure has increased with the use of ICT. The majority (56.90%) indicated their work pressure did not increase at all, also had a shortage of knowledge on which teaching and learning situations are best suited for ICT use. Even the respondents (37.10%) who admit to an increase in work pressure indicated that they had less ICT-related pedagogical knowledge.

Table 5.32 **Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and there is increased work pressure ***

		There is increased work pressure		
		Not at all	A little - Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**56.90%**	24.60%	18.50%
	ICT knowledge to a certain extent	17.10%	45.80%	**37.10%**
	Adequate ICT knowledge	16.40%	49.30%	**34.20%**

* (SITES, 2006a)

Thus many teachers acknowledge an escalation in work pressure with the use of ICT. Table 5.33 shows the effect sizes of the correlations in Table 5.32.

Table 5.33 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and there is increased work pressure

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.42	.30	.00

A medium effect (V= 0.30), which tends towards a practically significant correlation is found between the teachers' knowledge regarding in which teaching situations to use ICTs and an increased work pressure. Many teachers are overworked and having new teaching mechanisms without adequate training will make teachers less likely to embrace the challenge knowing they will have more work.

5.3.3.12 Correlation with becoming less effective as a teacher

Results for the correlation of the main variable 21J (knowledge about which teaching and learning situations are suitable for ICT use) and 19L (I have become less effective as a teacher) will not be reported as the (V = 0.057) indicating that the correlation was Phi≤ 0.1 = small effect with no practically significant correlation. Nearly none of the respondents could convey that the pedagogical use of ICT made them less effective as teachers.

5.3.4 Correlation with impact of ICT use on learners

Fourthly, the main variable 21J (knowledge about which teaching and learning situations are suitable for ICT use) were correlated with questions 20 (Part VI-Impact of ICT Use on learners) in order to answer the research question: *Can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?*

The respondents had to indicate whether they made use of ICT in the teaching and learning, and whether ICT had an impact on their learners. Question 21J (knowledge about which teaching and learning situation are suitable for ICT use) were correlated with the questions 20A, 20B, 20C, 20D, 20E, 20F, 20G, 20H, 20I, 20J, and 20N. The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations. Question 20 focussed specifically on the impact of ICT on learners in grade 8 mathematics classrooms, and on aspects relating to their knowledge, skills and assessment results. Five result indicators were used: Decreased a lot, Decreased a little, No impact, Increased a little, Increased a lot.

5.3.4.1 Correlations with learners' subject matter knowledge

As illustrated in Table 5.34, more than forty percent (46.30%) of the respondents indicated making use of ICT had no impact on their learners' subject matter knowledge, also indicated that they had no knowledge which teaching and learning situations are best suited for ICT use. Even though they had some pedagogical knowledge of ICT use, they said there was a slight increase in their learners' subject matter knowledge with the use of ICT. The 42.50% of the respondents said their learners' subject matter knowledge increased tremendously with the use of ICT, also indicated efficient knowledge which teaching and learning situations are best suited for ICT use. None of (0.0%) of the respondents indicated that there was a decrease in their learners' subject matter knowledge; therefore we can say that knowledge in which teaching and learning situations to use ICT can contribute towards the teaching and learning of mathematics in grade 8.

Table 5.34 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learner subject matter knowledge *

		Impact of ICT use on subject matter				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	10.40%	4.50%	**46.30%**	31.30%	7.50%
	ICT knowledge to a certain extent	0.00%	6.10%	15.20%	57.60%	21.20%
	Adequate ICT knowledge	0.00%	6.80%	19.20%	31.50%	**42.50%**

* (SITES, 2006a)

In conclusion teachers who had adequate ICT pedagogical knowledge and regularly made use of ICT admit a growth in their learners' subject matter knowledge. Table 5.35 shows the effect sizes of the correlations done in Table 5.34.

Table 5.35 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and Impact of ICT on learner subject matter knowledge

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.51	.36	.00

A medium effect (V= 0.36), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs, and the impact of ICT use on learners' subject matter knowledge. In SITES M1 results disclosed that 27% of primary, 22% of lower secondary, and 24% of upper secondary teachers acknowledge an increase in ICT knowledge and skills (Voogt, 2008: 219).

5.3.4.2 Correlations with learners' learning motivation

According to Table 5.36, 43.80% of the respondents indicated their learners' learning motivation increased a lot when they regularly made use of ICT in their teaching and learning practices, also indicated they had sufficient knowledge about which teaching and learning situations are best suited ICT use. None (0%) of the respondents, even those lacking ICT pedagogical knowledge, indicated that the use of ICT decreased their learners' motivation. More than fifty percent (51.50%) of the respondents indicated they observed a slight increase in their learners' learning motivation even though they had less knowledge which teaching and learning situations are best suited for ICT use.

Table 5.36 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' learning motivation *

		Impact of ICT on learners' learning motivation				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	9.00%	4.50%	47.80%	31.30%	7.50%
	ICT knowledge to a certain extent	0.00%	6.10%	18.20%	**51.50%**	24.20%
	Adequate ICT knowledge	0.00%	2.70%	23.30%	30.10%	**43.80%**

* (SITES, 2006a)

The regular interaction with ICT increased learners' learning motivation as they become more skilled with the various ICT programs and their level of confidence will increase. Table 5.37 shows the effect sizes of the correlations on learning motivation.

Table 5.37 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and Impact of ICT on learner learning motivation

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.48	.34	.00

A medium effect (V= 0.34), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' learning motivation. If teachers are motivated to make use of ICT and to be positive their learners will develop persistence and curiosity and ultimately become motivated to experience with ICT as they are exposed to it (Jarred, 1998: 40).

5.3.4.3 Correlations with impact of learners' information handling skills

As illustrated in Table 5.38, 41.10% of the respondents who indicated having their learners repeatedly making use of ICT in their learning practices ensured an increase in their information handling skills also indicated that they had adequate knowledge which teaching and learning situations best suited ICT use. Only those respondents (43.30%) who indicated no impact to their learners' information handling skills also lacked ICT pedagogical knowledge.

Table 5.38 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and Impact of ICT on learners' information-handling skills *

		Impact of ICT on learners' information-handling skills				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	9.00%	4.50%	**43.30%**	34.30%	9.00%
	ICT knowledge to a certain extent	0.00%	9.10%	21.20%	45.50%	24.20%
	Adequate ICT knowledge	1.40%	1.40%	23.30%	32.90%	**41.10%**

* (SITES, 2006a)

This shows that if teachers do posses the ICT pedagogical knowledge and are optimally using it in their teaching practices, they will ensure that their learners' information handling skills will increase gradually.

Table 5.39 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on information-handling skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.42	.30	.00

A medium effect (V= 0.3), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs, and the impact of ICT use on learners' information handling skills.

5.3.4.4 Correlation with impact on learners' problem solving skills

According to Table 5.40, 50% of the respondents who indicated making use of ICT had no impact on their learners' problem solving skills also indicated that they had no sufficient knowledge of which teaching and learning situations are best suited to ICT use. Derived from this we can say that not having ICT relevant pedagogical knowledge will prevent teachers from selecting the appropriate software to enhance their learners' problem solving skills. The 48.50% of the respondents who acknowledged that their learners' problem-solving skills increased slightly also indicated that they had some knowledge of which teaching and learning situations are best suited for ICT use. Problem-solving is a higher order thinking skill; through problem solving activities learners can attain one of the critical outcomes addressed in the National Curriculum Statement.

Table 5.40 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' problem-solving skills *

		Impact of ICT on learners' problem-solving skills				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT in	No knowledge to use ICT	9.10%	3.00%	**50.00%**	31.80%	6.10%
	ICT knowledge to a certain extent	0.00%	6.10%	24.20%	48.50%	21.20%
	Adequate ICT knowledge	0.00%	4.10%	24.70%	**32.90%**	**38.40%**

* (SITES, 2006a)

If teachers allow their learners to interact with problem solving activities either through application software or project-based learning it will help to develop their higher order thinking skills. Table 5.41 illustrates the effect sizes of the correlations of Table 5.40.

Table 5.41 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' problem-solving skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.46	.32	.00

A medium effect (V= 0.32), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' problem solving skills.

5.3.4.5 Correlations with learners' self-directed learning skills

Self-directed learning is one of the outcomes not essentially being focussed on in foundation or intermediate phase education where the teacher is central in helping learners acquire the basic knowledge skills and attitudes (South Africa, 2002: 1). Only as learners progress to senior phase education they are expected to use the knowledge acquired in the other phases and develop their self-directed learning skills. As illustrated in Table 5.42, more than fifty percent (53.70%) indicated making use of ICT had no impact on their learners' self-directed learning skills, and also indicated they had no knowledge of which teaching and learning situations best suited ICT use. More than thirty percent (37%) of the respondents indicated their learners are developing self-directed learning skills and also indicated they had adequate knowledge of which teaching and learning situations are best suited for ICT use.

Table 5.42 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' self-directed learning skills *

		Impact of ICT on learners' self-directed learning skills				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	9.00%	0.00%	**53.70%**	31.30%	6.00%
	ICT knowledge to a certain extent	0.00%	6.10%	21.20%	63.60%	9.10%
	Adequate ICT knowledge	0.00%	6.80%	28.80%	27.40%	**37.00%**

* (SITES, 2006a)

In conclusion many teachers admit the majority of their learners' self-directed learning skills are progressing as they interact with ICT during teaching and learning. This shows that teachers who regularly make use of ICT realise that ICT allows learners to think more deeply which allows them to solve problems (Jarred, 1998: 32).

Table 5.43 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' self-directed skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.54	.38	.00

A medium effect (V= 0.38), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' self-directed learning skills.

5.3.4.6 Correlations with impact on learners' collaborative skills

At many schools learners are not allowed to freely make use of the Internet (Childs *et al.*, 2005: 30). They are restricted to access only under supervision and many learners do not have access to the Internet at home. As illustrated in Table 5.44, 33.30% of the respondents admit their learners' collaborative skills increased a lot, and also indicated they had the knowledge of which teaching and learning situations are suitable for ICT use. It is a possibility that many of these teachers have adequate knowledge to create Blogs and Wiki's for their learners as a method of communication. More than fifty percent (53.70%) of the respondents indicated using ICT made no impact on their learners' collaboration skills, and also indicated not having sufficient knowledge to know which teaching and learning situations are best suited for ICT use (Bramald *et al.*, 2000: 6).

Table 5.44 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use and impact of ICT on learners' collaborative skills *

		Impact of ICT on learners' collaborative skills				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	9.00%	3.00%	**53.70%**	29.90%	4.50%
	ICT knowledge to a certain extent	0.00%	3.20%	25.80%	51.60%	19.40%
	Adequate ICT knowledge	0.00%	2.80%	26.40%	**37.50%**	**33.30%**

*

This shows that if teachers are confident in their ICT abilities they will allow their learners to collaborate more with them and their peers. It will enable teachers to know the level of their learners' ICT skills and knowledge. Sharing ideas through Wiki's and Blogs will ensure that their mathematical knowledge will improve, and the less confident learners will use this method of communication (Bramald *et al.*, 2000: 6).

Table 5.45 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on collaborative skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.46	.32	.000

A medium effect (V= 0.32), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' collaborative skills.

5.3.4.7 Correlations with impact on learners' communication skills

A growth in confidence will occur if learners are given the opportunity to raise their opinions and share their thoughts with their teachers and peers. Often you find learners with brilliant ideas, but they are not confident enough to share their ideas with their peers and teachers. Having ICT at their disposal will enable those learners to interact with their peers and teachers (Kolderie *et al.*, 2009: 1-9). According to Table 5.46, 41.70% of the respondents who indicated their learners' communication skills improved a lot also had sufficient knowledge of which teaching and learning situations are best suited for ICT use. Only those respondents (48.50%) who indicated ICT had no impact on their learners' communication skills, lacked ICT pedagogical knowledge.

Table 5.46 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' communication skills *

		Impact of ICT on learners' communication skills				
		Decreased a lot	Decrease d a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	10.60%	1.50%	**48.50**%	30.30%	9.10%
	ICT knowledge to a certain extent	0.00%	3.00%	33.30%	42.20%	21.20%
	Adequate ICT knowledge	1.40%	1.40%	22.20%	33.30%	**41.70**%

* (SITES, 2006a)

Constant communication will ultimately improve their mathematical knowledge as any concepts not understood and areas of concern will be addressed immediately and remedial exercises will help them to overcome any learning barriers (Balanskat *et al.*, 2006: 2)

Table 5.47 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on communication skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.43	.30	.00

A medium effect (V= 0.3), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' communication skills. This shows that if teachers are knowledgeable which Internet resources and facilities to use to develop their learners' communication skills both teachers and learners will gain from having ICTs.

5.3.7.8 Correlations with impact on learners' ICT skills

As illustrated in Table 5.48, 50% of the respondents indicated their learners ICT skills had only increased slightly since making use of ICT, also indicated that they had knowledge of which teaching and learning situations are best suited for ICT use. Those 52.20%, who indicated no impact on their learners' ICT skills, also had no knowledge of the pedagogical uses of ICT. The 50% of the respondents who indicated a small growth in their learners' ICT skills had knowledge of which teaching and learning situations are best suited for ICT use. Only 25.70% of the respondents who indicated a significant increase in their learners' ICT skills were ICT-pedagogical knowledgeable teachers.

Table 5.48 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' ICT communication skills *

		Impact of ICT on learners' ICT skills				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	11.90%	4.50%	**52.20%**	25.40%	6.00%
	ICT knowledge to a certain extent	0.00%	6.10%	21.20%	63.30%	9.10%
	Adequate ICT knowledge	1.40%	2.70%	20.30%	**50.00%**	**25.70%**

* (SITES, 2006a)

The teachers who had adequate ICT pedagogical knowledge indicated that with the use of ICT skills increased.

Table 5.49 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' communication skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.49	.35	.00

A medium effect (V= 0.35), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' ICT skills. This shows that if teachers have adequate ICT they will practice communication through ICT regularly and learners' communication skills will develop.

5.3.4.9 Correlations with impact on learners' learning at own pace

One of the main purposes for the implementation of an outcomes-based curriculum in South Africa was to ensure that learners will be able to learn and achieve at their own pace. Many teachers are faced with overcrowded classroom and have very little time to spend with slower learners. When teachers make use of the computer laboratory for teaching they will have time to spend with their slow learners while the other learners are working on projects or enrichment exercises (Kolderie *et al.*, 2009: 1-7). According to Table 5.50, more than thirty percent (37%) of the respondents indicated that their learners' ability to learn at their own pace increased much, and they also had knowledge of which teaching and learning situations are best suited for ICT use.

Table 5.50 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' learning at their own pace *

		Impact of ICT on learners' learning at their own pace				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	10.40%	3.00%	50.70%	28.40%	7.50%
	ICT knowledge to a certain extent	0.00%	6.10%	21.20%	57.60%	15.20%
	Adequate ICT knowledge	1.40%	2.70%	21.90%	**37.00%**	**37.00%**

*** (SITES, 2006a)**

Making use of ICT will allow learners to learn at their own pace and teacher will be able to spend more time on remedial exercises with their slower learners. The more competent learners will engage in enrichment exercises.

Table 5.51 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' learning at their own pace

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.48	.34	.00

A medium effect (V= 0.34), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' learning at their own pace. The results indicate that if teachers know the abilities of their learners and the ICT software most appropriate for their level of development they will select the exercises best suited for them.

5.3.4.10 Correlations with impact on learners' assessment results

Assessment at the end of each term allows teachers to measure their learners' performance and it gives an indication of the areas that needs to improve (South Africa, 2004a: 6). Without assessment teachers will not be able to plan their teaching practices and determine whether the use of their selected resources were successful in their teaching practices. The Internet has many sites where teachers can retrieve assessment rubrics and tasks e.g. Rubistar. Using versatile methods of assessment will help learners to gain better results at the end of each term (Kolderie *et al.*, 2009: 1-7). As illustrated in Table 5.52, 32.40% of the respondents indicated using ICT increased their learners' assessment results a lot also indicated they had knowledge of which teaching and learning situations are best suited for ICT use. Only the 44.80% respondents who indicated no impact on their learners' assessment results also lacked ICT pedagogical knowledge indicated ICT had.

Table 5.52 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' assessment results *

		Impact of ICT on learners' assessment results				
		Decreased a lot	Decreased a little	No impact	Increased a little	Increased a lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	9.00%	4.50%	**44.80%**	32.80%	9.00%
	ICT knowledge to a certain extent	0.00%	3.00%	24.20%	57.60%	15.20%
	Adequate ICT knowledge	0.00%	0.00%	29.60%	**38.00%**	**32.40%**

* (SITES, 2006a)

Making use of multiple assessment methods provides learners with the opportunity to gain better results at the end of each term.

Table 5.53 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and impact of ICT on learners' assessment results

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.42	.30	.00

A medium effect (V= 0.3), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and the impact of ICT use on learners' assessment results. Having versatile methods for assessment allows teachers to select the most suitable method of assessment, using the various websites, for their learners to gain good results that will enable them to progress to a next grade (Goldsmith *et al.*, 1993b: 124-131).

5.3.5 Correlation with confidence in the pedagogical use of ICT

Fifthly, the main variable 21J (knowledge about which teaching and learning situation are suitable for ICT use) was correlated with questions 21 (Part VII-Pedagogical use of ICT) in order to answer the research question: *Can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?* The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extend (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations

The respondents had to indicate whether they made use of ICT in their teaching and learning, and whether they can prepare lessons that involve the use of ICT by their learners. Question 21J (knowledge about which teaching and learning situations are suitable for ICT use) were correlated with the questions 21I (I can prepare lessons that involve the use of ICT by learners. Question 21 focussed specifically on the pedagogical use of ICT in grade 8 mathematics classrooms. Four result indicators were used: Not at all, A little, Somewhat and A lot.

As illustrated in Table 5.54 more than ninety percent (90.70%) of the respondents indicated they were unable to prepare lessons using ICT as they had no knowledge which teaching and learning situations are best suited for ICT use. Only 45.70% of the respondents were able to use ICT to prepare lessons for their learners had sufficient knowledge of the pedagogical use of ICT

Table 5.54 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and I can prepare lesson that involve the use of ICT by learners *

		I can prepare lesson that involve the use of ICT by learners			
		Not at all	A little	Somewhat	A lot
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**90.70%**	7.10%	1.10%	1.10%
	ICT knowledge to a certain extent	32.50%	48.80%	16.30%	2.40%
	Adequate ICT knowledge	8.00%	15.10%	31.20%	**45.70%**

* (SITES, 2006a)

The teachers who had sufficient knowledge of in which teaching and learning situations to use ICT and were able to prepare lessons that involve the use of ICT by learners will steer their learners towards more interactive and collaborative teaching and learning, ultimately working towards achieving 21st century skills. Therefore, if teachers are able to prepare lessons with the use of ICT by their learners, they can conduct their lessons using the Interactive whiteboard and they can create spreadsheet activities where learners conduct activities across the five learning outcomes of mathematics. Additionally, teachers can develop a lot of tasks to orientate learners to inquire information using the various resources at their disposal (Lambert *et al.*, 1998: 110).

Table 5.55 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and I prepare lessons that involve the use of ICT by learners

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.90	.63	.00

A large effect (V= 0.63), which indicates a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs to prepare lessons that involve the use of ICT by learners. This shows that teachers do not have the ICT pedagogical skills to prepare lessons. Therefore they avoid the use of ICT and are not exposing their learners to the multiple resources available to gain knowledge and ICT skills preparing them to compete in a global society.

5.3.6 Correlations with enhancing ICT in teaching and learning

To determine whether priorities in teaching and learning in grade 8 mathematics are ICT related, the main variable 21J (knowledge about which teaching and learning situation are suitable for ICT use) were correlated with questions 22 (Part VII-Pedagogical use of ICT) in order to answer the research question: *Can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?*. The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations.

The respondents had to indicate whether they had priorities relating to the use of ICT in the teaching and learning for the coming two years, and whether they can prepare lessons that involve the use of ICT by their learners. Question 21J (knowledge about which teaching and learning situation are suitable for ICT use) were correlated with the questions 22C, 22F, 22G, 22I, 22J, 22K, and 22L. Question 22 focussed specifically on the pedagogical use of ICT and priorities for the coming two years in grade 8 mathematics classrooms. Four result indicators were used: Not at all, Low priority, Medium priority, and High Priority.

The questions 22 C (to provide better and more interesting lectures or presentations to learners), 22F (to involve learners in collaborative, short projects), 22G (to involve learners in extended collaborative projects), 22H (to involve learners in scientific investigations), 22I (collaboration with outside peers and external experts), 22J (collaborate with fellow teachers), 22K (provide opportunities for learners to collaborate with classmates), and 22L from Part VII (Information about you and your school) correlated with the main variable 21J had a V or Phi ≤ 0.1 = small effect with no practically significant correlation or a V or Phi value less than 0.25, therefore these results are not reported. Collaborative activities with teachers and learners in grade 8 mathematics classrooms are an area we need to explore.

5.3.7 Correlations with barriers in using ICT

To determine whether the barriers teachers experience using ICT in their teaching and learning has an effect on their knowledge, or lack thereof, it is necessary to determine the correlations of barriers with knowledge in which teaching and learning situations to use ICT in grade 8 mathematics. The main variable 21J ((knowledge about which teaching and learning situation are suitable for ICT use) was correlated with questions 23D and 23I to answer the second research question: *Can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?*. The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations

5.3.7.1 Correlations with ICT-related skills

The foundation of ICT teaching starts with the mastering of basic ICT skills. The Western Cape Education Department in co-operation with Microsoft have a three phase ICT program for teachers called MSPhil, Webquests, and IntelTeach. Firstly, for eighteen months teachers attend an ICT skills program. Afterwards they receive training in web quests and Internet teaching. Unfortunately only a small percentage of teachers in schools received this training. As illustrated in Table 5.56, 57.70% of the respondents who had the ICT-related skills knew which teaching and learning situations are best suited for ICT use. Nearly eighty percent (77.30%) of the respondents indicated they had no ICT-related skills also indicated they had no ICT pedagogical knowledge. Those respondents (59.10%) who lacked ICT-related skills had marginal ICT pedagogical knowledge.

Table 5.56 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and having the necessary ICT-related pedagogical skills *

		I do not have the necessary ICT-related skills	
		No	**Yes**
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	22.70%	**77.30%**
	ICT knowledge to a certain extent	40.90%	**59.10%**
	Adequate ICT knowledge	**57.70%**	42.30%

* (SITES, 2006a)

Teachers who have knowledge which teaching and learning situations are best suited for ICT use, must help those teachers who struggle. Mastering certain ICT skills will enable more teachers to hosts ICT-related workshops at their schools, so that more grade 8 mathematics teachers can use ICT in teaching and learning. The general professional development initiatives status in South Africa in 2006 revealed by the technical coordinators were: 32% for introductory courses (word-processing, spreadsheet, databases), 19% for technical courseware for operating and maintaining computer systems, 16% for advanced courses for application or standard tools (advanced word-processing, relational databases, etc.), 15% for advanced courses for Internet, 17% in learning area specific training and 13% on multimedia use (Pelgrum, 2008b: 100-101). The various provincial Departments of Education have to invest more in developing teachers ICT competencies. Having more ICT pedagogical related skilled teachers can contribute towards the teaching and learning of grade 8 mathematics.

Table 5.57 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and having the necessary ICT-related pedagogical skills

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.32	.32	.00

A medium effect (V= 0.32), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and I do not have the necessary ICT-related pedagogical skills. This shows that many teachers do not have the necessary ICT pedagogical skills to make use of ICT in teaching and learning of mathematics.

5.3.7.2 Correlations with identifying useful tools

Only if teachers are able to identify which ICT tools and resources will be most effective to transfer the knowledge and skills to their learners they will be able to teach effectively with ICT (Ertmer *et al.*, 1999: 47). According to Table 5.58, 68.50% of the respondents were able to identify which ICT tools will be useful in their teaching practices and 31.50% indicated they had no knowledge which teaching and learning situations are best suited for ICT use. However, 72.30% of the respondents were unable to identify ICT useful tools for their teaching practices also indicated they had the ICT pedagogical knowledge.

Table 5.58 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and knowledge how to identify which ICT tools will be useful *

		Do know how to identify which ICT tools will be useful	
		No	**Yes**
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**31.50%**	68.50%
	ICT knowledge to a certain extent	43.50%	**56.50%**
	Adequate ICT knowledge	**72.30%**	27.70%

* (SITES, 2006a)

The knowledgeable teachers, who know in which teaching and learning situations to use ICT and are able to identify which ICT tools will be useful, should assist those teachers who struggle with the pedagogical use of ICT. This could result in more grade 8 mathematics teachers making use of ICT in teaching and learning. Having more ICT and pedagogically equipped teachers who know how to identify which ICT tools will be useful for teaching and learning purposes in grade 8, can contribute towards the teaching and learning of grade 8 mathematics (Bramald *et al.*, 2000: 5).

Table 5.59 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and knowledge how to identify which ICT tools will be useful

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.37	.37	.00

A medium effect (V= 0.37), which tends toward a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and know how to identify which ICT tools will be useful. This shows that mathematics teachers do not know how to select the ICT to teach their learners therefore they will use the tools that are familiar to them and they are comfortable with like books, etc.

5.3.8 Correlations with teaching-related activities

To determine whether ICT was used for teaching related activities, the main variable 21J (knowledge about which teaching and learning situation are suitable for ICT use) were correlated with questions 30A (Do you use this computer for teaching related activities) to answer: *Can knowledge of the pedagogical use of ICTs in grade 8 mathematics contribute toward more effective mathematics teaching in schools?*. The three analysis criteria, i.e. no knowledge to use ICT (not at all), ICT knowledge to a certain extent (A little and Somewhat), and adequate ICT knowledge (A lot) were used for this correlations

According to Table 5.60 more than fifty percent of the respondents (58%) indicated they never make use of ICT when teaching had no knowledge which teaching and learning situations are best suited for ICT use. However, more than eighty percent (84.10%) of the respondents regularly made use of ICT in their teaching practices had knowledge which teaching and learning are best suited for ICT use.

Table 5.60 Cross tabulations between teacher knowledge of teaching and learning situations best suited for ICT use, and computer use for teaching related activities *

		Use the computer for teaching related activities	
		No	**Yes**
Knowledge about which teaching and learning situations to use ICT	No knowledge to use ICT	**58.00%**	42.00%
	ICT knowledge to a certain extent	22.10%	**77.90%**
	Adequate ICT knowledge	15.10%	**84.10%**

* (IEA, 2006: 53)

Teachers who had the knowledge regarding the use of ICT in their teaching will be able to use the computer for teaching related activities. They will be more confident to make use of ICT in their teaching and learning practices (Bramald *et al.*, 2000: 5).

Table 5.61 Effect size of the relationship between teacher knowledge of teaching and learning situations best suited for ICT use, and computer use for teaching related activities

Phi Coefficient	Cramer's Effect Size (V)	Pearson Chi-Square (p value)
.42	.42	.000

A medium effect (V= 0.42), which tends towards a practically significant correlation, is found between the teachers' knowledge regarding in which teaching situations to use ICTs and Do you use this computer for teaching related activities. It shows that teachers who do have ICT pedagogical knowledge will be more confident to explore with the versatile tools at their disposal. If more teachers in our schools use the computers for teaching they will explore with the ICT more frequently. They will share information and ideas with their colleagues and the use of ICT for teaching and learning will grow in our schools (Bramald *et al.*, 2000: 5).

5.4 Summary

This chapter reported on the results of the data frequencies of the mathematics teachers' general skills and use of ICTs, the pedagogical use of ICT, the proportion of learners in mathematics classrooms with operating skills, the impact of ICT use, barriers of ICT use for teaching and learning mathematics. It also presents the data frequencies and the results of the SDA of the descriptive statistics and cross tabulations of the SITES 2006 Teachers' Questionnaire, Part VII, Item 21J, which was the main variable correlated with other variables from Part II, Part III, Part IV, Part V, Part VI, and Part VII within the same questionnaire.

In terms of the teachers' general skills and the use ICTs, more than 50% of the participating teachers indicated that they were confident to use word-processing, nearly 50% were confident with electronic filing, using spreadsheet for budgeting and learner administration, more than 45% reported that they had somewhat to a lot of confidence in performing those tasks and 45% indicated that they were confident to use e-mail.

The lack of ICT use for pedagogical purposes is evident in the results: more than 50% of the respondents reported that they do not make use of ICT to prepare lessons, monitor learners' progress, effective presentations, collaboration or Internet support for learner learning, and the remaining pedagogical activities more than 45% indicated not at all for: in which teaching and learning situations to use ICT, and find curriculum resources on the Internet. The teachers who reported somewhat to a lot for the use of ICT for pedagogical purposes were mostly just above 30% of the participating teachers. This indicates that even though presentation software can enhance the teaching and learning of mathematics many teachers and learners do not have the skills to take advantage of the equipment at their disposal.

More than 50% of the teachers reported that nearly none of their learners had knowledge of database software, and were not competent to operate spreadsheets, apply multimedia and use e-mail. About 45% of the respondents indicated that nearly none of their learners could do word-processing. More than 20% of the teachers indicated that they did not know whether their learners had any of the operating skills. Only small percentages, mostly between 2% and 3%, of the teachers indicated that nearly all their learners had operating skills.

ICT had a positive impact on teachers. The majority of teachers indicated that their word-processing has increased, they incorporate ICT in their teaching and learning, they provide individualised feedback to their learners, they incorporate ICT to organise learner learning, they collaborate with their colleagues, they are able to complete their administrative tasks more easily, and they did not become less effective as a teachers. Unfortunately, only 15.31% of the teachers use word-processing to prepare for lessons shows that most of the teachers are not able to take the lead to introduce word-processing to their learners and prepare them for 21st century skills.

Barriers identified were that many teachers did not have the required ICT related skills or ICT related pedagogical skills, they were not confident to try new approaches, their learners did not have access to ICT outside school, there was a lack of time to develop and implement ICT activities, and a lack of resources for them to use.

The results from the SDA indicated that correlations with knowledge of in which teaching and learning situation to make use of ICT and the curriculum goals did not have any significant results.

The correlations with the teacher practice and the main variable indicated that the majority of the respondents did not know in which teaching and learning situations to use ICT, therefore they did not make use of ICT for extended projects, teacher lecturing, to present information, demonstrations or class instruction. Only the teachers who had somewhat to a lot of knowledge in which teaching and learning situations to use ICT, made use of ICT in the various teacher practice activities.

The impact of ICT correlated with the main variable indicated that most of the participating teachers' ICT skills did not improve, nor did they incorporate new methods, they did not use ICT to provide individualised feedback to their learners, they did not use ICT to incorporate new ways to organise learners' learning, nor did they monitor more easily their learners' learning using ICT. The respondents did not: access more diverse and higher quality learning resources, collaborated with peers in and outside their schools, complete tasks more easily, and no increase in work pressure or workload was found. The teachers who indicated that ICT did have a positive impact on them were those teachers who made use of ICT somewhat to a lot.

Teachers who had the necessary knowledge in which teaching and learning situation to use ICT, indicated that there was a substantial increase in their learners' subject matter knowledge, learning motivation, information handling skills, problem solving skills, self-directed learning skills, collaborative skills, communication skills, and learning at their own pace. Only a slight increase was indicated for ICT skills and assessment results. No impact was indicated by those respondents who had no knowledge in which teaching and learning situations to use ICT.

The correlations with the main variable and the barriers revealed that teachers had a lack of ICT skills and they lack the knowledge in which teaching and learning situations to use ICT.

Those teachers who indicated that they had the confidence to prepare lessons that involve ICT are those who had the knowledge in which teaching and learning situations to use ICT. Most interesting was that most of the teachers want to prepare better or more interesting lectures or presentations to their learners, even though they had no, a little, somewhat or a lot of knowledge in which teaching and learning situations to use ICT.

If grade 8 mathematics teachers had more knowledge of in which teaching and learning situations to use ICT, they would use it more effectively in their classes. The knowledge of the pedagogical use of ICTs will ensure that teachers access more diverse or high-quality resources, and with a variety of methods and resources at their disposal, it will enable them to explore within their teaching and learning. Teachers will have multiple support methods to assist them with their teaching, a variety of instruction methods will help them to teach more effectively, and exposing learners to different methods of solving a problem with the help of ICT, ultimately all the resources support and variety of methods, will contribute toward more effective teaching and learning of grade 8 mathematics.

Chapter Six

Conclusions and Recommendations

6.1 Introduction

It is through the global knowledge economy that ICT has taken the world by storm. Many researchers agree on the positive contribution of ICT on education: promoting problem solving, creativity, productivity and collaboration with people in all spheres of life (Balanskat *et al.*, 2006: 1; Bloom, 1976; Galloway, 2007; Gardner, 1986). Therefore, one can question the reluctance of teachers to use ICT. This research investigated the pedagogical use of ICTs for the teaching and learning of mathematics in South African schools. It used SDA to answer the research questions of how knowledge of the pedagogical use of ICTs contributes toward more effective mathematics teaching in schools. In this chapter, the conclusions and implications of the findings are discussed according to the implications of the e-Education policy (South Africa, 2004b: 22-23); the three phase plan of ICT integration into teaching and learning by 2013, and the barriers teachers experience when implementing ICT in their teaching and learning practices. Reflections are offered for future research on the integration of ICT into teaching and learning in Mathematics in schools.

6.2 Summary of chapters

A summary of the chapters for the research conducted.

6.2.1 Chapter one

Chapter one outlined the aim of the study, and identified the use of SDA as research methodology as the data of SITES 2006 data were available in the public domain and has not been published elsewhere. The researcher posed two questions (§ 1.3) to determine teachers' pedagogical use of ICTs for mathematics in South African schools.

6.2.2 Chapter two

Chapter two discussed the mathematics education in South African schools in relation to the philosophical views of mathematics teachers, the NCS, and the e-Education implementation model. The problem-centred approach (PCA) represents a socio-constructivist approach embedded in the NCS and one of the critical outcomes is to use science and technology effectively and critically (South

Africa, 2002: 1). The effective teaching of mathematics demands that teachers have a sound technological pedagogical content knowledge of mathematics. They should promote mathematical understanding, learners should be engaged and motivated, and teachers should manage teaching and learning effectively with the multiple resources available. TIMMS, PILRS and SITES 2006 indicated that South Africa was the poorest performing country in terms of mathematics reading skills and ICT integration in schools. The NDoE and teachers have a huge task to raise the level of teaching and learning in South African schools. Supplying schools with the necessary ICT infrastructure is the first step towards ICT integration in education. Engaging with ICT when teaching their learners is the second step. The e-Education policy (South Africa, 2004b: 22-23) with its three phase plan guides the ICT integration process and managing the integration process. The NDoE is responsible for managing ICT at system level, while the SMT at school level is tasked with specific ICT-related obligations, including the planning and arranging of the ICT CPTD plan, ICT purchasing, ICT planning, and ICT numeracy and literacy. Teachers should manage ICT at classroom level using adequate resources, tools, training and opportunities to develop their ICT skills in line with achieving the 21st century skills (Reynolds *et al.*, 2003: 159).

6.2.3 Chapter three

This chapter reflect on the findings from the SITES Module 1, SITES Module 2, and SITES 2006. One of the most important findings of SITES 2006 was that the conditions at school level in South Africa is one of the aspects that needs to be addressed in order to achieve equality with the rest of the participating system, especially those system that performed well in SITES 2006. South Africa did not measure up to the other participating systems as it boasted the lowest availability of infrastructure (38%) in 2006 whereas other participating systems had an availability of 95-100%. Access to the results gave the NDoE an opportunity to evaluate the countries' status of pedagogy, the ICT-use in mathematics and science classes, the contextual factors at school and system level compared to the rest of the participating systems. The SITES 2006 data indicated teacher professional development opportunities were insufficient for the training of teachers for ICT integration.

Positive findings related to the development of materials for ICT use in teaching and learning and ICT based teaching and learning takes a higher priority in South Africa than in other countries. School principals were more eager to attend ICT training than the remaining participating systems.

Generally, teachers in South Africa are resistant to change. The majority of teachers prefer to use the traditional method of teaching with traditional goal orientations. Many teachers only make use of ICT to search for information. In some areas progression in terms of ICT use in teaching was found since SITES Module 1. In South Africa in 1998 only 18% of schools used ICT and in 2006 it increased to a mere 38%. Teachers in grade 8 Mathematics preferred to make use of teacher lectures and exercises to practice skills and procedures. Even though a variety of resources were available in many schools, mathematics teachers more frequently used tutorials or exercise software. Many schools have sufficient ICT and infrastructure, but a low level of confidence due to insufficient ICT pedagogical knowledge. The general use of ICT encountered the lowest usage level in South Africa, which was only 18% for mathematics and 15.9% for natural sciences.

6.2.4 Chapter four

This chapter outlines the research methodology followed during this study. It followed basic SDA of the stratified data of 504 computer and non-computer using schools in South Africa which participated in the SITES 2006. The study focused on the data from the mathematics Teachers' Questionnaire. The SITES 2006 dataset allowed the researcher to explore different themes and correlations between variables not reported in the main study. The research collected no additional data. Data analysis was guided by the Statistical Consultation Services from the North-West University, Potchefstroom Campus.

A total of 640 South African grade 8 mathematics teachers comprised this dataset. The gender distribution of the participating grade 8 mathematics teachers in South Africa was well-balanced with 306 male teachers and 334 female teachers. No identifiable information was available on the teachers or schools that participated in the main study. Research ethics adhered to previously approved permissions obtained during the SITES 2006. The variables of this research constituted the pedagogical use of ICTs in the teaching and learning of mathematics.

6.3 Executive summary of the pedagogical use of ICT for the teaching and learning of grade 8 mathematics in South African schools

Chapter 5 discussed descriptive statistics relating to frequencies of the data from the SITES 2006 mathematics Teachers' Questionnaire. The research questions addressed the extent of ICT pedagogical practices of mathematics teachers, as well as their perceptions of the value of ICT for mathematics education. An executive summary outline the most important findings. Table 6.1 provides a summary of the findings from the first research question, *What are the pedagogical use of ICTs for the teaching and learning of grade 8 mathematics in South African schools?*

Table 6.1 Executive summary of the pedagogical use of ICT for teaching and learning of grade 8 mathematics in South African schools

Use of ICT	Findings from the SITES 2006 and the SDA of this study
General use of ICT	• Mathematics teachers (42.22%) used word-processing with confidence to create documents (e.g. tests and exams) • Respondents were less confident in the use of emails, electronic filing, and spreadsheets • Few teachers (13%) had email accounts • Some schools (67%) had access to the Internet for teachers
Pedagogical use of ICT	• Most respondents (48.96%) had no confidence in knowing in which teaching and learning situation to use ICT • Teachers struggled (46.02%) to find curriculum resources on the Internet • Teachers struggled (52.59%) to monitor learners' performance using ICT • Teachers were not confident in the pedagogical use of ICT • Few teachers used ICTs in planning, monitoring, supporting and conducting pedagogical activities
Learners' competence with operating skills	• Few learners (44.59%) could use word-processing • Few learners (54.71%) could access database software • Almost no learners (60.62%) could operate data-logging tools
Impact of ICT on teachers	• Little or no (39.21) change in teacher's ICT skills • Teachers struggled with confidence to operate ICT and software • Many of teachers (32.70%)did not use ICT to monitor learners' progress • Teachers acknowledged (61.57%) ICT did not make than less effective teachers • Few teachers (34.70%) shared ideas with colleagues outside their own schools
Barriers of ICT for teaching and learning	• Insufficient (42.77%) ICT skills all around • Not time (41.30%) to develop and implement ICT-related activities • Little support to develop ICT-related skills • Little confidence (41.25%) to try new approaches

Table 6.1 indicates that the use of ICT is trivial to most mathematics teachers in South African schools. Mathematics teachers do not have pedagogical knowledge, content knowledge, and technological knowledge which is central to ICT integration in teaching and learning. South African teachers experienced difficulties to represent concepts with the assistance of ICT. They do not have the pedagogical techniques to use ICT in constructive ways to teach mathematical content to learners and build new concepts from their existing knowledge. The insufficient TPCK contributed to the level of confidence in ICT when planning, teaching and communicating in grade 8 mathematics classrooms.

6.4 Executive summary of how pedagogical knowledge contributed toward more effective mathematics teaching in schools

The presence of technological pedagogical content knowledge (TPCK) forms the core component in ICT integration in teaching and learning (Mishra *et al.*, 2006b: 1029). It was used to address the second research question, *Can knowledge of the pedagogical use of ICT's in grade 8 mathematics contribute toward more effective mathematics teaching in schools?*

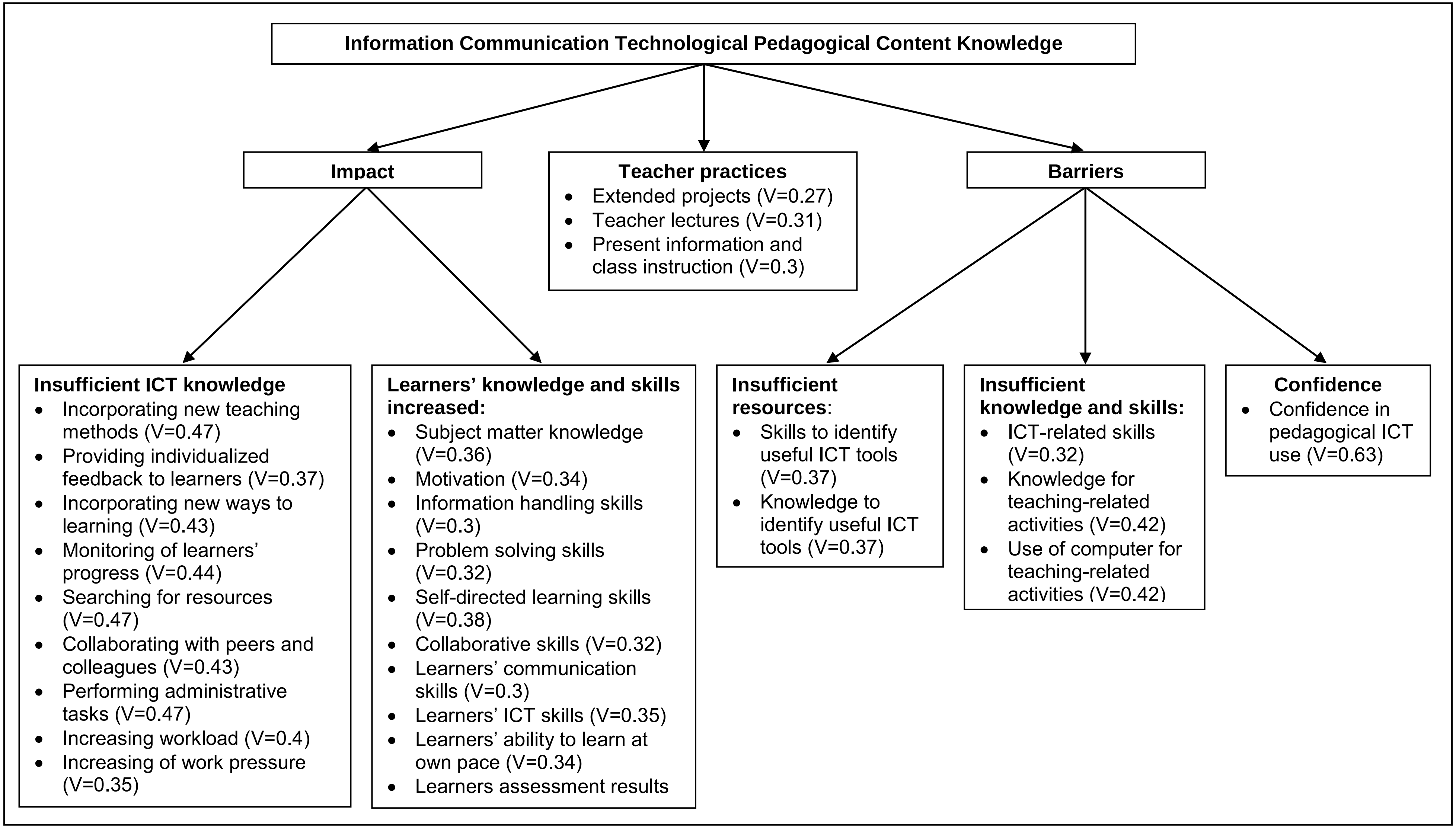

Figure 6.1 Summary of the correlations study between the main variables and other variables from the SITES 2006 teachers' questionnaire

Figure 6.1 shows a summary of the correlations study (§ 5.3.1-5.3.8) between the main variable (i.e. *I know which* **[K]** *teaching and learning situations* **[PC]** *are suitable for ICT* **[T]** *use*) and other variables in the SITES 2006 teachers' questionnaire. The main variable relates to TPCK (Figure 2.1). From the correlation study three main clusters (themes) of TPCK was identified, i.e. impact, teacher practices, and barriers.

6.4.1 Impact of ICT use

Figure 6.1 illustrates items pertaining to impact (grouped into two sub-categories, i.e. (i) insufficient ICT knowledge and (ii) learners' knowledge and skills) correlated to a medium effect ($0.3 \leq V \leq 0.4$) and a large effect ($V = 0.47$) with TPCK, which indicates that insufficient ICT knowledge to provide individualised feedback to learners, to incorporate new ways of learning, to monitor of learner progress, to collaborate with peers outside the school, increased workload and increased work pressure, as well as subject matter knowledge, increased motivation, information handling skills, problem solving skills, self-directed learning skills, increase in collaborative skills, learner communication skills, increase in learner ICT skills, learners' ability to learn at own pace, and increase in learner assessment results, tend towards practically significant correlations with TPCK; while insufficient ICT knowledge to incorporate new teaching methods, to search for resources, and to do administrative tasks, show practically significant correlations with TPCK. As seen from the descriptive statistics and the correlation study, even though ICT were available in many schools teachers' ICT skills did not improve, teachers did not use ICT to incorporate new teaching methods. Mathematics teachers did not use ICTs to provide individualised feedback to their learners, or to monitored their learners' progress. The teachers did not access more diverse and higher quality learning resources, collaborated with peers in and outside their schools, complete tasks more easily, and no increase in work pressure or workload. The teachers who indicated that ICT did have a positive impact on them were those teachers who made use of ICT regularly. Teachers who had the TPCK, indicated that there was a visible increase in their learners' subject matter knowledge, learning motivation, information handling skills, problem solving skills, self-directed learning skills, collaborative skills, communication skills, and learning at their own pace. Only a slight increase was noticeable for ICT skills and assessment results (Tables 5.12-5.53).

6.4.2 Teacher practices

Figure 6.1 lists items pertaining to teacher practices (one category) correlated to a medium effect ($V = 0.3$) with TPCK, which indicates that extended projects, teacher lectures and class instruction tend towards practically significant correlations with TPCK. As seen from the descriptive statistics and the correlation study, the majority of mathematics teachers did not have TPCK with regard to teacher practices. A total of 88.70% of the grade 8 mathematics teachers did not make use of ICT for extended projects. More than ninety percent (91.40%) of the grade 8 mathematics teachers indicated insufficient TPCK to use ICTs specifically in teacher lecturing. An interesting finding was that 62.50%

of the grade 8 mathematics teachers who had adequate TPCK did not make use of ICT when teaching and learning. Only 29.90% of the grade 8 mathematics teachers had the TPCK and were able to present information, provide demonstrations, and facilitate a class using ICT. Only the teachers who had adequate ICT knowledge, made use of ICT in the various teacher practice activities (Tables 5.6-5.11).

6.4.3 Barriers

Figure 6.1 illustrates the items pertaining to barriers (grouped into three sub-categories, i.e. (i) resources, (ii) knowledge and skills, and (iii) confidence) correlated to a medium effect ($0.3 \leq V \leq 0.4$) and a large effect ($V = 0.5$) with TPCK, which indicates that insufficient skills to identify ICT useful tools, insufficient knowledge to identify ICT useful tools, insufficient ICT related skills, insufficient knowledge for teaching-related activities, and insufficient use of computers for teaching-related activities, tend towards practically significant correlations with TPCK; while confidence in pedagogical ICT use shows a practically significant correlation with TPCK. As seen from the descriptive statistics and the correlation study, teachers did not have adequate ICT skills and their insufficient TPCK to use ICT was a major barrier identified (Table 5.56). Teachers who had the confidence to prepare lessons that involve ICT were those who had adequate knowledge in which teaching and learning situations to use ICT. Most interesting was that most of the teachers wanted to prepare better or more interesting lectures and presentations to their learners, even though they had no ICT pedagogical knowledge (Table 5.60). If mathematics teachers had more TPCK they will be able access more diverse or higher quality resources, and with a variety of methods and resources at their disposal, it would enable them to explore within their teaching and learning. Teachers will have multiple support methods to assist them with their teaching, a variety of instruction methods will help them to teach more effectively, and exposing learners to different methods of solving a problem with the help of ICT, ultimately all the resources support and variety of methods, will contribute toward more effective teaching and learning of grade 8 mathematics. The development of the pedagogical knowledge of teachers form an integral part in ensuring integration takes place and the NDoE are first and foremost responsible for the CPTD.

6.5 Policy implications

An aim of the research was to determine the pedagogical use of ICT’s is within the teaching and learning of grade 8 mathematics in South African schools, and to determine to what extend knowledge of the pedagogical use of ICT’s is in grade 8 mathematics contribute toward more effective mathematics teaching in schools. Additionally it can provide the NDoE insight regarding the progress of ICT integration by teachers in mathematics classroom in South Africa, and the areas at system, school and teacher level that needs to be addressed in order to achieve those aims. The e-Education policy stipulates a three phase plan to integrate ICT into all schools in South Africa by 2013 specifically in the teaching and learning of all learning areas (subjects) (South Africa, 2004b: 39-41).

Tables 6.2-6.4 includes the three Phase ICT plan, the aims of each phase and the progress South Africa made with implementing ICT in all educational schools, and the findings from SITES 2006 regarding the achievement of those aims set by the NDoE. It provides an overview of the plan for ICT integration in South African schools and to what extend the NDoE achieved its aims according to the time frames stipulated for each phase for ICT integration in schools.

6.5.1 Phase I of the e-Education policy and findings from the SDA

Phase I (2004-2007) of the e-Education policy strives to prepare the education systems ready for the ICT integration process. However, less than 50% of the participating schools had an ICT strategic plan in place, 11.43% of the teachers have received laptops, and 32% of the participating teachers had access to introductory courses. One of the aims of Phase I were that managers and teachers had to obtain a computer to assist them in administrative tasks and lesson planning. We are already in the final quarter of 2010 and still the laptop initiative for all educators is not yet implemented. More than 40% of the participating teachers indicated they received no technical support even though 60.83% of managers required support. It is disheartening that only 50.86% of schools in 2007 throughout South Africa have computers available for teaching and learning. In order for any plan to be successfully integrated the initiation process had to adhere to 100%. Unfortunately the shortcomings of the first phase will influence the whole integration process as it has to be dealt with in the next phase, even if each phase has its individual targets (Table 6.2).

Table 6.2 e-Education Phase I and findings from SITES 2006 and the SDA conducted for this research *

Phase I (2004-2007)	Aims	Findings from SDA of this study and South Africa's progress
Enhance system-wide and institutional readiness to use ICT's for teaching and learning (South Africa, 2004b: 39-41)	**Build an education system to support ICT integration in teaching and learning:** • Expertise at different levels: planning, management, support, monitoring, and evaluation • Ongoing support to managers at different levels • Provinces collaborating and pool resources	• SITES 2006 indicated (Principal Questionnaire) that (44.19%) of school managers in South Africa acknowledged that to develop a strategic plan for ICT integration
	Build teachers' and managers' confidence in the use of ICTs: • Every teacher and manager obtain a personal computer for administration and lesson preparing • Teachers and managers access to basic training to use ICT • Technology incentives • Case studies as examples to teachers and managers to assist the integration process	• Principals in South Africa indicated that 11.43% of their teachers have received laptops. Government laptops initiative ready for implementation stages • Few teachers (32%) had access to introductory courses • School managers (11.43%) indicated that they provided teachers with laptops or mobile devices • SITES Module 2
	Build a framework for competencies for teacher development in the integration of	

Phase I (2004-2007)	Aims	Findings from SDA of this study and South Africa's progress
	ICTs into the curriculum: • Norms and standards for educators • Pre-service training in the higher education include basic ICT training • Teachers have access to in-service training to integrate ICT in teaching • Teachers have access to ICT support • School managers have access to in-service training • Provincial managers are trained in ICT integration and offer support to schools	• White Paper on e-Education • University programs include ICT integration courses (South Africa, 2007b) • About 40% of technical coordinators indicated no ICT support for teachers (SITES, 2006a) • More than sixty percent (60.83%) of school managers indicated to improve the technical skills of their teachers is a high priority to them (SITES, 2006a)
	Establish an ICT presence in schools: • Every school has a computer and software for administrative purposes • All schools have access to a networked computer facility for teaching and learning • ICT facilities are being used effectively to facilitate ICT integration into teaching and learning	• Insufficient schools (38%) have computers nationally • According to *The Need for an e-Education Initiative in South Africa* (South Africa, 2007b: 56) in the Western Cape (50.40%) of schools, in Limpopo Province only (1.24%) of schools were connected for teaching and learning purposes
	Schools are using education content of high quality: • Content developed according to norms and standards • Access to updated databases of evaluated content resources and are able to select content for usage • Access to educational content on the Educational Portal Thutong (Department of Education, 2010)	• NCS from grade R-12 • School managers (51.69%) indicated insufficient digital educational resources (SITES, 2006b) • The Portal exists to provide access to curriculum resources and materials
	Schools are connected, access the Internet and communicate electronically: • Schools (50%) are connected to the Educational Network • Networks are safe and information security is monitored • Schools use electronic means to communicate with provincial offices • All schools have access to an affordable telecommunication and Internet	• About half (53.53%) of school managers indicated there are security measures in place to prevent unauthorized system access • Most schools (98.30%) in Western Cape Education Department communicate electronically. In The Need for an e-Education initiative in South Africa (South Africa, 2007b: 54)) the majority of the provinces and schools did not have access to a wide area network Limited initiatives in the Western Cape Education Department, the Very Small Aperture Terminal (VSAT) also implemented in Gauteng, and the New Partnership for African Development (NEPAD)

* Adapted from the e-Education (South Africa, 2004b: 22-23) and SITES 2006 (2006a)

The vision of Phase I of the e-Education policy to achieve system-wide readiness for the integration of ICT could have been realised, if South Africa did not have so many social and economic differences between provinces and schools. The shortcomings at system (infrastructure), school level (ICT management) and teacher level hindered the integration process particularly the development of TPCK.

6.5.2 Phase II of the e-Education policy and findings from the SDA

Currently we are in the final stages of Phase II (2007-2010) of the e-Education policy. Its aim was to achieve system wide integration of ICTs into teaching and learning and in all spheres of education in terms of planning, teaching, collaboration with internal and external sources, communication with parents and other role players, and monitoring and budgeting. SITES 2006 indicated the status on the implementation of the e-Education policy, particularly when it comes to administration, availability of training and technical support, availability of tutorial and general software and the security measures in place ensure the functionality of the computer application at school. Only 15% of the participating teachers had access to ICT training, 19% had access to technical training, 63.10% of school managers used ICT for planning, 10% of schools had tutorial software, 35% had general software, and 54% of the participating schools had security measures in place.

Table 6.3 e-Education Phase II and findings from SITES 2006 and the SDA conducted for this research *

Phase II (2007-2010)	Aims	Findings from the SDA of this study and South Africa's progress
System wide integration of ICT's into teaching and learning (South Africa, 2007b: 39-41)	**Teachers and managers integrate ICTs into management and the curriculum:**	
	• Teachers (50%) are trained in basic ICT integration into teaching and learning	• Only 15% of teachers had access to ICT integrated teaching and learning training
	• Teachers have access to ICT technical support training	• Only 19% of the participating schools indicated that teachers had access to ICT technical training (SITES, 2006a).
	• Schools managers (80%) integrate ICTs in management and organisation	• School managers (24.26%) collaborated with their teachers via ICT and (19.94%) collaborated with parents via ICT • About 80.25% used ICT to write documents letters, 63.10% used ICT for planning purposes, 52.94% used ICT for budgeting, monitoring and controlling expenses • Less than half used ICT daily (45.31%) • Less than half (41.32%) used ICT to communicate with teachers(SITES, 2006b)
	• Provinces support ICT integration into the curriculum	• ICT integration training programs Webquest, IntelTeach, in the Western Cape was cancelled in 2010 due to insufficient funds (Western Cape Education
	• Research and evaluation inform	

Phase II (2007-2010)	Aims	Findings from the SDA of this study and South Africa's progress
	developments and directions in ICT integration	Department, 2008)
	ICTs are widely present in schools:	
	• Most schools (80 %) have access to a networked computer facility for teaching and learning	• Some South African schools (38%) had computers available for grade 8 mathematics
	•	• Some schools (10%) had tutorial software, and 35% had general software
	• All of schools have legal software	
	• ICT facilities are safe, effective, designed to facilitate ICT integration into teaching and learning, and in working conditions	• About half of South Africa schools (54%) indicated they have security measures in place
	• All schools with ICT facilities have a dedicated teachers to manage the facility and to champion the use of ICTs in the institution	• Some schools (28%) had a teacher to provide support, (41%) of the schools received their support from the ICT coordinator and (24%) of the participating schools had ICT staff
	Schools are using education content of high quality:	
	• The Education Portal Thutong provides access to resources in all learning areas in the GET and all subjects in the FET	• Table 6.2
	• Schools use the Educational Portal to communicate, collaborate and access content resources	
	• Schools have access to digital libraries	
	• Teachers are producing digital content of high quality and making it available to other teachers	
	Schools are connected, access of Internet and communicate electronically:	
	• All schools are connected to the educational network	
	• Networks are safe and information security is monitored	
	• Schools use electronic means to communicate with provincial offices	
	Communities support ICT facilities:	
	• SMME's provide technical support to schools • Community involvement supports schools to sustain ICT facilities	• School managers (65.46%) indicated that the parental community supported the development of ICT

* Adapted from the e-Education (South Africa, 2004b: 22-23) and SITES 2006 (SITES, 2006a)

The only area in line with the aims for Phase II was the 80.25% of school managers that used ICT to write documents. The shortage of tutorial software discourages teachers to use ICT when teaching. Even though the percentage increased in relation to SITES 2006 data, does not mean the percentages generally at system level in all South African schools will reflect the same percentage.

6.5.3 Phase III of the e-Education policy and findings from the SDA

The aim of Phase III is to have ICT's integrated and used by all role players in education. ICT's must be embedded to have the various schools function effectively with little time spend on planning and more spend on getting the learners to use ICT in developing their 21st century skills.

Table 6.4 e-Education Phase III and findings from SITES 2006 and the SDA conducted for this research *

Phase III (2010-2013)	Aim	Findings from the SDA of this study and South Africa's progress
ICT's integrated at all levels of the education system-management, teaching, learning and administration (South Africa, 2007b: 39-41)	• All departments use ICTs seamlessly in planning, management, communication, and monitoring and evaluation • All learners and teachers are ICT capable • ICT are integrated into teaching and learning in all schools • All teachers integrate ICTs into the curriculum • All schools have access to a networked computer facility for teaching and learning that are safe, effective, designed to facilitate ICT integration into teaching and learning and in working condition • All schools use software of high quality • All schools use the Educational Portal for teaching and learning in an outcomes-based education fashion • Communities are integrally involved in e-schools • ICT interventions are informed by research	• Mathematics and science teachers (80%) indicated that they do not make use of ICT's in their teaching practices

Adapted from the E-Education (South Africa, 2004b: 22-23) and SITES 2006 (2006a)

As we are entering the final phase of the e-Education plan, aiming at system wide integration of ICTs into teaching and learning, there are many facets of the previous two stages not in place and fully functioning according to the aims and target set by the policy. If having all teachers with adequate TPCK by the end of 2013, what are the NDoE going to do to deal with all the shortcomings and backlog of ICT integration in the teaching and learning.

6.6 Recommendations

South Africa has to confront many challenges regarding integration of ICT in schools, eventually, making it impossible to compete with other systems in all areas relating to education, but in order for us to compete within a global society we have to deal with the inequalities within our system. For this research we focused on the TPCK of grade 8 mathematics teachers. It becomes evident that there are many aspects influencing the effective ICT integration process at system and school level. If all these disparities are coherently dealt with it will ensure the level of teachers' TPCK increase, allowing South Africa to have an acceptable standard of ICT integrated education in a global society.

6.6.1 System level

At system level South Africa firstly need to address the shortcomings within the e-Education policy. The Department of Education need to deal with the social and economic disparities in all the provinces, allowing all schools to have equal access to basic resources as well as ICT infrastructure and not at 22.59% of schools in South Africa. Strategic planning for e-learning integration at national and regional level must be in place. Nongovernmental schools must assist the NDoE in training teachers for in achieving the TPCK required for ICT integration. For the stages an integrated ICT curriculum program must be developed to assist teachers in knowing which ICT devices and software are applicable for the content taught. The University must extend their current training program to based on the developing of TPCK and ensure they make use of ICT when practice teaching.

Even tough OLSET, Thutong Portal and other websites are available to assist managers and teachers in ICT integration these provisions are not adequate to address the shortcomings at system level, therefore more websites must be created specifically to assist schools in ICT integration.

6.6.2 School level

School managers and SMT members must make ICT qualifications a prerequisite in all new staff appointments. SMT members must motivate teachers to attend ICT training to ensure teachers have a sound TPCK. Additionally they must supply their staff with sufficient time and opportunity to develop ICT mediated lessons. All learning and teaching material must be held in one central location, ensuring easy access for both teachers and learners. All schools must create a homepage so that all parents can have access important information. A school ICT policy must be in place to address the different elements needed to regulate the daily activities within the laboratory as well as the duties of the different ICT committee members. Additionally a vision statement for ICT integration in all subjects (learning areas). A framework must also be designed where teachers can work collaboratively on ICT-mediated lessons and regular workshops should be held to showcase examples of ICT mediated lessons.

6.6.3 Teacher level

The four areas influencing the use of ICT of teachers need to be addressed: confidence, time, access to resources and adequate professional development. To raise the level of confidence of teachers they have to be exposed to sufficient professional development to increase TPCK. They should use of the time at their disposal to create ICT-mediated lesson in collaboration with their peers and colleagues. The access to resources must be dealt with at system and school level. Knowledgeable teachers can arrange informal ICT mediated work sessions to assist those who need guidance.

In order to raise the level of confidence of our mathematics teachers in South African schools from 30% to 100%, each stakeholder in education (system, school and teacher) must contribute to ensure teaching and learning with ICT in South African schools become part of the daily practices.

6.7 Reflection on the research journey

Conducting SDA allowed the researcher to analyse the data from the SITES 2006 in order to gain insight regarding the pedagogical practices of ICT in mathematics education in South African schools. It allowed the researcher to correlate with the existing data to determine whether relationships between the variables and to determine whether TPCK in grade 8 mathematics contribute towards more effective mathematics teaching in schools. The researcher gained insight on the TPCK of mathematics teachers and could determine the barriers hindering ICT integration in South African schools. One restriction of using SDA from the SITES 2006 data was that it allowed the researcher to correlate with only the data from the three questionnaires namely the teachers', principals', and the technical questionnaires. The participants from the SITES 2006 in South Africa comprised 640 mathematics teachers, which is a small percentage of the total mathematics teachers in South Africa. Therefore, more positive results could have been achieved if more teachers participated in this study. Thank you to the IEA and SITES 2006 for being able to use the reliable dataset for my study.

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