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THE INFORMATION AND COMMUNICATION TECHNOLOGY REQUIREMENTS OF THE NATIONAL CURRICULUM STATEMENT: IMPLICATIONS FOR IMPLEMENTATION IN SCHOOLS

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ABSTRACT

This study investigates the integration of information and communication technologies (ICTs) in learning in grades 10 – 12 of South African schools. It originated from observations by leading educationists that while technology has fundamentally changed the 21st century workplace and other dimensions of society, this did not happen in education in spite of multiple efforts in the past. This raises the issue of requirements for technology integration in learning to succeed, and whether the National Curriculum Statement (NCS) as the national curriculum for grades 10 – 12 complies with it. Linked to this is the extent to which technology is integrated in the NCS and its subjects.

Against this background the research endeavours to answer the question: What are the ICT requirements of the NCS and its implications for schools? It is guided by three research objectives: to research and describe an acceptable and appropriate underlying theoretical foundation for integrating ICTs in 21st century classroom teaching and learning; to identify, analyse, interpret, classify and record the spectrum of ICT requirements in the NCS; and to develop theoretical and practical guidelines in a framework of understanding for implementing and integrating the ICT requirements of the NCS in learning.

The research commences with a literature study of 21st learning needs and learning theories that comply with and accommodate those needs. It proposes a theoretical foundation for integrating ICTs in learning that is based on a complementary and conditional view of objectivism and constructivism. Based on

this foundation, seven technology roles in learning and the importance of a technology-integrated curriculum are identified and described.

The second phase of the research involves a qualitative analysis of the curriculum documentation of the 31 NCS subjects in order to identify, analyse, interpret, classify and record the ICT requirements of the NCS. The three typologies of requirement types, technology roles in learning and application types are used for this purpose.

The final phase involves contemplating the implications of the research findings and synthesising it in a conceptual framework that educators can use as a context for understanding, interpreting and implementing the ICT requirements of the NCS.

CHAPTER 1: RESEARCH ORIENTATION

> *The new technologies that are changing our world are not a panacea or a magic bullet. But they are, without doubt, enormously powerful tools for development. They create jobs. They are transforming education, health care, commerce, politics and more. …One of the most pressing challenges in the new century is to harness this extraordinary force, spread it throughout the world, and make its benefits accessible and meaningful for all humanity, in particular the poor* (United Nations Information and Communication Technologies Task Force 2001).

1.1 INTRODUCTION

The words of the previous Secretary-General of the United Nations, Kofi Anan, above confirm that the emergence of the computer late in the 20th century, and its convergence with other technologies along the way to the 21st century, have had a profound impact on humankind. The computer and its associated technologies have played a considerable role for the past 50 years: they have fundamentally changed the way people communicate and do business in manufacturing, engineering, finance, medicine, agriculture and other fields. This transformation resulted in the Information (or Knowledge) Age; this is how the National School Board Association (2002) in America describes it:

> *The defining characteristic of the Knowledge Age is perpetual change. Unlike previous transformations, the transformation to the Knowledge Age is not a period of change, followed by stability. It will usher in an epoch of continuous change on an accelerating time cycle. This means that the kinds of knowledge that will serve each individual and our society as a whole are constantly evolving. Consider these facts:*

1. *Every two or three years, the knowledge base doubles.*
2. *Every day 7,000 scientific and technical articles are published.*
3. *Satellites orbiting the globe send enough data to fill 19 million volumes in the Library of Congress – every two weeks.*
4. *High school graduates have been exposed to more information than their grandparents were in a lifetime.*
5. *Only 15 percent of jobs will require college education, but nearly all jobs will require the equivalent knowledge of a college education.*
6. *There will be as much change in the next three decades as there was in the last three centuries.*

It is especially the convergence of **information technology** (computer hardware and software) and **communication technology** (data and telecommunication networks) into new **information and communication technologies** (ICTs) that have huge potential and implications for humankind. In South Africa the challenge to harness this extraordinary potential is being acknowledged. The National Research Foundation (2003), for example, has declared *"ICT and the Information Society in South Africa"* as one of its eight research focus areas. It argues that the country finds itself at the intersection of many forces of change. At a global level, South Africa is seeking to optimise participation in global markets, and at the local level to integrate ICTs successfully into society. The National Research Foundation maintains that ICTs will have a continuing and dynamic presence in societies in future, but warn against the perception that the future development of ICTs is simply a process of roll-out, or diffusion of already established technologies. Taking such a perspective would be a grave error. There is much to be won, and lost, in the next few years in terms of the development of ICTs.

What are the challenges for education against this background? UNESCO (2002:14-15) provides the answer stating that there is a growing awareness and concern among policy-makers, business leaders and educators that the education system, which is designed to prepare learners for an agrarian or industrially-based economy, will not provide the young generation with the knowledge and skills they will need to thrive in the 21st century. The young generation of today is entering a changing technology-oriented and knowledge-based global economy and society in which national economies have become more globalised, with an increasing flow of information, technologies, products, capital and people between nations. This technology-oriented change demands new knowledge and skills in the workplace and poses a challenge to education systems to provide students with the knowledge and skills needed to thrive in a new and dynamic environment of continuous technological change and accelerating knowledge growth.

The South African Government started to address this challenge with the introduction of outcomes-based education (OBE) into the education system. The national OBE curriculum for grades R - 9, known as Curriculum 2005, was announced in 1996 and implemented in phases, starting with grade 5 in 1998 (Department of Education 1997). Curriculum 2005 was reviewed during 2000 to 2002, and reissued in 2002 as the Revised National Curriculum Statement Grades R - 9 (Department of Education 2002:5-6). The national OBE curriculum for grades 10 - 12, known as the National Curriculum Statement Grades 10 - 12 (NCS), was introduced in 2003 (Department of Education 2003a). Implementation was again done in phases, starting with grade 10 in 2006. The NCS collectively consists of subject statement, learning programme guideline and subject assessment guideline documents for 31 subjects.

Grades 10 - 12 represent the Further Education and Training (FET) Band that is located between the General Education and Training Band and Higher Education and Training Band on the National Qualifications Framework, and alongside the world of work. According to the NCS FET schools are required to provide access to Higher Education and Training for some learners, and to facilitate the transition of other learners from school to the workplace, while being sensitive to imperatives for globalisation (Department of Education 2003a:viii&2-4). This means that FET schools have to prepare learners with the knowledge and skills, including ICT knowledge and skills, needed to thrive in 21st century higher education and the workplace in a global context of continuous technological change and accelerating growth in knowledge production.

One of the objectives of the NCS was to streamline, consolidate and update the subjects for grades 10 - 12. As a result the 124 subjects (264 if the higher, standard and lower grades are taken into account) of the outgoing Senior Certificate curriculum have been reduced to and redefined as 31 subjects in the NCS (Department of Education 2003a:1&12). Another objective was to accommodate the needs of modern society, such as the need for ICT knowledge, skills and values in the 21st century. The question that this research is concerned with is: **What are the ICT requirements of the NCS, and its implications for schools in implementing it?** A cursory review of the NCS reveals the following:

- In the case of at least 10 subjects, requirements are stated for specific ICT applications. These are ICT applications unique to specific subjects, for example the use of an accounting package in the subject Accounting (Department of Education 2003b:12).

- The subjects Computer Applications Technology and Information Technology are inherently based on ICTs (Department of Education 2003e & 2003n). This implies, for instance, that these subjects will require full-time dedicated ICT facilities in grades 10 - 12.

- There are numerous references in the NCS that prescribe or imply the use of general computer application packages in learning activities. For example, the subject Dance Studies requires learners to be able to design flyers/pamphlets/posters/advertisements, create marketing strategies which may include electronic and print media, and develop budgets for dance performances (Department of Education 2003g:24-25).

- The following assertion in the Languages – English Home Language subject statement is another indication of how important the NCS considers ICT in learning (Department of Education 2003p:9):

    The range of literacies needed for effective participation in society and the workplace in the global economy of the twenty first century has expanded beyond listening, speaking, reading, writing and oral traditions to include

> *various forms such as media, graphic, information, **computer**, cultural, and critical **literacy**. The language curriculum prepares learners for the challenges they will face as South Africans and members of the global community* (own emphasis).

In comparison, the overview document of the Revised National Curriculum Statement Grades R - 9 contains only one ICT-related phrase (Department of Education 2002:28). The former Senior Certificate curriculum for grades 10 - 12, on the other hand, was conceived and developed many decades ago with adjustments, upgrades and revisions from time to time. ICT, as it is known today, did not exist at the time when this curriculum came into being. Later adjustments did allow for some computer-related subjects (e.g. Computer Studies), but an exclusive approach was taken because it allowed only the most talented and intelligent learners into this 'mysterious' and 'difficult' subject.

It is, therefore, clear that the NCS has a fundamentally different approach to ICTs than is the case with both the former Senior Certificate curriculum and the Revised National Curriculum Statement Grades R - 9. To succeed in implementing the ICT requirements of the NCS, schools need to know and understand:

- the role and value of ICTs in global society in general;
- the role and value of ICTs in education in particular;
- the specific ICT requirements of the NCS and its implications; and
- sound guidelines for integrating and utilising the power of ICTs in classrooms.

In other words, schools need a framework of understanding to guide them in implementing and integrating these ICT requirements into teaching and learning.

1.2 STATEMENT OF THE PROBLEM

The NCS requires FET schools to implement ICT requirements. To get a clear picture and fundamental understanding of this responsibility, it is necessary to answer the question: **What are the ICT requirements of the NCS, and its implications for implementation?**

The main purpose of this research is to identify, analyse, interpret and classify the ICT requirements of the NCS, and to synthesise the findings in a framework of understanding for implementing it in grades 10 - 12. This framework of understanding is seen as the culminating objective of the research. It is done through researching and solving the following sub problems:

- **What is an appropriate theoretical foundation for integrating ICTs in learning?** This question is researched in relevant authoritative literature sources on theories and paradigms of learning.

- **What are the uses of ICTs in learning?** Technology uses in learning are explored in relevant authoritative literature sources.

- **How can the ICT requirements of the NCS be identified and classified?** This question is answered, firstly, by analysing examples and the nature of ICT requirements in the curriculum documentation of the 31 NCS subjects, and formulating a definition. Secondly, classification categories are identified through the qualitative procedures of deductive category application and inductive category development.

- **What are the ICT requirements of the NCS?** This research question is answered by applying the definition of an ICT requirement and classifying the identified ICT requirements according to categories of the chosen/developed classification systems

- **What are the implications of the ICT requirements of the NCS for implementation in schools?** Implications are formulated based on analyses of the impacts of the research findings on classroom teaching and learning.

- **Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?** The framework of understanding is developed by synthesising and fitting the findings of the research into a conceptual framework.

1.3 AIM OF THE RESEARCH

The aim of this research is driven by the view that the practice of integrating technology into teaching and learning should be based on and guided by theoretical foundations (Simonson & Thompson 1990:iii, Bednar, Cunningham, Duffy & Perry 1991:89-90, Ertmer & Newby 1993:51-52, Moallem 2001:113-114 & Newby, Stepich, Lehman & Russel 2006:26). This is how Simonson and Thompson (1990:iii) describe it: *"If computers are to have a significant, long-term impact on education, there must be a theoretical rationale for their use that is based on research"*. The main purpose of the research is to investigate the ICT requirements of the NCS and to synthesise its findings in a culminating framework of understanding for implementing it in grades 10 - 12 in secondary schools. This is achieved through the following three research objectives:

- To research and describe an appropriate underlying theoretical foundation for integrating ICTs in 21st century learning

- To identify and classify the spectrum of ICT requirements in the NCS

- To develop a framework of understanding for implementing the ICT requirements of the NCS in learning

1.4 DEMARCATION OF THE PROBLEM

The research is limited to three focus areas: a theoretical foundation for using ICTs in education; the actual ICT requirements of the NCS; and a framework of understanding for implementing the ICT requirements in teaching and learning. The following aspects, however, are excluded:

- The ICT requirements of the learning areas for grades 8 and 9. Although these grades are part of secondary schools, they are not part of the FET Band.

- Funding for the implementation of the ICT requirements. It is assumed that schools will be funded adequately through government, private sector, and school community initiatives for meaningful and affordable integration of technology in learning. This implies that funding models will not be explored and recommended in this study. However, affordability as an aspect of funding, will be used as a criterion in deciding whether particular technologies are relevant for South African secondary schools in general.

- The design and development of educational software systems for teaching and learning. This is a complex and expensive activity that is not (or rarely) undertaken at school level.

- Administrative use of ICTs. Although it is an important issue for schools, it falls outside the scope of the NCS, and therefore of this study.

- ICT training of teachers. Proper and relevant training for teachers is obviously a crucial factor for the success of implementing the ICT requirements of the NCS. It is, however, a comprehensive research topic that deserves its own study.

- The ICT requirements of the NCS are accepted as official policy that is not negotiable. This study does not attempt to critically evaluate and justify them, but focuses purely on identifying them and their implications for implementation.

1.5 RELEVANCE OF THE RESEARCH

The research is relevant for the following reasons:

1.5.1 Need for implementation guidelines

As with any policy, schools need some form of guidance in implementing the ICT requirements of the NCS. This research aims to contribute towards a greater understanding of schools' responsibilities in implementing the ICT requirements of the NCS in addition to the efforts of the national Department of Education and its provincial departments of education.

1.5.2 Academic scrutiny of new policies

Whenever a fundamentally new policy is introduced, such as Curriculum 2005 in 1996 and the NCS in 2003, a process is initiated that takes the policy through different phases on its way towards full implementation and acceptance. Such a process could include: comments by stakeholders; scrutiny by experts; interpretation of the requirements and implications for schools; developing action plans for implementation; implementing the action plans and reviewing the results. Scrutiny of a policy means that experts such as academics and professional researchers dissect, analyse, evaluate, interpret and debate the policy. The objectives of this activity are to:

- ensure that the policy conforms to existing theories or that new valid theories supporting the policy are developed;
- ensure that the policy meets scientific standards; and
- create a theoretical rationale that will guide the establishment of the policy's practice, and provide the means for evaluating such a practice.

The NCS, as the curriculum policy for grades 10 - 12 in FET schools, has to comply with the above requirements and needs to be scrutinised through academic research such as undertaken in this study.

1.5.3 The importance of ICTs

The importance of ICTs in all spheres of global society has already been described above. It is stated government policy that South Africa is seeking to optimise participation in global markets. The successful integration of ICTs into our society is a prerequisite for achieving this (NRF, 2002). This research with its aim of investigating the ICT requirements of the NCS and developing a framework of understanding for implementing it in grades 10 - 12 will hopefully make a contribution to this effect.

1.5.4 The need for reform in education

The years 1990/1991 are considered by many as the arrival of the information (or knowledge) age (e.g. Trilling & Hood 1999:5 & Gura & Percy 2005:v & 1). Since then we have seen dramatic technology-driven changes in the larger society: for example the way we entertain ourselves; the way we access information; the way we communicate; and the way we handle our financial matters. The most profound fundamental transformations are seen in the workplace. The new technologies are reshaping the nature of work from a reliance on physical labour to cultivating the intellectual ability to interact with sophisticated symbol systems. The nature and variety of jobs in the information-age workplace, for example, have become much more knowledge intensive (Collins & Haverson 2009:5 & 10). And yet schools as the institutions that are supposed to prepare learners for the world of work, reflect very little of the transformations in wider society (e.g. Reigeluth 1996, Trilling & Hood 1999, Gura & Percy 2005, Collins & Halverson 2009 & Bush & Mott 2009). There is therefore a need for research that focuses on reasons why education has failed to reform itself, requirements for educational reforms, and ways to achieve it.

1.6 CLARIFICATION OF CONCEPTS

In this section a number of concepts relevant to this research are clarified, described and defined.

1.6.1 National Curriculum Statement Grades 10 - 12

The Minister of Education eloquently answers the question of what a curriculum is (Department of Education 2002:1):

> *At its broadest level, our education system and its curriculum express our idea of ourselves as a society and our vision as to how we see the new form of society being realised through our children and learners. Through its selection of what is to be in the curriculum, it represents our priorities and assumptions of what constitutes a 'good education' at its deepest level. … It encapsulates our vision of teachers and learners who are knowledgeable and multi-faceted, sensitive to environmental issues and able to respond to and act upon the many challenges that will still confront South Africa in this twenty first century.*

The National Curriculum Statement Grades 10 - 12 (General), abbreviated as the NCS, is the vehicle for realising this vision in grades 10 - 12. It is the curriculum that is used to implement OBE in the FET Band of the South African education system. The focus of this study will be on this curriculum only and any reference in this study to the 'National Curriculum Statement' or 'NCS' should be understood as the national curriculum for grades 10 - 12 in South African secondary schools. The following notes clarify the NCS:

- The total NCS documentation consists of 31 subject statements (Department of Education 2003b-y & 2005a-g), 29 learning programme guidelines (Department of Education 2008a-ac) and 29 subject assessment guidelines (Department of Education 2008ad-bf) – a total of 89 documents.

- The NCS, as with any curriculum, is dynamic in the sense that it is continuously being developed, reviewed and refined. For the purpose of this research the NCS is studied in the status it was on 1 April 2008.

- The NCS offers three language subjects in the form of Home Language, First Additional Language and Second Additional Language. These subjects can be taken in any of the 11 official languages; they are all based on the same generic principles and standards. This research studied the English Home Language, English First Additional Language and English Second Additional Language versions.

1.6.2 Schools

In the context of this study schools refer to all South African educational institutions in the FET band with grades 10 - 12 classes that are compelled by law to implement the NCS. It includes public as well as private schools.

1.6.3 Information and communication technologies for education

The ICTs of today are characterised by the following:

- The development of ICTs continues rapidly with no sign of abating. The results are ever increasing processing power and greater functionality.

- Current ICTs are the result of a convergence of formerly distinct technologies such as computer, audio, video, radio and telecommunication technologies.

- There is an increasing spectrum of technologies available – some more relevant to specific domains than others, some more expensive than others, and some more advanced and specialised than others.

The education sector is traditionally known to be slower and more conservative in its adoption of ICTs than, for instance, the commercial sector (e.g. Reigeluth 1996, Trilling & Hood 1999, Gura & Percy 2005, Collins & Halverson 2009 & Bush & Mott

2009). Not all ICTs are relevant or applicable for education. ICTs for education should primarily meet educational needs and not provide ‘solutions’ to ‘problems’ that do not exist in education. They must be affordable in terms of available financial resources, and require expertise levels that can be expected to be available in education. The following ICTs are considered relevant and appropriate for education (Shelly, Gunter & Gunter 2010):

- **Personal computer hardware**
  - Basic computer with keyboard, mouse, system unit, hard and CD-ROM/DVD drives, flash disks/memory sticks, screen, speakers, and printer
  - Additional devices such as scanners, microphones, digital cameras, video cams, plotters, LCD overhead projectors, data projectors and electronic whiteboards
- **Personal computer software**
  - System software such as the operating system, and utility software such as anti-virus packages and backup systems
  - Software for general applications such as word processing, spreadsheets, databases, presentation graphics, e-mail, Internet access, multimedia authoring and delivery and school administration
  - Software for subject-specific applications such as accounting software in Accounting, geographical information system in Geography, programming languages in Information Technology, and computer-aided design software in Engineering Graphics and Design
- **Network hardware and software**
  - Hardware such as servers, network interface cards, wired and wireless communications media, network devices (hubs, bridges, routers, gateways,

etc.), and user-shared devices (printers, plotters, scanners, DVD drives, electronic whiteboards, etc.)

  - Software that enables functions such as sharing of files and devices, and communication within the network

- **Internet hardware and software**

  - Hardware such as modems and communication channels to enable a physical link to the Internet network infrastructure

  - Software that enables functions such as file transfer, e-mail, discussion forums, chat rooms, Internet relay chat, information publication, and information retrieval

- **Video technology** - including digital video and photo cameras, video (or data) projectors, display screens, and editing facilities

From Chapter 2 onwards the general term *technology* is used in describing the use of ICTs in education. Although there are other technologies in classrooms (e.g. books, black/white boards, overhead projectors and laboratory equipment), in the context of this study the use of the term *technology* refers to ICTs in particular.

1.6.4 ICT requirements of the NCS

An ICT requirement is seen as any reference in the NCS documentation that requires or implies the availability of ICT facilities for the purpose of learning. There are a great number of such requirements of which the following three are examples:

- Some requirements imply the gaining of specific ICT knowledge, skills and values. An example is the subject Information Technology that deals with ICT itself (Department of Education 2003n).

- Some requirements imply the use of an ICT application that is unique to a specific subject. For example, the following ICT requirement regarding the availability, integration and use of a geographical information system in the subject Geography (Department of Education 2003k:10):

  Analysing information: *… Observations can be synthesised into a meaningful interpretation by using important tools available in geographic analysis such as electronic (digital) databases and Geographic Information Systems.*

- Some requirements concern the use of general ICT applications in learning activities. An example is the use of computer technology for communication (e.g. e-mail to communicate messages and presentation graphics to communicate information/ideas) in Agricultural Technology (Department of Education 2005b:35).

One of the objectives of this research is to identify, record, analyse, interpret and classify the whole spectrum of ICT requirements in the NCS in order to understand its implications for schools.

1.7 RESEARCH DESIGN AND METHODOLOGY

The research design and methodology is fully described in Chapter 4, but a summary is given here by way of introduction and orientation. The research focuses on the following three tasks:

- Identifying and describing an appropriate underlying theoretical foundation for integrating ICTs in 21st century teaching and learning. This research task is achieved by means of a comprehensive literature study.

- Identifying, classifying and analysing the ICT requirements of the NCS. The research of this aspect follows the format of a qualitative design with the NCS as the only case and its unit of analysis. Research data is collected by means of a document analysis of the primary NCS documentation, validated by independent and experienced analysts.

- Developing a framework of understanding with theoretical and practical guidelines for implementing the ICT requirements of the NCS in teaching and learning. This is achieved by synthesising the findings of the above two research tasks in a conceptual framework.

The research is conducted in four phases.

1.7.1 Phase 1: Literature study

The literature study is focused on the following themes:

- **Learning theories for the 21st century:** The study and description of appropriate learning theories is seen as the first priority because it has to provide the theoretical foundation for integrating ICTs into 21st century learning in the classroom.

- **Uses of ICTs in schools:** To understand the use of ICTs in learning, it is necessary to explore their roles and forms in the wider context of the school. This is done by investigating and describing:

  - the ICT tools available for education;
  - the spectrum of ICT uses in schools;
  - classification systems for ICT uses in learning; and
  - the meaning of a technology-integrated curriculum.

1.7.2 Phase 2: Data collection and analysis

An analysis of the primary NCS documentation is the source for identifying and recording all ICT requirements. Various classification systems are used to analyse, interpret, classify and record the spectrum of ICT requirements.

1.7.3 Phase 3: Development of a framework of understanding

Based on the results of the literature study, data collection and analysis a framework of understanding is developed that will:

- enhance the interpretation of the implications of the ICT requirements of the NCS; and

- guide its implementation in classroom teaching and learning.

1.7.4 Phase 4: Report writing

The research report comprises of the following seven chapters:

Chapter 1 describes the background and rationale for the study, the research problem, the aim of the research, and an introduction to the research methodology and design.

Chapter 2 aims to describe the needs of modern society and the learning theories that will meet those needs, and to provide a theoretical foundation for integrating ICTs into learning.

Chapter 3 explores the uses of ICTs in schools by investigating and describing the ICT tools available for education, the spectrum of ICT uses in schools, classification systems for ICT uses in learning, and the meaning of a technology-integrated curriculum.

Chapter 4 gives a full description of the research design and methodology that is followed in this study.

Chapter 5 reports on the identification, interpretation, classification, recording and analysis of the ICT requirements in the NCS.

Chapter 6 describes a framework of understanding for interpreting the implications of the ICT requirements of the NCS, and for guiding its implementation in classroom learning.

Chapter 7 concludes the study with its conclusions, recommendations and limitations.

1.8 SUMMARY

Chapter 1 commenced with a background and rationale as an introduction to this study, followed by the statement of the research problem, the research aim, demarcation of the problem and relevance of the research. Certain concepts were clarified, the research design and methodology were briefly introduced, and the structure of the research report was outlined. The next chapter describes the results of a literature study about learning theories for the 21st century.

CHAPTER 2: LEARNING THEORIES FOR THE 21ST CENTURY

> *We have entered a new age in learning theory. Never in the relatively short history of learning theories (one hundred plus years) have so many theoretical foundations shared so many assumptions and common foundations. … Never have alternative theories of knowledge and learning been so consonant in their beliefs and the methods they imply. These theories are no longer the alternative; they represent the dominant paradigm of learning* (Jonassen, Hernandez-Serrano & Choi 2000:107).

2.1 INTRODUCTION

The words of Jonassen and his colleagues above imply that much has been happening in the field of learning theory development as society moved into the 21st century. Learning is one of the most important and fundamental human endeavours, because it determines how well individuals are developed and accepted as members into a society. It also determines the further growth and development of that society through the contributions of its members. If we are to succeed in implementing a new national curriculum in grades 10 - 12, then it will be of paramount importance that we take cognisance of these learning theory developments in order to lay valid foundations for integrating ICTs into the learning environments of our schools. It is essential that learning theory foundations should inform and guide the practice of integrating technology in teaching and learning (Simonson & Thompson 1990:iii, Bednar, Cunningham, Duffy & Perry 1991:89-90, Ertmer & Newby 1993:51-52, Moallem 2001:113-114 & Newby, Stepich, Lehman & Russel 2006:26).

This chapter aims to answer the following research question: **What is an appropriate theoretical foundation for integrating ICTs in learning?** Such a foundation should be learning theory based because learning theories describe how we learn. This in turn determines the role(s) that technology should play in teaching and learning activities. The purpose of this chapter, therefore, is to study learning theories in the context of the education needs of modern society. It begins with a study of the attributes and requirements of the 21st century workplace, and the key areas for learning outcomes that reflect the needs of the workplace and other dimensions of modern society. This is followed by a look at school reform in the information age to determine whether the technology-driven transformations that have occurred in so many dimensions of society, also occurred in education. Finally, the chapter investigates prominent learning theories, and proposes a learning theory-based foundation for implementing the ICT requirements of the NCS in learning environments.

2.2 WORKPLACE OF THE 21ST CENTURY

The objective of analysing the workplace is based on the assumption that one of the responsibilities of schools is to equip learners with the basic knowledge, skills and values needed to be effective in the workplace, an assumption that is confirmed and acknowledged by the Department of Education (2003a:viii & 2-4). Following from this, it is safe to assume that the skills and competencies required by the 21st century workplace must be reflected in the outcomes that learners are expected to achieve at the end of schooling.

At the close of the 20th century society had moved from the industrial age to the information (or knowledge, digital) age. Trilling and Hood (1999:5) consider 1991 as the year of the arrival of the information age when spending on information age capital goods exceeded spending on industrial age capital goods for the first time in the USA. Since then society has seen and experienced fundamental changes in especially the workplace. Technology and globalisation are identified as the two main factors responsible for these changes. Its impact on the world of work is described as dramatic, pervasive and extremely rapid, and not nearly over (Canadian Government 1997:v, vi, 5, 8-11, 119-125). The US Department of Labor (in North Central Regional Educational Laboratory/Metiri 2003:5) comments that we are living in a new economy that is powered by technology, fuelled by information, and driven by knowledge. Because of this the influence of technology will go beyond new equipment and faster communications, as work and skills are redefined and reorganised.

The following are some of the characteristics of the workplace of the 21st century:

- The workplace is one of the dimensions of society in which it can be clearly seen that while society is developing new technologies, those technologies are also shaping it (Mehlinger 1996:400-401).

- The emergence of the personal computer as an external extension of human intelligence and the Internet as a multidimensional communications system have literally redefined the way people think, communicate, and work (Gura & Percy 2005:v).

- The variety of jobs in the knowledge age have changed to become much more knowledge-intensive (Collins & Halverson 2009:5).

- The technology tools of the knowledge age are reshaping the nature of work from a reliance on physical labour to cultivating the intellectual ability of ordinary people to interact with sophisticated symbol systems. *"Computer tools greatly extend the power of the ordinary mind in the same way that the power tools of the Industrial revolution extended the power of the ordinary body"* (Collins & Halverson 2009:10).

- The technology tools of the knowledge age are changing the basis of communication in the workplace from *communities of place* to *communities of interest*. This means that workplace communications are not bound by locality anymore, but extend to collaborators involved in particular projects anywhere in the world (Collins & Halverson 2009:11).

- When labour sources are combined with high-speed communications technologies, suddenly many kinds of work can be done around the clock, offsite, or in low wage areas. The era of outsourcing and offshoring has arrived (Partnership for 21st Century Skills 2007:4).

- Workers will have multiple careers during their lifetime, often accept short-term contract or casual work, and are expected to rely on themselves rather than on employers (Canadian Government 1997:v).

- Changes in the workplace lead to much insecurity in society with massive layoffs. Young people must overcome numerous barriers before finding their first job, while older workers are confronted with a workplace that is increasingly complex and foreign to them (Canadian Government 1997:vi).

- Workers are pressurised to constantly upgrade their skills to adapt to the ever-changing reality of the workplace (Canadian Government 1997: 8-11).

- Technology is affecting where, how and when work is done. This results in (Canadian Government 1997:119-125 & Mehlinger 1996:400-401):

  - fundamental impacts on the spatial organisation of employment;

  - the adoption of new forms of organisation, frequently eliminating several layers of middle management; and

  - 'just in time' labour force strategies that enable non-standard employment forms such as telecommuting and subcontracting.

- Technology has displaced labour by increased resource utilisation efficiency in traditional industries, as well as created new knowledge industries with new possibilities and categories of employment (Canadian Government 1997:v, vi, 8-11, 119-125).

These changes obviously demand new knowledge, skills and competencies in order to be successful in the 21st century workplace and other dimensions of society. Exactly what it should be is investigated in the next section.

2.3 LEARNING OUTCOMES FOR THE 21ST CENTURY

The Partnership for 21st Century Skills (2007:1) believes that throughout human history, education has been shaped by the societal needs of the societies in which it is set. Education, after all, is the attempt to convey from one generation to the next the knowledge, skills and values that are required to succeed in life.

Learning outcomes are here defined as the knowledge, skills and values that learners are expected to achieve and demonstrate at the end of schooling. Because the school is an institution of society, it could be expected that these outcomes should reflect the needs of society. The objective of this section is to identify and describe key areas of societal needs that reflect, inter alia, the skills and competencies required by the 21st century workplace. Why only the workplace? What about the other dimensions of society? The answer is that technology, which is the focus of this study, has the greatest impact on the workplace. This by no means implies that the other dimensions of society are less important – these needs must also be reflected in the learning outcomes. Developing and describing learning outcomes are part of a complex curriculum development process that falls outside the scope of this study. The focus of this section is rather on key areas of 21st century workplace needs from which specific learning outcomes can be developed and formulated.

Several comprehensive studies of 21st century skills were conducted and reported since the 1990s. Notable ones include the report of the Secretary's Commission on Achieving Necessary Skills (the SCANS Report) (US Department of Labor 1991), the report of the American Association of School Administrators (Uchida, Cetron & McKenzie 1996) and the Advisory Committee on the Changing Workplace (Canadian Government 1997). However, the focus of this section is on two subsequent studies that not only incorporated these earlier findings, but had the benefit of contemporary insights.

In the first study the US North Central Regional Educational Laboratory (2003) commissioned the Metiri Group, a California-based learning and technology consulting firm, in 2001 to research 21st century skills. Two years of research were conducted through a process that included literature reviews, research on emerging characteristics of the Net-Generation, a review of current reports on workforce trends from business and industry, analysis of nationally recognised skill sets, input from educators, data from educator surveys, and reactions from constituent groups. The research findings, published in a report entitled *enGauge 21st century skills: Literacy in the digital age* (2003), identify and describe four skill clusters: *digital-age literacy*; *inventive thinking*; *effective communication*; and *high productivity.* These skill clusters that are summarised in Table 2.1 below, are intended to provide the public, business and industry, and educators with a common understanding of what is needed by students, citizens and workers in the digital age (North Central Regional Educational Laboratory/Metiri 2003:9).

Table 2.1: 21st century skill clusters needed by students, citizens, and workers in the digital age (North Central Regional Educational Laboratory/Metiri 2003:13-40)

SKILL CLUSTER 1: DIGITAL-AGE LITERACY includes:
Basic Literacy: Language proficiency (in English) and numeracy at levels necessary to function on the job and in society to achieve one's goals, and develop one's knowledge and potential in this Digital Age
Scientific Literacy: Knowledge and understanding of the scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity
Economic Literacy: The ability to identify economic problems, alternatives, costs, and benefits; analyze the incentives at work in economic situations; examine the consequences of changes in economic conditions and public policies; collect and organize economic evidence; and weigh costs against benefits
Technological Literacy: Knowledge about what technology is, how it works, what purposes it can serve, and how it can be used efficiently and effectively to achieve specific goals
Visual Literacy: The ability to interpret, use, appreciate, and create images and video using both conventional and 21st century media in ways that advance thinking, decision-making, communication, and learning
Information Literacy: The ability to evaluate information across a range of media; recognize when information is needed; locate, synthesize, and use information effectively; and accomplish these functions using technology, communication networks, and electronic resources
Multicultural Literacy: The ability to understand and appreciate the similarities and differences in the customs, values, and beliefs of one's own culture and the cultures of others
Global Awareness: The recognition and understanding of interrelationships among international organizations, nation-states, public and private economic entities, socio-cultural groups, and individuals across the globe

SKILL CLUSTER 2: INVENTIVE THINKING is comprised of the following “life skills”:

Adaptability/Managing Complexity: The ability to modify one’s thinking, attitude, or behavior to be better suited to current or future environments, as well as the ability to handle multiple goals, tasks, and inputs, while understanding and adhering to constraints of time, resources, and systems (e.g., organizational, technological)

Self-Direction: The ability to set goals related to learning, plan for the achievement of those goals, independently manage time and effort, and independently assess the quality of learning and any products that result from the learning experience

Curiosity: The desire to know or a spark of interest that leads to inquiry

Creativity: The act of bringing something into existence that is genuinely new and original, whether personally (original only to the individual) or culturally (where the work adds significantly to a domain of culture as recognized by experts)

Risk-taking: The willingness to make mistakes, advocate unconventional or unpopular positions, or tackle extremely challenging problems without obvious solutions, such that one’s personal growth, integrity, or accomplishments are enhanced

Higher-Order Thinking and Sound Reasoning: Include the cognitive processes of analysis, comparison, inference/interpretation, evaluation, and synthesis applied to a range of academic domains and problem-solving contexts

SKILL CLUSTER 3: EFFECTIVE COMMUNICATION involves:

Teaming and Collaboration: Cooperative interaction between two or more individuals working together to solve problems, create novel products, or learn and master content

Interpersonal Skills: The ability to read and manage the emotions, motivations, and behaviors of oneself and others during social interactions or in a social-interactive context

Personal Responsibility: Depth and currency of knowledge about legal and ethical issues related to technology, combined with one’s ability to apply this knowledge to achieve balance, integrity, and quality of life as a citizen, a family and community member, a learner, and a worker

Social and Civic Responsibility: The ability to manage technology and govern its use in a way that promotes public good and protects society, the environment, and democratic ideals

Interactive Communication: The generation of meaning through exchanges using a range of contemporary tools, transmissions, and processes

SKILL CLUSTER 4: HIGH PRODUCTIVITY is currently not a high-stakes focus of schools, yet the skills involved in this cluster often determine whether a person succeeds or fails in the workforce:

Prioritizing, Planning, and Managing for Results: The ability to organize to efficiently achieve the goals of a specific project or problem

Effective Use of Real-World Tools: Effective use of these tools – the hardware, software, networking, and peripheral devices used by Information Technology (IT) workers to accomplish 21st century work – means using these tools to communicate, collaborate, solve problems, and accomplish tasks

Ability to Produce Relevant, High-Quality Products: Intellectual, informational, or material products that serve authentic purposes and occur as a result of students using real-world tools to solve or communicate about real-world problems. These products include persuasive communications in any media (print, video, the Web, verbal presentation), synthesis of resources into more useable forms (databases, graphics, simulations), or refinement of questions that build upon what is known to advance one’s own and others’ understanding

This study also cross matched the enGauge 21st century skills with recognised skill sets such as the Secretary's Commission on Achieving the Necessary Skills by the US Department of Labor, the National Education Technology Standards by the International Society for Technology in Education, and the Standards for Technological Literacy by the International Technology Education Association (North Central Regional Educational Laboratory/Metiri 2003:49-54).

The second study investigated in this section is the Partnership for 21st Century Skills (2003, 2007 and 2009). The Partnership was formed in 2002 with wide representation from the US Department of Education, technology business community, educational associations and foundations, and educational technology organisations (2003:ii). Instead of focusing on 21st century workplace skills only, the Partnership for 21st Century Skills study took a more integrated approach by allowing the three themes of education and society, education and learning science, and education and learning tools to converge to form a new educational framework that is built around the acquisition of 21st century knowledge and skills (Partnership for 21st Century Skills 2007:7). Their proposed skills framework describes the 21st century student outcomes that schools need to impart, as well as the educational support systems that will enable them to do so. The latter consists of *21st Century Standards*, *Assessment of 21st Century Skills*, *21st Century Curriculum and Instruction*, *21st Century Professional Development* and *21st Century Learning Environments* (Partnership for 21st Century Skills 2009:7-9). Their 21st century student outcomes are summarised in Table 2.2 below.

Table 2.2: The knowledge, skills and expertise students should master to succeed in work and life in the 21st century (Partnership for 21st Century Skills 2009:2-7)

CORE SUBJECTS AND 21st CENTURY THEMES   **CORE SUBJECTS** include: English, reading or language arts; World languages; Arts; Mathematics; Economics; Science; Geography; History; and Government and Civics.   Schools must also promote understanding of academic content at much higher levels by weaving the following **21ST CENTURY INTERDISCIPLINARY THEMES** into the core subjects:
Global Awareness: Using 21st century skills to understand and address global issues. Learning from and working collaboratively with individuals representing diverse cultures, religions and lifestyles in a spirit of mutual respect and open dialogue in personal, work and community contexts. Understanding other nations and cultures, including the use of non-English languages.   **Financial, Economic, Business and Entrepreneurial Literacy:** Knowing how to make appropriate personal economic choices. Understanding the role of the economy in society. Using entrepreneurial skills to enhance workplace productivity and career options.   **Civic Literacy:** Participating effectively in civic life through knowing how to stay informed and understanding governmental processes. Exercising the rights and obligations of citizenship at local, state, national and global levels. Understanding the local and global implications of civic decisions.   **Health Literacy:** Obtaining, interpreting and understanding basic health information and services and using such information and services in ways that enhance health. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance and stress reduction. Using available information to make appropriate health-related decisions. Establishing and monitoring personal and family health goals. Understanding national and international public health and safety issues.   **Environmental Literacy:** Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water and ecosystems. Demonstrate knowledge and understanding of society's impact on the natural world (e.g. population growth, population development, resource consumption rate, etc.). Investigate and analyze environmental issues, and make accurate conclusions about effective solutions. Take individual and collective action towards addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues).
LEARNING AND INNOVATION SKILLS   **CREATIVITY AND INNOVATION**   **Think Creatively:** Use a wide range of idea creation techniques (such as brainstorming). Create new and worthwhile ideas (both incremental and radical concepts). Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts.   **Work Creatively with Others:** Develop, implement and communicate new ideas to others effectively. Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work. Demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas. View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes.   **Implement Innovations:** Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur.

CRITICAL THINKING AND PROBLEM SOLVING

Reason Effectively: Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation.

Use Systems Thinking: Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems.

Make Judgments and Decisions: Effectively analyze and evaluate evidence, arguments, claims and beliefs. Analyze and evaluate major alternative points of view. Synthesize and make connections between information and arguments. Interpret information and draw conclusions based on the best analysis. Reflect critically on learning experiences and processes.

Solve Problems: Solve different kinds of non-familiar problems in both conventional and innovative ways. Identify and ask significant questions that clarify various points of view and lead to better solutions.

COMMUNICATION AND COLLABORATION

Communicate Clearly: Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts. Listen effectively to decipher meaning, including knowledge, values, attitudes and intentions. Use communication for a range of purposes (e.g. to inform, instruct, motivate and persuade). Utilize multiple media and technologies, and know how to judge their effectiveness a priori as well as assess their impact. Communicate effectively in diverse environments (including multi-lingual).

Collaborate with Others: Demonstrate ability to work effectively and respectfully with diverse teams. Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal. Assume shared responsibility for collaborative work, and value the individual contributions made by each team member.

INFORMATION, MEDIA AND TECHNOLOGY SKILLS

INFORMATION LITERACY

Access and Evaluate Information: Access information efficiently (time) and effectively (sources). Evaluate information critically and competently.

Use and Manage Information: Use information accurately and creatively for the issue or problem at hand. Manage the flow of information from a wide variety of sources. Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information

MEDIA LITERACY

Analyze Media: Understand both how and why media messages are constructed, and for what purposes. Examine how individuals interpret messages differently, how values and points of view are included or excluded, and how media can influence beliefs and behaviors. Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of media.

Create Media Products: Understand and utilize the most appropriate media creation tools, characteristics and conventions. Understand and effectively utilize the most appropriate expressions and interpretations in diverse, multi-cultural environments.

ICT (INFORMATION, COMMUNICATIONS AND TECHNOLOGY) LITERACY

Apply Technology Effectively: Use technology as a tool to research, organize, evaluate and communicate information. Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy. Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies.

LIFE AND CAREER SKILLS

FLEXIBILITY AND ADAPTABILITY

Adapt to Change: Adapt to varied roles, jobs responsibilities, schedules and contexts. Work effectively in a climate of ambiguity and changing priorities.

Be Flexible: Incorporate feedback effectively. Deal positively with praise, setbacks and criticism. Understand, negotiate and balance diverse views and beliefs to reach workable solutions, particularly in multi-cultural environments.

INITIATIVE AND SELF-DIRECTION

Manage Goals and Time: Set goals with tangible and intangible success criteria. Balance tactical (short-term) and strategic (long-term) goals. Utilize time and manage workload efficiently.

Work Independently: Monitor, define, prioritize and complete tasks without direct oversight.

Be Self-directed Learners: Go beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise. Demonstrate initiative to advance skill levels towards a professional level. Demonstrate commitment to learning as a lifelong process. Reflect critically on past experiences in order to inform future progress.

SOCIAL AND CROSS-CULTURAL SKILLS

Interact Effectively with Others: Know when it is appropriate to listen and when to speak. Conduct themselves in a respectable, professional manner.

Work Effectively in Diverse Teams: Respect cultural differences and work effectively with people from a range of social and cultural backgrounds. Respond open-mindedly to different ideas and values. Leverage social and cultural differences to create new ideas and increase both innovation and quality of work.

PRODUCTIVITY AND ACCOUNTABILITY

Manage Projects: Set and meet goals, even in the face of obstacles and competing pressures. Prioritize, plan and manage work to achieve the intended result.

Produce Results: Demonstrate additional attributes associated with producing high quality

products including the abilities to: work positively and ethically; manage time and projects effectively; multi-task; participate actively, as well as be reliable and punctual; present oneself professionally and with proper etiquette; collaborate and cooperate effectively with teams; respect and appreciate team diversity; be accountable for results.

LEADERSHIP AND RESPONSIBILITY

Guide and Lead Others: Use interpersonal and problem-solving skills to influence and guide others toward a goal. Leverage strengths of others to accomplish a common goal. Inspire others to reach their very best via example and selflessness. Demonstrate integrity and ethical behavior in using influence and power.

Be Responsible to Others: Act responsibly with the interests of the larger community in mind.

The two studies discussed above clearly describe a wide variety of key areas of 21st century societal needs that can be used as a basis for the development of outcomes for 21st century learning. However, what is significant in terms of the focus of this research, is the extent of skills that require the use of technology. The following lists demonstrate this:

Skills that require the use of technology included in the *enGauge 21st Century Skills* (North Central Regional Educational Laboratory/Metiri 2003:13-40):

- Technological literacy
- Visual literacy
- Information literacy
- Social and civic responsibility
- Interactive communication
- Effective use of real-world tools
- Ability to produce relevant high-quality products.

Skills that require the use of technology included in the *21st Century Skills Framework* (Partnership for 21st Century Skills 2009:2-7):

- Communicate clearly
- Access and evaluate information
- Use and manage information
- Create media products
- Apply technology effectively

These 21st century skills confirm the fundamental role that technology has to play in wider society and, more importantly, in education. Whether that is true in the case of education is investigated in the next section.

2.4 SCHOOL REFORM IN THE INFORMATION AGE

In section 2.2 we have seen that technology has changed the workplace fundamentally. But it happened not only to the workplace – other dimensions of society have also changed dramatically: the way we communicate; the way we exercise our professions; the way we entertain ourselves; the way we access information; the way we handle our financial matters; and so forth – the list is endless. What make these changes remarkable are both their width (the spectrum of dimensions that were affected) and depth (the level of change it brought about), to such an extent that it can truly be described as a transformation.

However, this is not true for education. There is wide-spread agreement that the fundamental technology-driven transformations that we are seeing in most dimensions of society are not happening in education (Bush & Mott 2009:3,17, Collins & Halverson 2009:xiv & 9-10, Gura & Percy 2005:v-vi, xii & xiv, Maddux, Johnson & Willis 2001:14, Mehlinger 1996:401-403, Morton 1996:416-418, Resnick 2002:32 & UNESCO 2002:14-15). This anomaly is perhaps best described by Gura and Percy (2005:v-vi):

> *Over the past two decades digital technologies have profoundly revolutionalized intellectual work on planet earth. The emergence of two items have literally redefined the way people think, communicate, and work: the personal computer, an extension of human intelligence that becomes increasingly cheaper, more portable, and more ubiquitous daily, and the World Wide Web, a multidimensional communications breakthrough that can put the entire human family on the same page nearly instantly.*
>
> *These two innovations ... represent a vast step forward. Even casual contact with thought institutions like libraries, businesses, news organizations, and governmental agencies reveals how much more gets done, and how greatly the quality of action and interaction can be expanded through the application of digital technologies.*

One institution, ironically, remains largely unaffected – the institution most associated with the intellect and its training and growth – [the] school. This is more than just unfortunate. It is outrageous!

UNESCO (2002:14-15) warns that because of this lack of fundamental change in education, there is a growing awareness and concern among policy-makers, business leaders and educators that the educational system designed to prepare learners for an agrarian or industrially-based economy will not provide the young generation with the knowledge and skills they will need to thrive in the 21st century. If we want our learners to succeed in the 21st century, it is imperative that we understand the reasons and barriers that prevent the technology-driven transformation in wider society to occur in education.

There are, of course, secondary and practical barriers to successful integration of technology in teaching and learning in terms of, for example, teacher training, technology skills, curriculum materials, technology saturation, cost, access, and classroom management (Gura & Percy 2005:xiii & 1-11 & Collins & Halverson 2009:6 & 37-43). However, the intention in this section is to focus more on the fundamental aspects of this problem.

One fundamental aspect of the problem of a lack of technology-driven change in education, is the school system's unwillingness and inability to change. Collins and Halverson (2009:4-7 & 31-35) believe that this problem is fundamentally rooted in the historical emergence of universal schooling during the Industrial Revolution of the 19th century. They argue that when people started working in factories the existing practices for passing on knowledge based on apprenticeships in family environments, broke down. This created a need for a schooling system that offers a standard educational program for massive numbers of learners from increasingly non-agricultural families. As it evolved over time, the components of universal schooling have reinforced each other, developed interdependencies, and settled together to establish an equilibrium that reflects a balance among the components. The result is that universal schooling developed into a robust system that became so entrenched (Pearlman 2009:15) that it is to this day the predominant paradigm of education in most schools. It is this equilibrium that makes it so difficult to change the system, because changing one component of such a system usually results in the other components pushing back to restore the initial balance. Hence it becomes locked in place and very difficult to change. Other commentators such as Gura and Percy (2005:2-3 & 30) and Bush and Mott (2009:8) refer to this 'locked in place' as 'resistance to change'. They believe that the institution of the school is inherently resistant to change, especially profound change, and that a culture of status quo maintenance prevails in the world of schooling.

Maddux et al. (2001: 8) look to anthropology for answers to this perplexing problem. According to them it is essential that we understand how change occurs and how changes in society and culture at large relate to change in schools. Anthropologists such as Kneller (in Maddux et al. 2001:8-9) point out that changes in institutions of formal education, such as schools, typically follow changes in the culture at large, and that this cultural lag makes it unlikely that schools can act as agents of cultural change. One of the reasons for this has to do with the purpose of formal education and those who control it. In this context the primary purpose of education is seen as to help transmit the cultural way of life of a people (cultural heritage) to their offspring. Those that are chosen to control schooling, that is the members of governing bodies, are invariably models of a specific way of life. They have already attained a level of professional success and esteem in society that make them thus well suited to fulfil this role. For them, the existing culture has led to success and prosperity, and they have a vested interest in preserving the status quo of the current culture and in resisting change.

This unwillingness and resistance to fundamental change do not mean that no efforts were made in the past to implement technology in teaching and learning. Literally hundreds of such projects are reported in the literature. Collins and Halverson (2009:35-37) describe how traditional schooling has developed three strategies to deal with efforts to introduce new innovative technologies. The first is simply to ban them if they are perceived as posing a risk to existing instructional practices. The second is to co-opt them only if they support existing curricular outcomes and instructional practices. The third strategy is to marginalise them by allowing interested teachers to create innovative boutique programmes alongside the general school context, as long as it does not interfere with or try to change the very fabric of existing instructional practices. Salomon (2002:71-72) identifies trivialising technology as another such strategy and argues that it results from the consistent tendency of the education system to preserve itself and its practices by the assimilation of new technologies into existing instructional practices. The following are some of the consequences of such strategies:

- New digital technologies are kept on the periphery of core instructional practices. In other words computers are not at the core of schools, are not integrated in the curriculum and are seen as 'add-ons' (Collins & Halverson 2009:xiv, 6 & 34, Gura & Percy 2005:xi & 5, Bush & Mott 2009:6, & Morton 1996:417-418).

- New technologies are only assimilated and tolerated if they support and fit into existing instructional practices, thereby perpetuating 19th century, teacher-centric, didactic models of education (Bush & Mott 2009:4 & 6, Morton 1996:417-418 & Pearlman 2009:15).

- Instead of integrating and accepting technology as a powerful tool to support, enhance, amplify and fundamentally change teaching and learning, it is only co-opted and assimilated as an end in itself (i.e. a separate discipline) in an already overburdened curriculum (Gura & Percy 2005:xi & 5, Salomon 2002:72 & Collins & Halverson 2009:xiv, 6 & 9).

Gura and Percy (2005:xiv & 2) identify another fundamental aspect of the problem of a lack of technology-driven change in education by saying that the epicentre of this issue amounts to defining the role and place of technology in the educational experience, that is in 21st century teaching and learning. After so many years it is time that we get certainty about how the technology is to be used. Until technology is given its proper role in our instructional programmes, 21st century learners will not be receiving a 21st century education. Collins and Halverson (2009:6) comment that there are deep incompatibilities between the demands of the new technologies and the traditional school. And this is the root of the problem. The traditional school sees the teacher as an expert whose job it is to transmit that expertise to learners through lecture, recitation, drill and practice (Collins &

Halverson 2009:32). Technology is then given exactly the same function of transmitting, delivering or communicating learning content to learners (Resnick 2002:32-33), thereby perpetuating teacher-centric, didactic models of education (Bush & Mott 2009:4 & 6, Morton 417-418 & Pearlman 2009:15). *"... [W]e have consistently, almost single-mindedly, used technology to automate the past ..."* (Bush & Mott 2009:3). In trying to determine appropriate roles for technology we need to answer questions like 'Do we teach *about* technology, or do we teach *with* technology?' (Gura &Percy 2005:xi) and 'Should learners learn *from* technology or learn *with* technology?' (Bush & Mott 2009:9). Collins and Halverson (2009:4 & 43-47) point out that while the imperatives of industrial-age learning technologies can be thought of as uniformity, didactism and teacher control, the knowledge-age learning technologies have their own imperatives of customization, interaction and user-control. This implies that the role of technology in 21st century teaching and learning should be fundamentally different from that in the traditional model of universal schooling. It is therefore imperative for successful technology implementations that appropriate and relevant roles of technology that support and enhance knowledge-age teaching and learning practices, are identified.

Misguided research is identified as another fundamental barrier to successful and appropriate use of technology use in 21st century teaching and learning. Salomon (2002:74) argues that research on the new media is misguided in at least two ways. One misguided way is trying to answer the ubiquitous question 'Does medium X produce better learning results than medium Y?' Literally hundreds of studies keep repeating this all too familiar 'horse-race paradigm', *"... a paradigm that has been condemned and sentenced to death years ago ..."* (Salomon 2002:74). Such studies end up with the omnipresent conclusion of 'no significant differences' in most cases. This type of research focuses on using technology to reinforce traditional didactic methods (Morton 1996:419). The other misguided issue pertains to the kinds of outcomes that are measured or observed (Salomon 2002:74). Basically it means that there is no sense in using the powerful technology that we are concerned with today to attain the same old goals traditional education has tried to achieve. This type of research should rather focus on using technology to achieve outcomes such as the ability to: formulate new questions; solve novel, real-life and complex problems; and constructively work in problem-solving teams. Morton (1996:418) expresses this sentiment as follows:

> *The value of a computer environment is not so much the improvement of students' achievement through computer use as it is the improvement of students' ability to achieve. The difficulty of understanding this crucial difference is exacerbated by ... insist[ing] that the computer is there to enhance abilities already developed. … To look for research that shows computers have improved student performance is misguided for two reasons: 1) schools are not teaching the skills that computer environments best support, and 2) schools have not recognized the skills that students will need in the future.*

In conclusion, it is interpreted in this research that two issues underlie the above fundamental barriers to the real integration and adoption of technology in 21st century teaching and learning are distinguished. Firstly, there is no real understanding of how learning has changed from the industrial to knowledge age. This also implies that there is not a clear understanding of the **learning theory** that should form the basis for using and integrating technology in learning in the knowledge age. Evidence of this is the comment above that refers to perpetuating 19th century, teacher-centric, didactic models of education as one of the fundamental barriers to true technology integration in 21st century teaching and learning. Secondly, there is a lack of understanding of the real **role of technology in 21st century learning**. This is evidenced by the comments that technology is given the role of transmitting, delivering or communicating learning content to learners in line with teacher-centric, didactic models of education. This is in contrast to technology's potential to support and enhance teaching and learning compatible with information age needs in ways that were unimaginable or impossible before. It is clear that if the integration of technology into a new curriculum is to be fully understood, it is necessary to further investigate learning theories that address 21st century learning needs and the role of technology in the learning environments that result from such theories. Learning theories are investigated in the rest of this chapter, while the role of technology in the learning process is examined in Chapter 3.

2.5 AN OVERVIEW OF LEARNING THEORIES

The purpose of this section is to contextualise current understandings of learning by reviewing learning theory development as society moved form the industrial age to the information age. Learning theories, as one of the most fundamental aspects of education, have been the focus of intense and prolonged debate over many decades and will continue to be so in the future. The roots of learning theories extend far into the past. It is not the intention in this and subsequent sections to trace and report its developmental history in detail, but rather to identify and describe major and significant developments that could assist the formulation of an appropriate theoretical framework for integrating technology into learning environments.

Before learning theories are explored it is necessary to understand the meaning of the concepts of *learning* and *theory*. Although most people agree that learning is a fundamental characteristic of being human, there is no agreement on a universally accepted definition of what learning is (Newby et al. 2006:5). The following are some examples:

> *Learning is an enduring* ***change*** *in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of* ***experience*** (Schunk in Newby et al. 2006:5).

> *Learning is a relatively permanent* ***change*** *in behavior due to* ***experience****. Learning is a relative permanent* ***change*** *in mental representations or associations as a result of* ***experience*** (Omrod in Newby et al. 2006:5).

> *Learning is a persisting* ***change*** *in performance or performance potential that results from* ***experience*** *and interaction with the world* (Driscoll in Newby et al. 2006:5).

> *Learning refers to lasting* ***changes*** *in the learner's knowledge, where such changes are due to* ***experience*** (Mayer in Newby et al. 2006:5).

According to Newby et al. (2006:5&27) each of these definitions refers to change that is brought about through experience or some form of interaction with the environment. To learn is to change or have the capacity to change one's knowledge or abilities in a permanent way. Learning is measured by measuring the amount of change that occurs within a learner's level of knowledge, performance or behaviour. A central idea in these definitions is change. The question is: Change in what? This question will be answered when a number of broad theoretical perspectives of learning theories are described below.

The second concept of *theory* is described by Schunk (2008:3) as a scientifically acceptable set of principles that explain a phenomenon. By combining and integrating the definitions of the concepts *learning* and *theory*, a learning theory is described for the purpose of this research as a scientifically acceptable set of principles that explain learning as an enduring change in ability that is brought about through experience or some form of interaction with the environment. Exactly what a 'change in ability' entails is determined by the philosophical perspectives of particular learning theories.

It is essential that the practice of teaching and learning, including the integration of technology in teaching and learning, should be informed and guided by learning theory foundations (Simonson & Thompson 1990:iii, Ertmer & Newby 1993:51-52, Moallem 2001:113-114 & Newby et al. 2006:26). Why is this so? Ertmer and Newby (1993:51) identify four reasons. Firstly, learning theories are a *source* of verified instructional strategies, tactics and techniques that are critical for selecting an effective instructional design for a particular instructional problem. Secondly, learning theories provide the foundation for intelligent and reasoned strategy *selection*. This means that educational practitioners (i.e. teachers) must have an adequate repertoire of strategies available, and possess the knowledge of when and why to employ each. Thirdly, learning theories provide information about relationships among instructional components and the design of instruction that is of critical importance for the *integration* of a selected strategy in a given instructional context. Lastly, knowledge of learning theories allows for reliable *prediction*, meaning that a knowledgeable instructional designer will be able to predict which strategy will have the highest chance to succeed in the context of the constraints of a given instructional problem.

The boundaries between the many learning theories that have been studied over the past century, are not always clear and each theory is not a distinct set of constructs. It is not unusual to see the same concepts and theorists associated with more than one theory. Furthermore, each theory is not always singular, but is often a synthesis of related yet independent perspectives, principles and models. This may even result in competing theories overlapping in some areas (Feldman & McPhee 2008:38 & Ertmer & Newby 1993:53).

Learning theories are often distilled and categorised into the three broad theoretical perspectives of *behaviourism*, *cognitivism* and *constructivism* (e.g. Ertmer & Newby 1993:50-72, Newby et al. 2006:26-38, Feldman & McPhee 2008:39-63 & Shelly et al. 2010:367-382). Cognitivism is also known as *information processing theory,* named after its most prominent constituent (Newby et al. 2006:30-34). Feldman and McPhee (2008:63-70) indicate a fourth category of *humanism*, but because of its androgogy (adult learning) focus it is not considered in this study that is focused on school learning. The following are metaphors for these broad learning theory perspectives:

- **Behaviourism – the mind as a container and 'black box':** This perspective conceives the mind as an empty, opaque container or 'black box' that is unavailable for direct study – it only holds what is placed there from outside sources, completely subjective to these external influences. Human learning is only explained in terms of observable behaviours and the environmental conditions that influence them (Feldman & McPhee 2008:40-41).

- **Cognitivism – the mind as a computer:** Cognitivists use the metaphor of an information processing device or 'computer' to describe how the human mind operates. This perspective suggests that, like a computer, the mind operates on the basis of programs or rules that govern the ways it receives, processes, stores, retrieves and acts on information (Feldman & McPhee 2008:46-47).

- **Constructivism – the mind as maker of meaning:** Constructivists depict the mind as a 'builder' or 'maker of meaning'. Essentially, it means that knowledge is what we make of it, and that without minds there would be no knowledge. The mind builds what it knows in an organic and subjective fashion to create (or construct) meaning from experience through the interpretation of this experience (Feldman & McPhee 2008:53).

The three broad learning theory perspectives of behaviourism, cognitivism and constructivism are investigated and described in some more detail in subsequent sections. They are presented in a roughly historical order rather than in order of importance.

In a fairly recent development Siemens (2005) proposed *connectivism* as a learning theory for the digital age. Judging by its description, it may have potential for the integration of technology in teaching and learning in the digital age which is the focus of this research. Connectivism is, therefore, also investigated and described in some more detail.

2.6 BEHAVIOURISM

Behaviourism began its rise as the leading psychological discipline in the early part of the 20th century with Pavlov, Watson and Skinner as some of its prominent proponents (Schunk 2008:27-76). In education, however, behaviourism is mostly associated with Skinner's operand conditioning theory in contrast to other forms of behaviourism such as Pavlov's classical conditioning theory (Newby et al. 2006: 26-27).

2.6.1 Behaviourist definition of learning

A primary assumption of the behaviourist perspective is that the focus should be on the behaviour of the learner, and that learning is largely determined by the external environment (Newby et al. 2006:27). From this perspective, human learning can be explained only in terms of observable behaviours and the environmental conditions that influence them. All human behaviours can be described and predicted in terms of the associations between external stimuli and the responses to these stimuli (Feldman & McPhee 2008:41). Behaviourists acknowledge the existence of internal (or hidden) mental operations and events, but do not consider them necessary to describe learning because they believe that the causes of learning are external, observable environmental events (Schunk 2008:16 & Feldman & McPhee 2008:41).

Schunk (2008:16) defines behaviourist learning as a change in the rate, frequency of occurrence, or form of behaviour or response, which occurs primarily as a function of environmental factors. Behaviourism contends that learning involves the formation of associations between stimuli (from the environment) and responses (by the learner). The probability that a response to a particular stimulus will occur in the future is seen as a function of the consequences of the response: reinforcing consequences make the response more likely to occur, whereas punishing consequences make it less likely.

2.6.2 Basic assumptions of behaviourism

According to Feldman and McPhee (2008:29) all dominant forms of behaviourism postulate the following three principles:

(i) There is a predictable and reliable link between a stimulus and the response it produces.

(ii) It is possible to predict and shape with a high degree of certainty someone's behaviour in a specific situation by studying and manipulating the environmental conditions that influence behaviour.

(iii) Learner behaviour can be strengthened or weakened by introducing various kinds of reinforcement.

The behaviourist learning process can be described by the following A-B-C model:

A (Antecedent) ⇨ B (Behaviour) ⇨ C (Consequence)

The environment (e.g. parent, teacher or instructional system) presents an '**A**ntecedent' (stimulus) that prompts a '**B**ehaviour' (response) that is followed by some '**C**onsequence' (reinforcement). Reinforcement involves adding a stimulus to a response which increases the future likelihood of a desired response occurring again in that situation. Learning is said to have occurred when a learner consistently behaves in the desired way in response to a specific antecedent (Newby et al. 2006:28 & Schunk 47-48).

2.6.3 Behaviourist view of teaching

The behaviourist learning theory assumes that the teacher serves as a subject-matter authority who controls the amount, manner and sequence of the delivery of information. Teaching is seen as the process of transferring (dispensing, communicating, conveying and mapping) information from teacher to learner (Feldman & McPhee 2008:42). Another responsibility of the behaviourist teacher is to arrange the environmental conditions (antecedents and consequences in the A-B-C model) in such a way that will help learners to learn optimally. This can be achieved as follows (Newby et al. 2006:28):

- State instructional objectives as specific learner behaviours (B in the A-B-C model) that, when successfully performed, will indicate that learning has occurred. This includes identifying the goal and breaking it into a set of simpler behaviours that can be combined to form the desired behaviour.

- Use cues (A) to guide learners to the goal. These can be gradually withdrawn to ensure that the behaviour is linked to the appropriate antecedent.

- Use consequences to reinforce desired behaviour by identifying appropriate reinforcers and arrange them so that the desired behaviour is reinforced.

2.6.4 Behaviourist view of learning content

Behaviourists construe knowledge (learning content) not as something that resides in the mind and guides our actions, but rather as an ability to do things. In this view, knowledge is a repertoire of actions or the rules of actions that can be demonstrated or performed (Feldman & McPhee 2008:41-42). Furthermore, behaviourists believe that there is an ‘objective’ real world that is external to humans and independent of human experience, and that this real world is structured. This is why they structure and compartmentalise the real world (reality) into a curriculum with discrete and separate subjects with virtually no cross-curriculum integration. Behaviourists further believe that this ‘objective’ reality and its structure and meaning can be modelled for, ‘mapped’ onto, and transmitted and communicated to the learner. They also believe that everybody gains the same understanding of reality. A concept (learning content) from this ‘objective’ real world that serves as a lesson topic, is usually decomposed, simplified and broken up into smaller units and presented piece by piece to learners. Such a presentation of learning content is almost always done decontextualised, meaning that learning content is presented outside its natural context in which it is embedded, or from which it originates (Jonassen 1991a:8-10).

Feldman and McPhee (2008:43) believe that behaviourist methods are most effective in teaching topics (learning content) for which there is a single correct response, easily memorised materials, and/or discrete content such as facts, formulas, definitions and vocabulary. It is also effective in teaching manual skills and other performance activities with simple sequences of steps.

2.6.5 Behaviourist view of the role of technology

Behaviourist teaching is about transmitting and communicating knowledge (information, messages, etc.) to learners. This is exactly the role that behaviourists assign to technology: transmitting and communicating knowledge (information, messages, etc.) to learners. Newby et al. (2006:28-29) describe how the A-B-C model is used to create instructional computer programmes consisting of carefully sequenced learning content units, often called frames. A concept is broken up into smaller units and each assigned to a frame. Each frame includes information along with a question, problem or exercise (the antecedent in the A-B-C model), an opportunity for the learner to respond (the behaviour in the A-B-C model), and a reinforcing feedback (the consequence in the A-B-C model). The knowledge needed to move from one frame to the next is purposely kept small in order to increase the frequency of correct responses and, therefore, the frequency of reinforcement.

Computer-assisted instruction (CAI - also known as computer-based instruction (CBI)) that was the most common application of the computer in learning since the 1970s until recently, is based on behaviourist approaches. Well-known CAI modes include tutorial, drill and practice, game, simulation and problem-solving programs (Newby et al. 2006:28-30, Feldman & McPhee 2008:45 & Schunk 2008:69-71). In these technology applications learners learn from technology what the technology knows or has been taught, just as they learn from the teacher what the teacher knows. This role of technology is described as **learning from technology** *(*Jonassen, Peck & Wilson 1999:2).

2.6.6 Critique of behaviourism

Although behaviourism has provided the basis for many innovations in teaching over the past century, it also has its shortcomings. The following are some of the concerns highlighted by Feldman and McPhee (2008:70-71):

- The full range of human learning cannot be adequately explained in terms of simple stimulus-response relationships, external reinforcements and other behavioural principles.

- Dissecting learning content into simpler elements or units to narrowly focus learning objectives and then sequencing it for increasing levels of difficulty, is not suitable for all subjects and learning tasks.

- Behaviourist learning can be highly mechanistic and fail to engage learners in more natural ways of learning that involve real-life situations.

- Behaviourist approaches can produce inflexible, rote learning that is only the reproduction of information or habitual performance of a skill rather than deep learning that involves higher-order thinking skills.

- Behaviourist assessment that assesses only that which can be easily measured in objective terms, is too narrow in its scope and cannot determine whether learners actually possess competence.

2.7 COGNITIVISM

Behaviourism developed as a reaction to the study of mental phenomena that characterised 19^{th} century psychology. Similarly, cognitivism developed as a reaction to behaviourism. During the 1950s a growing dissatisfaction with behaviourism's inability to adequately explain complex behaviours such as language acquisition came to a head. This led to a search for new ways of explaining human learning. Theorists began to move away from a behavioural orientation where the emphasis is on promoting a learner's overt performance by manipulating stimulus material, to a cognitive orientation where the emphasis is on promoting mental processing (Ertmer & Newby 1993:58 & Newby et al. 2006:30-31). This movement occurred more or less at the same time as the development of high-speed computers. The coming together of these two trends resulted in the development of the information processing view of human cognition. Although this view is not the only one that has developed from cognitive psychology, it has been a prominent view in instructional practice (Newby et al. 2006:31).

2.7.1 Cognitivist definition of learning

In contrast to behaviourism's definition of learning as a change in behaviour, learning is defined in cognitivism as a change in knowledge stored in memory (Newby et al. 2006:31). Cognitive theories focus on the conceptualisation of learning processes and address the issues of how information is received, organised, stored and retrieved by the mind. Knowledge acquisition (learning) is described as a mental activity that entails internal coding and structuring of information by an active learner (Ertmar & Newby 1993:58).

2.7.2 Basic assumptions of cognitivism

Cognitivists do not entirely reject behaviourist principles. They recognise the role of the environment in shaping learning, but do not try to explain all aspects learning in terms of changes in behaviour (Feldman & McPhee 2008:47). The focus is more on the internal (mental) processes that intervene between receiving stimuli and producing responses (Schunk 2008:132). Learners are seen as active seekers and processors of information in which they select and attend to features of the environment, transform and rehearse information, relate new information to previously acquired knowledge, and organise knowledge to make it meaningful (Mayer in Schunk 2008:132). Some of the sub-theories that contribute to the cognitive perspective of learning are the schema, stage and cognitive load theories.

Central to schema theory is the concept of schemata. Schunk (2008:155) describes a schema as a structure that organises large amounts of information into a meaningful system. Feldman and McPhee (2008:47) explain it as a dynamic, evolving cognitive representation that functions as a 'mental' map or knowledge network used by the mind to focus attention, organise memory, interpret experiences and govern behaviour. Learners' understanding and recall of what they experience depend largely on how the content of these experiences interacts and integrates with and modifies their pre-existing mental models.

According to Feldman and McPhee (2008:47-48) the stage theory (described by Schunk (2008:132-133) as the two store (dual-memory) model) examines how information and experiences are processed in terms of three steps: the input of sensory data; the processing of this data in short-term memory; and if important, the transfer of this information to and its consolidation in long-term memory. Driscoll (in Newby et al. 2006:31) identifies and describes three processes involved in the mind's processing of information: attention, encoding and retrieval. Attention refers to the process of taking in some information from the environment while ignoring other information, encoding means translating information into some meaningful, memorable form, and retrieval refers to recalling information for a particular purpose. Figure 2.1 is a schematic representation of the stage theory.

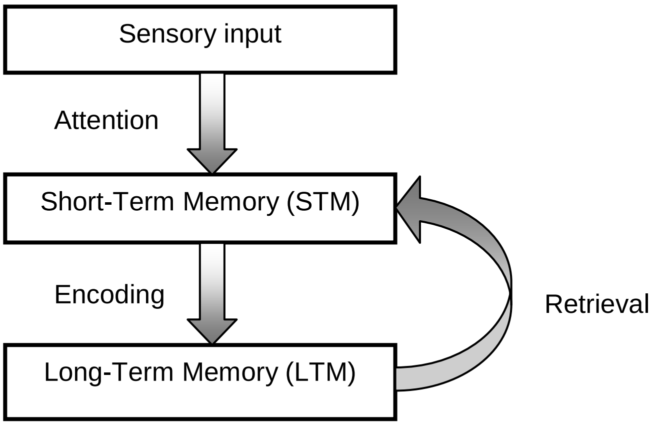

Figure 2.1: The role of attention, encoding and retrieval in human memory (Newby et al. 2008:31)

Information processing in the mind is described as follows (Schunk 2008:133, Feldman & McPhee 2008:47-48 & Newby et al. 2006:31). It begins when a stimulus input impinges on one or more of the senses. The appropriate sensory register receives the input and holds it briefly in sensory form. It is here that perception (pattern recognition) occurs as the process of assigning meaning to a stimulus input (i.e. matching an input to known information). Next, the sensory register transfers the information to the short-term memory (STM) or working memory that has a capacity of approximately seven units of information and a duration of about 20 seconds. While the information is in the STM, related knowledge in the long-term memory (LTM) is activated and placed in the STM to be integrated with the new information. In other words, the new information is encoded in a process that: creates a coherent organization that makes new information more meaningful; allows related information to be linked together; and stores it with 'search cues' that enables finding and retrieving information at a later time.

Cognitive load theory states, according to Feldman and McPhee (2008:48), that the amount of information a learner can handle and learn is determined by the rules and limits of the STM which is considered to be about seven pieces of information. 'Chunking' is used to overcome this by organising information into 'chunks' or units that are more easily manipulated and transferred to the LTM.

Cognitivists often use the computer as an analogy of how the human mind stores information. However, Schunk (2008:151) highlights an important difference. He describes human memory as *content addressable*, meaning that related information on the same topic is stored together. In contrast, computer memory is described as *location addressable*, meaning that computers have to be told where the information is stored.

2.7.3 Cognitivist view of teaching

The emphasis in the cognitivist perspective is on learners' cognitive processes, and on the critical role that memory plays in helping them to translate new information into a meaningful form that they can remember and use. Teaching in this context, is seen as a deliberate effort to help learners make this translation. The primary responsibility of the teacher, therefore, is to effectively communicate, transmit or transfer information to the learner, and to create conditions that will support the learner's cognitive processing of this information (Ertmer & Newby 1993:60-61, Newby et al. 2006:31-32 & Feldman & McPhee 2008:50). This includes doing the following:

- Organize and sequence new information (learning content) in some explicit way that establishes order in the information. This will assist learners in making sense of it and to encode it.

- Link new information to existing knowledge to make it more meaningful.

- Use memory aids (e.g. highlighting, mnemonics, analogies, metaphors and imagery) to help learners attend to important information, encode that information into a memorable form, and retrieve that information when needed.

2.7.4 Cognitivist view of learning content

Cognitivists share the behaviouristic believe in the existence of the real world external to humans and independent of human experience. Knowledge (learning content), therefore, is viewed as external to and independent of the learner.

Knowledge is treated as an 'object' that can be manipulated by a teacher and transferred to and deposited in the mind of the learner. The difference, however, is that whereas behaviourists describe knowledge only in terms of external observable behaviours, cognitivists also view knowledge in terms of unobservable representations of the world transmitted to the mind and held there in dynamic mental networks (Jonassen 1991a:8-10 & Feldman & McPhee 2008:48-49).

In cognitivist approaches learning content is organised, sequenced and presented in a manner consistent with the rules and processes that govern how the mind works. Such rules and processes include the importance of linking new information to prior knowledge, and information-processing and memory limitations. Content topics are presented in a manner that mirror the way the mind naturally processes information by, for example, linking it to prior knowledge, organising it in manageable chunks, and using conceptual frameworks that highlight the structure of the content (Feldman & McPhee 2008:50-51).

2.7.5 Cognitivist view of the role of technology

Cognitivism is characterised by its view of learners as active seekers and processors of information in which they translate and integrate new information into pre-existing knowledge structures to make it more meaningful and memorable. Feldman and McPhee (2008:52) declare that this cognitive view of the mind naturally leads to the use of computers as an extension of the human mental modelling system. Newby et al. (2006:32-34) agree by stating that technology has the potential to provide the means (or tools) to facilitate the organisation, chunking, linking, assimilation and accommodation of new information in memory. The following are some examples of how technology can be used to support and enhance learners' cognitive processing of new information into knowledge structures:

- Mind/concept map software that chunks large amounts of information and develops usable outlines that could help learners to recognise key elements within a targeted concept (Newby et al. 2006:32).

- Simulation and graphics software that model and simulate concepts that could assist learners in forming and developing mental models (Feldman & McPhee 2008:52).

- Software that guides learners how to deal with the overwhelming volume of Web information by providing basic information pages that give the overall content, but then also facilitates information processing by providing tools that assist learners in organising, reflecting about, discussing, visualising and assessing the information they have gathered (Newby et al. 2006:32-33).

- Spreadsheet software that helps learners to visualise data in the form of charts and graphs (Newby et al. 2006:33).

- Word processor software that assists learners to see information in different and more relevant ways – for example, a table that compares characteristics of different concepts (theories, principles, types, etc.). Structuring information in this way could enhance the processing and assimilation of the presented information (Newby et al. 2006:33).

- Multimedia software that provides multiple perspectives of a topic in audio, textual and pictorial formats could help learners in recognising meaningful prior knowledge, its relationship with the new information and the overall structure of the new information (Newby et al. 2006:33-34).

2.7.6 Critique of cognitivism

Feldman and McPhee (2008:72-73) raise the following limitations of and concerns about cognitivism:

- The basic assumption that the human mind works by developing mental representations and in accordance with computational rules is still largely conjecture that might be fundamentally mistaken. Many theorists see the mind not as a computing device, but as a dynamic, adaptive and highly complex system that cannot be understood in terms of elementary components, logic and computational rules.

- Cognitive science with its many sub theories or partial theories, lacks the unity and clarity that are required to apply its concepts and findings readily in classroom practice.

- The emphasis on limited, pre-determined expectations and goals for acquiring skills and procedural knowledge can limit the potential for learning deeper conceptual knowledge and higher-order thinking skills.

- Rules that describe how the mind works do not provide the flexibility needed to address individual differences such as differences in learning needs and preferences in processing information.

- It can be a challenge, especially for novice teachers, to systematically implement cognitivist strategies because classroom applications of cognitive research are not always clear and evident.

2.8 CONSTRUCTIVISM

Constructivism is a relatively recent development that gained prominence since the early 1990s. Like most other learning theories, it has multiple roots in the philosophical and psychological viewpoints of the past, especially the theories of prominent thinkers such as Piaget, Vygotsky and Bruner (Ertmer & Newby 1993:62, Newby et al. 2006:34, Feldman & McPhee 2008:54 & Schunk 2008:235). Constructivism represents the current status of a shift that is evident in the history of learning theory development. This shift started with the advent of cognitivism which disputed the claims of behaviourism that stimuli, responses and consequences are adequate to explain learning. Cognitivism emphasises learners' processing of 'objective' information as a central cause of learning. However, some researchers have felt that cognitivism fails to capture the complexity of human learning. Their focus has shifted to how knowledge is constructed, rather than how it is acquired (Jonassen 1991a:5-6, Ertmer & Newby 1993:62 & Schunk 2008:235).

Two dominant strands of constructivism have emerged from the many theoretical perspectives that are loosely grouped as constructivism: cognitive constructivism and social constructivism. Cognitive constructivism is based on Piaget's cognitive development theory that focuses on the personal, individual character of learning. Social constructivism is based on Vygotsky's sociocultural theory that emphasises the social-cultural nature of learning (Maddux et al. (2001:133&142 & Feldman & McPhee 2008:54). However, for the purpose of this research these two strands are considered to be complementary perspectives in the broader concept of constructivism.

2.8.1 Constructivist definition of learning

Newby et al. (2006:34) define constructivist learning simply as a change in meaning constructed from experience. Meaning in this case is defined as a *subjective interpretation* of experience, as opposed to cognitivism's definition of knowledge as an *objective representation* of experience (Jonassen 1991b:28-29).

A basic assumption of constructivism is that learners actively construct, reconstruct, create, invent, and develop their own knowledge (Marlowe & Page 1998:10, Schunk 2008:237 & Feldman & McPhee 2008:56) through interactions with other humans and artefacts of the world in an effort to make sense of the world around them (Jonassen et al. 2000:108). Learners construct their own reality or at least interpret it based on their perceptions of experiences. A learner's knowledge is a function of his or her prior experiences, mental structures, and beliefs that are used to interpret objects and events. The mind, the agent of knowing (and learning), filters input from the world in making those interpretations. What someone knows is grounded in the perceptions of physical and social experiences that are comprehended by the mind. The mind produces mental models that represent what the knower has perceived and experienced. These models are then used to explain, predict, or infer phenomena in the real world (Jonassen 1994:34-35).

Our prior experiences, knowledge, and schemata affect how we interpret and experience new events. Our interpretations of these new events, in turn, define our new learning and affect the construction of new knowledge structures and/or the reconstruction of existing knowledge structures (Marlowe & Page 1998:10). Attaining knowledge is, therefore, a dynamic process, subject to multiple revisions, elaborations and interpretations (Jonassen et al. 2000:108).

There is also a social dimension to constructivist learning. Vygotsky (in Maddux et al. 2001:135-136) emphasises the critical importance of interaction with people (other children, parents, teachers, etc.) in cognitive development. For him learning is significantly influenced by the social context, because the culture gives the child the cognitive tools needed for development. Adults such as parents and teachers are conduits for the tools of the culture, including language, cultural history, and social context. Learners' cognitive development occurs in social or group settings, which form the basis for what is known as collaborative learning today.

2.8.2 Basic assumptions of constructivism

Jonassen, Peck and Wilson (1999) describe a number of basic assumptions of constructivist learning that are summarised below:

- **In constructivist learning knowledge is constructed, not transmitted**: Constructivists believe that knowledge cannot be simply transmitted by the teacher or an instructional system to the learner. Teaching is not a process of transmitting, imparting or mapping the teacher's knowledge onto the learner because the learner has not experienced all that the teacher has. Instead teaching is seen as a process of helping learners to construct their own meaning from their own experiences by providing those experiences in meaningful learning environments, and by guiding them in the meaning-making process (Jonassen et al. 1999:3).

- **Knowledge construction results from activity, in other words, knowledge is embedded in activity**: Constructivists argue that we cannot separate our knowledge of things from our experiences with them. We can only interpret knowledge in the context of our own experiences (interactions) which implies that the meaning we make emerges from the interactions we have. Learners can certainly memorise facts that they have not experienced, but they probably do not make much meaning of those facts (Jonassen et al. 1999:3).

- **Knowledge is anchored in and indexed by the context in which the learning activity occurs**: The knowledge of phenomena that learners construct and the associated skills they develop include information about the context in which they experience those phenomena. The knowledge that learners construct consists of not only the ideas (content), but also of the context in which it was acquired. So, the more directly and interactively learners experience phenomena in meaningful contexts, the more meaning about it they are likely to construct. In contrast, knowledge that is taught divorced from its context, have little meaning for learners, and results in inert knowledge that learners are unable to use outside the classroom (Jonassen et al. 1999:3-4).

- **Meaning is in the mind of the knower**: Through the meaning-making process perceptions of the external, physical world are constructed in the mind. These perceptions are unique to every individual. This is so because every individual has a unique set of experiences that produce unique combinations of beliefs and knowledge structures about that world. The perceptions that one learner constructs of the world are necessarily somewhat different from those of another learner. They can, however, share their perceptions by socially negotiating shared meanings. In other words, the meaning-making process is also a function of social negotiation by conversing with others and agreeing on the meaning of things. The important point is that knowledge is not an existing, external object that is transmitted to and acquired by the learner – it can only be constructed in the mind by the learner (Jonassen et al. 1999:4).

- **There are multiple perspectives on the world**: No two persons have the same set of experiences of the world and perceptions of those experiences. Everyone constructs his or her own knowledge, which in turn affects the perceptions of the experiences that we have and those we share. The perceptions and beliefs that a person constructs in this way differ somewhat from those of others. This explains why there are often ‘differences of opinion’ on any given subject (Jonassen et al. 1999:4).

- **Meaning making is prompted by a problem, question, confusion, disagreement, or dissonance, and involves personal ownership of that problem**: Meaning making often starts with a problem, question, discrepancy, curiosity, wonderment, puzzlement, perturbation, expectation violation, cognitive dissonance, or disequilibrium. The knowledge construction process is, therefore, initiated by a dissonance (a need or desire to know) between what is known and what is observed in the world. When a learner seeks to resolve that dissonance, it becomes his or her problem and not the teacher’s. Resolving that dissonance ensures some ownership of the solution and answers on the part of the learner. It is this ownership that makes the knowledge that has been constructed, more relevant, important and meaningful to the learner (Jonassen et al. 1999:5).

- **Knowledge building requires articulation, expression, or representation of what is learned**: It often happens that no knowledge is constructed from activities in which people are engaged, because they do not reflect on or think about their experiences from those activities. For knowledge to be constructed, learners not only need to become actively involved, but they also need to reflect on what they did and articulate what it means. This articulation, expression, or representation can be in a verbal, written, visual, or auditory format (Jonassen et al. 1999:5).

- **Meaning can be shared with others, so meaning making can also result from conversation**: Humans are social creatures who rely on interactions with fellow humans to determine their own identity and the viability of their personal beliefs. Constructivists believe that meaning making is also a process of social negotiation among members of a culture through dialogues and conversations. Such dialogues occur most effectively within knowledge-building, discourse, or conversation communities where people share their interests and experiences (Jonassen et al. 1999:5).

- **Meaning making and thinking are distributed throughout our tools, culture, and community**: As members of knowledge-building communities interact and share with each other, their knowledge and beliefs about the world are influenced by that of the community. Through participating in the activities of the community, its members absorb part of the community's integral culture, just as the culture is affected by each of its members. Communities of learners can be seen as a widely distributed memory of what the group as a whole knows which is clearly more capacious than individual memories. This also implies that just as the cognitive achievements of individuals vary, the cognitive attributes and accomplishments of communities also vary. Just as an individual's knowledge is influenced by his or her individual activities in and interactions with the world, it is also influenced by the perceptions and beliefs of fellow community members (Jonassen et al. 1999:5-6).

- **Not all meaning is created equally**: Constructivists do not subscribe to the view that all meaning is equally valid because it is personally constructed. The 'litmus test' for individually constructed knowledge is its viability. That is, an individual's ideas must be in agreement, compliance, and consonance with community standards that represent the mutually agreed and accepted collective wisdom of the community at any point in time (Jonassen et al. 1999:6).

These eleven basic assumptions of constructivist learning are synthesised into five **constructivist principles of learning** because it represents the nature, character and essence of constructive learning. That is, it describes that which is inherent to constructivist learning. The five principles are based on the characteristics of meaningful (i.e. constructivist) learning described by Jonassen, Howland, Marra and Crismond (2008:2-5) as active, constructive, intentional, authentic, and cooperative. The value of such principles is that it can be used as guidelines in designing and implementing constructivist learning events.

(a) Principle of active learning

Human learning is a natural, adaptive process. When humans learn about things in natural contexts, they interact with their environment and manipulate the phenomena in that environment. By observing the effects of their manipulations they construct their own interpretations and meaning of the phenomena and the results of their manipulations (Jonassen et al. 2008:2-3). Knowledge and meaning therefore results from activity, in other words it is embedded in activity. Constructivists believe that we cannot separate our knowledge of phenomena from our experiences and interactions with those phenomena. We can only interpret knowledge in the context of our own experiences (interactions), which implies that the meaning we construct of phenomena emerges from our interactions with it. Learners can certainly memorise facts that they have not experienced, but they probably do not make much meaning of those facts (Jonassen et al. 1999:3).

(b) Principle of own knowledge construction

Activity on its own is not sufficient for meaningful learning. It is essential that learners reflect on their manipulations and activities and articulate what they have accomplished. New experiences often provide learners with a discrepancy between what they observe and what they know and understand. This creates puzzlement that is the catalyst for meaning making. By reflecting on the puzzling experience, learners integrate their new experiences with their prior knowledge about the world in order to make sense out of what they observe. In this way learners begin constructing their own simple mental models of what they observe. With more experience, reflection and support their mental models become increasingly complex. The active and constructive parts of the meaning-making process are symbiotic and rely on each other for meaning making to occur (Jonassen et al. 2008:3). Teaching is not seen as a process of transmitting, imparting or mapping the teacher's knowledge onto learners, but as helping and guiding them to reflect and construct their own knowledge, and to articulate, express and represent what they have learned and achieved (Jonassen et al. 1999:3).

(c) Principle of social interaction

This principle is based on Vygotsky's (in Maddux et al. 2001:135-136) social dimension of learning. He emphasises the critical importance of interaction with people (other children, parents, teachers, etc.) in cognitive development. For him learning is significantly influenced by the social context, because the culture gives the child the cognitive tools needed for development. Jonassen et al. (1999:5 & 2000:109) argue that humans naturally work together in learning, solving problems and performing tasks by exploiting each other's skills and appropriating each other's knowledge. They are social creatures who rely on interaction with fellow humans to determine their own identity and the viability of their personal beliefs. Meaning can be shared with others, so meaning making can also result from discussions and conversations with others. Constructivists believe that meaning making includes a process of social negotiation in which members of a culture share experiences, understandings and meanings, and reach consensus through dialogue and conversation.

(d) Principle of situated learning

This principle has its origins in the work of Brown, Collins and Duguid (1989) in which they argue that cognition should be situated in social and physical contexts. Jonassen et al. (1999:3-4 & 2008:4) explain that part of the meaning of a phenomenon is embedded in its context. Learning and cognition (understanding) of phenomena should, therefore, be situated in the social and physical context from which the phenomena originate. The knowledge of phenomena that learners construct and the associated skills they develop include information about the context in which they experience those phenomena. So, the more directly and interactively learners experience phenomena in meaningful contexts, the more meaning they are likely to construct. The implication is that teaching and learning a new concept should always take place in its real-life context, that is in the context in which the concept is embedded and from which it originates. Conversely, a concept that is taught divorced from its context (i.e. decontextualised), has little meaning for learners, and results in inert knowledge that learners are unable to use outside the classroom.

(e) Principle of intentional learning

All human behaviour is goal directed in the sense that everything we do is intended to fulfil some goal or need. The goal may be simple, like satiating hunger, or complex, like developing new career skills. Constructive learning usually results from puzzlement or some other dissonance between what is perceived about a phenomenon and what is understood. When this occurs, learners seek to understand the phenomenon in a way that resolves the dissonance. Learning then becomes oriented by an intention to resolve the dissonance. Resolving the dissonance becomes the cognitive goal for learners. When learners are actively and deliberately trying to achieve such a cognitive goal, they think and learn more because they are fulfilling an intention (Jonassen et al. 2000:111 & Jonassen et al. 2008:4).

2.8.3 Constructivist view of teaching

The primary responsibility of a teacher is to support learners to learn, which in a constructive perspective is described as constructing their own knowledge. Newby et al. (2006:35) see the role of the constructivist teacher as creating and maintaining a learning environment that has two essential characteristics: learning in context and collaboration. Learning in context implies that learners should apply their knowledge within the context of solving realistic and meaningful problems. Collaboration means that learners should get opportunities to work together as peers in solving problems. The resulting dialogues and interactions provide learners with opportunities to explore alternative interpretations and to test and refine their understanding.

Cunningham (in Ertmer & Newby 1993:66), on the other hand describes the role of the teacher in constructivist approaches as: showing learners how to construct knowledge; promoting collaboration between learners and others; showing multiple perspectives of a problem to be solved; and supporting learners in arriving at own understandings, while realising the basis of other views with which they might disagree.

Copley (in Maddux et al. 2001:134) provides yet another view in which constructivist teachers are viewed as facilitators whose main function is to help students become active participants in their learning and make meaningful connections between prior knowledge, new knowledge and the processes involved in learning.

In conclusion, the responsibilities of the teacher in the constructivist perspective can be described as creating and maintaining constructivist learning environments and facilitating learners in those environments to actively create and construct their own knowledge. Jonassen (1994:35) believes that constructivist learning environments have the following attributes:

- Provide multiple representations of reality
- Represent the natural complexity of the real world
- Focus on knowledge production, not reproduction
- Emphasise authentic tasks in meaningful contexts, rather than abstract instruction out of context
- Provide real-world, case-based learning environments, rather than predetermined instructional sequences
- Foster reflective practice by encouraging thoughtful reflection on experience
- Enable context- and content-dependent knowledge construction
- Support collaborative construction of knowledge through social negotiation, not competition among learners

2.8.4 Constructivist view of learning content

The nature of knowledge is so critical in constructivist teaching and learning that many theorists consider constructivism to be as much a theory of knowledge (or epistemology), as a theory of learning (Feldman & McPhee 2008:56 & Schunk 2008:236). Constructivists oppose the behaviouristic view that there is an 'objective' real world that is external to humans and independent of human experience, and that it can be communicated, transferred and mapped onto a learner. Instead, they believe that reality is more in the mind of the knower and that the knower constructs a reality or at least interprets it based on personal experiences and interactions with others. Constructivism does not reject the existence of an external reality, but merely claims that individuals construct their own realities through interpreting perceptual experiences of the world (Jonassen 1991a:10, Jonassen 1991b:28-29, Ertmer & Newby 1993:62-63 & Feldman & McPhee 2008:56-57).

Constructivists agree that the acquisition of knowledge that is advanced, complex, ill-structured and non-linear and that requires a high level of cognitive processing, is better supported by constructivist approaches. On the other hand, the acquisition of introductory knowledge that is linear, structured and requiring a low level of cognitive processing, is better supported by behavioural and/or cognitive approaches (Jonassen 1991b:30-31 & Ertmer & Newby 1993:64&67-69).

2.8.5 Constructivist view of the role of technology

Jonassen et al. (2008:5-7) describe the constructivist view of the role of technology as *learning with technology*, as opposed to the behaviourist view of *learning from technology*. The latter assumes that information (learning content) can be recorded or embedded into technology in order to communicate, transmit and deliver it to learners who have to passively assimilate it. In this way learners learn from technology what the technology 'knows', just as they learn from teachers what they know.

In contrast, the constructivist view of *learning with technology* is described as using technology as learning or cognitive tools to support, enhance and extend learners' abilities to construct their own knowledge. In particular, Jonassen et al. (2008:7-8) identify the following roles of technology in constructivist approaches:

- Technology as tools to support knowledge construction

- Technology as information vehicle for exploring knowledge to support learning by constructing

- Technology as authentic context to support learning by doing

- Technology as social medium to support learning by conversing

- Technology as intellectual partner to support learning by reflecting

The roles (or uses) of technology in learning are further explored and described in the next chapter.

2.8.6 Critique of constructivism

The constructivist learning theory does not necessarily provide theoretical foundations for all kinds of learning in all kinds of contexts. The following are some of its limitations that have been raised:

- **Theoretical perspective**: Constructivism is criticised for being more a theory/philosophy of knowledge (or epistemology) than a theory of learning. It is less amenable to research and experimentation than either behaviourism or cognitivism (Feldman & McPhee 2008:73).

- **Appropriateness for knowledge acquisition:** Constructivists argue that constructivist learning environments are most effective for advanced knowledge acquisition in ill-structured, multi-dimensional, and non-linear knowledge domains. However, there is also a need for acquiring the ‘nuts and bolts’ of facts, concepts and other concrete information, in other words introductory knowledge that is linear and well structured. Such knowledge acquisition is better supported by more behaviourist and/or cognitive approaches (Jonassen 1991b:30-32, Spiro, Feltovich, Jacobson & Coulson (1991:25 & Feldman & McPhee 2008:74).

- **Instructional design complexity:** Objectivist instructional designers seek to predetermine a set of learning outcomes, and a prescribed sequence of teaching and learning activities to achieve it. Well-developed instructional design models exist to guide teachers in this process. Constructivist designers, on the other hand, emphasise the design of learning environments in which learners construct their own knowledge through internal and social negotiations, and by means of authentic activities in authentic contexts. In such environments it is impossible to predetermine and prescribe a sequence of teaching and learning activities. Designing constructivist learning environments is much more difficult because there is no explicit design model for prescribing the sequence of instructional events. Many teachers may find this challenging (Jonassen 1994:35-37 & Feldman & McPhee 2008:74).

- **Learner preferences:** Some learners prefer instruction that moves from specific details to more general concepts and do not always benefit from the broad conceptual approach of constructivist teaching (Feldman & McPhee 2008:74).

- **Classroom organisation:** Constructivist approaches put high demands on planning, time, space and resources. This implies that it does not fit neatly in the traditional school organisation with its structured classrooms and time table (Maddux et al. 2001:172 & Feldman & McPhee 2008:74-75).

2.9 A LEARNING THEORY FOR THE DIGITAL AGE: CONNECTIVISM

Siemens (2005a) proposed *connectivism* as *"a learning theory for the digital age"* in 2005. The relevance of this development is immediately evident for this research that endeavours to identify and describe an appropriate theoretical foundation for integrating ICTs in 21st century learning. Being a recent development implies that connectivism is still in its infancy, and that literature debating its foundational principles and describing relevant research results is limited. It is therefore not possible to describe the principles and practices of connectivism to the same levels as for the other learning theories.

Siemens (2005a & 2006) argues that behaviourism, cognitivism and constructivism do not meet the learning needs of the digital age, because they were developed at a time when learning was not impacted by technology. Learning needs and theories that describe learning principles and processes, should be reflective of underlying social environments. In a changed and changing environment theorists naturally attempt to continue to revise and evolve theories. At some point, however, the underlying conditions have changed so significantly that further modification is no longer sensible. An entirely new approach then becomes imperative.

A number of change drivers in digital society that necessitate such a new approach are identified. This includes, firstly, that knowledge is growing exponentially. Gonzales (in Siemens 2005a) describes it as the shrinking half-life of knowledge (i.e. the time span from when knowledge is gained to when it becomes obsolete). This growth and abundance of information exceed human capacity to manage and make sense of it. Secondly, networks are everywhere. The persistent advancement of technology, especially the World Wide Web, has raised the profile of networks as a means of human organization (Siemens 2006 & 2008:). It provides a practical framework for communication, collaboration and content creation opportunities. Today's digitally literate students, also known as millennials, are immersed in a digital, media-rich and networked world in which they are constantly connected and in communication. When they enter educational spaces, they expect a participative, engaging, active and connected environment that is congruent with their digital lifestyles and skills. Thirdly, the increase in knowledge and the advancement of technology have contributed to complexification of knowledge (Siemens 2006). Through the use of an abundance of technology tools students are now able to create and produce more complex content that previously required substantial effort. Learning, augmented by technology, permits the assimilation and cognition of complex knowledge elements that are not possible without the technology. Siemens (2006) believes that these change drivers have brought society to a point of substantial change. *"A necessary reorganization is underway, resulting in new metaphors of learning and existence as a whole".*

The best metaphor to describe connectivism is ‘the mind as a network’. Connectivists describe learning as the act of forming network connections and recognising patterns of information distributed across networks (Siemens 2006 & 2008:10). The underlying assumptions and principles of connectivism are elaborated in the next section.

2.9.1 Basic assumptions of connectivism

Siemens (2008:10) describes the epistemological framework of connectivism as follows:

> *The concept of emergent, connected, and adoptive knowledge provides the epistemological framework for connectivism ... as a learning theory. Connectivism posits that knowledge is distributed across networks and the act of learning is largely one of forming a diverse network of connections and recognizing attendant patterns ... .*

In this view knowledge resides in a distributed manner across networks, and learning is the act of recognising patterns shaped by complex networks. These networks are internal, as neural networks where knowledge is distributed across the brain of the learner, and external, as networks actively formed by learners in which they learn about and adopt to the world around them (Siemens 2006).

Networks is a central tenet of connectivism, and this is how Siemens (2005b) describes it. A network requires at least two elements: nodes and connections. A node can be virtually any element that can be scrutinised or experienced, for example thoughts, feelings, interactions with others, and new data and information. A connection can be any type of link between nodes. The aggregation of such nodes and connections results in a network, which in turn can be combined with other networks to form a larger network. The information system underlying networks includes: data (i.e. a raw element with neutral meaning); information (i.e. data with intelligence applied); knowledge (i.e. information in context and internalised); and meaning (i.e. comprehension of the nuances, value and implications of knowledge). Data and information are database elements, meaning that they need to be stored and processed in a manner that permits dynamic updates within existing networks. Knowledge and meaning get their worth from the underlying data and information elements. Learning is the process of transforming knowledge into something of meaning. One part of this process includes the act of encoding and organising nodes to facilitate data, information and the flow of knowledge (i.e. forming a diverse network of connections). The other part comprises pattern recognition which is the process of recognising the nature and organisation of various types of information and knowledge (i.e. recognising attendant patterns).

Siemens (2005a) identifies the following principles of connectivism:

- *Learning and knowledge rests in diversity of opinions.*
- *Learning is a process of connecting specialized nodes of information sources.*
- *Learning may reside in non-human appliances.*
- *Capacity to know more is more critical than what is currently known.*
- *Nurturing and maintaining connections is needed to facilitate continual learning.*
- *Ability to see connections between fields, ideas, and concepts is a core skill.*
- *Currency (accurate up-to-date knowledge) is the intent of all connectivist learning activities.*
- *Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.*

It is clear that some of these connectivist principles differ fundamentally from behaviourist, cognitivist and constructivist perspectives.

2.9.2 Critique of connectivism

Most of the criticisms against connectivism are directed at its claim of being a learning theory. Verhagen (2006) argues that connectivism is a pedagogical view and not a learning theory. According to him connectivism addresses the curriculum level (*what* is learned and *why* it is learned) and not the instructional level (*how* learning takes place) as learning theories should. Kerr (2007) believes that, although we are entering some sort of period of radical change in which technology is affecting learning, connectivism does not provide the answers. Existing learning theories are sufficient to deal with it.

This research is not so much about the philosophical perspectives of learning theories, but rather about the principles, models, guidelines and designs for the implementation of learning practices. The emphasis in this study is on an appropriate theoretical foundation for the integration (implementation) of the technology requirements in the curriculum of secondary education in South Africa. From this perspective the following concerns about connectivism are raised:

- Connectivism is in its infancy and is not confirmed and accepted as a learning theory yet. Until connectivism is developed in all dimensions of a learning theory, it cannot be considered as a theoretical foundation for implementing aspects of a national curriculum. Connectivism in its current status, provides very little guidelines for the implementation of learning practices, especially at secondary school level.

- One of connectivism's key tenets is that knowledge resides in a distributed manner across networks. It includes technology networks, especially the Internet. It assumes that the learning environments for all learning institutions and all learners are saturated with the kind of technology that is required for the connectivist learning activities of forming diverse networks of connections, and communicating and collaborating. This assumption is at the moment not true or valid for schools in general in a developing country such as South Africa.

It is clear from the concerns above that connectivism in its current status of acceptance and development cannot be considered as a potential theoretical foundation for implementing the ICT requirements of the NCS. However, connectivism is an effort to understand and describe learning in a digital society with its exponential growth in knowledge, technology advancements and fundamental changes in human activities. It will be worth monitoring to see how it develops and succeeds in addressing the learning needs of the digital era.

In conclusion, the four learning theories are compared and summarised in Table 2.3 below.

Table 2.3: A comparison of the learning theories of behaviourism, cognitivism, constructivism and connectivism (Siemens 2008:11).

Property	Behaviourism	Cognitivism	Constructivism	Connectivism
How learning occurs	Black box – observable behaviour main focus	Structured, computational	Social, meaning created by each learner (personal)	Distributed within a network, social, technologically enhanced, recognising and interpreting patterns
Influencing factors	Nature of reward, punishment, stimuli	Existing schema, previous experiences	Engagement, participation, social, cultural	Diversity of network, strength of ties
Role of memory	Memory is the hardwiring of repeated experiences – where reward and punishment are most influential	Encoding, storage, retrieval	Prior knowledge remixed to current context	Adaptive patterns, representative of current state, existing in networks
How transfer occurs	Stimulus, response	Duplicating knowledge constructs of "knower"	Socialisation	Connecting to (adding) nodes
Types of learning best explained	Task-based learning	Reasoning, clear objectives, problem solving	Social, vague ("ill defined")	Complex learning, rapid changing core, diverse knowledge sources

2.10 OBJECTIVISM AND CONSTRUCTIVISM

Learning theories are often classified on the basis of their epistemological perspectives (i.e. views on the nature of knowledge). The two paradigms of learning theories identified and described in this way, are objectivism and constructivism (Bednar et al. 1991:90-92, Jonassen 1991a, Hannafin 1997 & Moallem 2001). Jonassen (1991a:8) describes them *"… as polar extremes on a continuum from externally mediated reality (objectivism) to internally mediated reality (constructivism)"*. The intention of this section is to contrast and compare these two paradigms in terms of their philosophical assumptions (refer Table 2.4) and classroom practices (refer Table 2.5). The purpose of such comparisons is to contrast their characteristics in order to enhance our understanding of the two paradigms of learning.

Behaviourism and most of the early cognitive theories are firmly rooted in the philosophical paradigm of objectivism. The metaphysical position (view on the nature of reality) of objectivism is that it believes in the existence of an 'objective' real world external to humans and independent of human experience, that this real world is structured, and that this structure can be modelled for the learner. This position assumes that everybody gains the same understanding of reality. The epistemological position (view on the nature of knowledge) of objectivism holds that the purpose of the mind is to 'mirror' that reality and its structure. It assumes that learning is the process of mapping the concepts of this external reality onto learners. Learners are not encouraged to make their own interpretations of what they perceive because it is the role of the teacher or the instruction to interpret objects or events for them. Learners are told about the world and are expected to replicate its content and structure in their thinking (Jonassen 1991a:8-10 & Bednar et al. 1991:90-91).

The metaphysical position of constructivism, on the other hand, claims that reality is constructed by the knower based upon the mental activities of perceiving and interpreting, and is therefore more in the mind of the knower. It assumes that everybody perceives the external reality somewhat differently, based on unique experiences with that reality. The epistemological assumption of constructivism is that the learner constructs his or her own knowledge, in other words that meaning is a function of how the learner creates meaning from his or her experiences. The role of the teacher is to create learning environments that provide opportunities for learners to experience reality through authentic activities in authentic contexts (Jonassen 1991a:10 & Bednar et al. 1991:91-92).

The philosophical assumptions of objectivism and constructivism are contrasted and summarised in Table 2.4.

Table 2.4: Assumptions inherent in objectivism and constructivism (Jonassen 1991a:9)

	OBJECTIVISM	**CONSTRUCTIVISM**
Reality (real world)	External to the knower Structure determined by entities, properties, and relations Structure can be modelled	Determined by the knower Dependent on human mental activity Product of the mind Symbolic procedures construct reality Structure relies on experiences/interpretations
Mind	Processor of symbols Mirror of nature Abstract machine for manipulating symbols	Builder of symbols Perceiver/interpreter of nature Conceptual system for constructing reality
Thought	Disembodied: independent of human experience Governed by external reality Reflects external reality Manipulates abstract symbols Represents (mirrors) reality Atomistic: decomposable into “building blocks” Algorithmic Classification What machines do	Embodied: grows out of bodily experience Grounded in perception/construction Grows out of physical and social experience Imaginative: enables abstract thought More than representation (mirrors) of reality Gestalt properties Relies on ecological structure of conceptual system Building cognitive models More than machines are capable of

Meaning	Corresponds to entities and categories in the world Independent of the understanding of any organism External to the understander	Does not rely on correspondence to world Dependent upon understanding Determined by understander
Symbols	Represent reality Internal representations of external reality ('building blocks')	Tools for constructing reality Representations of internal reality

Objectivism and constructivism can also be contrasted in terms of the characteristics of their respective practices in the classroom. This is done in Table 2.5 where the two paradigms are compared in terms of the role of the teacher, role of the learner, learning content, and learning environment.

Table 2.5: A comparison of some classroom characteristics of objectivism and constructivism (the references are valid for both objectivism and constructivism)

	OBJECTIVISM	**CONSTRUCTIVISM**
Role of the teacher	Authoritarian (Reeves & Harmon 1994) Always being viewed as the content expert and source for all answers (Newby et al. 2006:13) Being viewed as the primary source of information who continually directs it to learners (Newby et al. 2006:13) Always asking the questions and controlling the focus of learning activities (Newby et al. 2006:13) Transmitter of knowledge (McRae 2001:81) 'Sage on the stage' (Reigeluth 1996:14)	Egalitarian (one who believes in equal rights) Participating at times as one who may not know it all but desires to Being viewed as a support, collaborator, and coach for learners as they learn to gather and evaluate information for themselves Actively coaching learners to develop and pose their own questions and explore their own ways of finding answers Facilitator of learning 'Guide on the side'

Role of the learner	Passively waiting for teacher to give directions and information (Newby et al. 2006:13) Always being in the role of the learner (Newby et al. 2006:13) Always following given procedures (Newby et al. 2006:13) Viewing the teacher as the one who has all the answers (Newby et al. 2006:13)	Actively searching for needed information and learning experiences, determining what is needed, and seeking ways to attain it Participating at times as the expert/knowledge provider Desiring to explore, discover, and create unique solutions to learning problems Viewing the teacher as a resource, model, and helper who will encourage exploration and attempts to find unique solutions to problems
Learning content	Compartmentalism (syllabus is content-based and broken down in subjects) (Reigeluth 1996:13, comments in brackets added) Single perspectives are offered (McRae, 2001:81)	Holism (an integration of knowledge; learning relevant and connected to real-life situations) Multiple perspectives are offered and cultivated
Learning environ-ment	Provides oversimplified single representations of reality (Jonassen 1994:35) Emphasises abstract instruction out of context (Jonassen 1994:35) Provides predetermined sequences of instruction (Jonassen 1994:35)	Provides multiple representations of reality that reflect the complexity of the reality Emphasises authentic tasks in a meaningful context Provides real-world settings and case-based learning

A comparison of two entities such as in Tables 2.4 and 2.5 should be read with great caution. McRae (2001:81) calls it a binary comparison and points out certain problems associated with it. It is not simply a case of two opposite, disjunct or discrete approaches to learning in which no characteristics of the one will ever be found in the other. In practice, for example, the constructivist teacher will at times find it necessary to transmit basic knowledge by means of a lecture (a behaviourist characteristic). Likewise, a behaviourist teacher may involve learners in collaborative learning by means of a group task (a constructivist characteristic). In practice it is possible for a teacher to assume a position anywhere between these two ‘polar extremes’ on a continuum of learning views.

The investigation in this research regarding an appropriate theoretical framework for integrating ICTs in the NCS is continued in terms of the objectivist and constructivist paradigms of learning.

2.11 THEORETICAL FOUNDATION FOR INTEGRATING TECHNOLOGY IN LEARNING

This chapter set out to determine an appropriate theoretical foundation for integrating technology into the learning environment. After studying the seemingly opposing learning paradigms of objectivism and constructivism, there is the expectation that constructivism is the way to go. The objective of this section is to consider these two philosophical approaches in the broader context of learning in the 21st century, and propose a theoretical foundation for integrating the ICT requirements of the NCS into classroom learning.

2.11.1 Learning theory foundation of the NCS

OBE is recognised as the foundation of the NCS (Department of Education 2003n:2). It prescribes a hierarchical set of outcomes at different levels that learners should achieve at the end of the education process. However, as important as OBE is, it is in itself is not a learning theory. To identify and understand the learning theory foundation of the NCS it is necessary to examine some of the key concepts and characteristics of OBE, and to interpret it (by the researcher) in terms of learning theories. This is done in Table 2.6 below.

Table 2.6: A learning theory interpretation of some of the key concepts of the NCS

Key concepts of NCS/OBE	Learning theory interpretation
OBE encourages a learner-centred and activity-based approach to education (Department of Education 2003:2)	Constructivist principle of active learning
Critical outcome 2: Learners should be able to work effectively with others as members of a team, group, organisation and community (Department of Education 2003:2)	Constructivist principle of social interaction
Critical outcomes 1 and 3: Learners should be able to identify and solve problems and make decisions using critical and creative thinking, and organise and manage themselves and their activities responsibly and effectively (Department of Education 2003:2)	Constructivist principle of knowledge construction
Learning contexts support the learning process (Department of Education 2003:32)	Constructivist principle of situated learning

More key concepts can be added, but they all relate in principle to constructivist approaches. So it is clear that constructivism is the learning theory foundation of the NCS. Does this mean that objectivist approaches have no place in implementing the ICT requirements of the NCS? The next section investigates this issue.

2.11.2 Objectivism versus constructivism

Objectivism and constructivism are usually conveyed as incompatible and mutually exclusive (Jonassen 1999:217). This has created a tension between the two approaches to learning that is steeped in controversy and debate in which one side has to win and the other to lose (Cronje 2000 & Feldman & McPhee 2008:77). Jonassen (2003), in debating this issue in his article *The Vain Quest for a Unified Theory of Learning*, argues that ideologues have a natural tendency to protect their theoretical turf by rejecting other theories in order to prove the supremacy of their own preferred theory. Too many papers and conference presentations contrast the efficacy of objectivism and constructivism, thereby polemicising the debate. He believes that such a polemicising is retarding our understanding of learning, and gives two reasons why it is inappropriate. *Firstly*, polemicisation is a form of epistemological dualism. In other words, it is a very primitive and absolute belief that truth is more or less absolute and in conflict with falsehood, and that right and wrong, and good and bad can easily be distinguished. Such a dualism is an unacceptably simplistic epistemological foundation for understanding something as complex as learning. *Secondly*, learning is such a complex phenomenon that no single unified theory of learning is possible, let alone desirable. Just because the newer theory of constructivism describes learning in fundamentally different ways than the traditional theory of objectivism, it doesn't mean that constructivism necessarily obviates objectivism.

For Ertmer and Newby (1993:67), Newby et al. (200638-39) and Feldman and McPhee (2008:77) the question is not "Which is the best theory?", but "Which theory is the most effective in teaching and learning specific knowledge in specific circumstances?" In other words, they suggest there are circumstances in which one particular learning theory will be more effective, and other circumstances where another learning theory will be more effective. These theorists, therefore, recommend a complementary co-existence of learning theories that is described by Jonassen (2003:8) as follows:

> *All of the theories described before are able to describe some aspects of learning in some contexts. So let us consider them as views of different aspects of learning, because learning is a phenomenon so complex that it cannot be adequately explained by any single theory*.

Jonassen (1991a), Ertmer and Newby (1993:52&68) and Feldman and McPhee (2008:77-80) also suggest that learning theories can be positioned on a continuum. Jonassen (1991a:8) describes a continuum of philosophical paradigms of learning that ranges from externally mediated reality (objectivism) to internally mediated reality (constructivism).

The question now is “What are the ‘circumstances’ most appropriate for each paradigm of learning?” Jonassen (1991b:30-32), answers this question in terms of the level of expertise required in acquiring knowledge. He distinguishes three phases of knowledge acquisition: introductory, advanced and expert knowledge acquisition.

- **Introductory knowledge acquisition:** Knowledge acquisition in introductory learning occurs when learners have very little directly transferable prior knowledge about a skill or content area in a linear and well-structured knowledge domain. This kind of learning represents the initial stages of building and integrating internal knowledge structures and is better supported by more objectivistic approaches.

- **Advanced knowledge acquisition:** When learners need to acquire more complex knowledge they move into the second (and intermediate) phase that is called advanced knowledge acquisition. In this phase learners need advanced knowledge to solve complex problems in nonlinear, multi-dimensional and ill-structured knowledge domains (see also Spiro et al. (1991)). Constructivistic learning environments are considered to be the most appropriate approach for advanced knowledge acquisition.

- **Expert knowledge acquisition:** In the final phase, experts are more autonomous and cognitively skilled, and have more internally coherent yet more richly interconnected knowledge structures. They don't need any instructional support.

In the 20th century teaching and learning approaches in schools were mainly objectivistic because of the content-based and teacher-centred focus of education. It required learners mainly to assimilate and reproduce knowledge that was presented to them. In the 21st century, however, society needs and knowledge domains have become substantially more complex, nonlinear and ill-structured. In addition to basic knowledge, learners are required to acquire skills in areas such as problem solving, critical thinking, creativity, collaboration, life-long learning, technology, and social and global awareness. It can be concluded, therefore, that the objectivist model does not meet all of modern society's learning needs, and that there is a need for constructivist approaches to provide the conceptual basis for advanced knowledge acquisition (Norton & Wiburg 2003:34-35). Although there will still be room for objectivistic approaches when the learning content is relatively simple, linear and well-structured, it is believed that there will be a greater need for constructivist approaches because both society and knowledge domains are increasingly complex and ill-structured.

Another interpretation of the complementary nature of behaviourist and constructivist paradigms of learning is that it is possible to use constructivist principles to inform and enhance objectivist approaches. Evidence of this is found in the work of Gabler and Schroeder (2003) in which they have transformed traditional objectivist teaching methods such as deductive teaching and presentation (or lecture/tutorial) into constructivist approaches by applying constructivist principles to inform and enhance it.

2.11.3 A proposed theoretical foundation for integrating technology in learning

After studying, analysing and interpreting various views on theories and paradigms of learning, it is now possible to answer the research question: **What is an appropriate theoretical foundation for integrating ICTs in learning?**

FINDING 1: The integration of ICTs in learning should be based on the theoretical foundation that considers the two paradigms of learning of objectivism and constructivism to be complementary, meaning that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate than the other. However, due to the nature of 21st century learning needs for increasing advanced knowledge acquisition, a growing need for constructivist approaches is expected. This complementary view of objectivist and constructivist learning is based on the following assumptions:

- The objectivist and constructivist paradigms of learning are considered as the polar extremes of a continuum that ranges from externally mediated reality (objectivism) to internally mediated reality (constructivism) (Jonassen 1991a:8). Furthermore, the two learning theory philosophies are considered to be complementary and not opposing, meaning that each of them describes some aspects of learning in some contexts. They provide views of different aspects of learning (Jonassen 2003:8). This means that there are circumstances where a constructivist approach will be more appropriate, and others where an objectivist approach will be more appropriate.

- Constructivist teaching and learning approaches are more appropriate for advanced knowledge acquisition in complex, nonlinear, multi-dimensional and ill-structured knowledge domains that have become so characteristic of modern society (Jonassen 1991b:30-32).

- Objectivist teaching and learning approaches are more appropriate for introductory knowledge acquisition where learners have very little directly transferable prior knowledge about a skill or content area in a linear, uni-dimensional and well-structured knowledge domain (Jonassen 1991b:30-32).

- Constructivist principles of learning, such as the following, can be used to inform and enhance objectivist teaching and learning approaches (refer section 2.8.2): active learning; own knowledge construction; social interaction; situated learning; and intentional learning.

Figure 2.2 below illustrates this proposed theoretical foundation for integrating technology in learning.

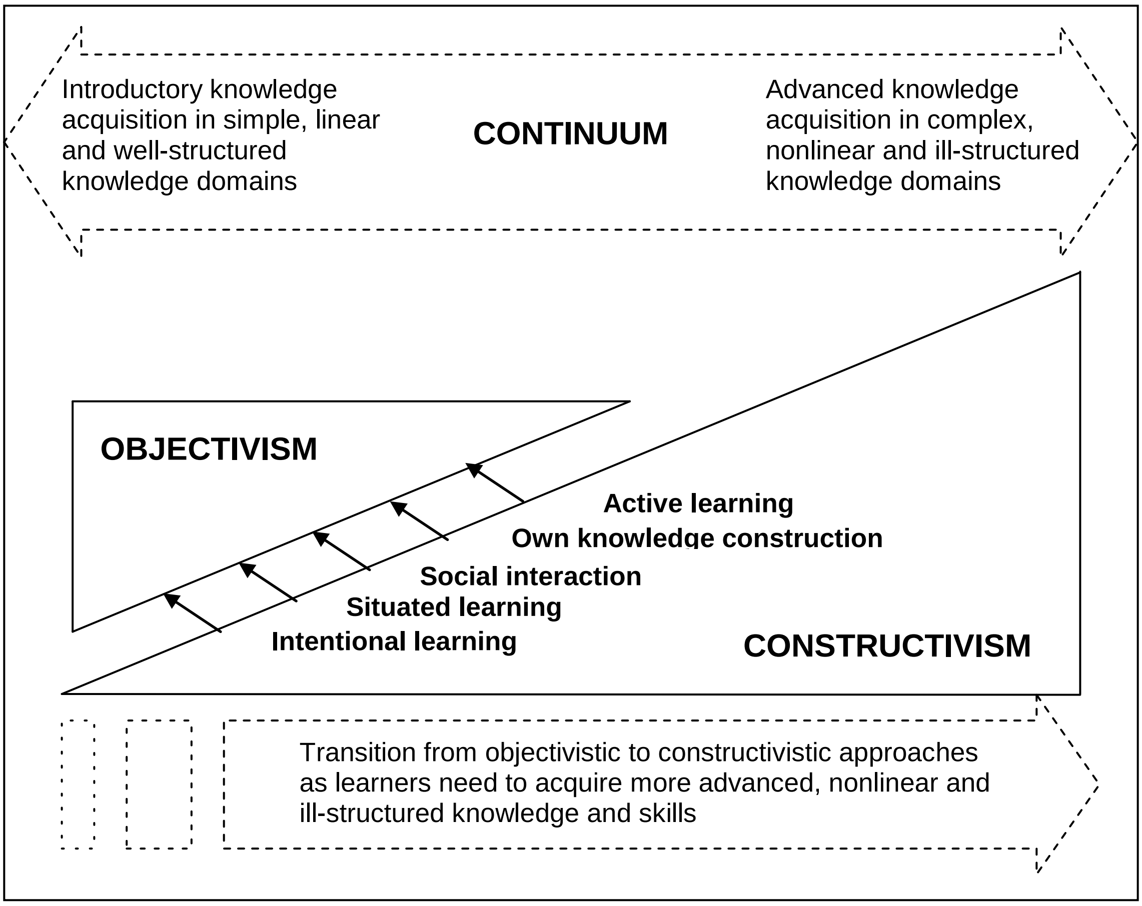

Figure 2.2: Proposed theoretical foundation for integrating ICTs in classroom teaching and learning

The model in Figure 2.2 not only demonstrates the assumptions of the proposed foundation, but also the expectation that in the context of modern society there is an increasing need for advanced knowledge acquisition in complex, nonlinear and ill-structured knowledge domains. This implies that constructivist approaches should be dominant in 21st century classroom teaching and learning.

2.12 SUMMARY

The chapter endeavoured to answer the following research question: **What is an appropriate theoretical foundation for integrating ICTs in learning?** Against this background its purpose was to investigate learning theories in the context of the education needs of modern society in general. Initially the 21st century workplace requirements and their resulting learning needs were examined. This was followed by an investigation of the behaviourist, cognitivist, constructivist and connectivist learning theories and the learning philosophies of objectivism and constructivism in order to determine which one is more appropriate for the learning needs of modern society. Finally, a theoretical foundation based on the findings of the study was proposed for integrating technology in learning.

CHAPTER 3: USES OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN 21ST CENTURY LEARNING

For the foreseeable future, computing will play an increasingly important role in human learning. However, no one yet knows exactly how great that role will eventually be, or precisely what form it will finally take (Taylor 1980:1).

3.1 INTRODUCTION

Robert Taylor, an early pioneer in the use of computer technology in education, made the above statement in 1980, and yet today, three decades later, we are still struggling to understand the role of technology in education, as well as the forms it may take. Perhaps it will never be possible to arrive at a final consensus on the role and forms of technology uses in education because of the dynamic nature of modern society and technology. In general the goal of this chapter is to get a deeper understanding of the roles of technology in 21st century learning and the forms in which they manifest in the classroom.

This chapter explores the research question: **What are the uses of ICTs in learning?** There are three categories of technology users in schools: managers, teachers and learners. Three categories of technology uses in schools can therefore be distinguished according to the type of user: technology uses in management, technology uses in teaching and technology uses in learning. So why is the focus of this chapter (and research) on technology uses in learning only? Simply because the NCS as a curriculum specifies learning outcomes that learners have to achieve. All ICT requirements of the NCS are related to learning activities that will enable learners to achieve the knowledge, skills and values represented in the learning outcomes (refer section 5.2.1 for more detail). However, the technology uses in management and teaching are not disregarded completely – they are explored cursorily in order to provide context and perspective.

The chapter begins by describing the technology tools available to education, and a general classification system of technology uses in schools. The categories of this system are technology uses in management, technology uses in teaching, and technology uses in learning. The chapter then proceeds to examine various views on the use of technology in learning in more detail, resulting in identifying and describing a set of technology uses in learning that comply with contemporary learning needs and the requirements of this research. The chapter concludes with an analysis of the meaning of a technology-integrated curriculum.

The uses of technology in learning are examined in the context of the learning needs of modern society in the 21st century. In other words, the uses of technology must comply with and meet the learning needs of contemporary society, as the NCS as a curriculum also aims to do. This will ensure that the ICT requirements of the NCS are matched with categories of technology uses that are based on current (and not outdated) learning needs.

3.2 TECHNOLOGY TOOLS AVAILABLE TO EDUCATION

The objective of this section is to give a brief and general description of the technology tools available to education. The description obviously represents the current (2010) technology developmental status, but it is limited to only those technologies that are non-exotic, generally available, affordable and relevant for all schools in South Africa.

According to Picciano (1998:253), technology as we know it today is the result of a convergence, merging and integration of three formerly distinct technologies: computer technology, communications technology and video technology. Computer technology includes all forms of programmable, electronic computers that accept input, process it, and produce output. Communications technology entails all technologies that use a variety of communication channels (e.g. cable, telephone line, wireless, microwave and satellite) to transfer information in formats such as text, graphics, audio and video. Video technology encompasses all forms of technology involved in the handling (production, storage and presentation) of images.

Technology tools are defined for the purpose of this study as application software packages that users use to perform particular tasks. Such packages obviously assume the availability of a suitable hardware platform, system software and network infrastructure if applicable. Table 3.1 contains a list of the most important basic and general technology tools available to education. These are described in terms of the type of application package, its purpose and examples. The list cannot be considered as conclusive or comprehensive because of the dynamic nature of technology, and the fact that the use of technology is only limited by the imagination and creativity of its users.

Table 3.1: Technology tools available to education

Type of application package	**Purpose**	**Example(s)**
Word processing packages	To create and edit various kinds of documents.	MS Word
Spreadsheet packages	To process data in tables by means of formula and to create graphs.	MS Excel
Database packages	To store related data in an orderly way and retrieve data selectively.	MS Access
Presentation packages	To develop and produce professional presentations about concepts and ideas, usually in the form of slides.	MS PowerPoint
Specialised application packages, e.g. accounting packages, computer-aided design packages and geographical information system packages	To enable specialised, unique and authentic technology applications in specific professions, sciences or industries.	Pastel, AutoCAD and GIS packages
Programming languages	To develop computer applications according to specific specifications (application packages).	Delphi and Java

Multimedia editing packages	To produce multimedia products by editing and combining text, images, video and sound.	Adobe Premiere (video), Adobe Photoshop (photo-graphs), Creative Labs Sound Blaster (sound), Adobe Dimension/3D (animation), and MS Paint (drawings)
Multimedia/hypermedia authoring packages	To create multimedia materials and Web documents that integrate sound, images, text, video, animation, colour and special effects. In addition, hypermedia (Web documents) has interactive navigational capabilities in a non-linear format.	MS FrontPage, HyperCard, HyperStudio and ToolBook
Web navigation packages	To search and retrieve information from the World Wide Web.	MS Internet Explorer and Netscape Navigator
E-mail packages	To create, send and receive electronic mail with or without file attachments.	MS Outlook
Other Internet communication packages	To enable communication forms such as mailing lists, newsgroups, discussion forums, chat (real-time communication between two or more persons), and file transfer	Discussion forum on myUnisa (learning management system of Unisa)

From an educational point of view it is important to realise that all the packages listed in Table 3.1 are in themselves ‘content free’. They were not developed with the specific needs of education in mind, but are general tools that can be applied in many knowledge domains, including education. Technology tools such as these can be used individually or in combination for instance to: develop technology-based learning materials that contain content; construct learning effects (such as an algorithm, essay, or presentation developed by a learner); or present, communicate and transmit learning content (concepts and ideas) during learning events. In complexity it might vary, for example, from the simple use of a word processor for essay writing in language teaching to a comprehensive collaborative research project in which learners might be required to search for information about a topic on the Internet using a web browser, consult with an expert on the topic using e-mail, use a discussion forum to collaborate with team members that can be geographically anywhere, write a research report using a word processor, and create a presentation to communicate their findings to others using a presentation package.

These packages are the tools for the various categories of technology uses in schools which are investigated in the next section.

3.3 A GENERAL TYPOLOGY OF TECHNOLOGY USES IN SCHOOLS

Proposing an appropriate classification system is essential for the important research activity of classifying the ICT requirements of the NCS that is to follow later. Classification systems for technology uses in schools in general, and learning in particular, are therefore a major focus of this research. According to Patton (2002:457-458), there are two types of classification systems that divide some aspect of the world into parts along a continuum, namely taxonomies and typologies. He defines taxonomies as classification systems which classify a phenomenon in detail through mutually exclusive and exhaustive categories. In contrast, he defines typologies as classification systems built on ideal-types or illustrative endpoints rather than a complete and discrete set of categories. In education it is not always possible to identify mutually exclusive and discrete categories of technology uses, especially technology uses in teaching and learning. Categories often overlap and represent illustrative endpoints rather than a complete and discrete set of characteristics. Therefore, the term typology is used in this study to describe classification systems for technology uses in education.

There are a multitude of technology uses in education throughout the world, ranging in complexity from simple and affordable to highly exotic, technical and expensive. These ‘high tech’ applications are obviously not relevant for the majority of South African schools because of the lack of the necessary funding and high expertise levels. For the purpose of this study the criteria of affordability and skills availability are applied in considering whether a particular technology application should be included in a typology of technology uses in schools.

The objective of this section is to establish a context for technology applications in schools, and distinguish broad basic categories of such uses. The simplest way to do this is to base it on the three categories of technology users in schools: managers, teachers and learners. Three categories of technology uses in schools can therefore be distinguished: technology uses in management, technology uses in teaching and technology uses in learning. The technology uses are described in a format that indicates them as tools with a specific function. For example, a category of technology use indicated as 'communication tool' refers to all technology uses in which messages are communicated between individuals and/or groups. As explained earlier, technology uses in management and teaching are examined only briefly and superficially, while technology uses in learning are explored and analysed in detail.

3.3.1 Technology uses in management

The management of a school includes the establishment of an administrative structure that supports the instructional functions of a school. According to Van Deventer and Kruger (2003:223-225) the following administrative duties are considered essential in a school's administration:

- **Communication:** Three types of communication are distinguished: external communication, internal communication and correspondence.

- **Dealing with reports:** This involves storing, summarising and retrieving information so that it can be supplied to organisations that require it (e.g. education departments and district offices).

- **Processing material:** The task of typing and duplicating various documents for staff and management team members.

- **Dealing with school organisational matters:** A variety of school organisational activities have to be arranged, for example school timetable, test and exam timetables, and duty rosters.

- **Administering school attendance:** Developing and implementing guidelines for controlling school attendance that include keeping daily attendance registers.

- **Procuring stock and equipment:** This duty includes procuring expendable items (e.g. stationary) and durable items (e.g. furniture and ICTs), as well as maintaining inventories of it.

- **Administering school finances:** The financial management of a school requires a systematic bookkeeping system.

- **Controlling of physical facilities:** This includes the proper management, use and maintenance of school buildings and other assets.

The potential of technology to support, enhance and extend schools' abilities to process, store and disseminate large volumes of data and information for various management purposes is obvious. Technology's attributes of speed, reliability, accuracy, storage and communication perfectly match and support responsibilities such as those above. Using these administrative duties as the basis, the following categories of a typology of technology uses in school management are proposed:

- **Information management tools:** Using database management systems for supporting the data and information needs in administrative functions such as: financial transaction processing; learner records; learner grading and reporting; staff records; inventory control; time table; and sport event management.

- **Time management tools:** Using specialised scheduling packages to manage: diaries; school, test and examination timetables; and programmes for extramural activities.

- **Document processing tools:** Using a word processor to process documents in schools such as: letters; minutes; class notes; and test and examination question papers.

- **Decision support tools:** Using spreadsheets for: budgeting; planning; and other “what-if” scenario-based management decisions.

- **Communication tools:** Using an e-mail package and other Internet communication facilities for communicating with: education departments; other schools; parents; and other organisations, groups and individuals.

- **Information accessing tools:** Using a Web browser for searching and retrieving information on the Web, for example to get policy documents, curriculum statements and implementation guidelines from an education department.

- **Information dissemination tools:** Using a Website development package to, for example, develop a school Website in order to: disseminate relevant information (notices, programmes, contact information, etc.) to parents on the Internet, and publish information as part of a school’s marketing initiatives.

3.3.2 Technology uses in teaching

Technology uses in teaching refer to the use of technology to support, enhance and extend teachers’ abilities to perform their teaching duties. One way of shedding more light on these duties is to study the seven educator roles as defined in the *Norms and Standards for Educators* policy document (Department of Education 2000). The roles are summarised below in order to provide a basis for defining technology uses in teaching.

- **Learning mediator:** The educator will mediate learning in contextualised learning environments, demonstrating sound subject content knowledge and strategies, and using appropriate resources.

- **Interpreter and designer of learning programmes and materials:** The educator will design learning programmes according to specific context requirements and select and prepare suitable textual and visual resources for learning.

- **Leader, administrator and manager:** The educator will manage learning in the classroom and carry out classroom administrative duties.

- **Scholar, researcher and lifelong learner:** The educator will achieve professional growth through lifelong study and research in educational and professional matters.

- **Community, citizenship and pastoral role:** The educator will: practice ethical behaviour, respect and responsibility towards others, and develop a supportive and empowering environment for learners.

- **Assessor:** The educator will: understand the purposes, methods and effects of assessment as an essential feature of teaching and learning; design and manage appropriate formative and summative assessment; and keep detailed and diagnostic records of assessment.

- **Learning area/subject/discipline/phase specialist:** The educator will be well grounded in the knowledge, skills, values, principles, methods, and procedures of his or her learning area/subject, and in the different approaches to teaching and learning it.

Technology's attributes of speed, reliability, accuracy, storage and communication provide abundant possibilities to support, enhance and extend teachers in performing their teaching duties. Using the teaching duties described in the seven educator roles as a basis, the following categories of technology uses in teaching are proposed for the purpose of this study:

- **Mediating tools:** The teacher uses mediating tools to create appropriate learning environments that support and enable learners to achieve the expected learning outcomes. It includes using technology tools to present the facts, concepts and/or problem about a lesson topic in contexts that are meaningful for learners. Quite often the teacher uses a tool that allows learners to explore the facts, concepts and/or problem of the lesson actively on their own. In other words the teacher's mediating tool becomes a learning tool for learners. A simple example is where the teacher uses presentation graphics slides to present the reasons/causes of World War II in a History lesson. A more advanced example is a Life Sciences lesson about the human heart in which the teacher uses an interactive multimedia simulation as a mediating tool to present multiple representations or views of the heart. It could include the physiology of the heart, (a simulation of) the functioning of the heart, heart diseases, cardiac surgery, lifestyle issues, and so on. This same multimedia program also becomes a learning tool for learners that allow them to explore the human heart in the context of the human body and its environment.

- **Resource tools:** This category includes technology tools such as the Worldwide Web, multimedia CD-ROMs/DVDs and library catalogues that a teacher can use to access information about a lesson topic, instructional strategies and ideas for lesson plans. It also includes accessing information resources for research and professional development purposes.

- **Planning tools:** Planning is a fundamental responsibility of a teacher, and an area in which technology can lend substantial support. Planning tools assist the teacher in developing a learning programme that comprises a subject framework, work schedules and lesson plans. In each of these, technology can provide meaningful support and enhancement, for example using a word processor to develop and store a subject framework and work schedules, and using a spreadsheet-based template to facilitate daily lesson planning.

- **Developing tools:** Teachers often have to develop learning and teaching support materials. There are multiple technology tools and facilities available to support teachers in this task. Examples include a word processor to develop class notes, a spreadsheet to develop learner worksheets, presentation graphics software to create presentation slides for communicating ideas or concepts to a class, multimedia authoring software to develop an interactive multimedia presentation of a lesson topic.

- **Assessment tools:** A teacher has the responsibility to plan, develop and conduct appropriate assessment activities. It includes developing assessment instruments (e.g. tests, examinations, projects, tasks and case studies) and assessment tools (e.g. scoring memoranda, marking grids, check lists and rubrics), assessing the assessment evidence (the actual process of grading and scoring), processing and interpreting the assessment results, and recording the assessment results. Examples of how technology can support the teacher in this process include using a word processor to compile a test paper and its memorandum, using a spreadsheet to develop check list or rubric, developing an interactive program that presents multiple choice questions and scores learners' responses, creating a spreadsheet to record test marks and process averages and standard deviations that enable teachers to interpret the assessment results, and developing a database for recording learners' assessment history over an academic year.

- **Communication tools:** A variety of technology tools are available to support teachers in the communication aspect of their teaching duties. It includes using e-mail for communicating with individuals such as learners, parents, colleagues and officials in departmental offices, mailing lists for communicating within groups such as clusters of subject teachers in a district, and Internet discussion forums for collaborating with other teachers enrolled in a further training module.

- **Administrative tools:** Examples of technology tools available to support teachers in their administrative responsibilities include spreadsheets for compiling class lists and class budgets and a school administration (database) system to record learners' personal details and academic history.

3.3.3 Technology uses in learning

Technology use in learning is defined as the use of technology to support, amplify and extend learners' abilities to perform learning activities. The intention in this section is to demarcate such uses in broad, general categories (specific uses of technology in learning are explored and described in detail in sections 3.4 and 3.5). It is possible to categorise the technology uses in learning in many different ways. However, the general typology of technology uses in learning described by Jonassen (1996:3-11), Jonassen et al. (1999:iii, 2 & 11-13) and Maddux et al. (2001:178-180) is selected because of its simplicity and wide acceptance. The broad, general categories of this typology are the following:

- **Learning about technology:** Learning in this category is about acquiring technological knowledge, skills and values. The technology itself is, therefore, the learning content and mastering it the learning objective.

- **Learning from technology:** This category is about using technology to teach learners and make teaching more productive. It assumes that knowledge can be embedded in the technology and transmitted to the learner. Learners learn *from* technology what the technology knows, just as they learn *from* the teacher what the teacher knows.

- **Learning with technology:** This category sees the role of technology as that of cognitive tools that enable and facilitate critical thinking and higher-order learning during knowledge construction. It assumes that technologies are learning tools *with* which learners learn.

As stated earlier, the focus of this research is on technology uses in learning simply because the NCS as a curriculum specifies learning outcomes that learners have to achieve. All the ICT requirements of the NCS refer to the use of technology in learning activities that will enable learners to achieve the knowledge, skills and values required by the learning outcomes (this is explained in more detail in section 5.2.1). It is therefore necessary to attain a better understanding of technology uses in learning which is done in sections 3.4 and 3.5.

3.3.4 Typology of technology uses in schools

The technology uses in management, teaching and learning discussed in the paragraphs above is combined into a general **typology of technology uses in schools** presented in Figure 3.1 below. Bear in mind that the category of technology uses in learning is incomplete and is analysed in more detail in the next two sections.

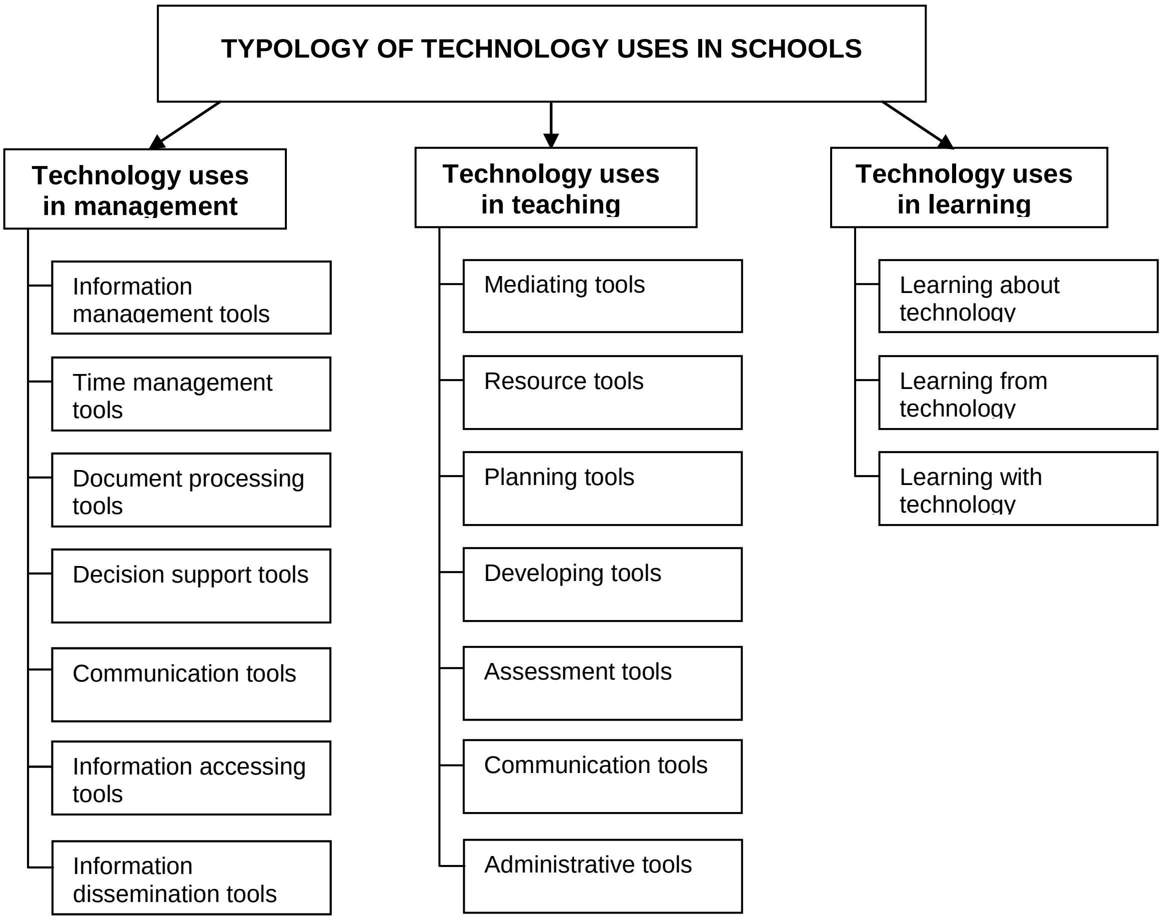

Figure 3.1: A preliminary typology of technology uses in schools

There is another category of technology applications in schools called computer-managed instruction (CMI). In a sense it combines the use of technology in management, teaching and learning. Picciano (1998:84) describes CMI as follows:

> *The use of the computer in an instructional process in which student progress is monitored and recorded for subsequent instruction and review. Most CMI*

applications also are able to adjust material to each individual student's level of understanding. A good example of CMI is an integrated learning system … [that is a] … single computer package for delivering instruction that combines hardware, software, curriculum, and management components. It is usually supplied by a single vendor.

However, this category of technology use is not often found in South Africa, and is considered to be both exotic and expensive. CMI is therefore in the context of this research considered not relevant for the majority of South African schools as they are unable to afford it and do not have the infrastructure and skills to implement it.

3.4 AN ANALYSIS OF TECHNOLOGY USES IN LEARNING

A fundamental understanding of the concept of 'using technology in learning' is essential for identifying and describing technology uses in learning that comply with contemporary learning needs and the requirements of this research. The objective of this section, therefore, is to examine the essence of using technology in learning. It is done by analysing the three broad categories of learning *about* technology, learning *from* technology, and learning *with* technology proposed by Jonassen (1996:3-11), Jonassen et al. (1999:iii, 2 & 11-13) and Maddux et al. (2001:178-180).

3.4.1 Learning about technology

Learning about technology is concerned with learners acquiring technological knowledge, skills and values. The technology itself is the learning content, and mastering it the learning objective. Its primary purpose is for learners to learn how to use the tools of technology to solve problems in society (Maddux et al. 2001:178-179). The justification for learning about technology is usually based on two reasons. Firstly, there is a need for technology knowledge and skills in the modern workplace (refer section 2.2). Because of this need educationists include technology in their lists of domains in which knowledge and skills are deemed necessary to prosper in the 21st century (refer section 2.3). The second reason, and perhaps a more important one, is concerned with using technology as learning tool. If technology is to be integrated into the curriculum, then learners will need appropriate knowledge, skills and values in order to learn with technology. In this sense, technological knowledge, skills and values becomes a prerequisite for effective learning with technology.

In general, it is the researchers' opinion that learning about technology focuses on acquiring knowledge, skills and values in the following four areas: computer systems and networks (hardware and system software); computer applications (the use of ready-to-use and user-friendly software packages to solve problems); computer programming (the use of a programming language to design, create and develop application programs as solutions to specific problems); and computer effects (the social and ethical issues involved in using computers to solve problems in society).

As far as the NCS is concerned, there are three forms of learning about technology involved: computer literacy for learners; technology-oriented subjects; and specialised application packages in specific subjects.

(a) Computer literacy for learners

The term computer literacy was first used by Andrew Molnar back in 1978 when computers became accessible to the man on the street (Simonson & Thompson 1990:31). The definition, purpose and content of computer literacy have been hotly debated ever since, but according to Jonassen (1996:7-9), it is no longer a major issue in schools (in developed countries) for two reasons. Firstly, an increasing number of learners are able to use computers without instruction in schools because of its increasing availability at home and ease of use. Secondly, a learner does not have to understand the inner-workings of a computer in order to use it productively, just as a person does not have to know the inner-workings of a car to drive it. Today it is generally accepted that computer literacy involves introductory level knowledge, skills and values in the areas of computer systems and networks and computer applications (the use of ready-to-use and user-friendly software packages to solve problems) (Shelly et al. 2010:3-4).

Regarding computer literacy in South African schools, the NCS does not address it specifically, but rather assumes it. This assumption will have to be addressed explicitly when FET schools implement the NCS. The Revised National Curriculum Statement Grades R – 9 does provide General Education and Training (GET) schools with a basis for computer literacy where it specifies the following outcome for the Technology learning area (Department of Education 2002:28):

> *Technology Processes and Skills: The learner is able to apply technological processes and skills ethically and responsibly using appropriate information and communication technologies*.

Although many GET schools do offer computer literacy programmes, often supported by initiatives from communities, private sector and/or education departments, it cannot be assumed that all learners will be computer literate when they reach the FET phase. Where necessary FET schools may have to institute computer literacy programmes in grades 8 and 9 to ensure that learners have the introductory-level (basic) technology knowledge, skills and values required by the NCS when they reach the FET Band.

(b) Technology-oriented subjects

Technology in this context refers to ICTs specifically. There are two subjects in the NCS that focus exclusively on ICTs as a knowledge domain: Computer Applications Technology (CAT) and Information Technology (IT). The purpose of CAT as a subject of the NCS is to equip learners with the knowledge, skills and values that will enable them to solve problems in society by using ready-to-use and user-friendly software packages (Department of Education 2003e:9). Compared to computer literacy, CAT is on a much more advanced level.

Like CAT, IT also focuses on the use of technology to solve problems in society. The difference lies in the tools they use. CAT uses existing user-friendly software packages such as word processor, spreadsheet, database, presentation graphics, web navigation and multimedia/hypermedia authoring packages. In contrast, IT requires learners to use a current programming language to design, create and develop application programs as solutions to specific problems (Department of Education 2003n:9). It is much more advanced than CAT because of the complexity of computer programming.

(c) Specialised application packages in specific subjects

In some subjects the NCS prescribes specific application packages that enable specialised, unique and authentic technology applications in those knowledge domains. These technology applications have become integral parts of the science, practice and profession of their respective knowledge domains. Examples include accounting package in Accounting (Department of Education 2003b:12), computer-aided design package in Engineering Graphics and Design (Department of Education 2005e:11) and geographical information system in Geography (Department of Education 2003k:10). Learners are initially required to acquire knowledge, skills and values about these packages themselves, in other words learning about technology. At a later stage learners will use these packages to perform learning tasks, when it becomes learning with technology.

3.4.2 Learning from technology

The first uses of computers to support teaching and learning in the 1970s and 1980s were in this category. Because behaviourism was the norm then, it is natural to expect that these instructional technology uses were based on behavioural theories of learning (Maddux et al. 2001:98&179 & Jonassen 1996:4-7). In this category technologies are used to teach learners with the belief that it can communicate, convey, transmit and deliver learning content, and hopefully its meaning, more effectively than a teacher (Maddux et al. 2001:96, Jonassen et al. 1999:iii & Taylor 1980:3). Jonassen et al. (1999:2) describe its underlying assumption as follows:

> *The underlying assumption is that people learn from technology – that is, students learn from watching instructional films … [or] responding to … computer-assisted instruction frames, just as they learn from listening to a lecture by the teacher. This view assumes that knowledge can be transmitted*

from the teacher to the student and that knowledge can be embedded in technology-based lessons and transmitted to the learner. Thus, students learn from technology what the technology knows or has been taught, just as they learn from the teacher what the teacher knows.

By implication it also assumes that learners are passive receptacles by absorbing and assimilating the learning content communicated, conveyed, transmitted and delivered to them by the technologies (Jonassen 1996:13).

This category of technology use became known as computer-based instruction (CBI), computer-assisted instruction (CAI) or computer-assisted learning (CAL) in the 1980s with modes such as drill and practice, tutorial, demonstration, simulation, games, modelling and problem-solving (Newby et a. 2006:52 & Shelly et al. 289-292). Today, it is preferred to view the modes of demonstration, simulation, modelling, problem-solving and exploration from a constructivist perspective, because its meaning and value are better understood and accommodated in this learning theory. It was especially the drill and practice, tutorial, and game modes of CAI that were used widely in schools in the 1980s and 1990s. It was based on an instructional model that Taylor (1980:3) describes as follows:

The computer presents some subject material, the student responds, the computer evaluates the response, and, from the results of the evaluation, determines what to present next.

This instructional model of typical learning-from-technology applications is illustrated in Figure 3.2 on the next page.

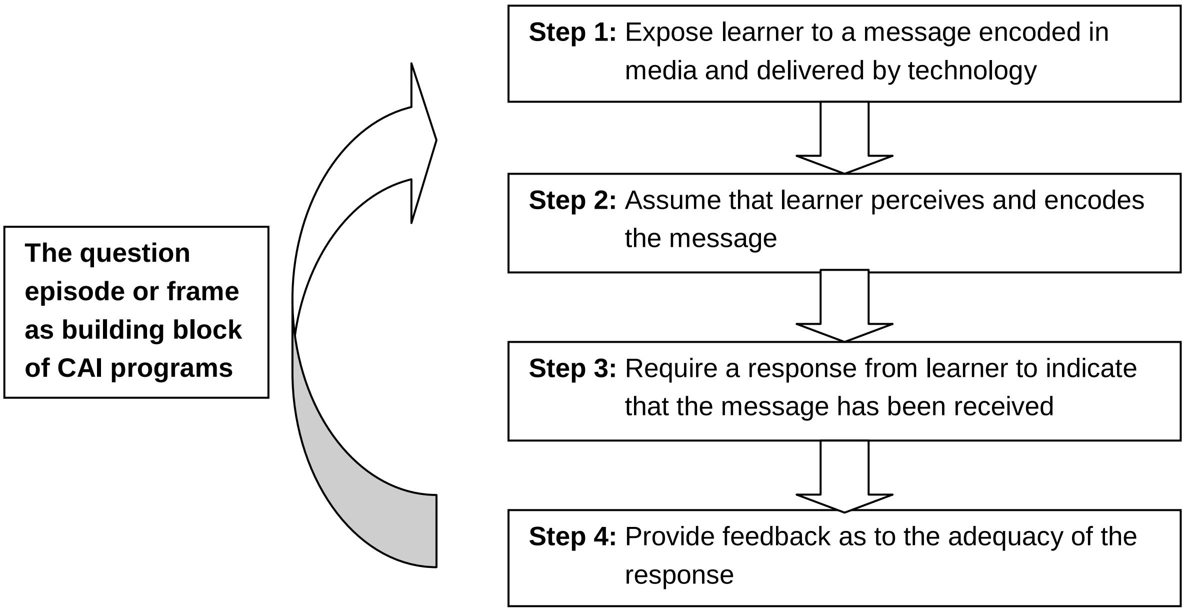

Figure 3.2: The instructional model used in typical learning-from-technology applications (adapted from Reeves in Maddux et al. 2001:179)

According to Maddux et al. (2001:97-98) drill and practice programs, which outnumbered the other types of CAI programs by far, were heavily criticised and even called ‘mind-killing drill and practice’ and ‘drill-and-kill’. Today there is a less negative trend towards drill and practice because of the much improved technical and pedagogical quality of the software. Maddux et al. (2001:100-101) also list a number of characteristics of learning-from-technology applications:

- Learning-from-technology applications generally stimulate relatively passive involvement on the part of the learner.

- With this type of application the software developer predetermines the learning content of the program, as well as almost everything that happens on the screen.

- The type of interaction between the learner and machine is predetermined by the software developers, and the contribution of the learner must conform to a very limited repertoire of acceptable responses.

- Learning-from-technology applications are usually aimed at the acquisition of facts by rote memory.

- Everything this type of software is capable of doing can usually be observed in a very short period of time.

In conclusion, it must be realised that learning-from-technology applications are designed to make it easier, quicker, or otherwise more efficient to continue teaching the same topics in the same ways we have always taught them. It does not make available any fundamentally new and better ways of teaching (Maddux et al. 2001:96). It can therefore be considered as an option or add-on to teaching and learning because the same learning outcomes can be achieved in ways that do not employ technology. This seriously questions whether this type of technology application in teaching and learning can be considered as curriculum integrated (refer section 3.7 for a description of a technology-integrated curriculum). In this study the view is taken that learning-from-technology applications do not qualify as being curriculum integrated because they do not comply with Earle's (2002:7) technology integration principle that stipulates "… *the technology must … allow new instructional and learning experiences not possible without them… ."*

3.4.3 Learning with technology

Learning-with-technology applications are constructivist-based (Maddux et al. 2001:179, Jonassen 1996:11 & Jonassen et al. 1999:2). Constructivists believe that knowledge cannot be simply transmitted by the teacher or technology to the learner who passively absorbs it. Instead they believe that learners actively construct and create their own knowledge and meaning from their experiences with the world and interactions with other humans in an effort to make sense of the world around them. Teaching is seen as a process of helping learners to construct their own meaning by providing learning experiences in meaningful learning environments, and by guiding them in the meaning-making process (Jonassen et al. 1999:3).

The role of technology is seen as that of **cognitive tools** which are computer-based tools that enhance the cognitive powers of human beings during thinking, problem solving and learning. Examples of such tools include, but are not limited to word processors, presentation programs, spreadsheets, databases, semantic networks, expert systems, communication software such as teleconferencing programs, multimedia/hypermedia authoring software, and programming languages (Jonassen & Reeves 2001:693). Jonassen (1996:9-10) argues that these tools are extensions and amplifiers of the capabilities of humans, and as cognitive tools they:

- extend cognitive functioning during learning;
- engage learners in cognitive operations while constructing knowledge that they would not otherwise could have capable of;
- are both mental and computational devices that support, guide, and extend the thinking processes of learners;
- are knowledge construction and facilitation tools that can be applied in various knowledge domains;
- scaffold meaningful thinking by engaging learners and supporting them once they are engaged; and
- therefore enable and facilitate critical thinking and higher-order learning in learners.

As with learning-from-technology applications, Maddux et al. (2001:101-102) also list and contrast a number of characteristics of learning-with-technology applications:

- Learning-with-technology applications stimulate relatively active involvement on the part of the learner.
- In this type of application the learner, rather than the software developer, is in charge of almost everything that happens.

- The learner has a great deal of control over the user-machine interaction, and the repertoire of acceptable user input is extensive.

- Learning-with-technology applications are usually aimed at accomplishing more creative tasks than are learning-from-technology applications.

- Many hours of use are generally necessary for a learner to discover everything a specific program is capable of doing.

In conclusion, it is important to realise that learning-with-technology applications support fundamentally new and better ways of teaching and learning. It means that these new and better ways of teaching and learning would be impossible or extremely difficult to achieve without the technology (Maddux et al. 2001:101). This complies with Earle's (2002:7) principle of technology integration that reads as follows:

> *[The technology] must go beyond information retrieval to problem solving; allow new instructional and learning experiences not possible without them; promote deep processing of ideas; increase student interaction with subject matter; promote faculty and student enthusiasm for teaching and learning; and free up time for quality classroom interaction – in sum, improve the pedagogy.*

3.5 TYPOLOGIES OF TECHNOLOGY USES IN LEARNING

The objective of this section is a literature study of typologies (i.e. classification systems) of technology uses in learning. Such typologies provide important background and contextual information for the process of identifying and describing technology uses in learning that comply with contemporary learning needs and the requirements of this research. It must be noted that the three broad categories of technology uses in learning described in section 3.4 are in fact categories of a typology of technology uses in learning. The rest of this section examines similar examples.

Since the introduction of computers into education, numerous attempts have been made to devise classification systems for learning applications of technology in order to better understand it. Squires and McDougall (1994:53) provide a way of structuring these classifications with their proposal of three approaches for devising classification systems for learning uses of technology: classification by application type; classification by educational role; and classification by educational rationale. Their three approaches, with representative examples, are presented below.

3.5.1 Classification by application type

This classification system is based on categories of application types to which software packages can be assigned. The software categories focus on the overall function, style or structure of a package (Squires & McDougall 1994:53-55). Some examples are presented and critically reviewed below.

(a) The OECD classification

This is an early example (1989) of a classification system proposed by the Organisation for Economic Co-operation and Development (in Squires & McDougall 1994:55). It contains the following application type categories:

- Drill and practice
- Tutorial
- Intelligent tutoring systems
- Simulation and model building
- Problem solving
- Educational games
- Information retrieval and database management
- Word processing
- Application programs
- Computer-managed learning
- Microcomputer-based instrumentation
- Exploration and discovery

(b) The Norton and Sprague classification

Norton and Sprague (2001:9-243) propose a much more contemporary classification that groups similar or related packages as follows:

- **Skills software:** Software that teaches and provides drilling and practicing exercises – drill and practice programs, tutorials and integrated learning systems.

- **Computer graphics software:** Software that provide tools for seeing the world around us and rendering our understanding about our experiences: print programs, draw programs, paint programs, idea processors and animation programs.

- **Editor software:** Software that makes informing and publishing possible: word processors, desktop publishers and web-based editors.

- **Databases:** Software for organising and analysing information: text-based databases, hypermedia databases and multimedia databases.

- **Telecommunications:** Software for communicating and accessing: asynchronous communication (e.g. e-mail, listservs, bulletin boards, Usenet and newsgroups, and telnet), synchronous communication (e.g. internet relay chat and conferencing tools), and tools for accessing information (Web browsers, search engines and file transfer).

- **Simulations:** Software that enable learners to experiment with a model of a phenomenon, and to construct and reconstruct their own knowledge framework of that phenomenon.

- **Multimedia/hypermedia:** Software for representing information in blocks and connecting them to other related blocks of information.

- **Mathematical devices:** Devices and software for computing and modelling: calculators, graphing calculators, spreadsheets, and programming languages.

(c) A critical review of classifications by application type

It is relatively simple to classify software using this approach, but it has three clearly identifiable problems (Squires & McDougall 1994:56-57). Firstly, the criteria for delineating the categories are often implicit, without a clear rationale for their choice. Application categories based on educational approaches, such as drill and practice, are often included in categories based on software function, such as word processing. Secondly, as technology development, experience and educational uses of software increase, the range of categories also needs to increase. Compare for instance the relatively simple classification of the OECD in 1989 with the fairly complex classification of Norton and Sprague (2001: 245-268). They are already anticipating a new (future) category based on emerging technologies. They call it virtual learning that includes forms such as artificial intelligence, virtual reality and distributed learning. Lastly, integrated software environments that combine a number of applications do not fall neatly into any one category. In addition to these three problems, it must be noted that classifications by application type focus on the technology first, in other words the pedagogy is subordinate to the technology.

3.5.2 Classification by educational role

In the second approach proposed by Squires and McDougall (1994:57-59), software packages are classified according to their educational roles. The emphasis is on the way the software is intended to perform, in other words on what the software is capable of doing in supporting learning.

(a) The Taylor classification

A classic example of this approach is the Taylor (1980) classification. It consists of his famous **tutor/tool/tutee** framework that is still used even today (compare for instance Merrill, Hammons, Vincent, Reynolds, Christensen & Tolman (1996), and Newby et al. (2006)). Taylor describes his classification system as follows:

- **Computer as tutor:** The basic role of the computer is that of a teacher. The computer presents some subject material, the student responds, the computer evaluates the response, and from the results of the evaluation determines what to present next (Taylor 1980:3). This category later became known as computer-assisted instruction (CAI), and provided the basis for the development of a number of forms or modes of CAI, such as drill and practice, tutorial, games, demonstration, simulation, modelling, problem solving, and exploration (Newby et al. 2006:52).

- **Computer as tool:** The role of the computer in this mode is that of an assistant to the learner by performing tedious labour intensive activities. This enables the learner to concentrate on essential concepts without being distracted by the demands of 'inauthentic' labour. Examples include using the computer as a calculator in mathematics and science, as a map-making tool in geography, or as a text editor in English (Taylor 1980:3-4).

- **Computer as tutee:** In this role the computer is a learner which is taught by a human such as a student (or teacher) to perform a particular task. In order to do that the student must learn to program, that is to talk to the computer in a language it understands. The assumption is that because you can't teach what you don't understand, the human tutor will learn what he or she is trying to teach the computer. Examples include teaching a computer to calculate loan interests, to draw a graph, and to 'tutor' other junior students (Taylor 1980:4).

(b) The ACCE classification

The Australian Council for Computers in Education (ACCE) (1995:7-9) describes the following five modes (or roles) for computers in learning:

- **Support mode:** In this mode a learner uses the computer to enhance the presentation of work. In essence, the computer enables the student to create or file information by increasing the accuracy the learner can achieve in comparison to the same information being transferred to paper. It includes technology tools such as word processors, presentation graphics, computer-aided drafting and design, and spelling and grammar checkers.

- **Exploration and control mode:** In this role learners use computers to examine, explore and build models or simulations of situations in the real world. Examples include using existing simulations to explore a historical event whilst making their own decisions about the events that unfold, or control a simulated experiment in a science laboratory. Learners can also construct their own models of phenomena in the real world, and experiment with variations within these models. Software packages to enable this include HyperCard, Toolbook, Model Builder, and Sense & Control.

- **Tutorial mode:** In this mode the computer teaches the learner new knowledge and skills. It presents information at an appropriate level and pace for each learner, and expects responses from learners. Based on these responses appropriate feedback is given and new information presented.

- **Resource mode:** Here the computer is used to access information and other resources such as a computer-based library catalogue or the World Wide Web using navigator packages such as Internet Explorer. In the process learners develop questioning skills by stating queries and re-shaping them to fit different resource frameworks.

- **Link mode:** Using computers in this mode enables communication between individuals and/or groups. Two of many examples are low-cost electronic mail for the exchange of textual messages (asynchronous or time-delayed communication) and video conferencing for visual personal communication (synchronous or immediate communication). Link mode (also known as computer-mediated communication) enhances learners' motivation to use technology, broaden their sense of cultural identity, and give them a global context for their thinking.

(c) The Jonassen, Peck and Wilson classification

Jonassen et al. (1999:194-201) provide a classification of six roles for technology in constructivist learning environments (CLEs). What makes this classification unique is that it is explicitly based on a constructivist view of learning. It provides a well-founded, holistic view of the integrated roles of technology in constructivist learning. A CLE is defined as a technology-based environment in which technologies afford learners the tools to explore, experiment, construct, converse, and reflect on what they are doing, so that they learn from their activities and experiences. They believe that CLEs comprise of six components in which technology has specific roles to play. These are demonstrated in Figure 3.2 below. The following is a brief description of each:

- **Problem/project space:** Jonassen et al. (1999:196-198) see ownership of an interesting, relevant and engaging problem to solve or project to complete as the key to meaningful learning. The role of technology is to provide a problem or project space in which the problem can be presented and conveyed. This space consists of three integrated and highly interrelated subcomponents:

  - **Problem context:** The context is so much part of any problem that it cannot be ignored. The social, cultural and physical context in which a problem or project occurs or will be solved defines, to a large degree, the nature of the problem. Technology can be used to create and present this problem context or scenario.

  - **Problem presentation/simulation:** The role of technology in problem presentation is to simulate the problem in the context in which it is normally and naturally encountered.

  - **Problem manipulation space:** The problem space must also provide learners with the opportunities and tools to manipulate or experiment with the problem. This can be done in micro worlds of reasonably accurate simulations of the environment being explored in which learners can manipulate phenomena in the problem, see the results of those manipulations, and test their hypotheses.

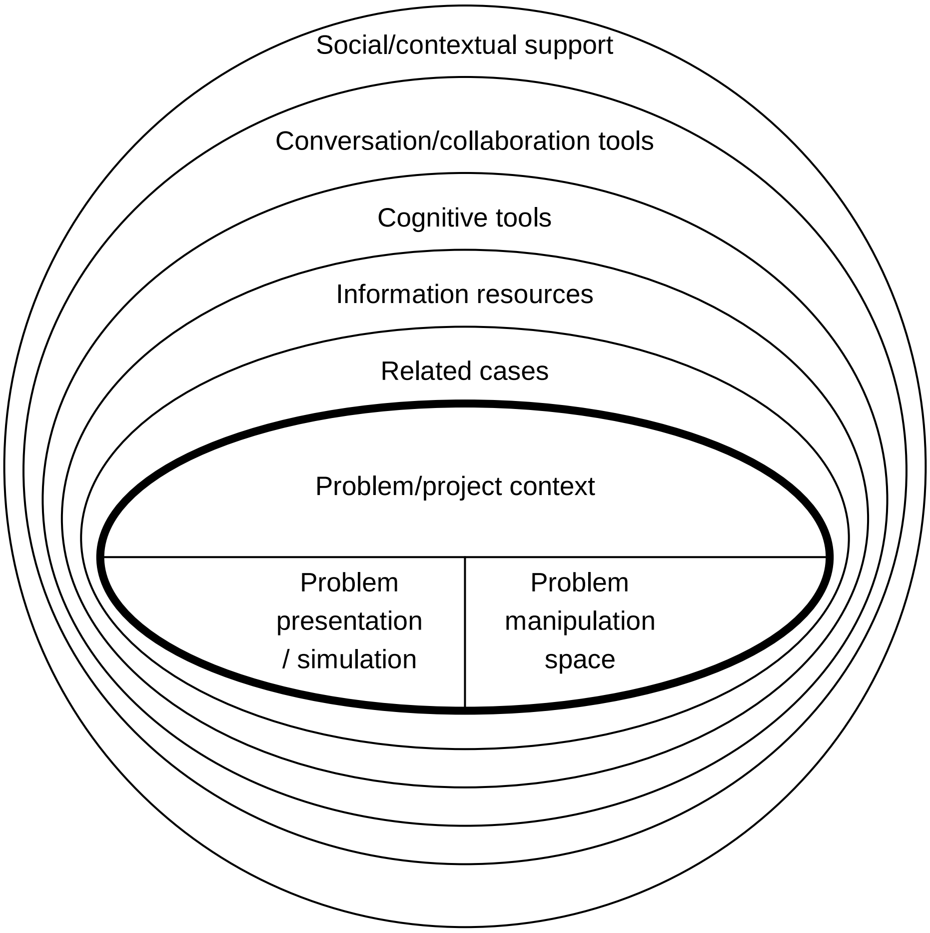

Figure 3.3: A conceptual model of constructivist learning environments (Jonassen et al. 1999:195)

- **Related cases:** When learners are expected to solve problems, it is important for the learning environment to provide access to a set of related experiences or cases. It is important for two reasons: to scaffold (support) learners by providing representations of experiences of similar problems that learners have not had; and to provide multiple perspectives or approaches to the problems or issues being examined by the learners (Jonassen et al. 1999:198-199). Technology has the role of providing learners access to resources that present such cases.

- **Information resources:** To investigate phenomena, learners need information about the phenomena. Repositories of such information must be appropriate for helping learners to understand its content well enough to be able to use it to solve problems. It may be in the form of text documents, graphics, sound resources, video or animations, but hypermedia is a most appropriate method for storing and retrieving information because it is organised in ways that support the kind of meaningful thinking you want learners to do (Jonassen et al. 1999:199).

- **Cognitive tools:** Cognitive tools, or mindtools, are knowledge-construction tools that extend and amplify learners' cognitive functioning during learning. This is done by engaging them during knowledge construction in cognitive operations they would not otherwise have been capable of. Using mindtools supports (scaffolds) learners in performing skills necessary to analyse phenomena, manipulate and observe models of such phenomena, interpret results, test hypotheses, articulate their findings or solutions, negotiate the meaning of phenomena internally, and integrate meaning in their personal knowledge structures. Mindtools are cognitive reflection and amplification tools that support higher-order thinking and help learners to construct their own knowledge. Such tools include databases, spreadsheets, semantic networks, expert systems, multimedia and hypermedia construction tools, micro worlds, model building tools, and visualisation tools (Jonassen et al. 1999:152-153 &196-198 & Jonassen 1995:62).

- **Conversation tools:** These are knowledge-negotiation tools that support conversation and collaboration among communities of learners. CLEs provide access to shared information and shared knowledge-building tools that help to collaboratively construct socially shared knowledge. Technology supports this in the form of tools such as electronic mail, file transfer, computer conferences, online chat, mailing lists, newsgroups, shared workspaces, and multi-user domains (MUDs) (Jonassen et al. 1999:200).

- **Social/contextual support:** In designing CLEs, it is essential to accommodate social, contextual and environmental factors. This includes ensuring adequate computer and network facilities, appropriate classroom environments, and teachers that are philosophically amenable to innovation and adequately skilled. Technology can support this by providing online professional developmental forums where teachers can explore the theoretical foundations of using technology in CLEs, and online implementation facilities where teachers receive support about practical and technical issues in implementing specific products (Jonassen et al. 1999:201).

(d) A critical review of classifications by educational role

Squires and McDougall (1994:58-59) allege that classifications based on educational roles are founded on the premise that the scope and nature of the software environment defines the educational possibilities. The focus is on the role that the software has been designed to play, not on the learner with personal learning needs, nor on the teacher with perceptions of appropriate curricula and pedagogies. This is how they describe it (Squires & McDougall 1994:59):

> *Inherent in this approach is a danger of ignoring important issues of learning and teaching, with education seen in terms of what software can offer rather than software seen in terms of educational needs and possibilities*.

This may be true in the case of software designers that focus on educational software as technical objects while ignoring the nature of education (for example Self in Squires & McDougall 1994:59). However, many modern educational software producers base their products on particular views of learning and teaching; Jonassen et al. (1999) describe many such examples. It can be argued that the Jonassen, Peck and Wilson classification is based on educational needs and not on software affordances. Squires and McDougall's perceived inherent danger of classifications by educational role, therefore, seems not to be true in all cases.

3.5.3 Classification by educational rationale

Another useful approach to classifying instructional uses of technology is to relate the application software to commonly accepted educational rationales (Squires & McDougall 1994:59).

(a) The Kemmis, Atkin and Wright classification

This is a most respected and widely used classification of instructional uses of technology. Their framework is based on the proposition of four paradigms of education: instructional paradigm, revelatory paradigm, conjectural paradigm and emancipatory paradigm (Squires & McDoughal 1994).

- **Instructional paradigm:** Associated with the instructional paradigm is the mastery of content, with subject matter seen as the object of learning. Instruction is seen as using techniques such as sequencing, presentation, (response requirement,) and feedback reinforcement. The role of the technology is to teach by transmitting subject material to learners, usually by breaking it up into small parts and presenting them one by one, and to elicit responses and provide feedback. It ranges from simple drill and practice programs in arithmetic to intelligent tutoring systems for teaching diagnosis of bacterial infections to medical students (Squires & McDougall 1994:60).

- **Revelatory paradigm:** This paradigm is based on the revelation of knowledge, concepts, ideas and meaning through exploratory and discovery activities. The role of technology is seen as providing environments for exploration and discovery. Examples include simulations where a computer-based model simulates a real-life phenomenon which might otherwise be difficult to study in the classroom. Learners study the model by changing the variables of the model, and observing the results. Through these exploratory and discovery activities the model reveals its key ideas and concepts. Simulations of nuclear power stations, business operations, ecology systems and laboratory experiments are well-known examples (Squires & McDougall 1994:60).

- **Conjectural paradigm:** The emphasis of this paradigm is on the development of understanding through the active construction of knowledge. It includes the articulation and manipulation of ideas, and testing of hypotheses. The role of technology is to provide environments that enable learners to explore a topic by formulating and testing their own hypotheses, articulating and exploring ideas, and creating and manipulating models and conceptual structures. Examples include software packages that allow learners to build and manipulate models, and computer-based micro worlds which enable learners to express their ideas and construct solutions to problems by changing the state of a computational object through programming (Squires & McDougall 1994:60-61).

- **Emancipatory paradigm:** In itself this paradigm is not seen as directly concerned with an educational rationale. Rather, it is seen as a way of facilitating the other three paradigms. It focuses on means of obviating 'inauthentic' labour, that is labour which does not contribute directly to intended or authentic learning activities. The role of the technology is to provide the tools that exploit the capacity of the computer to process large amounts of data accurately and quickly, and thereby saving learners from laborious tasks that are necessary but incidental to their learning. Examples include spreadsheets for processing and analysing data, and databases that enable selective data searches (Squires & McDougall 1994:61).

(b) A critical review of classifications by educational rationale

Although this classification system is relatively old, it still provides a useful and rigorous approach. However, it also has some limitations. The same software package (technology use) can be associated with more than one paradigm. For example, the use of a database package for information retrieval may support both pattern recognition (revelatory paradigm) and model building (conjectural paradigm). Furthermore, although the framework addresses curriculum issues by identifying relevant educational rationales, there is no consideration of the learning process (Squires & McDougall 1994:61-62).

3.5.4 Classification systems and learning theories

In Chapter 2 a theoretical foundation for integrating technology in learning is proposed. It is based on a 21st century view of learning theories that meet the learning needs of contemporary society. A typology of technology uses in learning that comply with contemporary learning needs and the requirements of this research obviously needs to conform to this learning theory foundation. This is the reason why it is deemed necessary to analyse the classification systems presented above in terms of the learning theory orientation of their categories. To further improve our understanding of the classification systems, their categories are also classified according to the three broad categories of learning about technology, learning from technology and learning with technology. The result of this exercise is presented in Table 3.2 below. Some of the categories refer to 'content-free' packages such as word processors, spreadsheets, and databases. In evaluating these categories the focus is not on the functions and features of the packages as such, but on how they are used in learning activities.

Table 3.2: Analysis of classification systems of technology uses in learning in terms of learning theory orientation and broad categories of learning about, from or with technology

Classification systems with categories	Learning theory orientation	Learning about, from or with technology
OECD		
Drill and practice Tutorial Educational games Intelligent tutoring systems Computer-managed learning	Classic behaviourist (objectivist) approach	Learning from technology
Simulation and model building Problem solving Information retrieval and database management Word processing Application programs Microcomputer-based instrumentation Exploration and discovery	Originated from a behaviourist (objectivist) approach but their meaning is today better understood from and accommodated in a constructivist perspective	Learning with technology

Norton and Sprague		
Skills software	Behaviourist (objectivist) approach	Learning from technology
Computer graphics software Editor software Databases Telecommunications Simulations Multimedia/hypermedia Mathematical devices	Categories are based on a classification by application type, but their uses are described from a constructivist perspective.	Learning with technology
Taylor		
Computer as tutor		
Drill and practice Tutorial Games	Classic behaviourist (objectivist) approach	Learning from technology
Demonstration Simulation Modelling Problem solving Exploration	Originated from a behaviourist (objectivist) approach but their meaning is today better understood from and accommodated in a constructivist perspective	Learning with technology
Computer as tool	Originated from a behaviourist (objectivist) view that saw it as an assistant for performing tedious and labour intensive activities, but from a constructivist view it is seen as a tool for constructing learning effects (i.e. cognitive tools)	Learning with technology
Computer as tutee	Originated from a behaviourist (objectivist) view that saw it as using programming skills to solve problems, but is better understood from and accommodated in a constructivist perspective that views it as cognitive tools	Learning with technology

ACCE		
Support mode	Seen as tool for constructing learning effects (i.e. cognitive tools) – fit constructivist view	Learning with technology
Exploration and control mode	Constructivist perspective	Learning with technology
Tutorial mode	Classic behaviourist (objectivist) approach	Learning from technology
Resource mode	Constructivist perspective	Learning with technology
Link mode	Constructivist perspective	Learning with technology
Jonassen, Peck and Wilson		
Problem/project space	Strong constructivist origin	Learning with technology
Related cases	Strong constructivist origin	Learning with technology
Information resources	Strong constructivist origin	Learning with technology
Cognitive tools	Strong constructivist origin	Learning with technology
Conversation tools	Strong constructivist origin	Learning with technology
Social/contextual support	Strong constructivist origin	Learning with technology

In the next section these learning theory interpretations of the classification systems are considered in proposing a typology of technology uses in learning that comply with the requirements of this research.

3.6 TYPOLOGY OF TECHNOLOGY ROLES IN LEARNING

This research has yielded the following thus far: 21st century learning needs (refer section 2.3); a theoretical foundation for integrating technology in learning (refer section 2.11.3); three broad areas of technology uses in learning (refer section 3.4); and an overview of typologies of technology uses in learning (refer section 3.5). With these fundamental findings, insights and guiding principles it is now possible to develop a typology that describes categories of contemporary technology uses in learning. It is done by proposing a **typology of technology roles in learning**. This typology is based on the assumption that the uses of technology in learning are determined by the roles that technology plays in learning activities. In other words, technology roles in learning are simply another way of describing technology uses in learning.

The proposed typology should comply with one very important criterion. It has to conform with and accommodate the recommended theoretical foundation for integrating technology in learning that is based on the learning needs of the 21st century (refer section 2.11.3). The recommended foundation considers the two learning theories of objectivism and constructivism to be complementary, meaning that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate than the other. However, due to the nature of 21st century learning needs for increasing advanced knowledge acquisition, a growing need for constructivist approaches is expected.

The proposed typology incorporates the complementary view of constructivism and objectivism, as well as the three broad areas of learning about technology, learning from technology and learning with technology. The constructivist learning-with-technology categories of context tool, resource tool, cognitive tool, collaboration tool and productivity tool are adapted from the Jonassen, Peck and Wilson (1999:194-201) classification (refer section 3.5.2(c)). To accommodate objectivistic learning-from-technology uses the category of didactic tool is added. Finally, the category of technology learning content is included to accommodate learning-about-technology uses. It is now possible to answer the research question: **What are the uses of ICTs in learning?**

FINDING 2.1: The uses of ICTs in learning can be described in terms of the categories of the typology of technology roles in learning which are technology learning content, didactic tool, context tool, resource tool, cognitive tool, collaboration tool and productivity tool.

The typology of technology roles in learning and its categories are presented in Table 3.3 as a three-tier typology with 'technology purpose', 'learning focus' and 'technology roles in learning' as its three levels. The levels and categories of the typology are described in detail following the table.

Table 3.3: Typology of technology roles in learning

Level 1	Level 2	Level 3	
Technology purpose	**Learning focus**	**Technology role in learning**	**Description of technology roles in learning**
Technology as learning content	Learning about technology	Technology learning content	▪ Computer literacy for learners ▪ Technology-oriented subjects (e.g. CAT and IT) ▪ Acquiring initial knowledge and skills about specialised application packages in specific subjects (e.g. accounting package in Accounting)
Technology as learning tool	Learning from technology	Didactic tool	Teach learners by transmitting learning content to learners who assimilate it (e.g. drill and practice, tutorial and educational game programs).
	Learning with technology	Context tool	Provide an environment or space that: describes the context of a problem; presents and/or simulates the problem; and allows manipulation and exploration of and interaction with the problem (e.g. interactive multimedia/hypermedia programs that present multiple views of a topic).
		Resource tool	Provide access to related cases and information (e.g. library catalogues and the WWW).
		Cognitive tool	Facilitate learners' own knowledge construction by: scaffolding learner performance; supporting internal meaning making; supporting reflection on what has been learned; enabling articulation of new meaning created; and facilitating construction of personal representations of meaning (e.g. using a word processor to compile a research report, and presentation graphics to articulate the findings).
		Collaboration tool	Facilitate knowledge construction (meaning making) by: enabling communication and collaboration with others; supporting discourse among members of learning communities; and facilitating consensus building among such members (e.g. learners from different communities using an Internet-based discussion forum to discuss a social problem and possible solutions).
		Productivity tool	Provide productivity support in inauthentic labour that is incidental to authentic learning (e.g. using a spreadsheet to process large volumes of experiment data)

3.6.1 Level 1: Technology purpose

The first level of the typology assumes that there are two basic purposes for using technology in learning.

- **Technology as learning content:** The use of technology as learning content means that technology is a knowledge domain in its own right and merits to be included in a curriculum of learning areas and subjects.

- **Technology as learning tool:** The purpose of using technology as a learning tool is to support, enhance and extend learners' abilities to perform learning activities in acquiring knowledge, skills and values.

3.6.2 Level 2: Learning focus

At the second level of the typology, the use of technology for learning is seen to have three foci:

- **Learning about technology:** The focus here is on learners acquiring technology knowledge, skills and values. The technology itself is, therefore, the learning content and its mastery the learning objective (refer section 3.4.1). The *technology purpose* (level 1) of this category is *technology as learning content*.

- **Learning from technology:** In this focus technology is viewed as learning tools that teach learners. It assumes that knowledge can be embedded in the technology and transmitted to the learner. Learners learn *from* technology what the technology knows, just as they learn *from* the teacher what the teacher knows. It is based on a behaviourist (i.e. objectivist) approach to learning (refer section 3.4.2). The *technology purpose* (level 1) of this category is *technology as learning tool*.

- **Learning with technology:** This instructional focus on technology is based on a constructivist approach to learning that views technology as learning tools for extending and amplifying learners' capabilities to explore, experiment, construct, converse and reflect. Such learning tools enable and facilitate critical thinking and higher-order learning during knowledge construction. This focus assumes that technologies are learning tools that learners learn *with* by using it as engagers and facilitators of thinking and knowledge construction (refer section 3.4.3). The *technology purpose* (level 1) of this category is *technology as learning tool*.

3.6.3 Level 3: Technology roles in learning

A number of technology roles (level 3 categories) are associated with each of the level 2 categories of learning about technology, learning from technology and learning with technology. The technology roles in learning are described as tools, because technology is viewed as tools that extend and amplify learners' capacity and abilities to perform learning tasks. The proposed roles are as follows:

(a) Technology learning content

This category refers to learning activities in which the technology itself is the learning content, that is learning is about technology. The purpose of technology in this role is to equip learners with technological knowledge, skills and values that will enable them to do various tasks in learning activities (refer section 3.4.1). The *technology purpose* (level 1) of this category is *technology as learning content* and the *learning focus* (level 2) is on *learning about technology*. The following are some examples of using technology in this role:

- **Computer literacy for learners:** Technology learning content in this case involves learners acquiring introductory level knowledge and skills about computers, networks and user-friendly software packages, and how to use them. Schools may have to institute computer literacy programmes in the lower grades to ensure that learners have the required technology knowledge and skills when they reach the senior grades (refer section 3.4.1(a)).

- **Technology-oriented subjects:** Using technology as learning content in this case refers to subjects that focus exclusively on ICTs as a knowledge domain. Computer Applications Technology (CAT) and Information Technology (IT) are examples of two NCS subjects in this category. The purpose of CAT is to equip learners with the knowledge, skills and values that will enable them to solve problems in society by using ready-to-use and user-friendly software packages (Department of Education 2003e:9). On the other hand, IT also focuses on using technology to solve problems in society, but uses programming languages to design, create and develop application programs as solutions to specific problems (Department of Education 2003n:9) (refer section 3.4.1(b)).

- **Specialised application packages in specific subjects:** Some subjects use specialised application packages for functions that are unique to their knowledge domains, practices and professions. Learners are initially required to acquire knowledge and skills about these packages themselves, in other words learning about technology. At a later stage learners will use these packages to perform learning tasks, when it becomes learning with technology. An example is learning the functions, features and facilities of an accounting package in Accounting (refer section 3.4.1(c)).

The *technology purpose* (level 1) of technology learning content is *technology as learning content* and its *learning focus* (level 2) is *learning about technology.*

(b) Didactic tools

This category refers to the use of technology to teach learners. It is based on the traditional behaviourist didactic model that works as follows: the technology transmits and presents some embedded learning content to the learner; the learner perceives the content and is required to respond; the technology evaluates the response and provides appropriate feedback; and determines what to present next based on the results of the evaluation (refer section 3.4.2). The following are examples:

- **Drill and practice programs:** This kind of program provides repetitive drill and practice exercises on content previously presented by other means, until the learner achieves a predetermined level of mastery.

- **Tutorial programs:** In these programs a topic is divided into smaller units and presented one by one to learners in a linear format according to the behaviourist didactic model.

- **Educational games:** This type of program is basically the same as drill and practice programs, but with competition and fun elements included.

The *technology purpose* (level 1) of didactic tools is *technology as learning tool* and its *learning focus* (level 2) is *learning from technology.*

(c) Context tools

The use of technology in learning as a context tool is based on the concept of a *problem/project space* described by Jonassen et al. (1999:196-198) as one of the roles of technology in CLEs (refer section 3.5.2(c)). It emphasises the principles of situated learning and problem-based learning. The former stipulates that learning a new concept must be situated in the context from which that concept originates and in which it naturally occurs (refer section 2.8.2(d)). The latter argues that the key to meaningful learning is a real-life authentic problem (or task) of which the learner takes ownership (refer section 2.8.2). The role of technology is to provide an environment or space in which such a problem is introduced, the context of the problem is described, and exploration of the problem and its context is effected. Three integrated and interrelated functions can be distinguished for context tools:

- To describe the social, cultural and physical context in which the problem occurs and will be solved

- To present and/or simulate the problem in the context in which it normally and naturally occurs in an interesting, appealing and engaging way

- To provide learners with a safe problem manipulation space in which they have opportunities to manipulate and experiment with the problem and observe the results

Spiro, Feltovich, Jacobson and Coulson (1991:30-32) describe the excellent example of an interactive multimedia program on videodisc that teaches learners processes of literary comprehension and interpretation in the classic film *Citizen Kane*. It provides: opportunities to explore multiple conceptual themes on Kane's character (e.g. 'Wealth Corrupts' and 'Hollow, Soulless Man'); a display of all relevant conceptual themes in each scene; background information on sections of the film; context-sensitive expert commentaries on meanings in specific themes and scenes; cross-references to other relevant cases/scenes in which a particular conceptual theme occurs; cross-references to other conceptual themes that interact and influence a theme in a particular scene; and so forth.

The *technology purpose* (level 1) of context tools is *technology as learning tool* and its *learning focus* (level 2) is *learning with technology.*

(d) Resource tools

A resource tool is seen as a combination of the concepts *related cases* and *information resources* described by Jonassen et al. (1999:198-199) as two of the roles of technology in CLEs (refer section 3.5.2(c)). Its function is to provide learners with access to information resources related to the problem being examined. To be effective, resource tools assume that learners have the ability (skills) to find, query, evaluate, analyse, organise, use and distribute the information contained in the resources. Resource tools serve two purposes:

- To provide access to information about the phenomenon being explored

- To provide access to related cases for two reasons: to scaffold learners by providing representations of experiences of similar problems that they do not have; and to provide multiple perspectives on the problem being examined

Examples include software to access information repositories such as the Worldwide Web and library catalogues.

The *technology purpose* (level 1) of resource tools is *technology as learning tool* and its *learning focus* (level 2) is *learning with technology.*

(e) Cognitive tools

These are cognitive reflection and amplification tools that support higher-order and mindful thinking, and help learners to construct their own knowledge (refer section 3.5.2(c)). As knowledge-construction tools they enhance, extend and amplify learners' cognitive powers during learning, by engaging them in cognitive operations that they would not otherwise have been capable of. It enables them to manipulate and observe models of phenomena, interpret results, test hypotheses, articulate their findings or solutions, negotiate the meaning of phenomena internally, and integrate meaning in their personal knowledge structures. A characteristic of the use of a cognitive tool by learners is that it results in some or other 'cognitive product' that can be in the form of a new understanding of a concept, an articulation of this new understanding, a representation of what has been learned, and a new/revised/extended personal knowledge structure. Practical examples include writing a poem or essay using a word processor, developing a mathematical model of an economic phenomenon using a spreadsheet, designing and developing a transaction system for a business using a programming language, creating a mind or concept map to illustrate the relationships between the components of a concept using graphics, software etc. The objectives of cognitive tools include the following:

- To scaffold learners in performing skills necessary to analyse and evaluate phenomena represented in the problem being examined
- To support learners in their internal negotiations of making meaning of the phenomena
- To support learners in reflecting on what they have learned and how they come to know it

- To enable learners to articulate what they know
- To facilitate learners in constructing personal representations of what they know

The *technology purpose* (level 1) of cognitive tools is *technology as learning tool* and its *learning focus* (level 2) is *learning with technology.*

(f) Collaboration tools

Collaboration tools are based on the concept of *conversation tools* (refer section 3.5.2(c). They are knowledge-negotiating tools that support communication, conversation and collaboration among communities of learners in discussing, arguing, negotiating and reaching consensus on the meaning of phenomena. It provides access to shared information and shared knowledge-building tools that aid the collaborative construction of socially shared knowledge. Their functions include the following:

- To enable communication and collaboration with others
- To support discourses about meaning among members of learning communities
- To facilitate consensus building among members of learning communities

Examples of collaboration tools include e-mail, mailing lists, Internet chat, message boards and discussion forums. All of them enable learners to communicate, collaborate, discourse and discuss with other learners or experts in the meaning making process.

The *technology purpose* (level 1) of collaboration tools is *technology as learning tool* and its *learning focus* (level 2) is *learning with technology.*

(g) Productivity tools

The productivity role of technology in learning is mostly based on the *emancipatory paradigm* (refer section 3.5.3 (a)). Productivity tools support learners in inauthentic labour that is incidental to authentic learning. In other words it enhances and extends learners' productive abilities, for example, to quickly and accurately process large volumes of experimental data using a spreadsheet.

The *technology purpose* (level 1) of productivity tools is *technology as learning tool* and its *learning focus* (level 2) is *learning with technology.*

This concludes the description of the proposed typology that has the specific function within the context of this study to assist in examining, understanding and classifying the ICT requirements of the NCS from a learning point of view. When applying the typology in classifying ICT requirements only the third level of technology roles in learning will be used as its categories.

3.7 THE CONCEPT OF A TECHNOLOGY-INTEGRATED CURRICULUM

There remains one final aspect that needs to be examined in order to complete our understanding of the relationship between a curriculum and technology uses in learning, and that is the concept of a *technology-integrated curriculum*. One of the reasons why technology implementations in the classroom failed in the past, is that technology was not integrated into the curriculum. Morton (1996:417) argues that instead of being integral to and integrated into the curriculum, technology remained on the periphery as an 'add-on'. This also implied that technology was not integrated into teaching and learning. This is how Heide and Henderson (2001:9) describe it:

> *Initially, a technology-enriched learning environment was considered one in which technology was layered on top of an existing, traditional approach to learning. This approach … led to little change in teaching and learning. We*

now know that to truly have a long-term effect, technology must be integrated into the teaching and learning experiences of the classroom.

Earle (2002:10) confirms these viewpoints by saying that to solve the problem technology must be integrated into teaching practices and learning experiences, as well as into the curriculum. There are therefore two concepts that presuppose each other: technology-integrated curriculum and technology-integrated teaching and learning. Earle (2002:10) interprets integration (from the Latin *integrare*, to make whole, to bring parts together into a whole) as a concept that includes a sense of completeness or wholeness and incorporates the need to overcome artificial separations by bringing together all essential elements in the teaching and learning process – including technology as one of the elements, but not as the sole element.

Furthermore, Earle (2002:7) sees technology not as a synonym for computer and other technologies, but as a problem-solving process using human and other resources to seek solutions to teaching and learning problems, encompassing the broader processes of teaching and learning. Technologies must be pedagogically sound. They must go beyond information retrieval to problem solving, allow new instructional and learning experiences not possible without them, promote deep processing of ideas, and increase learner interaction with subject matter – in sum, improve the pedagogy. Shelly, Gunter and Gunter (2010:4), Roblyer (2006:64) and Newby et al. (2006:18) add to this by saying that the technology must be appropriate: it must match the curriculum needs as represented by the learning outcomes, learning content and teaching and learning strategies.

Against this background technology integration into teaching and learning can be described as the systematic use of technology appropriately matched and combined with teaching and learning strategies and learning content in order to enhance the achievement of learning outcomes. According to Cuban (in Earle 2002:11) this is only possible if the curriculum is the vehicle for technology integration.

FINDING 2.2: For technology uses in learning to succeed it must be imbedded in a technology-integrated curriculum that is defined as a curriculum that supports, and in many cases, prescribes technology integration into teaching and learning. In other words the curriculum must prescribe and/or support the systematic use of technology appropriately matched and combined with teaching and learning strategies and curriculum content in order to enhance the achievement of curriculum-specified learning outcomes. The following criteria are inferred from the ideas of Earle (2002) about a technology-integrated curriculum:

- **Synergetic whole:** The curriculum must bring the components of technology, learning outcomes, learning content, and teaching and learning strategies together in an integrated and synergetic whole in which the combined effect of the components is greater than the sum of their individual effects.

- **Pedagogical soundness:** The use of technology promoted in the curriculum must focus on improving the practices for teaching and learning by supporting meaningful learning environments that, for example: allow learners to interact with phenomena in authentic contexts; promote deep critical thinking and processing of ideas; encourage learners in constructing their own knowledge and meanings; and accommodate collaborative activities and social interaction.

- **Appropriateness:** The technology prescribed by the curriculum must appropriately match the needs of presenting and learning new content. In other words, it must be applicable, meaningful and supportive for presenting learning content, performing teaching and learning activities, and achieving learning outcomes.

- **Integration vehicle:** The curriculum must be the vehicle for integrating technology into teaching and learning by prescribing learning activities that are not possible without technology. The technology must be weaved into the curriculum and therefore into the fabric of learning. It must become an integral, essential and intrinsic component of learning events. This does not mean that technology must be used in all learning events, only when it is appropriate and meaningful. Technology must be fitted to the curriculum, not the curriculum to the technology.

In section 1.1 of Chapter 1 evidence is given that the NCS clearly has a fundamentally different and new approach to technology than was the case with both the Revised National Curriculum Statement Grades R - 9 and the outgoing Senior Certificate Curriculum. The question now is: Can the NCS be considered as a technology-integrated curriculum? This question can only be fully answered once the NCS and its ICT requirements have been analysed thoroughly (in Chapter 5). However, the cursory review of the NCS in section 1.1 reveals several subjects in which learning activities are prescribed that are not possible without technology. It can therefore be stated at this stage that the NCS seems to be technology integrated with regard to the criterion of being an integration vehicle. However, it still needs to be confirmed.

3.8 SUMMARY

Broadly speaking, the goal of this chapter was to come to a deeper understanding of the role of technology in education in modern society, and the forms in which its use are manifested in the classroom. In particular, the purpose was to study the technology uses in a schools and classification systems for classifying it. A general typology of technology uses in schools with the categories of technology uses in management, technology uses in teaching and technology uses in learning was described. The first two categories were examined briefly, while the latter was explored in detail, resulting in a proposed typology of technology roles in learning. Figure 3.4 below summarises the subcategories of the three general categories.

In conclusion the concept of a technology-integrated curriculum was examined and described as a requirement for technology uses in learning to succeed. It included the identification of four criteria that can be used to determine whether a curriculum qualifies as a technology-integrated curriculum. Whether the NCS qualifies as a technology-integrated curriculum, can only be determined once the NCS and its ICT requirements have been analysed thoroughly (in Chapter 5).

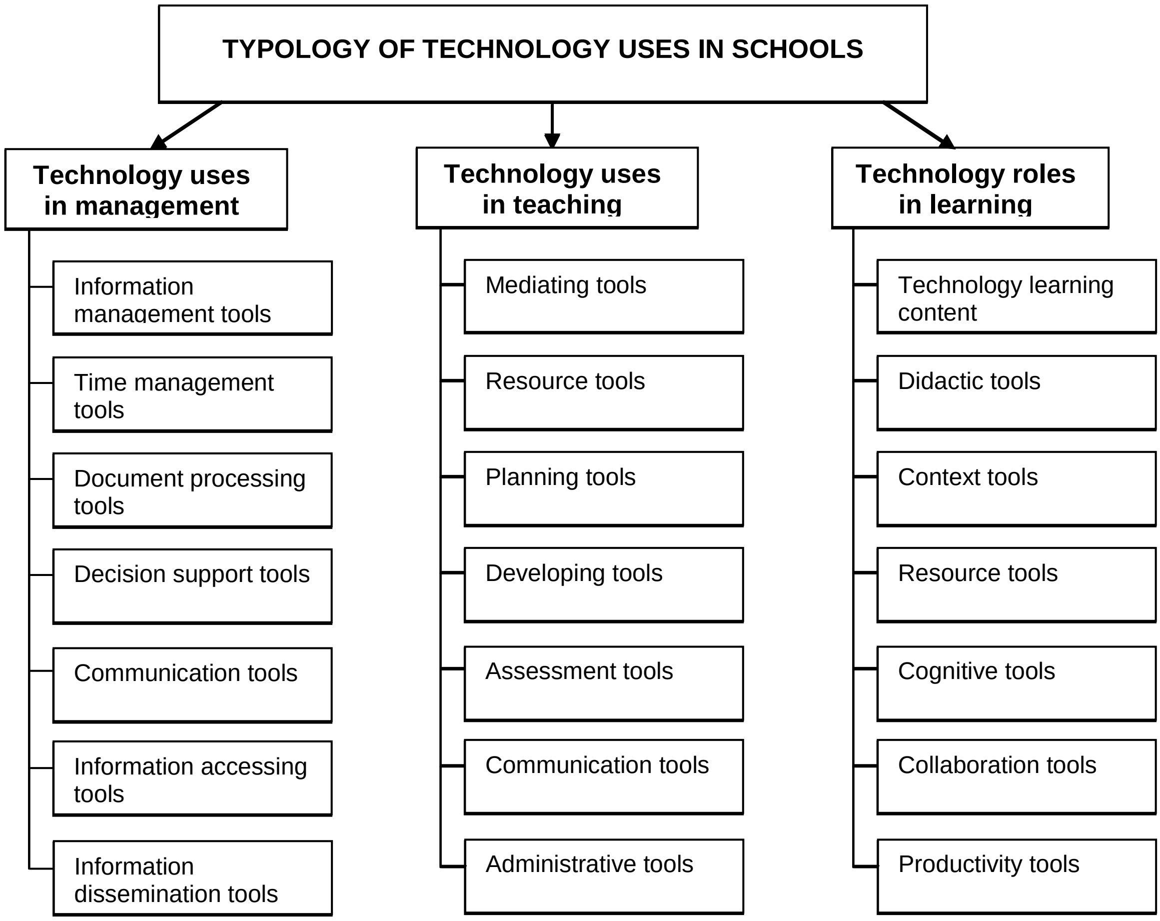

Figure 3.4: A general typology of technology uses in schools

CHAPTER 4: RESEARCH DESIGN

A well-conceived strategy, by providing overall direction, provides a framework for decision making and action. It permits seemingly isolated tasks and activities to fit together, integrating separate efforts toward a common purpose (Patton 2002: 37).

4.1 INTRODUCTION

The philosophical advice of Patton (2002) above was made in relation to research, but it is equally true for any other human endeavour. This research endeavours to solve a particular problem. Solving such a problem is an ill-structured and complex process consisting of multiple facets, perspectives, tasks and activities. Its success can only be guaranteed by a well-conceived strategy that provides overall direction and a framework for decision making and action. The purpose of this chapter is to describe the strategy in the format of a research design that provides the overall direction and a framework for decision making and action in the research. This strategy enables the piecing together of the many seemingly separate activities of the research into a holistic solution of the research problem.

4.2 CHOICE OF A RESEARCH PROBLEM

The choice of research problem for this study has its origin in the fact that when the NCS was introduced in 2003 (implementation only started in 2006) it became clear that it has a fundamentally different approach to the use of technology in learning than was the case with both the outgoing Senior Certificate Curriculum and the preceding Revised National Curriculum Statement for grades R - 9. Glancing through the documentation of the NCS reveals many instances of ICTs that are required for learning. In implementing the new curriculum, schools need to know and understand this paradigm shift in the role of technology in teaching and learning, and its implications for implementing it. In other words they need to be supported in the form of a framework of understanding for implementing the ICT requirements of the NCS. Against this background the research problem and its six sub problems are formulated as follows:

What are the ICT requirements of the NCS, and its implications for implementation?

- **What is an appropriate theoretical foundation for integrating ICTs in learning?**
- **What are the uses of ICTs in learning?**
- **How can the ICT requirements of the NCS be identified and classified?**
- **What are the ICT requirements of the NCS?**
- **What are the implications of the ICT requirements of the NCS for implementation in schools?**
- **Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?**

4.3 AIM OF THE RESEARCH

The following statement of Simonson and Thompson (1990:iii) guides the aim of this research: *“If computers are to have a significant, long-term impact on education, there must be a theoretical rationale for their use that is based on research”*. The main purpose of the research is to investigate the ICT requirements of the NCS and to develop a framework of understanding for implementing it in grades 10 - 12 in secondary schools. This is achieved through the following three research objectives:

- To research and describe an acceptable and appropriate underlying theoretical foundation for integrating ICTs in 21st century classroom teaching and learning. This objective is achieved by means of a comprehensive literature study.

- To identify, analyse, interpret, classify and record the spectrum of ICT requirements in the NCS. The approach to research in this case is in the format of a qualitative design that is described in detail in the rest of this chapter.

- To develop theoretical and practical guidelines in a framework of understanding for implementing the ICT requirements of the NCS in classroom teaching and learning. This is achieved by synthesising the findings of the two preceding research objectives.

4.4 CHOOSING A QUALITATIVE APPROACH

Leedy (in De Vos 1998:15) states that all research methodologies rest upon a bedrock axiom: *'The nature of the data and the problem for research dictate the research methodology'.* Considering the nature of this study's research problem, and using comparisons of qualitative and quantitative research paradigms by Patton (2002:12-17) and De Vos (1998:241-244), a **qualitative approach** to research the ICT requirements of the NCS is chosen for the following reasons:

- In qualitative research, data are in the form of words and quotes from documents and transcripts, as opposed to exact figures gained from precise measurement in quantitative research (De Vos 1998:243). This study is about the ICT requirements in the NCS that are defined as any reference (i.e. quotation of words) in the NCS documentation that refers to the use of technology in learning. There is no controlled experiment involved and no exact figures are gained from precise measurements. It is clear that this type of research data belongs to a qualitative approach.

- According to Patton (2002:14,227-228) quantitative methods are concerned with a great number of cases that can be studied in terms of a limited number of predetermined variables, while qualitative methods facilitate studies of a limited number of cases in great depth and detail (i.e. large numbers and limited depth versus limited numbers and great depth). This study fits the latter description because it focuses on only one curriculum (case), namely the NCS. The aspect of its ICT requirements is studied in depth in order to develop a framework of understanding for implementing it.

- The unit of analysis in quantitative inquiry is variables which are atomistic (elements that form part of the whole). In qualitative inquiry it is holistic, concentrating on the relationships between elements, context, and so on. The whole is always more than the sum (De Vos 1998:243). This research focuses on the NCS as the unit of analysis, and the purpose is to understand the ICT requirements it prescribes/implies in relation to subjects, learning outcomes and content. This implies a holistic focus and therefore a qualitative inquiry.

- Qualitative research seeks to understand phenomena. This is in contrast to quantitative research that seeks to control phenomena (De Vos 1998:243). This study endeavours to understand the phenomenon of ICT requirements in the NCS.

- In quantitative research the researcher starts off with hypotheses and then tests them. Qualitative research captures and discovers meaning once the researcher becomes immersed in the data (De Vos 1998:242), which is the case in this study.

4.5 PRINCIPLES GUIDING THE RESEARCH DESIGN

Patton (2002:37-73) offers 12 major principles of qualitative inquiry that, taken together, constitute a comprehensive and coherent strategic framework for overall direction, and decision-making and action. He classifies them in the three categories of design strategies, data collection strategies and analysis strategies. The paragraphs below provide a description of how those principles that are of particular relevance, apply to this study.

4.5.1 Design strategies

This study is guided by the following three design strategy principles:

(a) Naturalistic inquiry

According to Patton (2002:39) qualitative designs are naturalistic. Applying this principle means that the study of the NCS as the phenomenon of interest has to take place in real-world settings, allowing it to unfold naturally without any predetermined course established by and for the researcher. It also includes studying the NCS with openness to whatever emerges, and placing no prior constraints on what the outcomes of the research will be.

(b) Emergent design flexibility

One of the characteristics of qualitative research is that the research design is flexible and unique, and evolves as the fieldwork unfolds throughout the research process. There are no fixed steps that should be followed and the process cannot be exactly replicated (De Vos 1998:80,243). Patton (2002:43-45) calls it "emergent design flexibility", and states that because of the naturalistic and inductive nature of qualitative inquiry, it is both impossible and inappropriate to completely specify research designs in advance of fieldwork. Emerging design flexibility is also evident in this study as the research questions, analysis protocols, data categories and pattern analysis had to be reviewed several times. The research design presented here is the final result of this iterative process.

(c) Purposeful sampling

Qualitative inquiry typically focuses on relatively small samples, even single cases as is the situation in this study with the NCS as the only case of a curriculum under examination. The NCS is selected *purposefully* in order to permit inquiry into and understanding of it *in depth*. The logic and power of purposeful sampling derive from the emphasis on in-depth-understanding. This leads to selecting information-rich cases for in-depth study (Patton 2002:45-46). The NCS is such an information-rich case from which much can be learned about technology integration into teaching and learning.

4.5.2 Data collection strategies

The data collection principles of qualitative data and dynamic systems are of particular relevance for this study:

(a) Qualitative data

Qualitative data describes, it tells a story. It takes us, as readers, into the time and place of the observation so that we know what it was like to have been there. They capture and communicate someone else's experience of the world in his or her own words (Patton 2002:47). In this study, the qualitative data consist of excerpts from documents that collectively form the information-rich case of the NCS. It tells the story of how the curriculum developers saw, *inter alia*, the role of technology in teaching and learning in the various subjects.

(b) Dynamic systems

The qualitative researcher assumes change in a programme, organisation or culture as a natural, expected and inevitable part of human experience, and documenting that change is a natural, expected and intrinsic part of fieldwork (Patton 2002:54). Developing the NCS was a dynamic process, and implementing it, including its technology requirements, required and still is requiring fundamental changes. Some of the NCS documents, for example, are reviewed regularly to improve their implementation. This principle implies that it is imperative in this study to be mindful of the dynamic process that the implementation of the NCS requires.

4.5.3 Data analysis strategies

Of the five principles of qualitative data analysis that Patton (2002:55-66) describes, the following two are particularly relevant for this study:

(a) Inductive analysis and creative synthesis

Qualitative analysis can be viewed as both a science and an art – it draws on both critical and creative thinking. When ideas or possibilities need to be evaluated, analysts have to put on their critical caps, and when new ideas or possibilities are needed, they have to put on their creative caps (Patton 2002:513). Patton (2002:55-56) describes **inductive analysis** as follows:

> *Qualitative inquiry is particularly oriented toward exploration, discovery, and inductive logic. Inductive analysis begins with specific observations and builds toward general patterns. Categories emerge from open-ended observations as the inquirer comes to understand patterns that exist in the phenomenon being investigated. … The strategy of inductive designs is to allow the important analysis dimensions to emerge from patterns found in the cases under study without presupposing in advance what the important dimensions will be. The qualitative analyst seeks to understand the multiple relationships among dimensions that emerge from the data without making prior assumptions or specifying hypotheses about the linear or correlative relationships among narrowly defined, operationalized variables.*

Creative synthesis implies using creativity and creative thinking in the process of discovering and recognising the analysis dimensions (thematic structures or overarching constructs) that describe the patterns that emerge from specific observations. Through creative thinking, new and innovative dimensions can be discovered and recognised, but it is important to balance this with critical thinking in evaluating whether these creatively discovered dimensions are valid for their particular context (Patton 2002:513-514). Creative analysis also means bringing together the pieces that have emerged into a total experience, showing patterns and relationships. The fundamental richness of the experience is captured and communicated in a creative way (Patton 2002:487).

Inductive analysis and creative synthesis are achieved in this study by beginning with all the observations regarding ICT requirements in the NCS and looking for emerging patterns. By applying critical thinking, a number of categories for classifying the ICT requirements emerge from these patterns without any presupposition. These categories are confirmed as valid in the context of the NCS as the curriculum framework for using technology in schools. These categories in turn form the input for the creative process of developing a framework of understanding for implementing the ICT requirements of the NCS in schools.

(b) Holistic perspective

Researchers analysing qualitative data strive to understand a phenomenon as a whole. This means that a description and interpretation of a programme's external context is essential for overall understanding of what is observed during fieldwork. This holistic approach assumes that the whole is understood as a complex system that is greater than the sum of its parts (Patton 2002:59). In this study it means that, apart from analysing the technology requirements themselves, they also need to be interpreted and evaluated in terms of the NCS as a whole. The technology requirements must be understood in relation to the other parts and contextual factors of the NCS such as its view of education in modern society, principles, critical and developmental outcomes, subject learning outcomes and assessment standards.

4.6 RESEARCH DESIGN

Because of the qualitative approach in the research of the ICT requirements in the NCS, the research design evolved and emerged as the empirical work unfolded throughout the research process. The research design presented here is the final result of an iterative process in which the research questions, analysis protocols, data categories and pattern analysis were reviewed several times. It is described in terms of the following design issues:

4.6.1 Research approach

The research endeavours to answer the research question: What are the ICT requirements of the NCS, and its implications for implementation? It studies the NCS in depth as a single case (of a curriculum) in order to gain an understanding of its ICT requirements, and to develop a framework of understanding for implementing it. This is achieved through a **qualitative** approach.

4.6.2 Primary purpose

The primary purpose of this study is **applied research** in the sense that it aims to illuminate the educational concern of the ICT requirements of the NCS. Using Patton's (2002:217) definition of applied research, the primary purpose of the study can be described as to contribute knowledge that will help teachers understand the nature of the ICT requirements of the NCS in order to support them in controlling its implementation more effectively.

4.6.3 Unit of analysis

This research studies the NCS in depth to understand its ICT requirements and implications for schools. The focus is only on this one curriculum. Its unit of analysis is, therefore, the **NCS** as a single case of a curriculum.

4.6.4 Type and degree of control

The research follows a **naturalistic inquiry** design. This implies that studying the NCS as the phenomenon of interest has to take place in real-world settings, allowing it to unfold naturally without any predetermined course established by and for the researcher, with openness to whatever emerges, and placing no prior constraints on what the outcomes of the research will be. The researcher, therefore, exerts no control on what the outcomes of the research are to be.

4.6.5 Focus of the study

This design issue refers to question of breadth versus depth. The focus of this research is to study the phenomenon of the NCS in **more depth and less breadth**. Not only are the ICT requirements identified, analysed and classified, but they are also interpreted in relation to the other parts and contextual factors of the NCS such as its view of education in modern society, principles, critical and developmental outcomes, subject learning outcomes and assessment standards.

4.6.6 Analytical approach

Because of the pure naturalistic-qualitative strategy of the study, an analytical approach that can be described as **inductive analysis and creative synthesis** is used. The objective is to begin with specific observations and build toward general patterns. This is achieved by identifying all the ICT requirements in the NCS, followed by a qualitative analysis process in order to identify emerging patterns without any presupposition. The categories that emerge from this analysis are used to classify and record the ICT requirements.

4.6.7 Qualitative content analysis

This study applies a qualitative content analysis process that is described by Patton (2002:432&453) as any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to sift trivia from significance, identify core consistencies and patterns, and construct a framework for communicating the essence of what the data reveals. Mayring (2000:[4],[5]) defines qualitative content analysis as an approach of systematic, empirical, methodological controlled (rule guided) analysis of texts within their context of communication, following content analytical rules and step by step models, without rash quantification. The basic assumptions of this approach are described as follows (Mayring (2000:[7]):

- **Fitting the material into a model of communication:** It includes determining on what part of the communication inferences shall be made: aspects of the communicator; the context of the text production; the socio-cultural background; the text itself; or the effect of the message.

- **Rules of analysis:** The material should be analysed step by step, following rules of procedure, and devising it into content analytical units.

- **Categories in the centre of analysis:** The aspects of text interpretation, following the research questions, are classified into categories, which are carefully founded and revised within the process of analysis.

- **Criteria of reliability and validity:** The content analysis procedure should include checks for reliability and validity. Inter-coder reliability, in which the coding of the same passage of text by two or more capable and experienced analysts is compared, is an example of such a check.

For the purpose of this study and for the sake of clarity the term **object of analysis** is used to indicate the specific aspect of the textual material to be considered in the content analysis and on which inferences shall be made. In other words, 'object of analysis' in this study refers to the 'ICT requirements of the NCS'. The term **textual material** is defined as the documentation that is to be analysed qualitatively. In this case it refers to the NCS documentation that consists of 89 documents - 31 subject statements, 29 learning programme guidelines and 29 subject assessment guidelines.

Patton (2002:454-453) distinguishes between deductive and inductive analyses. Mayring (2000:[8]) makes a similar distinction and calls the procedures for these analyses deductive category application and inductive category development. The main difference lies in the classification categories that are used to examine the qualitative data. The first procedure involves prior formulated categories that are theoretically derived, while the latter uses categories that are developed inductively. Both procedures are applied in this research.

(a) *Deductive category application*

Qualitative analysis in this study is firstly deductive when it employs theory-derived categories for the typology of technology uses in learning developed in section 3.6 to examine the data. These categories are used as sensitising concepts to initially orient and guide the fieldwork. In other words, it gives the analyst a starting point, a general sense of reference and direction when starting to examine the volume of raw data (Patton 2002:278-279&456).

According to Mayring (2000:[13],[15]) the procedure of deductive category application works with previously formulated, theoretically derived aspects of analysis (categories), relating them to the text. The qualitative step of analysis consists of a methodological controlled assignment of a category to a passage of text. For each deductive category a coding agenda is required that consists of an explicit definition, examples and coding rules. The purpose of the coding agenda is to determine exactly under what circumstances a text passage can be classified in that category (refer section 5.2.4 and Annexure A for the combined coding agenda that was developed for the deductive as well as inductive categories used in this research). Figure 4.1 below illustrates this procedure.

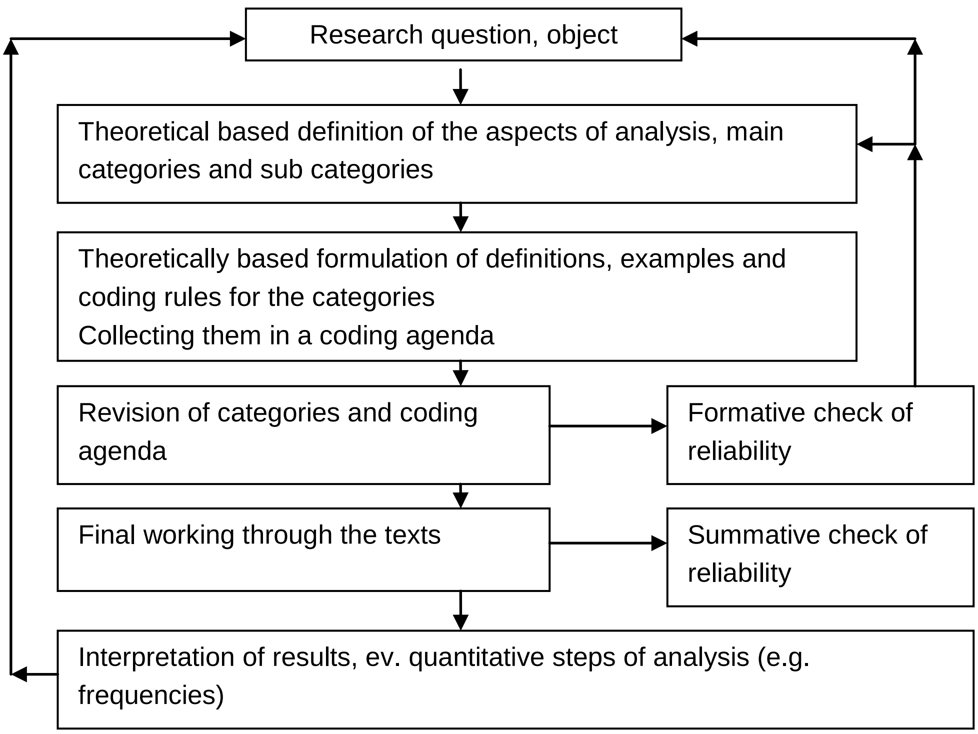

Figure 4.1: Step model of deductive category application (Mayring 2000:[14])

(b) Inductive category development

Inductive analysis involves discovering patterns and categories in the qualitative data. These findings emerge out of the data through interactions with the data during the process of inductive analysis (Patton 2002:453). Mayring (2000:[10]&[12]) describes the procedure of inductive category development as the development of the categories as near as possible to the material being analysed, in other words formulating them in terms of the material. The main idea is to define an object of analysis, derived from the theoretical background and research question, which determines the aspects of the textual material to be considered in the content analysis. Using this object the textual material is worked through to identify passages of text for analysis. Following this process categories are tentatively deduced step by step. In an iterative process these categories are revised, eventually reduced to main categories and checked for reliability. Figure 4.2 below illustrates this process.

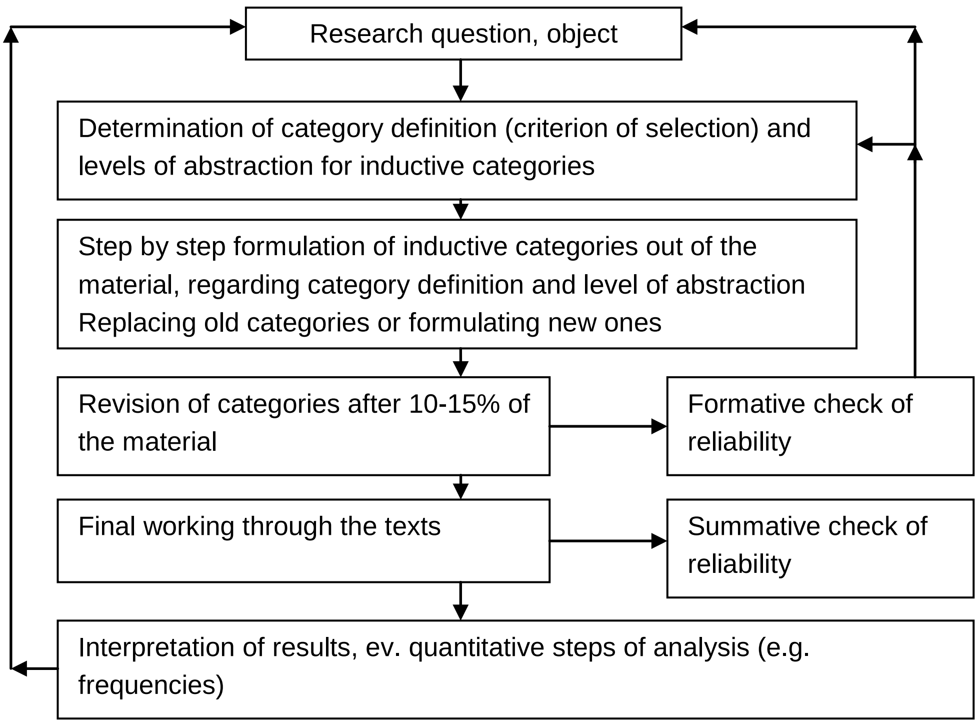

Figure 4.2: Step model of inductive category development (Mayring 2000:[11])

As in the case of the deductive categories, coding agendas consisting of explicit definitions, examples and coding rules are developed for the inductive categories deduced in this way (refer section 5.2.4 and Annexure A for the combined coding agenda that was developed for the deductive as well as inductive categories used in this research).

4.6.8 Triangulation

No single method or data source can be trusted to provide an accurate comprehensive perspective on the focus of a study. This problem can be overcome by a combination of analysts, methods and/or data sources to validate and cross-check the findings of such a study as one data type compensates for the weaknesses of another – a concept known as triangulation (Patton 2002:247-248,555-563). Triangulation is achieved in this study in two ways. Firstly, a combination of the two analysis procedures of deductive category application and inductive category development (Mayring 2000) is used to elucidate the research patterns and findings. Secondly, checks for reliability are performed in the form of inter-coder reliability checks (Mayring 2000:[7]) whereby a number of capable and experienced analysts are used to check and validate the data collection and analysis done by the researcher.

4.6.9 Data collection

The data collection process involves the following steps:

- **Defining the object of analysis:** This step involves identifying and defining the aspect of the textual material to be considered in the content analysis in this study, which is the concept of 'ICT requirements of the NCS'. This is done by analysing examples and the nature of references in the curriculum documentation for the 31 NCS subjects that require or imply the availability of ICT facilities for the purpose of learning. The result of this process is a formal definition of an ICT requirement (refer section 5.2.1 where the implementation of this step is described in detail).

- **Identifying the ICT requirements:** Using the formal definition of an ICT requirement, all 89 curriculum documents of the 31 NCS subjects are analysed in a qualitative process in order to identify all ICT requirements.

- **Classifying the ICT requirements:** This classification activity requires one or more classification system (i.e. taxonomy or typology) that provide the categories in which the ICT requirements can be classified. Such classification systems are developed through the qualitative procedures of deductive category application and inductive category development (refer section 4.6.7 for a theoretical description and section 5.2.2 for a practical description). To ensure the integrity of the classifications, a comprehensive coding agenda (refer Annexure A) is developed that includes explicit definitions, coding rules and examples for each of the categories used in the content analysis. Its aim is to determine exactly under what circumstances a passage of text can be coded with (i.e. classified in) a category (Mayring 2000: [15]). The main purpose of the coding agenda is to define a set of rules for performing a scientific process of document analysis that has the objective to identify, interpret and classify the ICT requirements of the NCS into various categories. The set of rules should enable any trained analyst to systematically and scientifically classify the ICT requirements found in the NCS documentation (refer section 5.2.4 for more details).

- **Recording the ICT requirements:** This is the equivalent of 'taking field notes' that refers to the process of recording the inferences of the object of analysis (ICT requirements) found when working through the textual material (NCS). Records should not only include the basic details (e.g. the actual passage of text, bibliographical reference details, context details of the passage, other supporting evidence, etc.), but also initial interpretations made during the actual data collection, as well as the results of the final analysis and classification. A properly designed computer database is used to capture and store all field notes (refer section 5.2.3 for a detailed description).

- **Analysing of the research data:** The last step in the data collection process is to statistically analyse the frequencies of the ICT requirements in the categories of the classification systems used for this purpose. This is done for the NCS as a whole, as well as for the individual NCS subjects (refer section 5.3 for a description how this was implemented).

4.6.10 Reporting

Patton (2002:434) argues that the primary purpose of the research guides the analysis and content of the report. The primary purpose of this study is applied research with policy makers and implementers as its primary audience. In such a case the relevance, clarity, utility and applicability of the findings reported in the research report become most important.

The research and its findings are reported in the following seven chapters:

Chapter 1 mainly describes the background and rationale for the study. It includes statement of the problem, aim of the research, demarcation of the problem, relevance of the research, clarification of concepts and an introduction to the research methodology and design. The research problem and sub-problems are as follows:

What are the ICT requirements of the NCS, and its implications for implementation?

- **Question 1: What is an appropriate theoretical foundation for integrating ICTs in learning?**

- **Question 2: What are the uses of ICTs in learning?**

- **Question 3: How can the ICT requirements of the NCS be identified and classified?**

- **Question 4: What are the ICT requirements of the NCS?**

- **Question 5: What are the implications of the ICT requirements of the NCS for implementation in schools?**

- **Question 6: Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?**

Chapter 2 endeavours to answer research question 1: **What is an appropriate theoretical foundation for integrating ICTs in learning?** Through a comprehensive literature study the learning needs of modern society and prominent theories and paradigms of learning is examined, and a theoretical foundation for integrating ICTs into learning is proposed..

Chapter 3 explores question 2: **What are the uses of ICTs in learning?** The chapter It investigates and describes the technology tools available in education, the spectrum of technology uses in education and classification systems for technology uses in education. It proposes a typology of technology roles in learning, and concludes with a definition of a technology-integrated curriculum.

Chapter 4 gives a full description of the research design and methodology used in this study.

Chapter 5 strives to answer question 3: **How can the ICT requirements of the NCS be identified and classified?** as well as question 4: **What are the ICT requirements of the NCS?** It reports on the implementation of the research design and the results of the analytical process. The latter includes the identification, analysis, interpretation, classification and recording of the ICT requirements in the NCS, and the description of the analytical results for the NCS as a whole, as well as for the individual NCS subjects.

Chapter 6 addresses questions 5 and 6: (a) **What are the implications of the ICT requirements for implementation in schools?** and (b) **Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements in learning?** This is done by synthesising all the findings of the research in a framework of understanding for interpreting and implementing the implications of the ICT requirements of the NCS.

Chapter 7 concludes the study with its conclusions, recommendations and statement of limitations.

4.7 SUMMARY

The purpose of Chapter 4 was to describe the research design and methodology of the study. The chapter began with an exposition of the research problem, followed by a discussion of the design principles that guides the research design. The actual research design was presented next plus an explanation of chapters of the research report.

CHAPTER 5: ANALYSIS OF THE INFORMATION AND COMMUNICATION TECHNOLOGY REQUIREMENTS OF THE NATIONAL CURRICULUM STATEMENT

> *The challenge of qualitative analysis lies in making sense of massive amounts of data. This involves reducing the volume of raw information, sifting trivia from significance, identifying significant patterns, and constructing a framework for communicating the essence of what the data reveal* (Patton 2002: 432).

5.1 INTRODUCTION

The research undertaken in this study indeed generated massive amounts of data - a total of 594 ICT requirements were identified in the NCS and classified in 26 categories of three typologies. In small print it covers 128 pages. In the words of Patton (2002) above the task of this chapter is to make sense of the generated data by identifying and communicating the essence of what it reveals.

Analysing qualitative data is no easy task. The problem is that *'we have few agreed-on canons for qualitative data analysis, in the sense of shared ground rules for drawing conclusions and verifying their sturdiness'* (Miles & Huberman in Patton 2002: 432-433). There are no formulas for determining significance, no ways for replicating the researcher's analytical thought processes, and no straightforward tests for reliability and validity (Patton 2002: 433). In this study the best the researcher could do was to rigidly follow and apply the principles and guidelines of the research design and critically analyse and interpret the data in the context of the research's aim and problem statement.

In terms of the study's original problem statement, Chapter 5 endeavours to answer the following two research questions: **How can the ICT requirements of the NCS be identified and classified?** and **What are the ICT requirements of the NCS?** The research design presented in the previous chapter answers the first question in the sense that a design was implemented with specific results. This chapter, therefore, has the two objectives of describing the implementation of the research design and reporting the findings of the analytical process. As before, such findings are clearly indicated by means of an appropriate heading.

5.2 IMPLEMENTATION OF THE RESEARCH DESIGN

Patton (2002: 434) is convinced that analysts have an obligation to monitor and report their own analytical procedures and processes as fully and truthfully as possible. This responsibility is complied with in the following sections that discuss the implementation of the research design in detail.

5.2.1 Definition of an ICT requirement

The term **object of analysis** is described in section 4.6.7 as the specific aspect of the textual material that is to be considered in the content analysis and from which inferences shall be made. In this study object of analysis refers to the ICT requirements of the NCS, and textual material to all NCS documents that represent the 31 subjects of the FET Band. In section 1.6.4 an ICT requirement is described as any reference in the NCS documentation that requires or implies the availability of ICT facilities for the purpose of learning. This description, however, is not detailed and specific enough. The objective of this section is to analyse the meaning of an ICT requirement in more detail and to define it in exact terms.

The NCS documentation consists of 89 documents - 31 subject statements (Department of Education 2003b-y & Department of Education 2005a-g), 29 learning programme guidelines (Department of Education 2008a-ac) and 29 subject assessment guidelines (Department of Education 2008ad-bf). The reason why there are fewer learning programme and subject assessment guidelines documents is that each of the three language subjects has its own subject statement, but shares the same learning programme guidelines and subject assessment guidelines.

All subject statements have the same content structure of three chapters (there is a fourth chapter about assessment, but it has been replaced by the assessment guidelines document). Chapter 1 is the same for all and introduces the NCS by presenting its principles and other key concepts. OBE, one of nine NCS principles, includes seven critical outcomes and five developmental outcomes that underpin and are reflected in the learning outcomes of all NCS subjects.

FINDING 3.1: Critical outcomes 4, 5 and 6 are recognised and interpreted as the foundation and justification for including ICTs as learning tools and resources in the NCS. They read as follows (Department of Education 2003b:2):

> *The Critical Outcomes requires learners to be able to:*
>
> - *collect, analyse, organise and critically evaluate information;*
> - *communicate effectively using visual, symbolic and/or language skills in various modes;*
> - *use science and technology effectively and critically showing responsibility towards the environment and the health of others;*

Chapters 2 and 3 of the subject statements are unique to each subject. Chapter 2 describes the key features (definition, purpose and scope) of the subject, and Chapter 3 the learning outcomes, assessment standards, and content and contexts of the subject. Assessment standards are criteria that collectively provide evidence of what a learner should know and be able to demonstrate at a specific grade. They embody the knowledge, skills and values required to achieve a subject’s learning outcomes (Department of Education 2003b:7). In other words, assessment standards provide the most basic and detailed prescription and description of what the NCS expects learners to be able to do. Assessment standards are the most critical and important key aspect of the NCS because they are the building blocks on which all aspects of teaching, learning and assessment in a subject are based. All the guidelines of the NCS documentation are linked back to assessment standards in one or other way. The conclusion is that if there is a requirement for learners to use ICT facilities in demonstrating their knowledge, skills and values, it will be found in the assessment standards. The assessment standards, therefore, are the real source of ICT requirements.

Other sections of subject statements such as the key features of the subjects and the content and contexts, as well as the learning programme and subject assessment guidelines also contain evidence of ICT requirements, but they all point to and support the ICT requirements found in the assessment standards. Such evidence is considered to be supporting evidence of ICT requirements and is used to interpret, clarify and confirm those requirements.

Because of the inductive nature of the qualitative approach followed in this research, the definition of an ICT requirement evolved and was reviewed several times as the empirical work unfolded throughout the research process. The definition of an ICT requirement presented below is the final result of this iterative process. In order to enhance the definition four types of ICT requirement types are included. These are in fact the categories of the inductive typology of requirement types (refer section 5.2.2(b) for further explanations).

FINDING 3.2: An ICT requirement of the NCS is defined as any assessment standard in the subject statement of an NCS subject in which the use of ICT facilities in a learning activity is prescribed, implied or potentially beneficial. When deciding whether an assessment standard qualifies as an ICT requirement all clarifying and supporting evidence from the rest of the relevant subject's curriculum documentation that may relate to this particular assessment standard must be taken into consideration. In order to further explain this definition four types of ICT requirements are distinguished:

(a) Prescribed and compulsory ICT requirements

An assessment standard is a **prescribed and compulsory ICT requirement** if it meets all of the following criteria:

- The assessment standard and/or supporting evidence from the subject's curriculum documentation that relates directly to this assessment standard explicitly prescribes the <u>compulsory</u> use of ICT facilities in learning activities.

- The assessment standard and/or its supporting evidence contain clear ICT-related terminology such as the following:

  Concepts of ICT: *computer, computer application, computer technology, database, digital, digital design, digital media, digital techniques, digital technology, e-mail, electronic communication, electronic communication skills, electronic media, hardware, hardware concepts, information and communications technology, information system, Internet, presentation graphics, slides, software, software concepts, Web site*

  Tools of ICT – general application packages: *database package, e-mail package, multimedia/hypermedia authoring package, presentation graphics package, Web browser, word processor, spreadsheet package*

  Tools of ICT – subject-specific application packages: *accounting package, computer-aided design package, dynamic geometry software, geographical information system, programming language*

(b) Prescribed but optional ICT requirements

An assessment standard is a **prescribed but optional ICT requirement** if it meets all of the following criteria:

- The assessment standard and/or supporting evidence from the subject's curriculum documentation that relates directly to this assessment standard explicitly prescribes the <u>optional</u> use of ICT facilities in learning activities.

- The assessment standard and/or its supporting evidence contain clear ICT-related terminology such as the following:

Concepts of ICT: *computer, computer application, computer technology, database, digital, digital design, digital media, digital techniques, digital technology, e-mail, electronic communication, electronic communication skills, electronic media, hardware, hardware concepts, information and communications technology, information system, Internet, presentation graphics, software, software concepts, Web site*

Tools of ICT – general application packages: *database package, e-mail package, multimedia/hypermedia authoring package, presentation graphics package, Web browser, word processor, spreadsheet package*

Tools of ICT – subject-specific application packages: *accounting package, computer-aided design package, dynamic geometry software, geographical information system, programming language*

(c) Implied ICT requirements

An assessment standard is an **implied ICT requirement** if it meets all of the following criteria:

- It does not explicitly prescribe the use of ICT facilities in learning activities.
- It refers to learning activities that can clearly be supported and enhanced by the use of ICT facilities.
- The subject's curriculum documentation contains general supporting evidence and encouragement that implies ICT facilities can be used in learning activities such as those indicated in this assessment standard.
- The assessment standard typically contains phrases that show potential for ICT use such as the following:

  access/acquire/capture/collect/obtain/organise/record/process/store data/ information; post to a journal; record data; communicate/compile/create/ design/develop/plan/prepare/present a(n) account/action plan/assignment/

budget/business plan/diagram/document/financial statement/graphics presentation/inventory/journal/ledger/marketing tool/menu/organogram/recipe/ report/research instrument/statement/table/trial balance; draw a curve/Gantt chart/graph/timeline; calculate price/interest/value

In this case the particular uses of ICT facilities in learning activities are identified and proposed by the analyst. The ICT uses must be meaningful, substantial, appropriate and not trivial.

(d) Potential ICT requirements

An assessment standard is a **potential ICT requirement** if it meets all of the following criteria:

- It does not explicitly prescribe the use of ICT facilities in learning activities, nor does supporting evidence exist that implies the use of ICT facilities in the learning activities indicated in the assessment standard.
- It refers to learning activities that clearly have the potential to be supported and enhanced by the use of ICT facilities.
- The assessment standard typically contains phrases that show potential for ICT use such as the following:

  access/acquire/capture/collect/obtain/organise/record/process/store data/ information; post to a journal; record data; communicate/compile/create/ design/develop/plan/prepare/present a(n) account/action plan/assignment/ budget/business plan/diagram/document/financial statement/graphics presentation/inventory/journal/ledger/marketing tool/menu/organogram/recipe/ report/research instrument/statement/table/trial balance; draw a curve/Gantt chart/graph/timeline; calculate price/interest/value

In this case the particular uses of ICT facilities in learning activities are identified and proposed by the analyst. The ICT uses must be meaningful, substantial, appropriate and not trivial.

The difference between potential and the other types of ICT requirements is that potential ICT requirements are not explicitly prescribed or implied in the NCS. However, they are still part of and originate from the NCS, and implementing them qualify as technology integration in the curriculum, just as the other types of ICT requirements.

(e) Example of an ICT requirement

Using the definition above it is now possible to analyse all assessment standards and identify those that qualify as ICT requirements. Consider the following example:

Geography assessment standard 10.1.4 (Department of Education 2003k:18): '*Analyse information obtained from a variety of resources'.*

The following evidence that supports this assessment standard is found in the rest of the curriculum documentation for Geography.

(i) Analysing information: Analysis involves establishing patterns, relationships and connections. It entails noting associations, similarities or differences between areas and/or phenomena, recognising patterns and drawing inferences from maps, graphs, diagrams, tables and other sources. Geographers also use statistical methods to identify trends, relationships and sequences. Observations can be synthesised into a meaningful interpretation by using important tools available in geographical analysis such as electronic (digital) databases and Geographical Information Systems (GIS) (Department of Education 2003k:10).

(ii) ***GRADE 10***

A. Geographical skills and techniques

……

- *Geographical Information Systems (GIS):*
  - *general concepts (e.g. systems, information systems, GIS, remote sensing);*
  - *geographical concepts (e.g. spatial objects, lines, points, nodes, scales [small versus large], resolution [spectral versus spatial])* (Department of Education 2003k:25-26).

(iii) In addition to knowing and understanding the basic concepts underpinning Geographical Information Systems (GIS), learners should be able to demonstrate enquiry skills to identify and select different data sets, organise them in different ways if necessary and analyse them to make informed deductions in terms of the geographical phenomenon or situation that is being studied (Department of Education 2008ar:7).

Although this assessment standard itself does not refer directly to the use of particular ICT facilities, there is substantial supporting evidence that particular technology tools are indeed required and prescribed. The conclusion is that this assessment standard is an ICT requirement because it requires learners to use databases and GIS in *'analysing information obtained from a variety of resources'*. Furthermore, because supporting evidence (ii) is directly related to assessment standard 10.1.4 and explicitly prescribes the <u>compulsory</u> use of a GIS, this ICT requirement can be classified as a prescribed and compulsory ICT requirement.

Once the ICT requirements are identified, the next step is to classify them.

5.2.2 Classification of ICT requirements

The research design of this study calls for the classification of ICT requirements in categories that were derived through the analysis procedures of deductive category application and inductive category development.

(a) Deductive category application

According to Mayring (2000:[13],[15]) the procedure of deductive category application involves the classification of inferences of the object of analysis (ICT requirements in this case) into previously formulated, theoretically derived categories. The categories of the **typology of technology roles in learning** that was theoretically developed in section 3.6 are used in this instance.

FINDING 3.3: The ICT requirements of the NCS can be classified according to the typology of technology roles in learning. Table 5.1 below summarises these categories in a form adapted for classifying ICT requirements.

Table 5.1: The theory-derived categories of the typology of technology roles in learning

Codes	Categories	Classification rules
TR1	Technology learning content	1. Use this category for ICT requirements in which the technology itself is the learning content, i.e. learners are primarily required to acquire knowledge, skills and values about ICTs. 2. ICT requirements from the subjects Computer Applications Technology and Information Technology all fall into this category.
TR2	Didactic tool	Use this category for ICT requirements that refer to a technology use that applies behaviourist learning principles to teach by transmitting knowledge embedded in computer programs to learners who assimilate it.
TR3	Context tool	Use this category for ICT requirements that refer to the use of technology for providing an environment or space that: describes the context of a problem; presents and/or simulates the problem; and allows manipulation and exploration of and interaction with the problem.
TR4	Resource tool	Use this category for ICT requirements that refer to the use of technology for accessing resources that provide information related to the learning problem/task/topic.
TR5	Cognitive tool	Use this category for ICT requirements that refer to technology uses that enhance, extend and amplify learners' cognitive powers and abilities during own knowledge construction by engaging them in cognitive operations that they would not otherwise have been capable of. Such learning activities result in a 'cognitive product' such as a new understanding of a concept, an articulation of this new understanding, a presentation of what has been learned, and a new, revised or extended personal knowledge structure.

TR6	Collaboration tool	Use this category for ICT requirements that refer to the use of technology for facilitating knowledge construction by: enabling communication and collaboration with others; supporting discourse among members of learning communities; and facilitating consensus building among such members.
TR7	Productivity tool	Use this category for ICT requirements that refer to the use of technology to provide productivity support in inauthentic labour that is incidental to authentic learning.

An ICT requirement may have such a broad scope that it accommodates more than one clear technology role. This means that it can be classified in more than one category of the typology of technology roles. Consider the example of the assessment standard that was confirmed an ICT requirement in section 5.2.1.

Geography assessment standard 10.1.4 (Department of Education 2003k:18): '*Analyse information obtained from a variety of resources'.*

This ICT requirement is classified in the category of **cognitive tool** because the learning activities involved in this assessment standard includes the cognitive activities of establishing patterns, relationships and connections, and synthesising observations into interpretations.

(b) Inductive category development

Inductive category development is the development of categories as near as possible to the material being analysed, in other words formulating them in terms of the material. The categories are tentatively deduced step by step by using the object of analysis (ICT requirements in this case) and working through the textual material (NCS documentation) in order to identify passages of text for analysis. In an iterative process these categories are revised, eventually reduced to main categories and checked for reliability (Mayring 2000:[10]&[12]). In this research inductive categories were developed in this way through several revisions for two typologies. The first one is the **typology of requirement types**.

FINDING 3.4: The ICT requirements of the NCS can be classified according to the typology of requirement types. Requirement type refers to types of ICT requirements differentiated according to how they are stipulated. The categories of the typology are identified and described in Table 5.2 below.

Table 5.2: The inductively derived categories of the typology of requirement types

Codes	**Categories**	**Classification rules**
RT1	Prescribed and compulsory ICT requirement	Use this category for ICT requirements that comply with all of the criteria listed in section 5.2.1(a).
RT2	Prescribed but optional ICT requirement	Use this category for ICT requirements that comply with all of the criteria listed in section 5.2.1(b).
RT3	Implied ICT requirement	Use this category for ICT requirements that comply with all of the criteria listed in section 5.2.1(c).
RT4	Potential ICT requirement	Use this category for ICT requirements that comply with all of the criteria listed in section 5.2.1(d).

ICT requirements are classified in only one of the categories of the typology of requirement types. Consider the example of the assessment standard that was confirmed an ICT requirement in section 5.2.1.

Geography assessment standard 10.1.4 (Department of Education 2003k:18): '*Analyse information obtained from a variety of resources'.*

This ICT requirement is classified in the category of **prescribed and compulsory requirement** because it's supporting evidence that is directly related to assessment standard 10.1.4 explicitly prescribes the compulsory use of databases and GIS (refer paragraph 5.2.1(e)(ii)).

The second set of categories developed inductively in this research was the **typology of application types**.

FINDING 3.5: The ICT requirements of the NCS can be classified according to the typology of application types. Application in this context refers to using an application package or software package (e.g. a word processor) to perform a particular task on a computer. In other words, application types refer to types of application packages. Some ICT requirements name the specific package that should be used in the learning activities. However, many ICT requirements don't mention specific packages in which case one or more application type is identified based on an interpretation of the requirements of the task specified in the assessment standard. The final categories of application types found during the analysis of the NCS documentation are presented in Table 5.3.

Table 5.3: The inductively derived categories of the typology of application types

Codes	Categories	Classification rules
AT1	Word processor	Use this category for ICT requirements in which the use of a word processor is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a word processor.
AT2	Spreadsheet	Use this category for ICT requirements in which the use of a spreadsheet is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a spreadsheet.
AT3	Database	Use this category for ICT requirements in which the use of a data base is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a data base.
AT4	Presentation graphics	Use this category for ICT requirements in which the use of a presentation graphics package is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a presentation graphics package.
AT5	Productivity suite that includes AT1, AT2, AT3 and AT4	Use this category for ICT requirements in which the use of more than two packages of the productivity suite is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of more than two packages of the productivity suite.
AT6	Web browser (navigator)	Use this category for ICT requirements in which the use of a Web browser is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a Web browser.
AT7	E-mail application	Use this category for ICT requirements in which the use of an e-mail package is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of an e-mail package.

AT8	Applications for other computer-managed communica-tion forms	Use this category for ICT requirements in which the use of packages for other computer-managed communication forms such as online chat, discussion forum/board and mailing list/user group is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of such packages.
AT9	Internet suite that includes AT6, AT7 and AT8	Use this category for ICT requirements in which the use of more than two packages of the Internet suite is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of more than two packages of the Internet suite.
AT10	Multimedia/ hypermedia authoring application	Use this category for ICT requirements in which the use of a multimedia/hypermedia authoring package is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a multimedia/ hypermedia authoring package to create Web pages or multimedia programs.
AT11	Subject-specific application	Use this category for ICT requirements in which the use of a subject-specific application is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of a subject-specific application (e.g. accounting package, computer-aided design package, geographical information system, programming language).
AT13	System software and utilities	Use this category for ICT requirements in which the use of system software (e.g. operating system) or utilities (e.g. anti-virus software) is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of system software (e.g. operating system) or utilities (e.g. anti-virus software).
AT14	Not applic-able/no software	Use this category for ICT requirements in which no software/computer programs are involved.
AT15	All relevant application types for the subject	Use this category for ICT requirements that refer to all the relevant application types for a subject
AT16	Database or multimedia application with subject-related information, excluding the Internet	Use this category for ICT requirements in which the use of a database or electronic multimedia resource with subject-related information (e.g. electronic reference works, library catalogues, electronic encyclopaedia), excluding the Internet is prescribed or that refer to learning activities that can clearly be supported and enhanced by the use of such a package.

Some ICT requirements prescribe more than one application type or refer to learning activities that can clearly be supported and enhanced by more than one application type. This means that such ICT requirements can be classified in more than one category of the typology of application types.

Consider again the example of Geography assessment standard 10.1.4 (Department of Education 2003k:18) that was confirmed an ICT requirement in section 5.2.1: '*Analyse information obtained from a variety of resources'.*

The supporting evidence for this ICT requirement reveals that GIS is part of Grade 10 content (Department of Education 2003k:26&34, Department of Education 2008o:37 & Department of Education 2008ar:21) and that the use of statistical methods, databases and GIS for analysing information and synthesising it into meaningful interpretations is included in this assessment standard (DOE2003k:10). Based on this evidence the ICT requirement is classified in the spreadsheet, database and subject-specific application categories of the typology of application types.

5.2.3 Recording of the ICT requirements

Every identified ICT requirement is recorded systematically as a database record with nine fields (refer Table 5.4). The first six fields represent the **identification details** and the last three the **classification details**.

Table 5.4: Database design for recording the ICT requirements

Field name	Description	Format/codes
ID	Database record number assigned automatically and consecutively from 1 by the database system	1, 2, 3, … etc.
Subject	Codes used to record the NCS subjects to which ICT requirements belong	S01 = Accounting S02 = Agricultural Management Practices S03 = Agricultural Technology S04 = Agricultural Technology S05 = Business Studies S06 = Civil Technology S07 = Computer Applications Technology S08 = Consumer Studies S09 = Dance Studies

		S10 = Design S11 = Dramatic Arts S12 = Economics S13 = Electrical Technology S14 = Engineering Graphics & Design S15 = Geography S16 = History S17 = Hospitality Studies S18 = Information Technology S19 = Languages - First Additional Language S20 = Languages - Home Language S21 = Languages -Second Additional Language S22 = Life Orientation S23 = Life Sciences S24 = Mathematical Literacy S25 = Mathematics S26 = Mechanical Technology S27 = Music S28 = Physical Science S29 = Religion Studies S30 = Tourism S31 = Visual Arts
Reference	Bibliographical reference of the NCS document in which the ICT requirement can be found.	DOE yyyyxx:pp where: DOE = Department of Education yyyy = year of publication xx = letter suffix for publications published in the same year by the same author pp = page number of the publication
AS number	Number of the assessment standard associated with the ICT requirement	aa.bb.cc where: aa = grade (i.e. 10, 11 or 12) bb = learning outcome number cc = assessment standard numbered according to horisontal level
ICT requirement	The assessment standard that is identified as an ICT requirement	Actual quotation of the assessment standard from the relevant subject statement
Descriptive notes	Notes that include supporting evidence from a subject's curriculum documentation that confirms and supports an assessment standard to qualify as an ICT requirement, as well as any interpretations regarding the identification and classification of the ICT requirement made by the analyst	Notes should include: 1. An indication of the type of supporting evidence (DSE = direct supporting evidence, GSE = general supporting evidence, NSE = no supporting evidence) 2. Reference(s) of the supporting evidence 3. Description/summary of the supporting evidence 4. Interpretations (IP) made in identifying and classifying the ICT requirement

Technology role	Technology role refers to the role that ICT plays in the learning activities prescribed by the ICT requirement	TR1 = Technology learning content TR2 = Didactic tool TR3 = Context tool TR4 = Resource tool TR5 = Cognitive tool TR6 = Collaboration tool TR7 = Productivity tool
Requirement type	Requirement type refers to the types of ICT requirements distinguished according to how they are stipulated.	RT1 = Prescribed and compulsory ICT requirement RT2 = Prescribed but optional ICT requirement RT3 = Implied ICT requirement RT4 = Potential ICT requirement
Application type	Application types refer to types of application/software packages that are used to perform particular tasks.	AT1 = Word processor AT2 = Spreadsheet AT3 = Database AT4 = Presentation graphics AT5 = Productivity suite (AT1+AT2+AT3+AT4) AT6 = Web browser (navigator) AT7 = E-mail AT8 = Applications for other computer-managed communication forms AT9 = Internet suite (AT6+AT7+AT8) AT10 = Multimedia/ hypermedia authoring application AT11 = Subject-specific application AT13 = System software and utilities AT14 = Not applicable/no software AT15 = All relevant application types for the subject AT16 = Database or multimedia application with subject-related information, excluding the Internet

A total of 594 ICT requirements were identified in the assessment standards of the 31 subjects of the NCS, and recorded using the above database design. The full database report that contains the complete records of these ICT requirements covers 128 pages in small print. Annexure B provides an example of the complete records of one subject, namely Geography. The full report includes quotations of the actual assessment standards that were identified as ICT requirements, as well as the notes on classification made during the document analysis process. However, this information is not required for the next stage of analysing the research data. The summary report of the ICT requirements in Annexure C that includes only the essential record fields of subject code, assessment standard number, record number, bibliographical reference and classification codes for the three relevant typologies, was used for this purpose.

5.2.4 Coding agenda

Mayring's (2000) two procedures of deductive category application and inductive category development are applied in the qualitative content analysis of the NCS. For this purpose a comprehensive coding agenda was developed (refer Annexure A) that includes explicit definitions, coding rules and examples for each of the categories used in the content analysis. Its aim is to determine exactly under what circumstances a passage of text can be coded with (i.e. classified in) a category (Mayring 2000: [15]).

The main purpose of the coding agenda is to define a set of rules for performing a scientific process of document analysis that has the objective to identify, interpret and classify the ICT requirements of the NCS into various categories. The set of rules should enable any trained analyst to systematically and scientifically classify the ICT requirements found in the NCS documentation. It is a scientific requirement that the coding agenda should produce consistent results, that is, ideally the use of the coding agenda by any analyst should produce the same results.

The comprehensive coding agenda developed for this research (refer Annexure A) includes the following aspects:

- A definition of the object of analysis, that is, a definition of an ICT requirement (refer section 5.2.1)

- Database design for recording the ICT requirements (refer section 5.2.3)

- Definitions, coding rules and examples for the theory-derived deductive categories of the typology of technology roles in learning (refer section 5.2.2(a))

- Definitions, coding rules and examples for the inductive categories of the typologies of requirement types and application types that were deduced, founded and revised within the process of analysing the NCS documentation (refer section 5.2.2(b))

A distinctive feature of the coding agenda is how it evolved and developed through several revisions as the process of analysing the NCS documentation progressed. All its definitions and coding rules underwent two fundamental reviews before they and the results of the content analysis of the NCS were submitted to three independent and expert analysts for checking reliability and validity. After feedback from them the coding agenda was again reviewed and fine-tuned a final time.

From the above it is clear that the coding agenda is a key tool in this research and has the following functions:

- The coding agenda provides practical guidelines for rigorously implementing the research design of this study.

- It enables the systematic identification of ICT requirements in the NCS.

- Its coding rules enable the systematic and rule-guided classification of identified ICT requirements in the categories of the one deductive and two inductive typologies used in this research.

- It provides the format for recording the ICT requirements in a database.

- It is a tool in the hands of independent and external analysts to check the reliability and validity of the results of the qualitative content analysis process.

5.2.5 Checks for reliability

Mayring (2000:[11]&[14]) indicates that the procedures of deductive category application and inductive category development should include formative as well as summative checks for reliability. In this research the former was performed during regular revisions as the text analysis process progressed, and the latter at the end of the process after the categories, definitions and coding rules were finalised. The checks for reliability focused on both the **identification** and **classification** of the ICT requirements. Any adjustments to them had direct implications for the coding agenda as it was in the first place the tool that enabled the systematic identification and classification of ICT requirements. The coding agenda, therefore, was automatically involved in the checks for reliability.

Mayring (2000:[7]) recommends the use of capable and trained analysts for the purpose of inter-coder reliability checks. This involves using analysts external to the research to analyse parts of the text and compare their results with those of the researcher. The analysts used in this research were Prof CH Swanepoel, an educational research and mathematics education specialist, Prof CP Loubser, an environmental and life sciences education expert, and Dr GJ van den Berg, a language education and qualitative document analysis expert.

(a) Formative checks for reliability

Formative checks for reliability were in the first place performed by the researcher. As the analysis progressed the emerging categories and the researcher's understanding of them changed, sometimes ever so slightly and at other times of lucid insight, fundamentally. This obviously necessitated reviews of the coding agenda and the content analysis of subject documentation already completed. In this way all the definitions and coding rules of the coding agenda and the identified and classified ICT requirements underwent two fundamental reviews before the researcher submitted it to two of the external analysts for a formative inter-coder reliability check.

Prof Swanepoel and Dr Van den Berg were requested to use the coding agenda to identify and classify ICT requirements in the curriculum documentation for the subjects Mathematics and English Home Language respectively. Subsequent discussions and comparisons between their and the researcher's analysis results raised the following issues.

Categories of the typology of requirement types: This typology initially consisted of only three categories: 'prescribed and compulsory requirements', 'prescribed but optional ICT requirements', and 'implied ICT requirements'. One of the criteria for the category of implied ICT requirements read as follows at that stage: 'The assessment standard does not explicitly prescribe the use of ICT facilities in learning activities, but refers to learning activities that can be clearly supported and enhanced by such facilities'. In discussions with the analysts it became clear that a further distinction can be made between subjects whose curriculum documentation contains general supporting evidence and encouragement for the use of ICT facilities where appropriate, and those subjects that do not. It was decided to add a category of 'potential ICT requirements' to accommodate this distinction. The criteria with regard to the particular aspect of supporting evidence for these two categories were differentiated and updated as follows in the coding agenda (refer Annexure A):

- **Implied ICT requirements:** An assessment standard is an implied ICT **requirement** if it meets all of the following criteria:
    - It does not explicitly prescribe the use of ICT facilities in learning activities.
    - It refers to learning activities that can clearly be supported and enhanced by the use of ICT facilities.
    - The subject's curriculum documentation contains general supporting evidence and encouragement that implies ICT facilities can be used in learning activities such as those indicated in this assessment standard.

- **Potential ICT requirements:** An assessment standard is a potential ICT requirement if it meets all of the following criteria:
    - It does not explicitly prescribe the use of ICT facilities in learning activities, nor does supporting evidence exist that implies the use of ICT facilities in the learning activities indicated in the assessment standard.
    - It refers to learning activities that clearly has potential to be supported and enhanced by the use of ICT facilities.

ICT requirements for Mathematics: In Mathematics the researcher initially focused only on assessment standards that require learners to do specific tasks with ICTs (e.g. use a graphing package to draw graphs, use Web browser, word processing and presentation graphics packages to research, report and present the history of the development of mathematical concepts). However, Prof Swanepoel, as a mathematics education specialist, was of the view that ICTs should play a more substantial cognitive role in supporting learners to develop an understanding of mathematical concepts. This can especially be achieved by employing ICT facilities in mathematical modelling (e.g. using dynamic geometry software in investigations to produce conjectures and generalisations related to triangles, quadrilaterals and other polygons). Based on his assessment an additional number of assessment standards for Mathematics were identified as ICT requirements. The researcher also applied the same approach to Mathematical Literacy, although mathematical modelling plays a lesser role in this subject.

Interpretation differences: In the case of 'prescribed and compulsory' and 'prescribed but optional' ICT requirements there are clear indications in the assessment standards and/or supporting evidences of which ICT tool should be used in learning activities and for what purpose. In 'implied' and 'potential' ICT requirements no such indications exist. The coding rule in this regard initially stipulated: 'In this case the particular uses of ICT facilities in learning activities are identified and proposed by the analyst'. Such identified uses of ICT facilities, in turn, affected the application types to be recorded for the ICT requirements. Dr Van den Berg indicated that this coding rule is open for different interpretations by different analysts. To overcome this problem it was agreed to add the following phrase to the coding rule: 'In this case the particular uses of ICT facilities in learning activities are identified and proposed by the analyst. **The ICT uses must be meaningful, substantial, appropriate and not trivial**.' This may still be somewhat open to different interpretations and may even be regarded as open to subjective interpretations.

This raises the debate of objectivity versus subjectivity that Patton (2002:50) believes has become so loaded with negative connotations and subject to acrimonious debate that neither term any longer provides useful guidance. This study has no intention or wish to enter this debate, but rather, as Patton (2002:541-571) advises, to focus on the credibility of the qualitative analysis in this research. Two elements that enhance the credibility of qualitative analysis are **methodological rigor** and **intellectual rigor**. Methodological rigor is described as using rigorous methods for doing fieldwork that yield high-quality data that are systematically analysed with attention to issues of credibility (Patton 2002:570-571). The research methodology of this study as described in section 4.5 and implemented in section 5.2, is considered to be rigorous because it is based on sound qualitative research design principles. Furthermore, the research methodology is embedded in the coding agenda (refer section 5.2.4). The researcher believes that his rigorous application and implementation of the coding agenda achieved methodological rigor that contributed to overcome the problem of different (and perhaps subjective) interpretations described above. Another way to overcome this problem was to apply intellectual rigor that includes professional integrity and methodological competence (Patton 2002:570). The researcher, as already indicated, applied intellectual rigor by repeatedly returning to his definitions, categories, rules and data to question them and ensure that his interpretations make sense and really reflect and represent the true nature of the object of his study. He rigorously maintained a neutral approach by allowing his research to unfold naturally and with openness to whatever emerges, placing no prior constraints on its outcomes.

Based on this feedback of and suggestions from the independent inter-coders, the coding agenda and data were reviewed fundamentally for the third time by the researcher.

(b) Summative check for reliability

After the researcher finalised the identification and classification of the ICT requirements of the NCS, Prof Swanepoel, Prof Loubser and Dr Van Den Berg were requested to do summative checks for reliability on the ICT requirements for the subjects Mathematics, Life Sciences and Languages (i.e. English Home Language, English First Additional Language and English Second Additional

Language) respectively. They concluded that the use of the final version of the coding agenda yielded reliable results in identifying and classifying the ICT requirements of the NCS for the purpose of this study.

A total of 594 ICT requirements for the 31 subjects of the NCS were identified, classified, checked for reliability, and recorded using the database design explained in section 5.2.3. The database report of all these ICT requirements in full record layout covers 128 pages in small print. However, not all the information in the full database report is required for the further analysis of the qualitative data. Instead, a scaled-down version that includes only the essential record fields of subject code, assessment standard number, record number, bibliographical reference and classification codes for the three relevant typologies (refer Annexure C) is used for this purpose.

This concludes the description of the implementation of the research design. The attention now moves to reporting the qualitative analysis results of this study.

5.3 RESULTS OF THE QUALITATIVE ANALYSIS

The aim of this section *"involves reducing the volume of raw information, sifting trivia from significance, identifying significant patterns, and constructing a framework for communicating the essence of what the data reveal"* (Patton 2002: 432). This is done by using quantitative methods to firstly summarise the data for individual subjects into frequencies, and into summaries for the NCS as a whole. Secondly, significant findings are identified and clearly indicated, followed by a discussion. Because of the focus of this study the findings concentrate on the NCS as a whole only. Although the analysis results for individual subjects are presented and briefly discussed, no findings regarding them are made.

5.3.1 Summary of the research data

The first phase of processing the research data in preparation for further analysis is done by summarising for each subject the number of occurrences (i.e. frequencies) of ICT requirements in the categories of the three typologies, and calculating the percentages that they represent of the total number of ICT requirements. Table 5.5 below, which consists of sub-tables A, B, C, and D, illustrates the results for the subject Accounting as an example. The category codes are explained in sections 5.2.2(a), 5.2.2(b) and 5.2.3, as well as in the coding agenda in Annexure A. The other abbreviations have the following meanings:

ICTRs = ICT requirements
ASs = assessment standards
IR = integration ratio
II = integration index

The following is important to note in Table 5.5 (and subsequent tables where applicable):

- A subject's true number of ICT requirements is reflected in sub-table A because the coding agenda (refer Annexure A) stipulates that an ICT requirement should be classified in only one of the categories of the typology of requirement types. The definitions of the other two typologies allow an ICT requirement to be classified in more than one category, resulting in totals in sub-tables B and C that may be greater than those in sub-table A.

- In sub-table B the code TR2 that represents the category of 'didactic tool' in the theory-derived deductive typology of technology roles in learning, is omitted simply because no occurrence of such ICT uses were found in the assessment standards of all the NCS subjects. A didactic tool refers to a technology use that applies behaviourist learning principles to teach by transmitting knowledge embedded in computer programs to learners who assimilate it. The NCS, on the other hand, is based on constructivist learning principles, making it no surprise that no ICT requirements were classified in the category of didactic tool.

Table 5.5: Summary and overview of the ICT requirements of the subject Accounting

	A: ICTRs according to requirement types									
	RT1		RT2		RT3		RT4		Total	
	n	%	n	%	n	%	n	%	n	%
Gr 10	0	0.0	3	75.0	0	0.0	1	25.0	4	100
Gr 11	0	0.0	4	57.1	0	0.0	3	42.9	7	100
Gr 12	0	0.0	3	50.0	0	0.0	3	50.0	6	100
Total	0	0.0	10	58.8	0	0.0	7	41.2	17	100

	B: ICTRs according to technology roles in learning													
	TR1		TR3		TR4		TR5		TR6		TR7		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Gr 10	0	0.0	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4	100
Gr 11	0	0.0	0	0.0	0	0.0	7	100.0	0	0.0	0	0.0	7	100
Gr 12	0	0.0	0	0.0	0	0.0	6	100.0	0	0.0	0	0.0	6	100
Total	0	0.0	0	0.0	0	0.0	17	100.0	0	0.0	0	0.0	17	100

	C: ICTRs according to application types																	
	AT5		AT9		AT10		AT11		AT13		AT14		AT15		AT16		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Gr 10	4	57.1	0	0.0	0	0.0	3	42.9	0	0.0	0	0.0	0	0.0	0	0.0	7	100
Gr 11	4	44.4	0	0.0	0	0.0	5	55.6	0	0.0	0	0.0	0	0.0	0	0.0	9	100
Gr 12	3	42.9	0	0.0	0	0.0	4	57.1	0	0.0	0	0.0	0	0.0	0	0.0	7	100
Total	11	47.8	0	0.0	0	0.0	12	52.2	0	0.0	0	0.0	0	0.0	0	0.0	23	100

	D: Integration			
	ASs	ICT Rs	IR	II
	n	n	%	%
Gr 10	13	4	30.8	19.2
Gr 11	12	7	58.3	31.3
Gr 12	13	6	46.2	23.1
Total	38	17	44.7	24.3

- In sub-table C all the ICT requirements that were classified in the categories AT1 (word processor), AT2 (spreadsheet), AT3 (database) and AT4 (presentation graphics) are grouped together with category AT5 (productivity suite) because these four application packages are mostly provided combined as a unit (suite) to computer users. Furthermore, these packages share many facilities making it possible to perform particular tasks in more than one of them. The same applies to the categories of AT6 (Web browser), AT7 (e-mail) and AT8 (other computer-managed communication forms) that are grouped together with AT9 (Internet suite) because they are all linked to Internet use and are usually automatically provided with every new computer. These two suites are the backbone of computer use in society.

- In sub-table D two integration values in the form of an **integration ratio** and **integration index** are calculated to give an indication to what extent technology is integrated in the individual subjects and the NCS as a whole. In section 5.3.2(a) the meaning and use of these values are fully explained.

Once the summaries for all 31 NCS subjects are completed, they are used to summarise the number of occurrences (i.e. frequencies) of ICT requirements in the categories of the three typologies for the NCS as a whole, and to calculate the percentages that they represent of the total number ICT requirements. This is done separately for each of the three typologies, resulting in Annexure D that represents the *Summary of the ICT requirements of the NCS according to requirement types*, Annexure E the *Summary of the ICT requirements of the NCS according to technology roles in learning* and Annexure F the *Summary of the ICT requirements of the NCS according to application types*.

Apart from summaries for the NCS as a whole, these tables also include summaries for the NCS as a whole minus the two special case subjects of Computer Applications Technology (CAT) and Information Technology (IT). What makes them unique is the fact that their contents are about ICTs, that is all their assessment standards are about and imply the use of ICTs in learning activities, making all of them prescribed and compulsory (i.e. RT1) ICT requirements. They completely dominate the total pool of ICT requirements. For example, of the total of 594 ICT requirements for 31 subjects in the NCS 152 or 25.6% of them belong to CAT and IT. In many of the individual categories their dominance is even more profound. This fact justifies a separate analysis of the NCS as a whole and the

NCS without CAT and IT. The first demonstrates the general picture, but the latter gives a clearer picture of the practical situation in schools. The implications of the ICT requirements for CAT and IT are easy to accept and understand, but for the rest of the subjects the situation is not so clear and obvious.

5.3.2 Discussion of the ICT requirements of the NCS

The ICT requirements of the NCS are now discussed in terms of each of the three typologies used to classify it as an answer to the research question: **What are the ICT requirements of the NCS?**

(a) The ICT requirements of the NCS according to requirement types

Table 5.6 (sub-table A) and Figure 5.1 below represent the distribution of ICT requirements according to requirement types. Table 5.6 (sub-table B) and Figure 5.2 illustrate integration values in the form of an integration ratio (IR) and integration index (II) that give an indication to what extend technology is integrated in the NCS.

Table 5.6: Analysis of the ICT requirements of the NCS according to requirement types

		A: ICTRs according to requirement types										B: Integration			
		RT1		RT2		RT3		RT4		Total		ASs	ICTRs	IR	II
		n	%	n	%	n	%	n	%	n	%	n	n	%	%
NCS	Gr 10	68	37.0	22	12.0	61	33.2	33	17.9	184	100	557	184	33.0	22.1
	Gr 11	70	33.7	28	13.5	68	32.7	42	20.2	208	100	569	208	36.6	23.8
	Gr12	62	30.7	29	14.4	66	32.7	45	22.3	202	100	552	202	36.6	23.2
	Total	200	33.7	79	13.3	195	32.8	120	20.2	594	100	1678	594	35.4	23.0
NCS - (CAT + IT)	Gr 10	16	12.1	22	16.7	61	46.2	33	25.0	132	100	505	132	26.1	14.1
	Gr 11	16	10.4	28	18.2	68	44.2	42	27.3	154	100	515	154	29.9	15.8
	Gr12	16	10.3	29	18.6	66	42.3	45	28.8	156	100	506	156	30.8	16.2
	Total	48	10.9	79	17.9	195	44.1	120	27.1	442	100	1526	442	29.0	15.4

The codes used in Table 5.6 refer to following requirement types as defined in the coding agenda (refer Annexure A): RT1 = prescribed and compulsory ICT requirements; RT2 = prescribed but optional ICT requirements; RT3 = implied ICT requirements; and RT4 = potential ICT requirements. Note that ICT requirements, as defined in the coding agenda, are each classified in only one of the categories of the typology of requirement types.

Table 5.6 reflects the distribution of the 594 ICT requirements for the NCS as a whole and 442 ICT requirements for the NCS without the special case subjects of CAT and IT. These and other figures indicate that CAT and IT dominate the number and distribution of ICT requirements in the NCS.

FINDING 4.1: The subjects CAT and IT have a dominant impact on the number and distribution of ICT requirements in the NCS because all their assessment standards are about and imply the use of ICTs in learning activities, making all of them prescribed and compulsory ICT requirements. Of the 594 ICT requirements for the NCS as a whole 152 or 25.6% of them belong to CAT and IT. This dominance is especially clear in the 'prescribed and compulsory' (RT1) ICT requirements where 152 or 78% out of a total of 200 RT1 requirements for the NCS belong to CAT and IT.

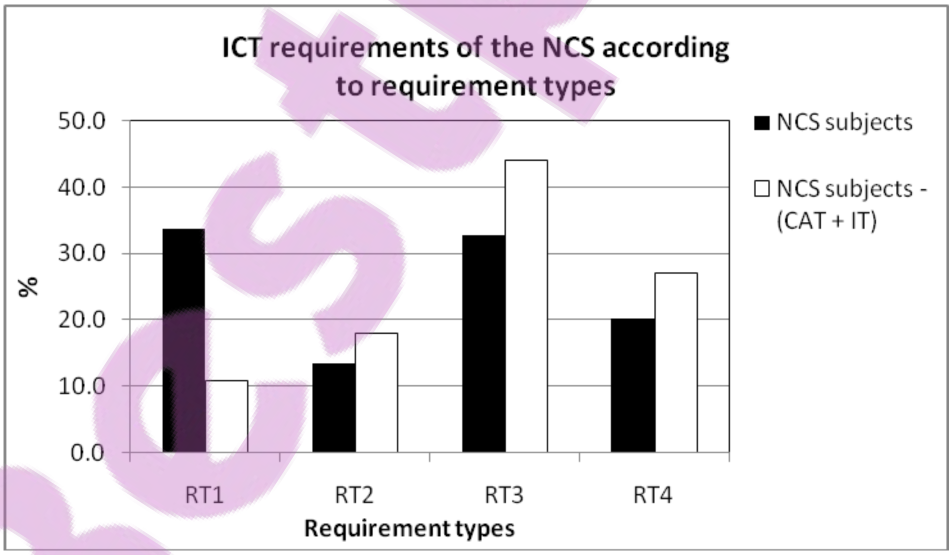

Figure 5.1: ICT requirements of all NCS subjects and NCS subjects other than CAT and IT according to requirement types

FINDING 4.2: The distribution of ICT requirements according to grades is fairly even. For the NCS as a whole (and for the NCS without CAT and IT) it is as follows: grade 10 – 31.0% (29.9%); grade 11 – 35.0% (34.8%); grade 12 – 34.0% (35.3%).

FINDING 4.3: In the requirement type distribution of ICT requirements for all NCS subjects the 'prescribed and compulsory' and 'implied' categories are dominant. When CAT and IT are excluded, the 'implied' and 'potential' categories are dominant. This is clearly illustrated in the column graph in Figure 5.1 and the figures below.

Category	All NCS subjects	NCS subjects other than CAT and IT
RT1	33.7%*	10.9%
RT2	13.3%	17.9%
RT3	32.8%*	44.1%**
RT4	20.2%	27.1%**

* Dominant categories for all NCS subjects (66.5% combined)

** Dominant categories for NCS subjects other than CAT and IT (71.2% combined)

FINDING 4.4: NCS subjects other than CAT and IT are in general hesitant to prescribe compulsory or optional uses of ICT facilities in learning activities. Most subjects do not prescribe any such ICT uses at all, while only a few clearly and pertinently prescribe compulsory or optional ICT uses where appropriate. With CAT and IT excluded, only 28.8% of the identified ICT requirements are classified as prescribed and compulsory (RT1) or prescribed but optional (RT2) ICT requirements. This low figure implies that subjects in general do not often prescribe the compulsory or optional use of ICT facilities in learning activities. Further analysis indicates that eight of the 31 subjects (i.e. Business Studies, Dance Studies, Dramatic Arts, Economics, History, Physical Science, Religion Studies and Visual Arts) do not prescribe any such ICT uses at all. This is in contradiction with subjects such as Agricultural Management Practices that specifically prescribe the use of ICT facilities when applicable (refer Assessment Standard 10.2.1, Department of Education 2005a:16). This exposes the problem of inconsistent recognition and uneven prescription of the use of ICTs in learning activities by the different subjects. It may even be that subjects that do not incorporate the use of ICTs in their learning activities are at a disadvantage.

Table 5.6 (sub-table B) also includes two integration values that are intended to give an indication to what extend technology is integrated in the NCS. The first is the **integration ratio (IR)** that is essentially an ICT requirement/assessment standard ratio that is calculated by expressing the total number of ICT requirements as a percentage of the total number of assessment standards. The integration ratio values calculated for the NCS and its subjects are reported in Annexure D.

The integration ratio, however, has one shortcoming in that the four types of ICT requirements are each allocated the same weight of one. It can be argued that a prescribed and compulsory (RT1) ICT requirement should certainly carry a greater weight than a potential (RT4) ICT requirement for example. To overcome this problem an **integration index (II)** was developed that accommodate more realistic weights. In the integration index ICT requirements in the RT1 category are assigned a weight of 1, those in RT2 a weight of 0.75, those in RT3 a weight of 0.5, and those in RT4 a weight of 0.25. The index is calculated per grade and for the three grades combined (i.e. the FET Band), using the following formula:

Integration index = (RT1 frequency x 1.0 + RT2 frequency x 0.75 +
RT3 frequency x 0.5 + RT4 frequency x 0.25)
÷ number of assessment standards x 100

The integration index values calculated for the NCS and its subjects are reported in Annexure D. The formula implies that a subject in which all its assessment standards are classified as prescribed and compulsory (RT1) ICT requirements, will have an integration index of 100% as is the case with the subjects CAT and IT. A subject with no identified ICT requirements will have an integration index of 0%. The integration index is believed to be a more realistic indicator of technology integration into the NCS and its subjects than the integration ratio.

The question is which integration index value constitutes an acceptable level of technology integration in a curriculum or subject? This research did not investigate this question further, but suggests that it could be a meaningful subject for further research. All that this study can do is merely to report the integration index values found for the NCS and its subjects, and thereby set a standard or bench mark that can be improved on in future revisions of the NCS (assuming of course that more meaningful and appropriate technology integration will be an improvement).

The level of technology integration in CAT and IT as two special cases is considered to be high (an integration index of 100%). However, in order to compare to what extent technology is integrated in the rest of the subjects their integration index values are sorted from low to high and divided roughly into three equal groups. The level of technology integration for the three groups of subjects is described as follows:

- Subjects with integration index value of less than 9.0% (10 subjects): level of technology integration is described as **low**.

- Subjects with an integration index value of more than 9.0% and less than 20.0% (9 subjects): level of technology integration is described as **moderate**.

- Subjects with an integration index value of more than 20.0% (10 subjects): level of technology integration is described as **considerable**.

FINDING 4.5: All subjects have identified ICT requirements. The integration ratio for the three grades combined and all 31 subjects of the NCS is 35.4%, meaning that 35.4% of all assessment standards in the NCS qualify as ICT requirements. When CAT and IT are excluded, then this figure is marginally lower at 29.0%.

FINDING 4.6: The integration index for all NCS subjects and the three grades combined is 23.0%. With CAT and IT excluded the integration index value drops to 15.4%. These figures can be used as benchmarks for improving technology integration in future NCS reviews.

The bar graph in Figure 5.2 below presents the integration index values of all NCS subjects. The dominance of CAT and IT is immediately evident with their 100% integration indexes. It makes sense to exclude these two subjects when analysing and comparing the integration indexes of the other NCS subjects. The dotted line represents the integration index for the NCS with CAT and IT excluded.

FINDING 4.7: Using the integration index as an indicator reveals that the subjects CAT and IT are 100% technology integrated. This is because all their assessment standards are identified and classified as prescribed and compulsory ICT requirements.

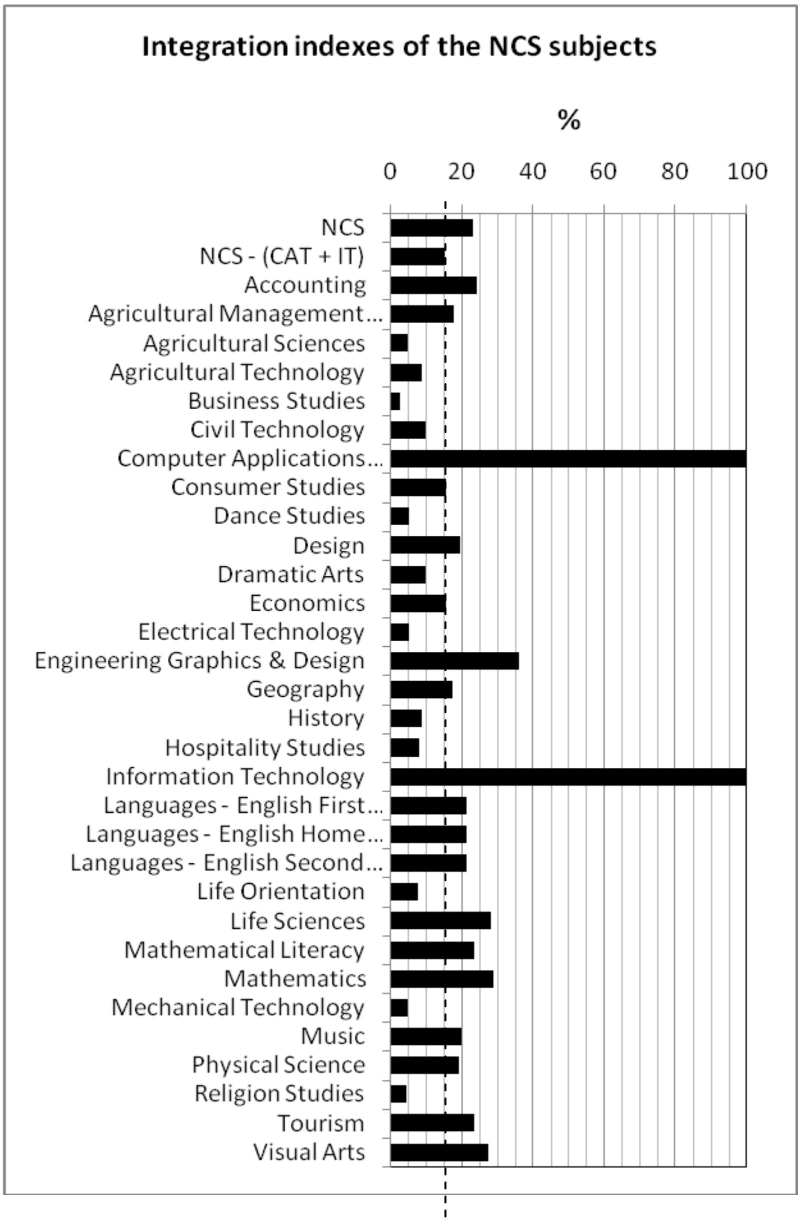

Figure 5.2: Integration indexes that indicate the level of technology integration in the subjects of the NCS

FINDING 4.8: Subjects with a considerable level of technology integration (an integration index of more than 20.0%) include Accounting (24.3%), Engineering Graphics and Design (36.1%), Languages – First Additional Language (21.4%), Languages – Home Language (21.4%), Languages – Second Additional Language (21.4%), Life Sciences (28.3%), Mathematical Literacy (23.6%), Mathematics (28.8%), Tourism (23.6%) and Visual Arts (27.5%). Although not unique, a characteristic of many of these subjects is that they prescribe the use of subject-specific application packages in learning activities. Examples include computer-aided design (CAD) software for Engineering Graphics and Design, specialised graphing software for Mathematical Literacy, specialised graphing and dynamic geometry software for Mathematics and visual arts software for Visual Arts.

FINDING 4.9: Subjects with a low level of technology integration (an integration index of less than 9.0%) include Agricultural Sciences (4.7%), Agricultural Technology (8.9%), Business Studies (2.8%), Dance Studies (5.2%), Electrical Technology (5.1%), History (8.9%), Hospitality Studies (8.0%), Life Orientation (7.8%), Mechanical Technology (4.8%) and Religion Studies (4.3). A low integration index is understandable in the case of subjects such as Dance Studies, Life Orientation and Religion Studies because their content lends itself less to technology integration. However, subjects such as Agricultural Sciences, Agricultural Technology, Business Studies, Electrical Technology, and Mechanical Technology should be able to apply technology meaningfully and beneficially to a much higher degree.

(b) The ICT requirements of the NCS according to technology roles in learning

Table 5.7 and Figure 5.3 below represent the distribution of ICT requirements according to technology roles in learning. The following codes are used for the different technology roles as defined in the coding agenda (refer Annexure A): TR1 = technology learning content; TR2 = didactic tool; TR3 = context tool; TR4 = resource tool; TR5 = cognitive tool; TR6 = collaboration tool; and TR7 = productivity tool.

As indicated in the coding agenda, an ICT requirement may have such a broad scope that it can be classified in more than one technology role. For example, CAT assessment standard 10.3.3 (Department of Education 2003e:18) stipulates that the learner should be able to *'Present and communicate information in electronic formats'.* In the first place this assessment standard is about learners learning to use technology itself in the form of word processing, spreadsheet, database and presentation graphics packages in order to present and communicate information (Department of Education 2008g:40). The role of technology in learning in this ICT requirement is therefore classified as technology learning content (TR1). Secondly, this ICT requirement also implies cognitive activities in using technology to create a cognitive product such as a word processing document, database report, spreadsheet or graphics presentation that contains the information to be presented and communicated. The second role of the technology in this learning activity is therefore classified as that of a cognitive tool (TR5).

Table 5.7: Analysis of the ICT requirements of the NCS according to technology roles in learning

		ICTRs according to technology roles in learning													
		TR1		TR3		TR4		TR5		TR6		TR7		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%
NCS	Gr 10	55	23.4	1	0.4	43	18.3	124	52.8	5	2.1	7	3.0	235	100
	Gr 11	58	21.4	1	0.4	53	19.6	147	54.2	4	1.5	8	3.0	271	100
	Gr12	51	19.3	1	0.4	57	21.6	140	53.0	3	1.1	12	4.5	264	100
	Total	164	21.3	3	0.4	153	19.9	411	53.4	12	1.6	27	3.5	770	100
NCS - (CAT + IT)	Gr 10	3	1.8	1	0.6	41	24.1	116	68.2	2	1.2	7	4.1	170	100
	Gr 11	4	2.0	1	0.5	48	24.5	134	68.4	1	0.5	8	4.1	196	100
	Gr12	5	2.5	1	0.5	54	26.5	131	64.2	1	0.5	12	5.9	204	100
	Total	12	2.1	3	0.5	143	25.1	381	66.8	4	0.7	27	4.7	570	100

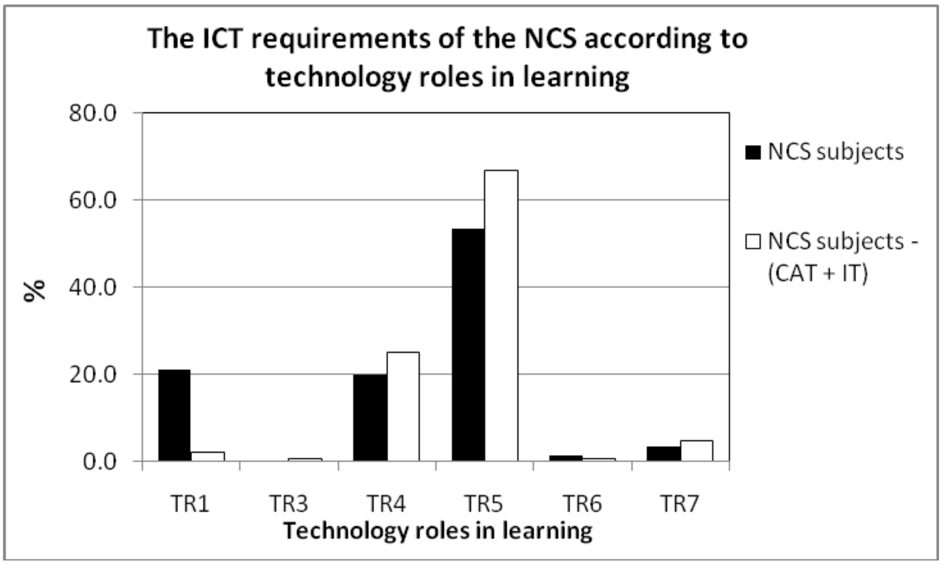

Figure 5.3: ICT requirements of all NCS subjects and NCS subjects other than CAT and IT according to technology roles in learning

FINDING 4.10: No ICT requirement of any NCS subject was classified in the didactic tool category. This category (TR2) from the theory-derived deductive typology of technology roles in learning refers to technology uses that apply behaviourist learning principles to teach by transmitting knowledge embedded in computer programs to learners who assimilate it. The NCS, on the other hand, is based on constructivist learning principles. It is therefore no surprise that no ICT requirements were classified in the category of didactic tool (this is also the reason why the category TR2 is omitted from Table 5.7 and Figure 5.3).

FINDING 4.11: 94.6% of the ICT requirements of all NCS subjects are classified in only three technology role categories: technology learning content (21.3%), resource tool (19.9%) and cognitive tool (53.4%). CAT and IT are virtually the only subjects with ICT requirements in the category of technology learning content. The 19.9% of ICT requirements in the resource tool category refers to using ICTs to access information on the Internet and other electronic resources. However, with more than half of all ICT requirements in category of cognitive tool, the main focus of the NCS is on using ICTs in cognitive activities that include constructing own knowledge. This emphasis confirms the OBE/constructivist foundation of the NCS. Many of the ICT requirements in the two categories of resource and cognitive tools stem from practical assessment tasks in subjects that require learners to research (search, analyse and select) information for a particular topic from a variety of electronic resources (TR4 – resource tool), prepare and compile a report, and present its findings (TR5 – cognitive tool).

FINDING 4.12: Only 5.5% of the ICT requirements are classified in the categories of context tool, collaboration tool and productivity tool. Although these technology roles in learning are specified in only a few assessment standards, they are still very relevant, meaningful and appropriate in actual learning activities in learning environments. Learners can, for example, explore a multimedia package with real-life and authentic background information about a problem they must solve (TR3 – context tool), use e-mail to communicate or collaborate with experts or other learners outside the classroom in solving the problem (TR6 – collaboration tool) and do ‘number crunching’ on data they may have collected (TR7 – productivity tool).

(c) The ICT requirements of the NCS according to application types

An application type in this context refers to the type of application package (or software package, e.g. a word processor) that is used to do a particular task. Some ICT requirements specifically name and prescribe the type of application package that should be used in learning activities. However, many ICT requirements don’t do that. In such cases the researcher used his extensive knowledge of and experience in the use of application packages in learning to identify and select appropriate application packages based on an interpretation of the requirements of the tasks/learning activities specified in the assessment standards.

Table 5.8 and Figure 5.4 below represent the distribution of the ICT requirements of the NCS according to application types. The following codes are used for the different categories of application packages in the typology of application types as defined in the coding agenda (refer Annexure A): AT1 = word processor; AT2 = spreadsheet; AT3 = database; AT4 = presentation graphics; AT5 = productivity suite that includes AT1, AT2, AT3 and AT4; AT6 = Web browser (navigator); AT7

= e-mail application; AT8 = applications for other computer-managed communication forms; AT9 = Internet suite that includes AT6, AT7 and AT8; AT10 = multimedia/hypermedia authoring application; AT11 = subject-specific application; AT13 = system software and utilities; AT14 = not applicable (no software involved); AT15 = all relevant application types for the subject; and AT16 = database or multimedia applications with subject-related information, excluding the Internet.

However, in Table 5.8 and Figure 5.4 all ICT requirements that were classified in the categories AT1 (word processor), AT2 (spreadsheet), AT3 (database) and AT4 (presentation graphics) are grouped together with category AT5 (productivity suite). This is done because these four application packages are mostly provided as a unit in the form of a productivity suite to computer users. Furthermore, these packages share many features, functions and facilities, making it possible in some cases to use any one of them to perform a particular task. The same applies to the categories of AT6 (Web browser), AT7 (e-mail) and AT8 (other computer-managed communication forms) that are grouped together with AT9 (Internet suite) because they are all linked and related to the use of the Internet, and are usually automatically provided with every new computer. These two suites are the backbone of computer use in society.

Table 5.8: Analysis of the ICT requirements of the NCS according to application types

		ICTRs according to application types																	
		AT5		AT9		AT10		AT11		AT13		AT14		AT15		AT16		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
NCS	Gr 10	117	40.6	56	19.4	17	5.9	48	16.7	7	2.4	16	5.6	7	2.4	20	6.9	288	100
	Gr 11	138	42.2	68	20.8	22	6.7	57	17.4	8	2.4	12	3.7	1	0.3	21	6.4	327	100
	Gr12	140	43.1	68	20.9	23	7.1	54	16.6	5	1.5	11	3.4	3	0.9	21	6.5	325	100
	Total	395	42.0	192	20.4	62	6.6	159	16.9	20	2.1	39	4.1	11	1.2	62	6.6	940	100
NCS – (CAT + IT)	Gr 10	104	44.6	51	21.9	16	6.9	42	18.0	1	0.4	0	0.0	0	0.0	19	8.2	233	100
	Gr 11	119	45.4	57	21.8	17	6.5	47	17.9	1	0.4	1	0.4	0	0.0	20	7.6	262	100
	Gr12	123	45.9	63	23.5	17	6.3	44	16.4	0	0.0	1	0.4	0	0.0	20	7.5	268	100
	Total	346	45.3	171	22.4	50	6.6	133	17.4	2	0.3	2	0.3	0	0.0	59	7.7	763	100

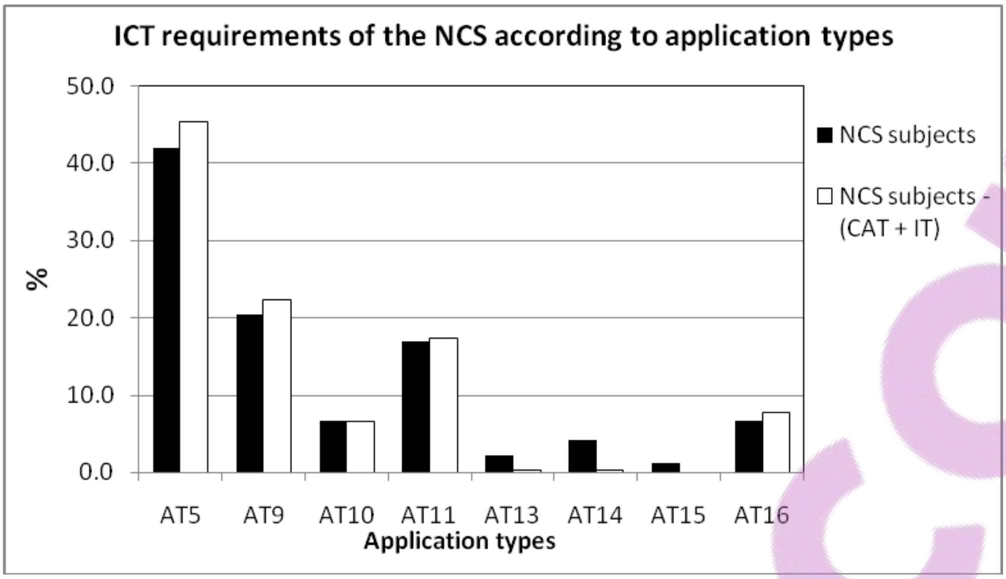

Figure 5.4: ICT requirements of all NCS subjects and NCS subjects other than CAT and IT according to application types

The application types required in the ICT requirements of the NCS can be analysed in the following four groups:

- The group that combines the application type categories of productivity suite (AT5) and multimedia/hypermedia authoring application (AT10) and enables learners to create cognitive constructs.

- The group that combines the application type categories of Internet suite (AT9) and database or multimedia applications with subject-related information. This combination is about accessing information and communication.

- The group that involves specialised and subject-specific applications (AT11).

- The group of application types that are mostly unique to CAT and IT. It includes the categories of system software and utilities (AT13), not applicable/no software (AT 14) and all relevant application types for the subject (AT15).

FINDING 4.13: The group of application type categories of system software and utilities, not applicable/no software and all relevant application types for the subject is mostly applicable to CAT and IT only.

FINDING 4.14: Almost half (48.6%) of all ICT requirements require the group of productivity suite and multimedia/hypermedia authoring application types that enable learners to create cognitive constructs. This finding again confirms the OBE/constructivist foundation of the NCS. In other words, the assessment standards of these ICT requirements expect learners to be able to: create documents (e.g. essays, research reports, etc.); do calculations in tables and draw graphs; record data in databases; present and communicate ideas (e.g. research findings) in the form of presentation slides; and create multimedia/hypermedia products (e.g. Web pages) that communicate information to others.

FINDING 4.15: More than a quarter (27,0%) of all ICT requirements specify the use of the group of application types that consists of the Internet suite and database and multimedia applications with subject-related information. These requirements require learners to access information and/or communicate with others outside the classroom. For example, learners can be expected to use a Web browser to access information on the Internet, a multimedia package to explore a particular topic in an electronic encyclopaedia, and an e-mail package to communicate with experts outside the classroom. It is clear that these ICT requirements stem from the needs of the information age.

FINDING 4.16: 16.9% of all ICT requirements require the use of unique subject-specific applications that are applied in specific professions, disciplines and sciences to provide specialised functions and facilities. The subjects and subject-specific applications involved are as follows:

Subject	**Subject-specific application**
Accounting	Accounting package
Agricultural Management Practices	Farm management system
Agricultural Technology	Process control system
Civil Technology	Computer-aided design package
Design	Design-specific package
Engineering Graphics and Design	Computer-aided design package
Geography	Geographical information system

Hospitality studies	Stock control system
	Point-of-sale system
Information Technology	Programming language
Mathematical Literacy	Specialised graphing software
Mathematics	Specialised graphing software
	Dynamic geometry software
Music	Music composition software
Visual Arts	Visual arts software

This concludes the discussion of the ICT requirements of the NCS according to requirement types, technology roles in learning and application types. The focus now moves to an analysis of the ICT requirements of individual subjects.

5.3.3 Discussion of the ICT requirements of individual subjects

In this section the ICT requirements are analysed per subject. Every subject analysis includes a table in which detailed data about the subject's ICT requirements is drawn from Annexures D, E and F and summarised. The codes of the typology categories are the same as before, while ICTRs is an abbreviation for 'ICT requirements'. The summary tables also includes values for the integration ratio (IR) and integration index (II) that are calculated for the subject as described in section 5.3.2(a). Significant aspects in the summary tables are identified and discussed.

(a) The ICT requirements of Accounting

Table 5.9 below provides a summary of the ICT requirements of the subject Accounting.

Table 5.9: A summary of the ICT requirements of the subject Accounting

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	3	0	1	0	0	0	4	0	0
Gr 11	0	4	0	3	0	0	0	7	0	0
Gr 12	0	3	0	3	0	0	0	6	0	0
Total	0	10	0	7	0	0	0	17	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	4	0	0	3	0	0	0	0	30.8	19.2
Gr 11	4	0	0	5	0	0	0	0	58.3	31.3
Gr 12	3	0	0	4	0	0	0	0	46.2	23.1
Total	11	0	0	12	0	0	0	0	44.7	24.3

The following are significant aspects:

- The majority (10 out of 17) of the subject's ICT requirements for all three grades are of the prescribed but optional (i.e. RT2) requirement type, while the rest are of the potential (RT4) type. This results in an integration index of 24.3% that indicates a considerable level of technology integration.

- The technology role in learning of all its 17 ICT requirements is classified as cognitive tool (TR5), meaning that Accounting puts a high premium on its learners being able to create cognitive constructs or products, mostly in the form of various accounting documents (e.g. statements and budgets).

- Accounting is one of the subjects that requires the use of a subject-specific application in the form of an accounting package that is used to create and develop (construct) various accounting documents. 12 of its 17 ICT requirements for all three grades require this package (AT11) against 11 that require the use of application packages of the productivity suite (AT5). The latter enables the creation of other forms of cognitive constructs. The two application types combined confirm the high premium the subject places on its learners being able to use ICTs as cognitive tools. However, none of its ICT requirements require the use of an application package from the Internet suite (AT9) to communicate and/or access information which may be a shortcoming.

(b) The ICT requirements of Agricultural Management Practices

A summary of this subject's ICT requirements appears in Table 5.10 below. The following aspects about it are noteworthy:

- The nine identified ICT requirements for all three grades represent 24% of the subject's assessment standards (i.e. integration ratio). Six of them are classified as prescribed and compulsory (RT1) and three as potential (RT4) ICT requirements, resulting in a moderate integration index of 17.8%. This is slightly above the average of 15.4% for the NCS with CAT and IT excluded.

Table 5.10: A summary of the ICT requirements of the subject Agricultural Management Practices

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	N	n	n	n	n	n
Gr 10	2	0	0	1	0	0	2	3	0	0
Gr 11	2	0	0	1	0	0	2	3	0	0
Gr 12	2	0	0	1	0	0	2	3	0	0
Total	6	0	0	3	0	0	6	9	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	N	n	n	n	%	%
Gr 10	3	3	0	1	0	0	0	0	23.1	17.3
Gr 11	3	3	0	1	0	0	0	0	25.0	18.8
Gr 12	3	3	0	1	0	0	0	0	23.1	17.3
Total	9	9	0	3	0	0	0	0	23.7	17.8

- Technology has the role of resource tool (TR4) in six of the subject's ICT requirements and the role of cognitive tool (TR5) in all nine.

- Agricultural Management Practices is another subject that requires the use of a subject-specific application – one ICT requirement per grade requires the use of a farm management system. It also requires the use of application packages from the Internet suite as well as the productivity suite in all nine of its ICT requirements. The subject's application type needs as determined by its ICT requirements are fairly well balanced.

(c) The ICT requirements of Agricultural Sciences

Table 5.11 below is a summary of the ICT requirements of the subject Agricultural Sciences and includes the following significant aspects.

Table 5.11: A summary of the ICT requirements of the subject Agricultural Sciences

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	1	0	0	0	1	1	0	0
Gr 11	1	0	1	0	0	0	2	2	0	0
Gr 12	0	0	1	1	0	0	1	2	0	0
Total	1	0	3	1	0	0	4	5	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	1	1	0	0	0	0	0	0	5.9	2.9
Gr 11	2	2	0	0	0	0	0	0	10.0	7.5
Gr 12	2	1	0	0	0	0	0	0	9.5	3.6
Total	5	4	0	0	0	0	0	0	8.6	4.7

- The subject has a low integration index value of only 4.7%. Only five of its 58 assessment standards are identified as ICT requirements – one is classified as prescribed and compulsory (RT1), three as implied (RT3) and one as potential (RT4). Agricultural Sciences is considered a subject that should have a much higher technology integration level.

- The role of technology in four of its ICT requirements is that of a resource tool (TR4 – accessing information) and in all five that of a cognitive tool (TR5 – creating cognitive constructs).

- In five of its ICT requirements the use of application packages from the productivity suite is required, and in four application packages from the Internet suite.

(d) The ICT requirements of Agricultural Technology

The ICT requirements of Agricultural Technology are summarised in Table 5.12 below. It includes the following noteworthy aspects:

Table 5.12: A summary of the ICT requirements of the subject Agricultural Technology

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	2	0	0	2	1	0	1	2	1	1
Gr 11	2	0	0	2	1	0	0	2	0	2
Gr 12	2	0	0	2	1	0	0	2	0	2
Total	6	0	0	6	3	0	1	6	1	5
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	2	0	0	0	0	0	0	14.3	8.9
Gr 11	2	0	0	2	0	0	0	0	14.3	8.9
Gr 12	2	0	0	2	0	0	0	0	14.3	8.9
Total	6	2	0	4	0	0	0	0	14.3	8.9

- Only 12 of its 84 assessment standards are identified as ICT requirements – six as prescribed and compulsory (RT1) and six as potential (RT4). This results in an integration ratio of 14.3% and a low integration index value of 8.9%. Agricultural Technology is another subject that should have a much higher technology integration level.

- The main focus of the subject's ICT requirements is to use technology as a cognitive tool in learning (TR5 - six out of 12 cases). Besides this, it also requires the use of technology in the roles of technology learning content (TR1 – three cases), resource tool (TR4 – one case), collaboration tool (TR6 – one case) and productivity tool (TR7 – five cases).

- The application types that the subject requires are application packages from the productivity suite (AT5 – six ICT requirements), Internet suite (AT9 – two ICT requirements) and a subject-specific application (AT11 – four ICT requirements) in the form of a process control system.

(e) The ICT requirements of Business Studies

Table 5.13 below is a summary of Business Studies' ICT requirements. The following aspects are significant:

- Only seven of the subject's 62 assessment standards are recognised as ICT requirements. All seven are classified as potential ICT requirements (RT4) that give the subject a disappointing integration ratio of only 11.3% and a low integration index of 2.8% (the lowest of all subjects). With its business-oriented content the subject should have a much higher integration index.

- The roles of technology in learning in the subject's ICT requirements are that of a cognitive tool (TR5 – seven cases) and a resource tool (TR4 – one case).

- The subject's ICT requirements require application packages from the productivity suite (AT5 – seven cases) and Internet suite (AT9 – one case).

Table 5.13: A summary of the ICT requirements of the subject Business Studies

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	0	3	0	0	0	3	0	0
Gr 11	0	0	0	3	0	0	1	3	0	0
Gr 12	0	0	0	1	0	0	0	1	0	0
Total	0	0	0	7	0	0	1	7	0	0

	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	3	0	0	0	0	0	0	0	14.3	3.6
Gr 11	3	1	0	0	0	0	0	0	15.0	3.8
Gr 12	1	0	0	0	0	0	0	0	4.8	1.2
Total	7	1	0	0	0	0	0	0	11.3	2.8

(f) The ICT requirements of Civil Technology

Table 5.14 below is a summary of the ICT requirements of Civil Technology. It includes the following noteworthy aspects:

- The subject has a moderate level of technology integration into its assessment standards with an integration index of 10.0%. Six of its 12 ICT requirements (out of 90 assessment standards) are classified as prescribed and compulsory (RT1), three as prescribed but optional (RT2) and three as potential (RT4).

- The dominant role of technology in learning in the ICT requirements of the subject is that of cognitive tool (TR5) in nine out of 12 cases. In the other three ICT requirements technology has the role of technology learning content (TR1). The subject lacks the use of technology in the role of resource tool (TR4) that expects learners to access the Internet and other electronic information resources.

Table 5.14: A summary of the ICT requirements of the subject Civil Technology

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	2	1	0	1	1	0	0	3	0	0
Gr 11	2	1	0	1	1	0	0	3	0	0
Gr 12	2	1	0	1	1	0	0	3	0	0
Total	6	3	0	3	3	0	0	9	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	N	n	n	n	n	n	n	n	%	%
Gr 10	2	0	0	2	0	0	0	0	13.3	10.0
Gr 11	2	0	0	2	0	0	0	0	13.3	10.0
Gr 12	4	0	0	2	0	0	0	0	13.3	10.0
Total	8	0	0	6	0	0	0	0	13.3	10.0

- Eight of the subject's ICT requirements require the use of application packages from the productivity suite (AT5), confirming a high focus on learners being expected to use technology in creating their own cognitive constructs. The subject also prescribes the use of a subject-specific application in the form of a computer-aided design package (AT11) in six of its ICT requirements.

(g) The ICT requirements of Computer Applications Technology

CAT has been identified earlier as a special case because all its content is focused on learners learning about ICT itself and how to use it in everyday life. Its ICT requirements are summarised in Table 5.15 below. The following aspects about the ICT requirements of CAT are noteworthy:

- All 46 of its assessment standards are about and imply the use of ICTs in learning activities, making all of them prescribed and compulsory (RT1) ICT requirements. This results in a value of 100% for both its integration ratio and integration index – one of only two subjects that have achieved this.

Table 5.15: A summary of the ICT requirements of the subject Computer Applications Technology

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	14	0	0	0	14	0	1	1	1	0
Gr 11	16	0	0	0	16	0	1	3	1	0
Gr 12	16	0	0	0	16	0	1	1	1	0
Total	46	0	0	0	46	0	3	5	3	0

	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	7	2	0	0	2	2	1	1	100.0	100.0
Gr 11	9	2	5	0	2	2	1	1	100.0	100.0
Gr 12	9	2	5	0	1	2	2	1	100.0	100.0
Total	25	6	10	0	5	6	4	3	100.0	100.0

- Because all 46 of its ICT requirements is about understanding and using ICTs, the dominant role of technology in learning is that of technology learning content (TR1). Some ICT requirements also indicate other roles of technology. In three cases technology figures as a resource tool (to access information on the Internet – TR4), in five cases as a cognitive tool (TR5), and in three cases as a collaboration tool (TR6).

- One of the aims of CAT is to expose learners to a broad range of application types, a fact that is reflected in the application types of its ICT requirements. 25 require the use of application packages from the productivity suite (AT5), six require the use of application packages from the Internet suite (AT9), 10 require the use of a multimedia/hypermedia authoring package (AT10), five are about system and utility software (AT13), and three require learners to access database/multimedia packages with subject-related information. In six

ICT requirements no actual application packages are required, and in four cases the ICT requirements refer to all application types that are relevant to the subject.

(h) The ICT requirements of Consumer Studies

A summary of the ICT requirements of the subject Consumer Studies is presented in Table 5.16 below. The following are significant aspects:

- Seven of the subject's ICT requirements are classified as prescribed but optional (RT2) and six as potential (RT4), giving a moderate integration index of 15.7%. This is one of a few subjects that require much higher ICT use in learning activities in the higher grades than in the lower grades.

- The role of technology in learning in the subject's ICT requirements is balanced between that of a resource tool (TR4) and a cognitive tool (TR5) with seven cases each.

Table 5.16: A summary of the ICT requirements of the subject Consumer Studies

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	1	0	1	0	0	1	1	0	0
Gr 11	0	2	0	2	0	0	2	2	0	0
Gr 12	0	4	0	3	0	0	4	4	0	0
Total	0	7	0	6	0	0	7	7	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	1	1	0	0	0	0	0	0	14.3	7.1
Gr 11	2	2	0	0	0	0	0	0	26.7	13.3
Gr 12	4	4	0	0	0	0	0	0	50.0	26.8
Total	7	7	0	0	0	0	0	0	30.2	15.7

- The subject's application type requirements are similarly balanced with seven cases each for application packages from the productivity suite and Internet suite.

(i) The ICT requirements of Dance Studies

The following is noteworthy regarding the ICT requirements of Dance Studies that are summarised in Table 5.17 below.

- Only six of the 43 assessment standards of Dance Studies are identified as ICT requirements. Three are classified as implied (RT3) and three as potential (RT4) ICT requirements. The subject has an integration index of only 5.2% which is understandable in view of the nature of the subject's contents.

- The role of technology in learning in three of the ICT requirements is classified as resource tool and in six as cognitive tool.

Table 5.17: A summary of the ICT requirements of the subject Dance Studies

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	1	1	0	0	1	2	0	0
Gr 11	0	0	1	1	0	0	1	2	0	0
Gr 12	0	0	1	1	0	0	1	2	0	0
Total	0	0	3	3	0	0	3	6	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	1	0	0	0	0	0	0	14.3	5.4
Gr 11	2	1	0	0	0	0	0	0	14.3	5.4
Gr 12	2	1	0	0	0	0	0	0	13.3	5.0
Total	6	3	0	0	0	0	0	0	14.0	5.2

- Six and three of the subject's ICT requirements require application packages from the productivity suite and Internet suite respectively.

(j) The ICT requirements of Design

Table 5.18 below is a summary of the ICT requirements of the subject Design. The following are noteworthy aspects of the subject's ICT requirements:

- The subject has a moderate but respectable level of technology integration with an integration index of 19.4%. 29 (or 38.2%) of its 76 assessment standards are identified as ICT requirements – three as prescribed and compulsory (RT1), 21 as implied (RT3) and five as potential (RT4).

- The role of technology in learning in the subject's ICT requirements is mainly that of a cognitive tool (TR5 – 27 cases), but also includes resource tool (TR4 – seven cases) and productivity tool (TR7 – one case).

Table 5.18: A summary of the ICT requirements of the subject Design

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	1	0	6	1	0	0	2	8	0	0
Gr 11	1	0	8	2	0	0	3	10	0	1
Gr 12	1	0	7	2	0	0	4	9	0	0
Total	3	0	21	5	0	0	9	27	0	1
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	7	2	2	6	0	0	0	0	32.0	17.0
Gr 11	9	3	3	6	0	0	0	0	42.3	21.2
Gr 12	8	4	2	6	0	0	0	0	40.0	20.0
Total	24	9	7	18	0	0	0	0	38.2	19.4

- Design is another subject that requires a subject-specific application in the form of a design-specific package. Its application type requirements also reflect the focus on using ICTs as a cognitive tool – in 49 cases application packages are required to create and develop designs of various forms (cognitive constructs): 24 ICT requirements require application packages from the productivity suite, seven require a multimedia/hypermedia authoring package and 18 require a design-specific package. In addition nine ICT requirements require the use of packages from the Internet suite to access information on the Internet.

(k) The ICT requirements of Dramatic Arts

Table 5.19 below presents a summary of the ICT requirements of the subject Dramatic Arts and illustrates the following noteworthy aspects:

Table 5.19: A summary of the ICT requirements of the subject Dramatic Arts

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	2	0	0	0	2	2	0	0
Gr 11	0	0	2	1	0	0	2	3	0	0
Gr 12	0	0	3	1	0	0	3	4	0	0
Total	0	0	7	2	0	0	7	9	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	2	2	0	0	0	0	0	15.4	7.7
Gr 11	3	2	2	0	0	0	0	0	18.8	7.8
Gr 12	4	3	3	0	0	0	0	0	33.3	14.6
Total	9	7	7	0	0	0	0	0	22.0	9.8

- The subject's ICT requirements have no direct prescriptions for the use of ICTs in learning activities as all nine are either of the implied type (RT3 – seven cases) or the potential type (RT4 – two cases). Its level of technology integration is a moderate 9.8%.

- The technology role in learning in Dramatic Arts' ICT requirements is balanced between resource tool (TR4 – seven cases) and cognitive tool (TR5 – 9 cases).

- The subject's ICT requirements require the use of application packages from the productivity suite in nine cases, application packages from the Internet suite in seven cases and a multimedia/hypermedia authoring package in seven cases.

(l) The ICT requirements of Economics

Table 5.20 below summarises the ICT requirements of the subject Economics. The following are its most important aspects:

Table 5.20: A summary of the ICT requirements of the subject Economics

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	5	0	0	0	0	5	0	0
Gr 11	0	0	5	0	0	0	0	5	0	0
Gr 12	0	0	4	0	0	0	0	4	0	0
Total	0	0	14	0	0	0	0	14	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	5	0	0	0	0	0	0	0	33.3	16.7
Gr 11	5	0	0	0	0	0	0	0	33.3	16.7
Gr 12	4	0	0	0	0	0	0	0	26.7	13.3
Total	14	0	0	0	0	0	0	0	31.1	15.6

- All 14 of the subject's ICT requirements (out of 45 assessment standards) are of the implied type (RT3). This means that the subject does not have any direct prescriptions (i.e. RT1 and RT2 types) for the use of ICTs in learning activities. Its integration index is a moderate 15.6%.

- The only focus of the ICT requirements is on using technology as a cognitive tool in learning. While this is commendable, it is also a shortcoming in the sense that no other roles of technology in learning are used. This is especially true for using technology as a resource tool to access information, which one would expect should be important for Economics with its global trade relations between nations.

- Economics' ICT requirements require application packages from the productivity suite only which confirms a shortcoming of using a wider range of application packages to, for example, access information on the Internet.

(m) The ICT requirements of Electrical Technology

Table 5.21 below is a summary of the ICT requirements of the subject Electrical Technology. The following is noteworthy:

- The subject has a disappointing low integration index of 5.1% based on its three prescribed but optional (RT2) and three implied (RT3) ICT requirements. It must be noted here that a number of the subject's assessment standards deal with electronic components (e.g. circuit boards and logic gates), but these are excluded from the definition of ICT requirements in this study.

- In three ICT requirements technology has the role of a resource tool, and in six that of a cognitive tool.

- In six cases the ICT requirements require application packages from the productivity suite and in three cases application packages from the Internet suite.

Table 5.21: A summary of the ICT requirements of the subject Electrical Technology

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	1	1	0	0	0	1	2	0	0
Gr 11	0	1	1	0	0	0	1	2	0	0
Gr 12	0	1	1	0	0	0	1	2	0	0
Total	0	3	3	0	0	0	3	6	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	1	0	0	0	0	0	1	8.0	5.0
Gr 11	2	1	0	0	0	0	0	1	7.7	4.8
Gr 12	2	1	0	0	0	0	0	1	9.1	5.7
Total	6	3	0	0	0	0	0	3	8.2	5.1

(n) The ICT requirements of Engineering Graphics and Design

The ICT requirements of the subject Engineering Graphics and Design are summarised in Table 5.22 below. The following are significant aspects:

- What makes this subject unique is that it prescribes the compulsory use (RT1) of a computer-aided design package in 21 of its 26 ICT requirements, giving it a considerable level of technology integration with its integration index of 36.1%. In addition it has two implied (RT3) and three potential (RT4) ICT requirements.

- The dominant technology role in learning in the subject's ICT requirements is that of a cognitive tool – 21 of its ICT requirements require the use of a computer-aided design package to create (i.e. design and develop) engineering designs (i.e. cognitive constructs). Other roles of technology in the ICT requirements include technology learning content (TR1 – five cases) and resource tool (TR4 – three cases).

Table 5.22: A summary of the ICT requirements of the subject Engineering Graphics and Design

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	7	0	0	1	1	0	1	7	0	0
Gr 11	7	0	1	1	2	0	1	7	0	0
Gr 12	7	0	1	1	2	0	1	7	0	0
Total	21	0	2	3	5	0	3	21	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	4	1	0	7	1	0	0	0	38.1	34.5
Gr 11	3	1	0	7	1	1	0	0	42.9	36.9
Gr 12	3	1	0	7	0	1	0	0	42.9	36.9
Total	10	3	0	21	2	2	0	0	41.3	36.1

- The use of a computer-aided design package as a subject-specific application (AT11) in 21 of the subject's ICT requirements has already been highlighted. The use of application packages from the productivity suite (AT5), application packages from the Internet (AT9) suite and system software and utilities (AT13) is also required in ten, three and two cases respectively. In two ICT requirements no software (AT14) is required.

(o) The ICT requirements of Geography

Table 5.23 below summarises the ICT requirements of Geography. The following are clear from the table:

- Geography prescribes the compulsory use (RT1) of a subject-specific package in the form of a geographical information system (GIS) in three of its 14 ICT requirements. The other 11 ICT requirements are of the potential type (RT4), resulting in a moderate integration index of 17.4%.

Table 5.23: A summary of the ICT requirements of the subject Geography

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	1	0	0	3	0	0	0	3	0	1
Gr 11	1	0	0	4	0	0	0	4	0	1
Gr 12	1	0	0	4	0	0	0	4	0	1
Total	3	0	0	11	0	0	0	11	0	3
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	4	0	0	1	0	0	0	0	36.4	15.9
Gr 11	5	0	0	1	0	0	0	0	45.5	18.2
Gr 12	5	0	0	1	0	0	0	0	45.5	18.2
Total	14	0	0	3	0	0	0	0	42.4	17.4

- Technology plays the roles of a cognitive tool (TR5) in 11 of the ICT requirements and a productivity tool (TR7) in three cases. Using technology in the role of resource tool (for example to access information on the Internet) is a possible shortcoming.

- The subject requires the use of application packages from the productivity suite in 14 of its ICT requirements and a GIS in three cases. The application packages from the Internet suite are not required in any of the ICT requirements, confirming the possible shortcoming identified in the previous paragraph.

(p) The ICT requirements of History

The ICT requirements of the subject History are presented in Table 5.24 below. The following can be concluded from it:

- The subject has only six ICT requirements of the implied type (RT4) and three of the potential type (RT4). This explains its low level of technology integration of 8.9%. It also indicates that History is fairly vague with regard to the use of ICTs in the learning activities prescribed by its assessment standards.

- In three of the subject's ICT requirements technology has the role of a resource tool, and in seven the technology role is that of a cognitive tool.

- In seven cases application packages are required from the productivity suite (AT5 – as cognitive tools), and five cases require application packages for accessing information – three cases require application packages from the Internet suite (AT9) and two require database/multimedia packages with subject-related information.

Table 5.24: A summary of the ICT requirements of the subject History

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	2	1	0	0	1	3	0	0
Gr 11	0	0	2	1	0	0	1	2	0	0
Gr 12	0	0	2	1	0	0	1	2	0	0
Total	0	0	6	3	0	0	3	7	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	3	1	0	0	0	0	0	0	21.4	8.9
Gr 11	2	1	0	0	0	0	0	1	21.4	8.9
Gr 12	2	1	0	0	0	0	0	1	21.4	8.9
Total	7	3	0	0	0	0	0	2	21.4	8.9

(q) The ICT requirements of Hospitality Studies

A summary of the ICT requirements of the subject Hospitality Studies is presented in Table 5.25 below. The following is noteworthy:

- The low level of technology integration in Hospitality Studies of 8% is the result of only one prescribed and compulsory (RT1) and 11 potential (RT4) ICT requirements.

- The role of technology in learning in eight of its ICT requirements is that of cognitive tool, supplemented by one ICT requirement in which the role is technology learning content and three in which the role is productivity tool. Using technology in the role of resource tool (for example to access information on the Internet) does not figure in the ICT requirements.

Table 5.25: A summary of the ICT requirements of the subject Hospitality Studies

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	0	2	0	0	0	2	0	0
Gr 11	0	0	0	4	0	0	0	3	0	1
Gr 12	1	0	0	5	1	0	0	3	0	2
Total	1	0	0	11	1	0	0	8	0	3
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	0	0	0	0	0	0	0	12.5	3.1
Gr 11	3	0	0	1	0	0	0	0	25.0	6.3
Gr 12	4	0	0	3	0	0	0	0	40.0	15.0
Total	9	0	0	4	0	0	0	0	25.5	8.0

▪ Four of the subject's ICT requirements require the use of subject-specific applications. Two different applications are involved – a stock control system and a point-of-sale system. The rest of the ICT requirements require application packages from the productivity suite.

(r) The ICT requirements of Information Technology

IT is the second subject that has been identified earlier as a special case because all its content and assessment standards are focused on learners learning about ICT itself and how to use it. Its ICT requirements are summarised in Table 5.26 below. The following aspects are significant:

▪ All 47 of its assessment standards are about and imply the use of ICTs in learning activities, making all of them prescribed and compulsory (i.e. RT1) ICT requirements. This results in a value of 100% for both its integration ratio and integration index – one of only two subjects that have achieved this.

Table 5.26: A summary of the ICT requirements of the subject Information Technology

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	38	0	0	0	38	0	1	7	2	0
Gr 11	38	0	0	0	38	0	4	10	2	0
Gr 12	30	0	0	0	30	0	2	8	1	0
Total	106	0	0	0	106	0	7	25	5	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	6	3	1	6	4	14	6	0	100.0	100.0
Gr 11	10	9	0	10	5	9	0	0	100.0	100.0
Gr 12	8	3	1	10	4	8	1	0	100.0	100.0
Total	24	15	2	26	13	31	7	0	100.0	100.0

- Because all 106 of its ICT requirements are about understanding and using ICTs, the dominant role of technology in learning is that of technology learning content (TR1). Some ICT requirements also involve other roles of technology. In seven cases technology figure as a resource tool (TR4 – to access information on the Internet), in 25 cases as a cognitive tool (TR5), and in five cases as a collaboration tool (TR6).

- In 31 ICT requirements no software is involved (AT14 – these assessment standards deal with hardware and other non-software aspects of ICTs). In the rest of the ICT requirements IT learners are exposed to the following broad range of application types: a subject-specific application in the form of a programming language (AT11) in 26 cases; application packages from the productivity suite (AT5) in 24 cases; application packages from the Internet suite (AT9) in 15 cases; a multimedia/hypermedia authoring package (AT10) in two cases; system and utility software (AT13) in 13 cases; and all subject-relevant application types (AT15) in seven cases.

(s) The ICT requirements of Languages – English Home Language, English First Additional Language and English Second Additional Language

The NCS provides language subjects on three levels: Home Language, First Additional Language and Second Additional Language. Each of these language subjects can be offered in any of the 11 official languages; they all use the same learning outcomes and assessment standards. However, the picture is somewhat different when the different levels are compared. The three language levels use the same learning programme and subject assessment guideline documents but different subject statement documents. The latter reveal that although the assessment standards are basically the same for the three levels, they are scaled down from Home Language to First Additional Language and Second Additional Language. The assessment standards of the three language subjects were analysed separately for ICT requirements, but the results were exactly the same. The ICT requirements for the three languages are therefore presented and discussed only once. Table 5.27 below presents a summary of the ICT requirements of the three language subjects. The following is noteworthy:

- The language subjects have against all expectations a considerable level of technology integration with their integration index value at 21.4%. This is the result of three ICT requirements of the prescribed but optional type (RT2), 12 of the implied type (RT3) and three of the potential type (RT4). The fact that languages use a text-based approach that includes electronic formats (Department of Education 2003p:42-45) explains the considerable level of technology integration.

- The roles of technology in language learning are balanced between a resource tool (TR4 – in 12 ICT requirements) and a cognitive tool (TR5 – in 15 ICT requirements).

Table 5.27: A summary of the ICT requirements of the language subjects English Home Language, English First Additional Language and English Second Additional Language

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	1	4	1	0	0	4	5	0	0
Gr 11	0	1	4	1	0	0	4	5	0	0
Gr 12	0	1	4	1	0	0	4	5	0	0
Total	0	3	12	3	0	0	12	15	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	6	6	4	0	0	0	0	4	42.9	21.4
Gr 11	6	6	4	0	0	0	0	4	42.9	21.4
Gr 12	6	6	4	0	0	0	0	4	42.9	21.4
Total	18	18	12	0	0	0	0	12	42.9	21.4

- Texts are ‘used’ and ‘produced’ in language learning (Department of Education 2003p:42-45). A wide range of application types is used to accommodate texts in various electronic formats. The language ICT requirements require the use of application packages from the productivity suite (AT5) in 18 cases, application packages from the Internet suite (AT9) in 18 cases, a multimedia/hypermedia authoring package (AT10) in 12 cases and database/multimedia packages with subject-relevant information (AT16) in 12 cases.

(t) The ICT requirements of Life Orientation

A summary of the ICT requirements of the subject Life Orientation is presented in Table 5.28 below. The following aspects are noteworthy:

- The subject has one ICT requirement of the prescribed and compulsory type (RT1) and 11 of the potential type (RT4). The low integration index of 7.8% is understandable in view of the nature of the subject's content that perhaps lends itself less to technology integration than other subjects.

Table 5.28: A summary of the ICT requirements of the subject Life Orientation

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	N	n	n	n	n	n
Gr 10	1	0	0	1	0	0	2	2	0	0
Gr 11	0	0	0	5	0	0	4	5	0	0
Gr 12	0	0	0	5	0	0	5	5	0	0
Total	1	0	0	11	0	0	11	12	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	N	n	n	n	%	%
Gr 10	2	2	0	0	0	0	0	0	12.5	7.8
Gr 11	5	4	0	0	0	0	0	0	31.3	7.8
Gr 12	5	5	0	0	0	0	0	0	31.3	7.8
Total	12	11	0	0	0	0	0	0	25.0	7.8

- The roles of technology in learning in the subject's ICT requirements are balanced between a resource tool (TR4 – in 11 cases) and a cognitive tool (TR5 – in 12 cases).

- The subject requires the use of application packages from the productivity suite in 12 of its ICT requirements and application packages from the Internet suite in 11 cases.

(u) The ICT requirements of Life Sciences

The following are noteworthy about the ICT requirements of Life Sciences that are summarised in Table 5.29 below:

- Life Sciences' considerable level of technology integration represented by its 28.3% integration index is due to its 17 prescribed but optional ICT requirements (RT2) out of 45 assessment standards.

Table 5.29: A summary of the ICT requirements of the subject Life Sciences

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	4	0	0	0	0	1	2	0	2
Gr 11	0	6	0	0	0	0	2	5	0	0
Gr 12	0	7	0	0	0	0	2	4	0	2
Total	0	17	0	0	0	0	5	11	0	4
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	3	1	0	0	0	0	0	0	30.8	23.1
Gr 11	5	2	0	0	0	0	0	0	40.0	30.0
Gr 12	6	2	0	0	0	0	0	0	41.2	30.9
Total	14	5	0	0	0	0	0	0	37.8	28.3

- The role of technology in learning reflected in the subject's ICT requirements is balanced between resource tool (TR4 – five cases), cognitive tool (TR5 – 11 cases) and productivity tool (TR7 – four cases).

- The subject's ICT requirements require application packages from the productivity suite (AT5) in 14 cases and Internet suite (AT9) in four cases.

(v) The ICT requirements of Mathematical Literacy

Table 5.30 below represents a summary of the ICT requirements of Mathematical Literacy and reflects the following noteworthy aspects.

- The subject has six prescribed but optional ICT requirements (RT2), 14 implied ICT requirements (RT3) and 4 potential ICT requirements (RT4). These 24 ICT requirements out of 52 assessment standards give the subject a considerable integration index of 23.6%

Table 5.30: A summary of the ICT requirements of the subject Mathematical Literacy

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	2	4	2	0	0	1	8	0	0
Gr 11	0	2	5	1	0	0	1	8	0	0
Gr 12	0	2	5	1	0	0	1	8	0	0
Total	0	6	14	4	0	0	3	24	0	0

	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	6	1	0	3	0	0	0	0	47.1	23.5
Gr 11	7	1	0	3	0	0	0	0	44.4	23.6
Gr 12	7	1	0	3	0	0	0	0	44.4	23.6
Total	20	3	0	9	0	0	0	0	45.3	23.6

- The role of technology in learning in the ICT requirements is predominantly that of a cognitive tool (TR5 – in 24 cases). It is supplemented by four ICT requirements in which technology has the role of a resource tool (RT4).

- Application packages from the productivity suite (AT5) and Internet suite (AT9) are required in 20 and three ICT requirements respectively. In addition the use of subject-specific applications in the form of specialised graphing software are required in nine cases.

(w) The ICT requirements of Mathematics

Table 5.31 below presents a summary of the ICT requirements of Mathematics. It reflects the following significant aspects:

- Mathematics has the second highest level of technology integration of NCS subjects with IT and CAT excluded. Its integration index of 28.8% results from five prescribed but optional (RT2) and 34 implied (RT3) ICT requirements out of 72 assessment standards. One of the key aspects of Mathematics as a knowledge domain is mathematical modelling in which technology can be used very successfully and appropriately for developing understanding of the concepts involved. Although the subject has relatively few direct instructions for the use of ICTs in learning (only five prescribed but optional (RT2) ICT requirements), 34 implied (RT3) ICT requirements were identified that are mostly focused on using technology for cognitive concept development in the area of mathematical modelling.

- The subject's ICT requirements point overwhelmingly to cognitive tool (TR5) as the role of technology in learning – all 39 cases require the use of technology in this role. Other roles identified are that of resource tool (TR4 – in six cases) and productivity tool (TR7 – in four cases).

Table 5.31: A summary of the ICT requirements of the subject Mathematics

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	1	13	0	0	0	2	14	0	2
Gr 11	0	2	12	0	0	0	2	14	0	1
Gr 12	0	2	9	0	0	0	2	11	0	1
Total	0	5	34	0	0	0	6	39	0	4
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	11	2	0	12	0	0	0	0	58.3	30.2
Gr 11	10	2	0	12	0	0	0	0	53.8	28.8
Gr 12	8	2	0	9	0	0	0	0	50.0	27.3
Total	29	6	0	33	0	0	0	0	54.2	28.8

- The subject puts a high demand on the use of subject-specific applications in mathematical modelling – 33 of its ICT requirements require the use of software such as specialised graphing and dynamic geometry packages. In addition, 29 and six cases require application packages from the productivity and Internet suites respectively.

(x) The ICT requirements of Mechanical Technology

Table 5.32 below is a summary of the ICT requirements of the subject Mechanical Technology and includes the following significant aspects:

- The subject has a disappointing low level of technology integration indicated by its 4.8% integration index. Only seven of its 84 assessment standards are identified as ICT requirements – three as prescribed but optional (RT2), three as implied (RT3) and one as potential (RT4) ICT requirements. Being a technology-oriented subject one would expect a higher level of ICT use in the learning activities prescribed by its assessment standards.

Table 5.32: A summary of the ICT requirements of the subject Mechanical Technology

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	1	1	0	0	0	1	2	0	0
Gr 11	0	1	1	0	0	0	1	2	0	0
Gr 12	0	1	1	1	0	0	1	2	0	1
Total	0	3	3	1	0	0	3	6	0	1

	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	1	0	0	0	0	0	1	7.1	4.5
Gr 11	2	1	0	0	0	0	0	1	7.1	4.5
Gr 12	3	1	0	0	0	0	0	1	10.7	5.4
Total	7	3	0	0	0	0	0	3	8.3	4.8

- The roles of technology in learning stipulated in the ICT requirements include that of a resource tool (TR4 – three cases), cognitive tool (TR5 – six cases) and productivity tool (TR7 – one case).

- Seven of the ICT requirements require application packages from the productivity suite (AT5 – for creating cognitive constructs), three require packages from the Internet suite (AT9 – for accessing Internet resources) and three require database/multimedia packages (AT16 – for accessing other electronic information resources).

(y) The ICT requirements of Music

A summary of Music's ICT requirements is presented in Table 5.33 below. The following aspects are noteworthy:

- 18 of Music's 84 assessment standards are identified as ICT requirements – five are classified as the prescribed but optional type (RT2), six as the implied type (RT3) and seven as the potential type. Based on this Music's level of technology integration is calculated at a moderate 19.8%.

Table 5.33: A summary of the ICT requirements of the subject Music

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	2	1	3	0	0	2	5	0	0
Gr 11	0	3	2	2	0	0	3	6	0	0
Gr 12	0	0	3	2	0	0	2	4	0	0
Total	0	5	6	7	0	0	7	15	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	2	2	0	3	0	0	0	1	37.5	17.2
Gr 11	3	3	0	3	0	0	0	2	50.0	26.8
Gr 12	1	2	0	3	0	0	0	1	38.5	15.4
Total	6	7	0	9	0	0	0	4	41.9	19.8

- The role of technology in learning in the subject's ICT requirements is balanced between resource tool (TR4 – seven cases) and cognitive tool (TR5 – 15 cases). The latter is explained by the requirement for learners to use specialised software to create musical compositions (cognitive constructs).

- The application types required by Music's ICT requirements can be divided in two groups. The first group requires learners to use application packages from the productivity suite (AT5 – six ICT requirements) and a music composition package (AT16 – four ICT requirements) to create various ingredients (cognitive constructs) for the production of musical compositions. The other group requires the use application packages from the Internet suite (AT9 – seven cases) and database/multimedia packages (AT16 – four cases) for accessing relevant Internet and other electronic information resources.

(z) The ICT requirements of Physical Science

The following aspects about the ICT requirements of Physical Science that are summarised in Table 5.34 below, are noteworthy:

- The subject has a considerable integration ratio of 53.3% - 16 of its 30 assessment standards are identified as ICT requirements. However, seven of them are classified as implied ICT requirements (RT3) and nine as potential ICT requirements (RT4), giving the subject a moderate integration of 19.2%.
- A variety of technology roles in learning are reflected in the ICT requirements of the Physical Science. In three cases the role of technology is that of a context tool (TR3 – one of a few subjects with ICT requirements in this category), in four the role is resource tool (TR4), in 13 it is cognitive tool (TR5) and in three it is productivity tool (TR7).

Table 5.34: A summary of the ICT requirements of the subject Physical Science

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	1	3	0	1	0	3	0	1
Gr 11	0	0	2	3	0	1	1	4	0	1
Gr 12	0	0	4	3	0	1	3	6	0	1
Total	0	0	7	9	0	3	4	13	0	3
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	3	1	0	0	0	0	0	1	40.0	12.5
Gr 11	4	2	0	0	0	0	0	1	50.0	17.5
Gr 12	6	4	0	0	0	0	0	1	70.0	27.5
Total	13	7	0	0	0	0	0	3	53.3	19.2

- On the one hand the subject's ICT requirements require learners to use application packages from the productivity suite (AT5 – 13 cases) to create various cognitive constructs. On the other hand application packages from the Internet suite (AT9 – seven cases) and database/multimedia packages (AT16 – three cases) are required for accessing relevant Internet and other electronic information resources.

(aa) The ICT requirements of Religion Studies

A summary of the ICT requirements of Religion Studies is presented in Table 5.35 below. The following is noteworthy:

- The subject has only eight potential ICT requirements, giving it a low integration index of 4.3%. The low level of technology integration is understandable in view of the nature of the subject's content that perhaps lends itself less to technology integration.

Table 5.35: A summary of the ICT requirements of the subject Religion Studies

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	0	3	0	0	0	3	0	0
Gr 11	0	0	0	2	0	0	0	2	0	0
Gr 12	0	0	0	3	0	0	0	3	0	0
Total	0	0	0	8	0	0	0	8	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	3	0	0	0	0	0	0	0	18.8	4.7
Gr 11	2	0	0	0	0	0	0	0	13.3	3.3
Gr 12	3	0	0	0	0	0	0	0	20.0	5.0
Total	8	0	0	0	0	0	0	0	17.4	4.3

- The only role of technology in learning that is reflected in the subject's ICT requirements is that of cognitive tool (TR5 – in eight cases). The absence of the role of resource tool in the ICT requirements is a possible shortcoming.

- The subject's eight ICT requirements require the use of application packages from the productivity suite (AT5). The fact that no application packages from the Internet suite (AT9) are required confirms that the use of ICTs as a resource tool to access Internet information is a possible shortcoming.

(bb) The ICT requirements of Tourism

Table 5.36 below that summarises the ICT requirements of the subject Tourism, reflects the following significant aspects:

- With its 11 prescribed but optional (RT2) and eight implied (RT3) ICT requirements, the subject has a considerable level of technology integration of 23.6%.

Table 5.36: A summary of the ICT requirements of the subject Tourism

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	3	2	0	0	0	4	3	1	0
Gr 11	0	3	3	0	0	0	3	4	1	1
Gr 12	0	5	3	0	0	0	5	7	1	2
Total	0	11	8	0	0	0	12	14	3	3
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	3	5	0	0	0	0	0	2	31.3	20.3
Gr 11	6	4	0	0	0	0	0	1	33.3	20.8
Gr 12	8	6	0	0	0	0	0	2	44.4	29.2
Total	17	15	0	0	0	0	0	5	36.5	23.6

- Tourism has a well-balanced mix of roles of technology in learning: 12 ICT requirements reflect technology in the role of resource tool, 14 in the role of cognitive tool, three in the role of collaboration tool and three in the role of productivity tool.

- In 17 cases the subject's ICT requirements require the use of application packages from the productivity suite (AT5) to create cognitive constructs. In 15 cases it requires application packages from the Internet suite and in 5 database/multimedia packages for communication and accessing relevant information resources.

(cc) The ICT requirements of Visual Arts

Table 5.37 below that summarises the ICT requirements of Visual Arts, reflects the following noteworthy aspects:

Table 5.37: A summary of the ICT requirements of the subject Visual Arts

	ICTRs according to requirement types				ICTRs according to technology roles in learning					
	RT1	RT2	RT3	RT4	TR1	TR3	TR4	TR5	TR6	TR7
	n	n	n	n	n	n	n	n	n	n
Gr 10	0	0	9	0	0	0	3	8	0	0
Gr 11	0	0	10	0	0	0	3	9	0	0
Gr 12	0	0	9	0	0	0	3	8	0	0
Total	0	0	28	0	0	0	9	25	0	0
	ICTRs according to application types								Integration	
	AT5	AT9	AT10	AT11	AT13	AT14	AT15	AT16	IR	II
	n	n	n	n	n	n	n	n	%	%
Gr 10	4	3	0	4	0	0	0	1	52.9	26.5
Gr 11	5	3	0	4	0	0	0	1	58.8	29.4
Gr 12	5	3	0	3	0	0	0	1	52.9	26.5
Total	14	9	0	11	0	0	0	3	54.9	27.5

- The ICT requirements of Visual Arts allow the use of subject-specific visual arts software to create artistic objects. This contributes to the considerable level of technology integration of 27.5% that is calculated from 28 implied ICT requirements (RT3) out of 51 assessment standards.

- The roles of technology in the subject's ICT requirements consist of resource tool (TR4 – in nine cases) and cognitive tool (TR5 – in 25 cases).

- In 11 ICT requirements subject-specific visual arts software is required to create artistic objects. In 14 cases application packages of the productivity suite are required to create other cognitive constructs. Application packages of the Internet suite (AT9 – nine cases) and database/multimedia packages (AT16 – three cases) are required for the purpose of accessing relevant information resources.

This concludes the description of the ICT requirements of individual subjects.

5.4 SUMMARY

Chapter 5 had two objectives. The first was to describe the implementation of the research design and report the results of the analytical process. This included the definition of an ICT requirement, the development of typologies for classifying ICT requirements, the development of a coding agenda for the process of identifying, classifying and recording the ICT requirements and a description of the checks applied to ensure data reliability. The second objective involved a summary of the research data generated by the research design, a discussion of the ICT requirements for the NCS as a whole and finally a discussion of the ICT requirements of individual subjects.

CHAPTER 6: A FRAMEWORK OF UNDERSTANDING FOR INTERPRETING THE IMPLICATIONS OF THE INFORMATION AND COMMUNICATION REQUIREMENTS OF THE NATIONAL CURRICULUM STATEMENT

> *Interpretation, by definition, involves going beyond the descriptive data. Interpretation means attaching significance to what was found, making sense of findings, offering explanations, drawing conclusions, extrapolating lessons, making inferences, considering meanings, and otherwise imposing order on an unruly but surely patterned world* (Patton 2002:480).

6.1 INTRODUCTION

This research has made a number of findings that were described in previous chapters. Findings have implications. A whole spectrum of implications is possible – some may include new insights that give birth to a new theory, while others may lead to recommendations that fundamentally improve a practice. What is the significance of the findings in this case? How can we make sense of them? In which context should they be understood? How can we impose order on them? These are the types of questions that need to be answered at this stage after illuminating the findings of the research.

Answering the questions above is done by synthesising the findings of the research into a conceptual framework that not only indicates its components, but also describes interrelationships between components and the context in which they function. The conceptual framework takes the form of a framework of understanding for interpreting the ICT requirements of the NCS. The intention is to describe a conceptual framework that educators and other functionaries concerned can use as a context for interpreting and implementing the implications of the ICT requirements and the other research findings with real understanding of the fundamental issues that are at stake.

As a prelude to formulating a framework of understanding, the first objective of this chapter is to identify and describe the implications that the findings of this research have for the NCS and its practice in schools. With the implications clearly identified and understood, the formulation of the framework can commence, which is the second objective of this study.

6.2 IMPLICATIONS OF THE RESEARCH FINDINGS

This research was directed and guided by the following research questions (refer sections 1.2 and 4.2).

- What is an appropriate theoretical foundation for integrating ICTs in learning?
- What are the uses of ICTs in learning?
- How can the ICT requirements of the NCS be identified and classified?
- What are the ICT requirements of the NCS?
- What are the implications of the ICT requirements of the NCS for implementation in schools?
- Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?

The first four questions were answered in the form of findings in Chapters 2, 3 and 5 respectively. This section endeavours to answer the fifth question: **What are the implications of the ICT requirements of the NCS for implementation in**

schools? It is done by listing the findings related to each of the first four research questions in separate tables and discussing its implications for implementation.

6.2.1 Findings and implications of the research question: What is an appropriate theoretical foundation for integrating ICTs in learning?

The finding and implications for implementation of this research question are presented in Table 6.1 below.

Table 6.1: Finding and implications of the research question: What is an appropriate theoretical foundation for integrating ICTs in learning?

Findings	**Implications for implementation**
Finding 1: The integration of the ICT requirements of the NCS in learning should be based on the theoretical foundation (described in section 2.11.3) that considers the two paradigms of learning of objectivism and constructivism to be complementary, meaning that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate than the other. However, due to the nature of 21st century learning needs for increasing advanced knowledge acquisition, a growing need for constructivist approaches is expected.	▪ Educators implementing the ICT requirements of the NCS should understand the fundamental view of the role of technology in learning according to this theoretical foundation. ▪ The categories of technology uses in learning should be based on this theoretical foundation. ▪ The practical aspects of implementing the ICT requirements in learning, including teaching and learning strategies, should be embedded in this theoretical foundation.

6.2.2 Findings and implications of the research question: What are the uses of ICTs in learning?

Table 6.2 below presents the findings and implications for implementation of this research question.

Table 6.2: Findings and implications of the research question: What are the uses of ICTs in learning?

Findings	**Implications for implementation**
Finding 2.1: The uses of ICTs in learning can be described in terms of the categories of the typology of technology roles in learning which are technology learning content, didactic tool, context tool, resource tool, cognitive tool, collaboration tool and productivity tool (refer section 3.6).	▪ Educators should understand, interpret and implement the uses of ICTs specified or implied in the assessment standards of NCS subjects in terms of the seven identified roles of technology in learning.
Finding 2.2: For technology uses in learning to succeed they must be imbedded in a technology-integrated curriculum that is defined as a curriculum that supports, and in many cases, prescribes technology integration into teaching and learning. In other words the curriculum must prescribe and/or support the systematic use of technology appropriately matched and combined with teaching and learning strategies and curriculum content in order to enhance the achievement of curriculum-specified learning outcomes (refer section 3.7).	▪ The NCS must be a technology-integrated curriculum for the implementation and use of ICTs in learning to succeed.

6.2.3 Findings and implications of the research question: How can the ICT requirements of the NCS be identified and classified?

The findings and implications for implementation of this research question are described in Table 6.3 below.

Table 6.3: Findings and implications of the research question: How can the ICT requirements of the NCS be identified and classified?

Findings	**Implications for implementation**
Finding 3.1: Critical outcomes 4, 5 and 6 are recognised and interpreted as the foundation and justification for including ICTs as learning tools and resources in the NCS (refer section 5.2.1).	▪ Educators should understand the foundation and justification for the inclusion of ICT requirements in the NCS.
Finding 3.2: An ICT requirement of the NCS is defined as any assessment standard in the subject statement of an NCS subject in which the use of ICT facilities in a learning activity is prescribed, implied or potentially beneficial (refer section 5.2.1).	▪ Educators should be able to apply this definition in order to recognise and identify ICT requirements in the assessment standards of their NCS subjects.

Finding 3.3: The ICT requirements of the NCS can be classified according to the typology of technology roles in learning (refer section 5.2.2(a)). **Finding 3.4:** The ICT requirements of the NCS can be classified according to the typology of requirement types (refer section 5.2.2(b). **Finding 3.5:** The ICT requirements of the NCS can be classified according to the typology of application types (refer section 5.2.2(b)).	▪ Educators should examine, understand and interpret the uses of ICTs specified or implied in the assessment standards of NCS subjects in terms of the three typologies of requirement types, technology roles in learning and application types.

6.2.4 Findings and implications of the research question: What are the ICT requirements of the NCS?

The findings and implications for implementation of this research question are presented in Table 6.4 below.

Table 6.4: Findings and implications of the research question: What are the ICT requirements of the NCS?

Findings	**Implications for implementation**
Finding 4.1: The subjects CAT and IT have a dominant impact on the number and distribution of ICT requirements in the NCS because all their assessment standards are about and imply the use of ICTs in learning activities, making all of them prescribed and compulsory ICT requirements (refer section 5.3.2(a)).	▪ CAT and IT educators require a high level of ICT knowledge and skills. ▪ Full time ICT facilities should be available for teaching and learning CAT and IT.
Finding 4.2: The distribution of ICT requirements according to grades is fairly even (refer section 5.3.2(a)).	▪ Curriculum developers and advisors should note this finding and keep it in mind when reviewing the NCS.

Findings regarding ICT requirements classified according to requirement types	
Finding 4.3: In the requirement type distribution of ICT requirements for all NCS subjects the ‘prescribed and compulsory’ and ‘implied’ categories are dominant. When CAT and IT are excluded, the ‘implied’ and ‘potential’ categories are dominant (refer section 5.3.2(a)). **Finding 4.4:** NCS subjects other than CAT and IT are in general hesitant to prescribe compulsory or optional uses of ICT facilities in learning activities. Most subjects do not prescribe any such ICT uses at all, while only a few clearly and pertinently prescribe compulsory or optional ICT uses where appropriate (refer section 5.3.2(a)).	▪ Subjects that do not clearly and pertinently incorporate and prescribe ICT uses in the learning activities of its assessment standards put themselves at a disad-vantage compared to subjects that do. ▪ Curriculum developers should note this problem of inconsistent recognition and uneven prescription of the use of ICTs in learning activities by the different subjects. ▪ A clear set of guidelines for integrating the use of ICTs in the learning activities of subjects should be developed and applied in reviewing the learning outcomes and assessment standards of NCS subjects.
Finding 4.5: All subjects have identified ICT requirements. The integration ratio for the three grades combined and all 31 subjects of the NCS is 35.4%, meaning that 35.4% of all assessment standards in the NCS qualify as ICT requirements. When CAT and IT are excluded, then this figure is marginally lower at 29.0% (refer section 5.3.2(a)). **Finding 4.6:** The integration index for all NCS subjects and the three grades combined is 23.0%. With CAT and IT excluded the integration index value drops to 15.4% (refer section 5.3.2(a)).	▪ Curriculum developers can use the current integration ratio and integration index values as bench marks for future NCS reviews. ▪ The question of which integration ratio and/or index value constitutes an acceptable level of technology integration in a curriculum or subject is a meaningful subject for further research. ▪ Educators should be appropriately trained for meaningful implementation of ICT requirements in learning activities. ▪ An ICT infrastructure that meets the collective needs of all relevant subjects in a school should be installed and maintained for every school. ▪ Different subjects have different access needs for their learners – some may need full-time yearlong access to dedicated ICT facilities, some on a full-time block basis, some regularly and some periodically. Appropriate access for learners to ICT facilities that comply with the collective needs of all individual subjects in a school, should be arranged by providing sufficient facilities and organising sufficient access time in school time tables.

Finding 4.7: Using the integration index as an indicator reveals that the subjects CAT and IT are 100% technology integrated. This is because all their assessment standards are identified and classified as prescribed and compulsory ICT requirements (refer section 5.3.2(a)).	▪ CAT and IT educators require a high level of ICT knowledge and skills. ▪ Full time ICT facilities should be available for teaching and learning CAT and IT.
Finding 4.8: Subjects with a considerable level of technology integration (an integration index of more than 20.0%) include Accounting (24.3%), Engineering Graphics and Design (36.1%), Languages – English First Additional Language (21.4%), Languages – English Home Language (21.4%), Languages – English Second Additional Language (21.4%), Life Sciences (28.3%), Mathematical Literacy (23.6%), Mathematics (28.8%), Tourism (23.6%) and Visual Arts (27.5%) (refer section 5.3.2(a)).	▪ Curriculum developers should consider these subjects as the norm for technology integration and strive to increase the integration levels of other subjects through reviews and redevelopments.
Finding 4.9: Subjects with a low level of technology integration (an integration index of less than 9.0%) include Agricultural Sciences (4.7%), Agricultural Technology (8.9%), Business Studies (2.8%), Dance Studies (5.2%), Electrical Technology (5.1%), History (8.9%), Hospitality Studies (8.0%), Life Orientation (7.8%), Mechanical Technology (4.8%) and Religion Studies (4.3%) (refer section 5.3.2(a)).	▪ A clear set of guidelines for integrating the use of ICTs in the learning activities of subjects should be developed and applied in reviewing the learning outcomes and assessment standards of NCS subjects. ▪ Curriculum developers should review the learning outcomes and assessment standards of subjects with a low technology integration level in particular in order to increase the benefits of using ICTs in the learning activities of those subjects.
Findings regarding ICT requirements classified according to technology roles in learning	
Finding 4.10: No ICT requirement of any NCS subject was classified in the didactic (teaching) tool category (refer section 5.3.2(b)).	▪ Educators should understand that although no ICT requirement is classified as a didactic tool, technology can still be used in this role in learning events for introductory knowledge acquisition when learners have very little directly transferable prior knowledge about a skill or content area in a linear and well-structured knowledge domain.

Finding 4.11: 94.6% of the ICT requirements of all NCS subjects are classified in only three technology role categories: technology learning content (21.3%), resource tool (19.9%) and cognitive tool (53.4%). CAT and IT are virtually the only subjects with ICT requirements in the category of technology learning content. The 19.9% of ICT requirements in the resource tool category refers to using ICTs to access information on the Internet and other electronic resources. However, with more than half of all ICT requirements in the category of cognitive tool, the main focus of the NCS is on using ICTs in cognitive activities that include constructing own knowledge. This emphasis confirms the OBE/constructivist foundation of the NCS (refer section 5.3.2(b)).	▪ Educators should understand, interpret and implement the uses of ICTs specified or implied in the assessment standards of NCS subjects in terms of the seven identified roles of technology in learning.
Finding 4.12: Only 5.5% of the ICT requirements are classified in the categories of context tool, collaboration tool and productivity tool (refer section 5.3.2(b)).	▪ Educators must realise that although these technology roles are specified in only a few ICT requirements, they are still very valid, relevant, meaningful and appropriate in actual learning activities during lessons.
Findings regarding ICT requirements classified according to application types	
Finding 4.13: The group of application type categories of system software and utilities, not applicable/no software and all relevant application types for the subject is mostly applicable to CAT and IT only (refer section 5.3.2(c)). **Finding 4.14:** Almost half (48.6%) of all ICT requirements require the group of productivity suite and multimedia/hypermedia authoring application types that enable learners to create cognitive constructs. This finding again confirms the OBE/constructivist foundation of the NCS (refer section 5.3.2(c)). **Finding 4.15:** More than a quarter (27.0%) of all ICT requirements specify the use of the group of application types that consists of the Internet suite and database and multimedia applications with subject-related information. These requirements require learners to access information and/or communicate with others outside the classroom (refer section 5.3.2(c)).	▪ Educators should understand, interpret and implement these groups of application types in the context of the total spectrum of application types required by the ICT requirements of NCS subjects.

Finding 4.16: 16.9% of all ICT requirements require the use of unique subject-specific applications that are applied in specific professions, disciplines and sciences to provide specialised functions and facilities (refer section 5.3.2(c)).	▪ Educators should be professionally trained in the use of these packages.

6.3 A FRAMEWORK OF UNDERSTANDING FOR IMPLEMENTING THE ICT REQUIREMENTS OF THE NCS

The objective of this section is to answer the research question: **Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?** The intention is to accommodate the findings of this research in a conceptual framework that educators in schools can use as a context for interpreting and implementing the implications of the ICT requirements with real understanding of the fundamental issues that are at stake. There are a host of factors that determine the success of technology implementation in learning, but not all of them were explored in this research. The framework has the important function of providing educators with a holistic picture of requirements for successful technology implementations in learning, including those addressed in this research as well as those that were not. In order to have a real understanding of these factors themselves, the interrelationships and interdependencies between them, and the context in which they function, it is necessary to fit them, like the pieces of a puzzle, into a conceptual framework. According to Mishra & Koehler (2006:1019,1034,1039,1043&1044), such frameworks offer new ways of looking at and perceiving phenomena. In general their functions can be described as to: serve as conceptual lenses to view the world; guide observations; provide concepts and terminologies to describe phenomena; offer information on which to base sound decision making; guide designs of practical implementations; and critique (evaluate) practical implementations.

The emphasis in the proposed framework is on providing schools with implementation guidelines, as the title of this research suggests. The functionaries in schools mainly responsible for this are teachers in classrooms and school managers. The purpose of the proposed framework, therefore, is focussed on providing teachers and school managers with theoretical and practical guidelines for implementing technology in learning. A multitude of frameworks and models are available for guiding such implementations. It ranges from models for technology-integrated lesson development such as the Technology Integration Process model (Newby et al. 2006) and the ASSURE model (Shelly et al. 2010), to technology adoption models at organisational levels such as the Technology Acceptance Model (Davis 1989) and the Diffusion of Innovations theory (Rogers 1962). However, as stated previously the intended framework is exclusively focussed on the school. Three levels of involvement in technology implementations in schools can be distinguished: the micro level – technology implementation in a particular learning event; the meso level – the conceptual knowledge that teachers require for optimal technology implementation in learning; and the macro level – management of school-wide technology implementations in learning. Comparing these levels with the aims of this research and the nature of its findings, the conclusion is made that the framework should address the meso and macro levels of technology implementations in schools. The proposed framework of understanding, therefore, consists of two components: a framework for teacher knowledge of technology implementations in learning; and a model for managing school-wide technology implementations in learning.

6.3.1 A framework for teacher knowledge of technology implementations in learning

The framework that is selected to guide teachers is the TPCK framework for teacher knowledge for technology integration developed by Mishra and Koehler (2006). The TPCK framework is the result of a five year research programme on teachers' professional development, and attempts to capture some of the essential qualities of teacher knowledge required for appropriate and optimal technology integration in teaching (and learning). It posits the complex roles of, and interplay among the three main components of learning environments: technology (T), pedagogy, (P) pedagogy and content (C). The TPCK framework is selected because it agrees with this research on a number of important issues such as: the belief that the fundamental changes in society is not reflected in 21st century education; the assumption that technology integration in teaching and learning should have a proper epistemological and learning theory foundation; and the goal of providing theoretical and practical guidelines for optimal technology implementations in learning (Mishra & Koehler 2006:1017-1020). Figure 6.1 is a representation of this framework.

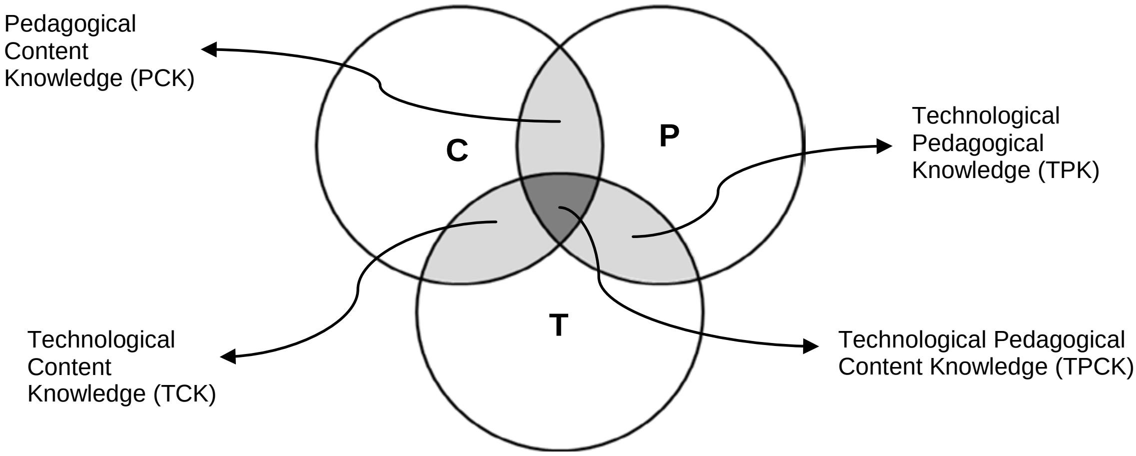

Figure 6.1: The TPCK framework for teacher knowledge for technology integration (Mishra & Koehler 2006:1025)

The basis of the TPCK framework is the understanding that teaching is a highly complex cognitive skill that draws on pedagogical knowledge (PK), content knowledge (CK) and technological knowledge (TK). It also emphasises the connections, interactions, affordances, constraints and complex interplay between and among these three bodies of knowledge. Apart from looking at each component in isolation, the framework also looks at them in pairs, resulting in pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK), and ultimately all three together as technological pedagogical content knowledge (TPCK) (Mishra & Koehler 2006:1020&1025-1026). The elements and relationships of the framework are presented below. Where appropriate, findings of this research are introduced and contextualised in this framework.

(a) Content knowledge (CK)

This knowledge is the knowledge that teachers should have about the actual subject(s) they are teaching. It includes knowledge of central facts, concepts, theories, structures and procedures within each subject, as well as the nature of its content and how to explore and experience it (Mishra & Koehler 2006:1026).

In the context of this research CK refers to the definition, purpose, scope, learning outcomes, assessment standards, and contents of the 31 subjects of the NCS as specified in the subject statement documents of the Department of Education (2003b-y & 2005a-g) (refer section 1.6.1). In this study there was a particular focus on assessment standards. They were analysed in order to identify ICT requirements (the identified ICT requirements themselves are not part of CK, but rather of technological content knowledge (TCK)) (refer sections 5.2.1 and 5.2.2). A sound knowledge and understanding of these aspects of the subjects that teachers teach is naturally one of the requirements for successful technology integration in learning in those subjects.

(b) Pedagogical knowledge (PK)

Teachers should have a deep knowledge and understanding of the theories and practices of teaching and learning. This is a generic form of knowledge that includes an understanding of theories of learning and how they guide and inform processes and methods such as teaching and learning strategies, lesson plan development and implementation and learner assessment (Mishra & Koehler 2006:1026-1027).

A substantial part of this research focussed on PK. 21st century learning needs (refer section 2.3) and the learning theories of behaviourism, cognitivism, constructivism and connectivism (refer sections 2.5 to 2.9) were explored and described. It is imperative that teachers understand the basic assumptions of these learning theories and their views of learning, teaching and learning content. They should also comprehend the differences between these theories, and the teaching-learning needs most suited for each theory. This knowledge is essential as a basis for selecting appropriate learning theory-based approaches, strategies and methods when developing and implementing learning events for particular learners and subject matter (content).

This research also identified constructivism as the learning theory foundation of the NCS (refer section 2.11.1). Teachers should, therefore, realise that the kind of learning envisioned by the NCS implies that learners are responsible for constructing their own knowledge through active exploration of and interaction with the learning content in authentic and real-life contexts. Furthermore, learning is not only an individual activity, but also occurs most naturally and effectively within a group of peers in which learners actively collaborate with others in a process of social negotiation of the meaning of the learning content (refer section 2.8.1).

(c) Pedagogical content knowledge (PCK)

PCK refers to the knowledge of pedagogy that is applicable to the teaching of specific content. It includes knowing different epistemological views on the nature of knowledge, which teaching approaches (strategies, techniques and methods) fit specific content, and how elements of the content can be arranged and presented for better teaching and meaningful understanding (Mishra & Koehler 2006:1027). In other words, PCK is the result of an interpretation and 'customisation' of general pedagogical knowledge in terms of the particularities (attributes, requirements, implications, etc.) of the content a particular subject.

In terms of PCK, this research investigated the behaviourist, cognitivist and constructivist views of learning content (refer sections 2.6.4, 2.7.4 and 2.8.4), as well as interpretations of the nature of knowledge by the epistemologies of objectivism and constructivism (refer section 2.10).

(d) Technology knowledge (TK)

TK is knowledge about and skills to operate standard technologies such as books, blackboards and overhead projectors, and more advanced technologies such as digital technologies and the Internet. In the case of digital technologies (or ICTs), teachers need to have knowledge of operating systems and hardware, and the ability to use standard software tools such as word processors, spreadsheets, Web browsers and e-mail. Because of the continuous development of such technologies, teachers also need to learn and adapt to new technologies (Mishra & Koehler 2006:1027-1028).

In the context of this study, TK refers to teachers' knowledge and understanding of ICTs and their everyday uses. This kind of knowledge was the focus of attention in a number of ways. Section 1.6.3 gave a general overview of ICTs, while section 3.2 reviewed software tools available for classroom use. One of the findings of the study (refer Finding 3.5 in section 5.2.2(b)) is that the ICT requirements of the NCS can be classified according to the inductively developed typology of application types. Application types refer to application packages (i.e. software tools), and includes packages for word processing, spreadsheets, databases, presentation graphics, Web browsing, e-mail, other forms of computer-managed communication, and multimedia/hypermedia authoring. These packages are in themselves content free (i.e. content neutral), meaning that they are designed, developed and made available with no specific content. Only when used for a particular purpose and application, are they filled with and do they carry content. The typology of application types also includes the categories of digital databases with subject-related information and subject-specific applications such as accounting, computer-aided design, geographical information and stock control systems. Systems in the latter category may not contain actual data (content) initially, but subject-specific concepts and processes are built into them that are interpreted as content. Because these software tools contain content, they are not associated with TK, but rather with the technological content knowledge (TCK) component of the TPCK framework.

(e) Technological content knowledge (TCK)

Mishra and Koehler (2006:1028) describe TCK as knowledge about the manner in which technology and content are reciprocally related. Teachers not only need to know the subject matter they teach, but also the manner in which the representation of subject matter can be changed and enhanced by the use of technology.

TCK is interpreted in this research to include subject matter (content) that requires or would benefit from the use of ICT facilities (technology) in teaching and learning it. The research addressed this kind of knowledge in the following ways:

- Critical outcomes 4, 5 and 6 are identified as the foundation and justification for including ICTs as learning tools and resources in the NCS (refer Finding 3.1 in section 5.2.1).

- An ICT requirement of the NCS (the primary object of analysis of this research) is defined as any assessment standard (content) in the subject statement of an NCS subject in which the use of ICT facilities (technology) in a learning activity is prescribed, implied or potentially beneficial (refer Finding 3.2 in section 5.2.1).

- The ICT requirements of the NCS can be classified according to the typology of requirement types that include the following categories: prescribed and compulsory ICT requirements; prescribed but optional ICT requirements; implied ICT requirements; and potential ICT requirements (refer Finding 3.4 in section 5.2.2(b)).

- The ICT requirements of the NCS can be classified according to the typology of application types that include the following categories: word processor; spreadsheet; database; presentation graphics; productivity suite (that includes the previous four application types); Web browser; e-mail; applications for other computer-managed communication forms; Internet suite (that includes the previous three application types); multimedia/hypermedia authoring application; subject-specific application; system software and utilities; not applicable/no software; all relevant application types for the subject; and database or multimedia application with subject-related information, excluding the Internet (refer Finding 3.5 in section 5.2.2(b)).

- By applying the definition of an ICT requirement, 594 out of a total of 1678 (or 35.4% of the) assessment standards were identified as ICT requirements. All findings relating to the classification of the identified ICT requirements according to the typologies of requirement types and application types are considered as TCK in the TCPK framework (refer Findings 4.1 to 4.9 and 4.13 to 4.16 in sections 5.3.2(a) and (c)).

(f) Technological pedagogical knowledge (TPK)

The TPK component of the TPCK framework is described as knowledge of the existence, components and capabilities of various technologies, and conversely, knowledge of how teaching might change as a result of using these technologies. This might include an understanding of: the range of possible technology tools that exists for a particular teaching or learning task and the affordances of each tool; the ability to choose a tool based on its appropriateness for the task; and knowledge of pedagogical strategies and the ability to apply those strategies in using technology for teaching and learning (Mishra & Koehler 2006:1028).

This research addressed a number of TPK aspects. One such aspect is an analysis of the views of different learning theories on the role of technology in teaching and learning (refer sections 2.6.5, 2.7.5 and 2.8.5). Another aspect is the research question of ‘What is an appropriate theoretical foundation for integrating ICTs in learning?’. The answer to this question is that the integration of the ICT requirements of the NCS in learning should be based on the theoretical foundation that considers the two paradigms of learning of objectivism and constructivism to be complementary. This means that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate than the other. However, due to the nature of 21st century learning needs for increasing advanced knowledge acquisition, a growing need for constructivist approaches is expected (refer Finding 1 in section 2.11.3)

The identification of the roles of technology in learning is another aspect of this research that is considered to be TPK. These are didactic tool, context tool, resource tool, cognitive tool, collaboration tool and productivity tool (refer Finding

2.1 in section 3.6). Technology learning content is also identified as a role of technology in learning, but it refers to technology as subject matter (e.g. in subjects such as Computer Applications Technology and Information Technology), and is not considered as TPK. In each role the technology has a particular function that can be related to a pedagogical purpose. For example, in the role of technology as a cognitive tool, the technology has the function of enhancing, extending and amplifying learners' cognitive powers during learning by engaging them in cognitive operations that they would not otherwise have been capable of.

These same roles of technology in learning are used to classify the 594 identified ICT requirements of the NCS (refer Finding 3.3 in section 5.2.2(a)). All findings relating to this classification of the identified ICT requirements are also considered to be TPK (refer Findings 4.10 to 4.12 in section 5.3.2(b)).

(g) Technological pedagogical content knowledge (TPCK)

This is where it all comes together. Mishra and Koehler (2006:1029) describe TPCK as the basis of effective and productive teaching with technology that requires an understanding of the following:

- The representation of learning content concepts using technologies
- Pedagogical techniques that use technologies in constructive ways to teach content
- Knowledge of what makes concepts difficult or easy to learn and how technology can help to redress some of the problems in this regard
- Knowledge of learners' prior knowledge and theories of epistemology
- Knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones

TPCK represents a class of knowledge that is central to teachers using technology to teach in a grounded, appropriate and optimal manner. This knowledge would not typically be held by technologically proficient subject experts, or by technologists who know little of the subject or pedagogy, or by teachers who know little about that subject or technology. The TCPK framework for integrating technology in teaching and learning argues that it requires a thoughtful interweaving of the three key sources of knowledge of technology, pedagogy and content. Effective and productive teaching with technology requires developing a nuanced understanding of the complex relationships between technology, pedagogy and content, and using this understanding to develop appropriate, context-specific strategies and representations of content (Mishra & Koehler 2006:1029).

One finding of this research that is considered to be TPCK is Finding 2.2 (refer section 3.7): For technology uses in learning to succeed they must be imbedded in a technology-integrated curriculum that is defined as a curriculum that supports, and in many cases, prescribes technology integration into teaching and learning. In other words the curriculum must prescribe and/or support the systematic use of technology appropriately matched and combined with teaching and learning strategies and curriculum content in order to enhance the achievement of curriculum-specified learning outcomes. This finding is considered as TPCK because it involves the systematic use of technology, teaching and learning strategies (pedagogy) and curriculum content in a complementary manner with the achievement of learning outcomes as goal.

It is interpreted in this research that TPCK comes into play when particular learning events are planned, developed and implemented. A particular learning event supposes specific learning content, a specific learner group and a specific range of technology tools available to support and enhance teaching and learning. It is in planning such learning events that teachers should employ their knowledge of technology, pedagogy and content, not only as individual knowledge domains, but also collectively with due allowance for the interplay and relationships among and between them. The following are examples of the kind of considerations (in no particular order) that are involved in planning learning events:

- Analysis of the learning content as prescribed in the curriculum in order to identify its concepts and structure, and to understand any curriculum prescriptions for the content (e.g. any particular teaching/learning approach and/or technology tool to be used).

- Analysis of the learners to identify any diversities in terms of, for example, learning styles, cognitive ability and prior knowledge.

- Analysis of the affordances of the range of technology tools available for the task.

- Review of learning theory-based teaching and learning strategies and the circumstances for which they are most appropriate.

- Selection of teaching/learning strategies, format of content presentations, and technology tools to support and enhance content presentations and learning activities, followed by balancing all of these selections to ensure effective, productive and optimal technology-integrated teaching and learning.

This research's contribution to teachers' knowledge for performing the above activities includes the following:

- Proposing an appropriate theoretical foundation for integrating ICTs in learning (refer Finding 1 in section 2.11.3)

- Describing the roles of technology in learning (refer Finding 2.1 in section 3.6)

- Identifying the ICT requirements of the NCS as subject matter (assessment standards) in which the use of technology is prescribed, implied or potentially beneficial (refer Finding 3.2 in section 5.2.1)

- Identifying typologies for analysing and classifying the identified ICT requirements of the NCS (refer Findings 3.3 to 3.6 in section 5.2.2)

- Describing the ICT requirements of the NCS as a whole (refer Findings 4.1 to 4.16 in section 5.3.2), and of individual subjects (refer section 5.3.3)

- Presenting a framework of understanding that teachers can use as a context for interpreting and implementing the research findings with real understanding of the fundamental issues that are at stake

6.3.2 A framework for managing school-wide technology implementations in learning

The school-wide implementation of technology in learning is a project that obviously requires proper management and the involvement of school managers. The framework that is proposed for this purpose (refer Figure 6.2), is based on the models of organisational life and strategic evaluation described by Whitaker (1998:33&94).

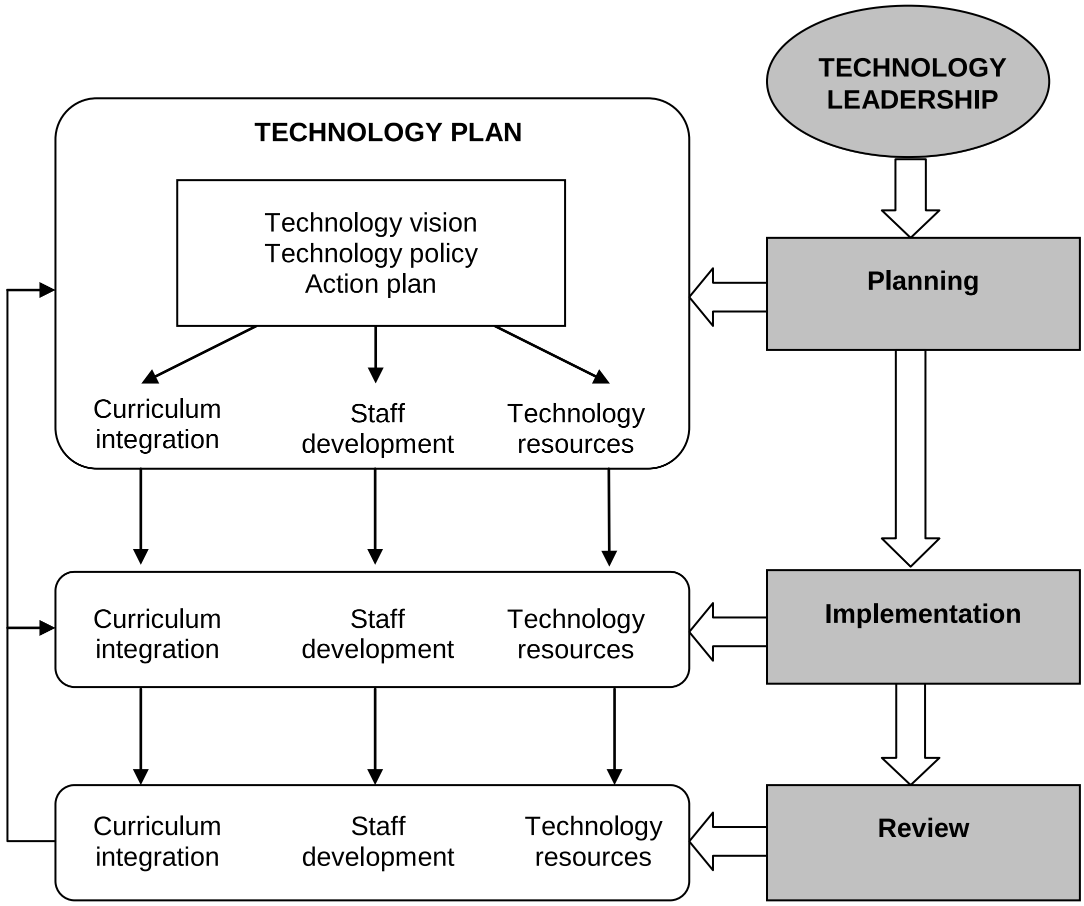

Figure 6.2: A framework for managing school-wide technology implementations in learning (adapted from the models of organisational life and strategic evaluation described by Whitaker (1998:33&94))

These models are selected because they identify key factors involved in technology implementations in learning and include typical project management features. In general the implementation and integration of technology in learning have implications in the four broad areas of technology leadership, curriculum integration, staff development and technology resources. These four key factors are presented and discussed as the pillars of the framework for school-wide technology implementations in learning.

(a) Technology leadership

Implementing and integrating technology in learning as is required by the NCS in many subjects requires strong leadership. It takes leaders with guts to pursue visions of realising the true promise of technology (Morton 1996:419). The following are some of the characteristics of technology leaders.

- **Understanding technology:** Technology leaders *"… must understand that the promise of computer environments is that they support changes in the educational structure, in the instructional processes, and in the development of lifelong learning within the whole population"* (Morton 1996:419). To understand the use of technology in FET schools, technology leaders first need to understand the kind of learning that the NCS envisions for learners. The purpose of technology then is to support and enable this kind of learning. The requirement of understanding technology therefore includes the following:

    - **Understanding what learning is:** The technology leader must understand that the learning envisioned by the NCS is based on OBE/constructivist principles (refer section 2.11.1). In essence this kind of learning implies that learners are responsible for constructing their own knowledge through active exploration of and interaction with the learning content in authentic and real-life contexts, because part of the meaning of learning content is embedded in the context from which it originates. Furthermore, learning is not only an individual activity, but also occurs most naturally and effectively within a group of peers in which learners actively collaborate with others in a process of social negotiation of the meaning of the learning content (refer section 2.8.1).

- **Understanding what the role of technology in learning is:** Not only is it essential for the technology leader to understand what technology is, but also what the role of technology in learning is. In this regard he or she must understand the following:

  - The three broad categories of technology uses in learning: learning *about* technology; learning *from* technology; and learning *with* technology (refer section 3.4)

  - The technology leader also needs to understand that the integration of technology in the learning activities required by the assessment standards of the NCS subjects should have a solid and sound foundation. The theoretical foundation proposed for this purpose (refer section 2.11.3) considers the two paradigms of learning of objectivism and constructivism to be complementary, meaning that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate than the other. However, due to the nature of 21st century learning needs for increasing advanced knowledge acquisition, a growing need for constructivist approaches is expected.

  - Finally, the technology leader needs to understand the technology roles in learning of technology learning content, didactic tool, context tool, resource tool, cognitive tool, collaboration tool and productivity tool (refer section 3.6), and the concept of a technology-integrated curriculum (refer section 3.7).

- **Having a vision:** A critical element in technology leadership is the ability to develop and articulate a vision of the desired future for the school and how technology could change teaching and learning for the better in the context of 21st century needs (Méndez-Morse 1992). Underlying such a vision is the implied requirement that technology leaders must understand and believe the role that technology can play in transforming teaching and learning (Kearsley & Lynch 1994:6).

- **Sharing the vision:** The true technology leader communicates and articulates the vision to stakeholders and wins their support for it. Rhodes (in Kearsley & Lynch 1994:30) motivates it as follows:

  Lasting change in education of any scale or scope … can succeed only if everyone touched by the change understands and shares the same vision of how the change will work to improve education for students. Teachers, [principals], parents, and the entire "learning community" must be involved in envisioning and planning change from the very beginning.

  It is through professional and collaborative relationships and conversations about the school and its future that shared visions are built (Méndez-Morse 1992).

- **Enacting the vision:** Technology leaders empower and inspire stakeholders to enact the vision and attain it. Technology leadership, therefore, includes the ability to translate a vision into reality (Kearsley & Lynch 1994:20) by initiating and coordinating the development of a **technology plan** for implementing technology in learning as required by the ICT requirements of the NCS. Such plans usually consist of three components.

  - **Technology vision:** It is a 'long term', realistic and achievable statement of intent that describes a deliberately created mental picture of how technology will contribute towards what a school wants to be and what they would like their learners to achieve in the future.

  - **Technology policy:** A technology policy not only represents a statement of commitment to develop teaching and learning with technology, but it also provides the framework, guidelines, aims and standards for doing so. It is likely to cover the following key areas:

- Technology leadership, e.g. guidelines regarding the composition and functions of the technology leadership structure

- Curriculum integration, e.g. guidelines for integrating technology in learning programmes, and providing technology facilities and access to it in accordance with the ICT requirements of individual NCS subjects

- Staff development e.g. prescribing staff development requirements that will ensure the effective implementation of the ICT requirements of the NCS

- Technology resources, e.g. guidelines regarding the planning, financing, running and maintenance of the technology infrastructure, and the functionaries responsible for it

- **Action plan:** An action plan is the instrument for implementing a policy and achieving its aims. It consists of a number of action statements. An action statement, in turn, should spell out achievable activities for the planning period (usually an academic year), who will perform those activities, and how the success thereof will be assessed.

(b) Curriculum integration

This research identified the following curriculum-related factors or requirements for successful technology implementations in learning.

- **The NCS as a technology-integrated curriculum:** This research has revealed that a fundamental requirement for technology integration into learning to succeed is that the technology must be integrated in the curriculum (refer section 3.7). In the case of the NCS it implies that the ICT requirements of the subjects should be embedded in a technology-integrated curriculum. In other words, the NCS should be a technology-integrated curriculum. Section 3.7 states that the question of whether the NCS is a technology-integrated curriculum can only be answered once the NCS and its ICT requirements have been analysed thoroughly. With the qualitative analysis of the ICT requirements of the NCS completed (in Chapter 5), this question can now be answered.

A technology-integrated curriculum is defined in section 3.7 as a curriculum that supports, and in many cases, prescribes technology integration into teaching and learning. In other words it prescribes and/or supports the systematic use of technology appropriately matched and combined with teaching and learning strategies and curriculum content in order to enhance the achievement of expected learning outcomes. Four criteria for a technology-integrated curriculum were identified and these are now analysed in Table 6.5 below in order to determine whether the NCS qualifies as a technology-integrated curriculum.

Table 6.5: Evaluation of the NCS as a technology-integrated curriculum

Criteria	Compliance
Synergetic whole: This criterion requires the curriculum to bring together the components of technology, learning outcomes, learning content, and teaching and learning strategies in an integrated and synergetic whole.	The NCS complies with this criterion because the curriculum documentation for every subject, especially the learning programme guidelines, clearly spell out the roles and functions of OBE learning outcomes, assessment standards, content, contexts, teaching and learning methodology, learning and teaching support materials (LTSMs – including ICTs) and assessment in developing learning programmes that consist of subject frameworks, work schedules and lesson plans (e.g. Department of Education 2008r:17-50).
Pedagogical soundness: In a technology-integrated curriculum the use of ICTs must focus on improving the practices for teaching and learning by supporting meaningful learning environments.	The NCS is firstly based on the constructivist-compatible educational approach of OBE (it complies with the constructivist principles of active learning, own knowledge construction, social interaction, situated learning and intentional learning – refer section 2.11.1). Secondly, the qualitative analysis of the NCS' ICT requirements revealed that in almost 92% of the ICT requirements (with CAT and IT excluded) technology is used in learning as resource and/or cognitive tools (TR4 & TR5 – refer section 5.3.2(b)). This is completely congruent with constructivist principles. The NCS therefore complies with the criteria of pedagogical soundness.

Appropriateness: This means that the technology prescribed by the curriculum must appropriately match and support the needs for presenting learning content, performing teaching and learning activities, and achieving learning outcomes.	Learning in the 21st century requires learners to be able to access, explore, evaluate and select relevant information in the cognitive process of constructing their own knowledge. This research indicates that in almost 92% of the ICT requirements (with CAT and IT excluded) ICTs are used in learning as resource tools (TR4) to access information and as cognitive tools (TR5) to create cognitive constructs (refer section 5.3.3(b)). This is clearly meaningful and appropriate, meaning that the NCS complies with this criterion.
Integration vehicle: This criterion requires the curriculum to be the vehicle for integrating technology into teaching and learning by prescribing learning activities that are not possible without technology. It must become an integral, essential and intrinsic component of learning events.	Section 5.3.2(a) indicates that out of 1678 assessment standards specified in the NCS 594 are identified as ICT requirements, resulting in an overall integration ratio of 35.4%. The NCS is the vehicle that makes this technology integration possible. Of these 594 ICT requirements 200 (33.7%) are prescribed and compulsory (RT1), meaning that the assessments standards associated with these ICT requirements cannot be achieved without the technology. The rest of the ICT requirements mean that technology supports and enhances learners' abilities to achieve the associated assessment standards. All of this is possible through the NCS that qualifies it indeed as the integration vehicle.

The conclusion is that the NCS qualifies as a technology-integrated curriculum. This implies that technology is an integral part of the curriculum and its teaching and learning practices. However, this does not mean that technology should be used in the learning activities of all assessment standards. It should only be used when it is impossible to achieve an assessment standard without technology, or when technology can truly support, enhance or extend learners' abilities to achieve an assessment standard.

- **The ICT requirements of the NCS:** To succeed in integrating technology in learning, educators must be able to: understand the concept of an ICT requirement (refer section 5.2.1); identify, analyse and classify ICT requirements (refer sections 5.2.1 and 5.2.2); comprehend the ICT requirements of their subjects (refer section 5.3); describe the implications of implementing the ICT requirements in their subjects (refer section 6.2); and apply a framework of understanding to interpret and implement the ICT requirements of their subjects (refer section 6.3).

- **Review of the NCS:** Figure 6.2 illustrates that the framework of understanding for school-wide technology implementations in learning includes a dynamic element in the sense that the implementation of the NCS and its ICT requirements involves phases of planning, implementation and review. As with any programme, its implementation needs to be reviewed regularly. However, the review of the NCS itself is a function of the national Department of Education. Curriculum issues identified for review in this research include the following:

  - There is no uniform and even incorporation of ICT uses in the learning activities of assessment standards of the different NCS subjects (refer Findings 4.3, 4.4, 4.8 and 4.9 in section 5.3.2(a)). An implication of this is that some subjects put themselves at a disadvantage with regard to harvesting the value of ICT uses in learning activities. This problem can be solved by developing a uniform set of guidelines for integrating the use of ICTs in learning activities, and applying it when reviewing the learning outcomes and assessment standards of NCS subjects.

  - Integration ratio and integration index values were calculated to indicate the level of technology integration in the learning activities for the NCS as a whole and for individual subjects (refer Findings 4.5 and 4.6 in section 5.3.2(a)). These values can be used as benchmarks for measuring technology integration levels in future reviews of the NCS.

  - Further research into what is an appropriate indicator for technology integration and what constitutes an acceptable level of technology integration could add value to NCS reviews.

(c) Staff development

Implementing and integrating technology in learning as required by the ICT requirements of NCS subjects obviously require specialised knowledge and skills, specialised in the sense that over and above normal subject knowledge and skills, educators also need knowledge and skills to use and integrate ICTs in the learning activities of their subjects. Educator training, either initial or in-service, should therefore include specific training in integrating technology in teaching and learning. In addition educators also need practical support in this specialised responsibility.

- **Training of educators:** Training of educators in this context specifically refers to training in the use and integration of technology in the learning activities of their NCS subjects. The following are some aspects that should be included in such training:

    - **Foundations of learning:** The training should provide educators with a sound understanding of the learning envisioned by the NCS that is based on OBE/constructivist principles (refer sections 2.11.1 and 2.8). However, the training should go further and introduce educators to a broader theoretical foundation for integrating technology in learning in general. It should provide educators with a fundamental understanding of the theoretical foundation that considers the two learning theories of objectivism and constructivism to be complementary, meaning that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate and vice versa (refer section 2.11.3).

    - **The roles of technology in learning:** It is essential that educator training should provide them with an understanding of not only computers and their uses, but also of what the roles of technology in learning are. In this regard the training should include the following topics:

        - The three broad categories of technology uses in learning: learning *about* technology; learning *from* technology; and learning *with* technology (refer section 3.4)

        - The seven roles of technology in learning inferred from the theoretical foundation for integrating technology in learning: technology learning content; didactic tool; context tool; resource tool; cognitive tool; collaboration tool; and productivity tool (refer section 3.6)

- **Curriculum guidelines:** Educators also need to be trained in the curriculum guidelines of their subjects. This training should enable educators to have a fundamental understanding of and become competent in the following aspects:

  - The use of curriculum principles, learning outcomes, assessment standards, content and contexts indicated in the curriculum guideline documents to develop learning programmes for a subject

  - The definition, identification and classification of the ICT requirements of NCS subjects (refer section 5.3), as well as their implications (refer section 6.2)

  - The development of technology-integrated learning events by matching appropriate technology with learning needs, teaching and learning strategies and content in order to support, enhance, extend and amplify learners' abilities to achieve learning outcomes

- **Technology coordinator:** From the researcher's experience it is clear that in many cases schools' ICT infrastructures required to provide facilities for implementing the ICT requirements of NCS subjects, have become so comprehensive that it necessitates a full-time technology coordinator. The responsibilities of such a staff member should include the day to day running and management of the technology resources and providing educators with technical and professional support in integrating technology in teaching and learning.

- **External support:** The researcher is convinced that educators in schools will require external support for a long time because of the specialised nature of ICTs and the fact that using ICTs in teaching and learning is a relative new experience for most. Such support, that should include departmental support as its main component, has the function of providing educator training and support in using and integrating ICTs in teaching and learning, and providing financial support to acquire and maintain the necessary ICT infrastructure.

(d) Technology resources

Implementing the ICT requirements of the NCS obviously requires a technology infrastructure. Establishing such an infrastructure, however, is neither easy nor simple. Doing it not properly is a recipe for failure as Picciano (1998:10) warns: *"The major impediment to establishing successful computer-based applications in schools … is the lack of careful planning."* Several factors are involved in establishing technology infrastructures.

- **Technology needs:** Careful technology planning, which should be the responsibility of a technology management committee, is at the heart of successful technology integration in learning. Such planning begins with determining the needs that the technology infrastructure must satisfy. Technology needs are found in the ICT requirements of the subjects (refer sections 5.3.2 and 5.3.3) that a school offers. A particular problematic issue in determining technology needs is the access required by learners to ICT facilities. Different subjects have different access needs for their learners – some may need full-time yearlong access to dedicated ICT facilities (e.g. CAT, IT and Engineering Graphics and Design), some on a full-time block basis (e.g. probably Accounting and Geography), some regularly and some periodically. These access requirements will probably require dedicated ICT facilities for certain subjects and other cafeteria-style facilities with 'open' access for other subjects (such 'open' access in turn may have time table implications). Once the access needs are determined the computer network size, number of workstations and peripheral devices and application software can be specified. Only now can the planning of the technology infrastructure by the technology management committee properly begin.

- **Technology planning:** Physical planning of technology resources that will ensure optimal and equal access for teachers and learners in compliance with curriculum requirements is best undertaken in a phased approach. Following the advice of experts such as Crawford (1997), Roblyer, Edwards and Havriluk (1997:27-53) and Picciano (1998) proper technology planning for schools can be achieved in an approach with the following phases: develop a technology rationale; assess the current status; develop a technology vision; develop a technology policy; develop a technology action plan; implement the technology plan; and evaluate the technology plan.

- **Operating and maintaining the technology resources:** It is the researcher's interpretation that operating the technology resources refers to the technology coordinator's functions such as administration and running of the network(s) and other facilities, establishment of the rules of conduct for using the ICT facilities, and monitoring responsible use of the ICT facilities in accordance with the rules of conduct. Maintaining the resources refers in the first place to the maintenance and security of the equipment (i.e. hardware and software). But more importantly, it also refers to the protection of data and data integrity by ensuring that data backup, disaster recovery and virus protection procedures are in place. The school's technology coordinator should take overall responsibility for these functions.

This concludes the framework of understanding for implementing the ICT requirements of the NCS as a conceptual framework for the findings of this research.

6.4 SUMMARY

The first objective of this chapter was to identify and describe the implications that the findings of this research have for the NCS and its practice in schools. This was done by listing the findings that resulted from the investigations of the research questions in a table and describing its possible implications for the implementation of the NCS. The second objective was to formulate a framework of understanding for interpreting the implications of the findings of this research. It consists of two components: a framework for teacher knowledge of technology implementations in learning; and a model for managing school-wide technology implementations in learning.

CHAPTER 7: SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

"The future belongs to those who prepare for it" (Emerson in GQ Website).

7.1 INTRODUCTION

Research always has findings, and findings have implications. Some may be insignificant, some may give birth to a new theory, while others may improve the future. After the analogy of the words of Ralph Waldo Emerson above, the aim of this chapter is to highlight the findings of this research, discuss its significance, and identify what needs to done to harness its value and prepare for the future.

This study investigates the integration of ICTs in learning in grades 10 – 12 of South African schools. It originated from observations by leading educationists that while technology has changed the 21st century workplace and other dimensions of society fundamentally, it did not happen in education in spite of multiple efforts in the past. This raises the issue of requirements for technology integration in learning to succeed, and whether the National Curriculum Statement (NCS) as the national curriculum for grades 10 – 12 complies with it. Linked to this is the extent to which technology is integrated in the NCS and its subjects.

Against this background the research endeavours to answer the question: **What are the ICT requirements of the NCS, and its implications for schools?** The main purpose of the research is to identify, analyse, interpret and classify the ICT requirements of the NCS, and to synthesise the findings in a framework of understanding for implementing the ICT requirements in grades 10 – 12. This is done through researching and solving the following sub problems:

- Question 1: What is an appropriate theoretical foundation for integrating ICTs in learning?

- Question 2: What are the uses of ICTs in learning?

- Question 3: How can the ICT requirements of the NCS be identified and classified?

- Question 4: What are the ICT requirements of the NCS?

- Question 5: What are the implications of the ICT requirements of the NCS for implementation in schools?

- Question 6: Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?

The research is conducted in four phases:

Phase 1: A literature study of learning theories for the 21st century and technology uses in schools in order to answer questions 1 and 2 (refer Chapters 2 and 3).

Phase 2: A qualitative document analysis of the primary NCS documentation in order to answer questions 3 and 4 (refer Chapter 5).

Phase 3: Synthesising the findings of the research in a framework of understanding in order to answer questions 5 and 6 (refer Chapter 6).

Phase 4: Report writing.

In the respective chapters the findings relating to each of the research questions are clearly indicated and discussed in full in the context it is inferred from. In Chapter 6 the findings are synthesised in a conceptual framework that educators can use as a context for interpreting and implementing the implications of the ICT requirements. In other words, the findings are interpreted from an implementation point of view. In this chapter the findings are summarised and discussed from a research point of view.

7.2 SUMMARY OF FINDINGS

7.2.1 Findings relating to the research question: What is an appropriate theoretical foundation for integrating ICTs in learning?

After a comprehensive literature study of learning theories for the 21st century it is concluded that the integration of ICTs in learning should be based on the theoretical foundation that considers the two learning theories of objectivism and constructivism to be complementary. This means that each one provides views of different aspects of learning and that there are circumstances where one will be more appropriate than the other. For example, objectivist teaching and learning approaches are more appropriate for introductory knowledge acquisition where learners have very little directly transferable prior knowledge about a skill or content area in a linear, uni-dimensional and well-structured knowledge domain. Constructivist teaching and learning approaches, on the other hand, are more appropriate for advanced knowledge acquisition in complex, nonlinear, multi-dimensional and ill-structured knowledge domains that have become so characteristic of modern society. Due to the increasing need for advanced knowledge acquisition in modern society, constructivist approaches should be dominant in 21st century classroom teaching and learning. This theoretical foundation is elucidated with its basic assumptions in Finding 1, section 2.8.3.

The research also shows that the constructivist learning theory is the learning theory foundation of the NCS (refer section 2.8.1). It is, however, the inclusion of objectivism (behaviourism to be more specific) in the proposed learning foundation that may be questioned and contested by some, especially fundamentalist OBE protagonists. The research, however, has found that objectivist learning approaches when the learning content is linear, uni-dimensional and well-structured is appropriate and can be justified on sound principles.

It is obvious that educators involved at all levels of integrating technology in teaching and learning – from curriculum planners, technology leaders in schools, learning programme developers to educators implementing technology in the classroom – should have a fundamental understanding of the theoretical foundation for integrating technology in learning. This can be achieved through training and staff development interventions.

7.2.2 Findings relating to the research question: What are the uses of ICTs in learning?

Various typologies of technology uses in learning are considered in the research (refer section 3.5). In some typologies the technology uses are classified by application type, some by educational role and some by educational rationale. Technology uses in learning for the purpose of implementing the ICT requirements of the NCS have to conform to and comply with the theoretical foundation for integrating ICTs in learning proposed above. Using the theoretical foundation as a basis three broad areas of technology uses in learning that emphasise particular learning foci are identified and described as learning *about* technology, learning *from* technology and learning *with* technology. Following this one or more technology roles in learning are identified for each of the broad areas of technology uses in learning (refer Finding 2.1 in section 3.6) that are summarised in the following sections.

(a) Learning about technology

Technology role: technology learning content: This role of technology in learning simply means that the focus is on learners acquiring technology knowledge, skills and values. The technology itself is, therefore, the learning content and its mastery the learning objective. The role of technology learning content is neutral with regard to learning theories.

(b) Learning from technology

In this broad area of technology use in learning technologies are viewed as learning tools that teach learners based on the behaviourist model of learning. Learners learn *from* technology what the technology knows, just as they learn *from* the teacher what the teacher knows.

Technology role: didactic tool: This technology role refers to the use of technology in a didactic (teaching) situation to teach learners. It is based on the traditional behaviourist didactic model that works as follows: the technology transmits and presents some embedded learning content to the learner; the learner perceives the content and is required to respond; the technology evaluates the response and provides appropriate feedback; and determines what to present next based on the results of the evaluation.

(c) Learning with technology

This instructional focus on technology is based on a constructivist approach to learning that views technology as learning tool for extending and amplifying learners' capabilities to explore, experiment, construct, converse and reflect. Such a learning tool enables and facilitates critical thinking and higher-order learning during knowledge construction. The technologies are learning tools that learners learn *with* by using them as engagers and facilitators of thinking and knowledge construction.

Technology roles: The following are the roles of technology associated with learning *with* technology:

- **Context tool:** The use of technology in learning as a context tool is based on the assumptions that learning a new concept must be situated in the context from which that concept originates and in which it occurs naturally, and that the key to meaningful learning is a real-life authentic problem (or task) of which learners take ownership. The role of technology is to provide an environment or space in which such a problem is introduced, the context of the problem is described, and exploration of the problem and its context is effected.

- **Resource tool:** In the information-rich modern age it is essential to provide learners with technology tools for accessing information resources related to the problem being examined. To use resource tools effectively, learners must have the ability (skills) to find, query, evaluate, analyse, organise and use the information in such resources – typical constructivist learning activities.

- **Cognitive tool:** In this role technologies are used as cognitive reflection and amplification tools that support higher-order and critical thinking, and help learners to construct their own knowledge. As knowledge-construction tools they enhance, extend and amplify learners' cognitive powers during learning, by engaging them in cognitive operations while constructing knowledge that they would not otherwise have been capable of. A characteristic of the use of technology as a cognitive tool by learners is that it results in some or other 'cognitive product or construct' that can be in the form of a new understanding of a concept, an articulation of this new understanding, a representation of what has been learned, and a new/revised/extended personal knowledge structure.

- **Collaboration tool:** This technology use supports the constructivist learning activities of communication, conversation and collaboration among learners themselves and with external experts in discussing, arguing, negotiating and reaching consensus on the meaning of phenomena. It provides access to shared information and shared knowledge-building tools that aid the collaborative construction of socially shared knowledge.

- **Productivity tool:** Using technology in this role is to support learners in inauthentic labour that is incidental to authentic learning. In other words it enhances and extends learners' productive abilities, for example, to quickly and accurately process large volumes of experimental data using a spreadsheet.

Another significant finding that relates to the success of using technology in the roles identified above, is described and explained in Finding 2.2 in section 3.7. It stipulates that technology uses in learning can only succeed if it is imbedded in a technology-integrated curriculum. The latter is defined as a curriculum that supports, and in many cases, prescribes technology integration into teaching and learning. In other words the curriculum must prescribe and/or support the systematic use of technology appropriately matched and combined with teaching and learning strategies and curriculum content in order to enhance the achievement of curriculum-specified learning outcomes.

The theoretical foundation, roles of technology in learning and the requirement of a technology-integrated curriculum are interrelated and form the basis of successful implementation of technology in learning. Educators at all levels should have a fundamental understanding of this – from curriculum planners, technology leaders in schools, developers of teaching and learning support material, learning programme developers to educators implementing technology in the classroom.

7.2.3 Findings relating to the research question: How can the ICT requirements of the NCS be identified and classified?

This question is especially important from a research point of view, because identifying and classifying the ICT requirements of the NCS is the central focus and concern of this study. The answer to this question is investigated in Chapter 5 that reports the implementation and results of the study's qualitative research design. The following findings are made:

- Critical outcomes 4, 5 and 6 of the NCS are recognised and interpreted as the foundation and justification for including ICTs as learning tools and resources in the curriculum (refer Finding 3.1, section 5.2.1). The essence of these outcomes is that learners are required to be able to: *collect, analyse, organise and critically evaluate information; communicate effectively using visual, symbolic and/or language skills in various modes; and use science and technology effectively and critically showing responsibility towards the environment and the health of others.* This clearly shows that the NCS expects and supports technology uses in learning activities.

- An ICT requirement of the NCS is defined as any assessment standard in the subject statement of an NCS subject in which the use of ICT facilities in a learning activity is prescribed, implied or potentially beneficial (refer Finding 3.2, section 5.2.1). This definition is further explained by distinguishing the following four ICT requirements types (these are also used as the categories of the typology of requirement types for classification purposes – refer the next finding):

- Prescribed and compulsory ICT requirements – these are assessment standards that explicitly prescribe the compulsory use of ICT facilities in learning activities.

- Prescribed but optional ICT requirements – these are assessment standards that explicitly prescribe the optional use of ICT facilities in learning activities.

- Implied ICT requirements – these refer to assessment standards that comply with two criteria. Firstly, it should refer to learning activities that can clearly be supported and enhanced by the use of ICT facilities. Secondly, the subject's curriculum documentation contains supporting evidence that supports and encourages the use of technology in the learning activities indicated in the assessment standards in question.

- Potential ICT requirements – these are assessment standards that refer to learning activities that clearly have potential to be supported and enhanced by the use of ICT facilities, but no supporting evidence exists in the curriculum documentation of the relevant subjects.

- The ICT requirements of the NCS can be classified according to the **typology of requirement types** (refer Finding 3.4, section 5.2.2). Its categories consist of prescribed and compulsory ICT requirements, prescribed but optional ICT requirements, implied ICT requirements and potential ICT requirements. This is an inductive typology because its categories were derived through a process of inductive category development.

- The ICT requirements of the NCS can be classified according to the **typology of technology roles in learning** (refer Finding 3.3 in section 5.2.2). The seven categories of this typology are the same as the technology roles that were identified earlier as the uses of ICTs in learning. This typology is described as a deductive typology because its categories are theory derived and applied in a process described as deductive category application to classify the ICT requirements of the NCS.

- The ICT requirements of the NCS can be classified according to the **typology of application types** (refer Finding 3.5 in section 5.2.2). Application type in this context refers to the type of application package or software package that is used to perform a particular task on a computer. The typology's categories are: word processor; spreadsheet; database; presentation graphics; productivity suite (that includes the previous four application types); Web browser; e-mail; applications for other computer-managed communication forms; Internet suite (that includes the previous three application types); multimedia/hypermedia authoring application; subject-specific application; system software and utilities; not applicable/no software; all relevant application types for the subject; and database or multimedia application with subject-related information, excluding the Internet. This is also an inductive typology because its categories were derived through a process of inductive category development during the qualitative content analysis.

These three typologies are used to classify and record the identified ICT requirements of the NCS. An analysis of the recorded data is used to answer the question of what are the ICT requirements of the NCS.

7.2.4 Findings relating to the research question: What are the ICT requirements of the NCS?

A coding agenda is used to identify, classify and record the ICT requirements of the NCS. It includes: a definition of an ICT requirement; the database design for recording the ICT requirements; and definitions, coding rules and examples of the categories of the three typologies used to classify the ICT requirements. The main purpose of the coding agenda is to define a set of rules for performing a scientific process of document analysis that has the objective to yield consistent results in identifying, interpreting and classifying the ICT requirements, no matter who performs it (refer section 5.2.4 and Annexure A).

By applying the coding agenda in the document analysis process a total of 594 out of 1678 assessment standards are identified as ICT requirements. Further analysis of the ICT requirements in terms of the typologies reveals a number of findings that collectively describe the footprint of ICTs in the NCS. These are summarised and presented in the following sections.

(a) ICT requirements according to requirement types

The following is a summary of the findings that resulted from analysing the identified ICT requirements in terms of the categories of the typology of requirement types. The categories are: prescribed and compulsory ICT requirements; prescribed but optional ICT requirements; implied ICT requirements; and potential ICT requirements.

- Computer Applications Technology (CAT) and Information Technology (IT) are unique subjects in the sense that all their assessment standards are about and imply the use of ICTs in learning activities, making all of them prescribed and compulsory ICT requirements. This implies that CAT and IT are 100% technology integrated (refer Findings 4.1 and 4.7 in section 5.3.2(a)). Because of this it is logical to analyse the ICT requirements of all NCS subjects as one group and NCS subjects other than CAT and IT as another group.

- The distribution of ICT requirements according to grades is fairly even (refer Finding 4.2, section 5.3.2(a)).

- The distribution of ICT requirements according to requirement types is as follows (refer Finding 4.3, section 5.3.2(a)):

Category	All NCS subjects	NCS subjects other than CAT and IT
Prescribed and compulsory	33.7%*	10.9%
Prescribed but optional	13.3%	17.9%
Implied	32.8%*	44.1%**
Potential	20.2%	27.1%**

* Dominant categories for all NCS subjects (66.5% combined)

** Dominant categories for NCS subjects other than CAT and IT (71.2% combined)

- There is a substantial variance in the level of technology integration in the subjects of the NCS (refer Findings 4.4, 4.7, 4.8 and 4.9 in section 5.3.2(a)). Most subjects other than CAT and IT do not include any prescribed and compulsory or prescribed but optional ICT requirements in their assessment standards. This exposes the problem of inconsistent recognition and uneven prescription of the use of ICTs in learning activities by the different subjects. In an effort to understand this problem two values are calculated that measure the extent or level of technology integration in the NCS and its subjects. The first is the **integration ratio** that is calculated by expressing the total number of ICT requirements as a percentage of the total number of assessment standards. The integration ratio, however, has one shortcoming in that the four types of ICT requirements are each allocated the same weight of one. It can be argued that a prescribed and compulsory ICT requirement should certainly carry more weight than a potential ICT requirement for example. To overcome this problem an **integration index** is calculated in which the weights of 1, 0.75, 0.5 and 0.25 are allocated to prescribed and compulsory, prescribed but optional, implied and potential ICT requirements respectively. The calculated integration index values clearly show the differences and discrepancies in the level of technology integration in the various NCS subjects.

- The technology integration levels calculated for the NCS are presented below (refer Findings 4.5 and 4.6 in section 5.3.2(a)). Whether these values are on par/acceptable is a subject for further research.

	Integration ratio	Integration index
All NCS subjects	35.4%	23.0%
NCS subjects other than CAT and IT	29.0%	15.4%

It must be emphasised that these seemingly low levels of technology integration do not contradict the conclusion that the NCS qualifies as a technology-integrated curriculum (refer section 6.3.2(b)). A technology-integrated curriculum does not imply that technology should be used in teaching and learning all content of all subjects. It should be used only when the technology can make appropriate and meaningful contributions to the achievement of learning outcomes in ways that are not possible without the technology.

(b) ICT requirements according to technology roles in learning

The following is a summary of the findings that resulted from analysing the identified ICT requirements in terms of the categories of the typology of technology roles in learning. The categories of this typology are: technology learning content; didactic tool; context tool; resource tool; cognitive tool; collaboration tool; and productivity tool.

- The distribution of ICT requirements according to technology roles in learning is as follows (refer section 5.3.2(b)):

Category	All NCS subjects	NCS subjects other than CAT and IT
Technology learning content	21.3%	2.1%
Didactic tool	0%	0%
Context tool	0.4%	0.5%
Resource tool	19.9%	25.1%
Cognitive tool	53.4%	66.8%
Collaboration tool	1.6%	0.7%
Productivity tool.	3.5%	4.7%

- No ICT requirement of any NCS subject was classified in the didactic tool category (refer Finding 4.10 in section 5.3.2(b)). This category from the theory-derived deductive typology of technology roles in learning refers to technology uses that apply behaviourist learning principles to teach by transmitting knowledge embedded in computer programs to learners who assimilate it. The NCS, on the other hand, is based on constructivist learning principles. It is therefore no surprise that no ICT requirements were classified in the category of didactic tool. However, the use of ICT as a didactic tool in learning activities in the classroom is provided for in the proposed theoretical foundation for integrating ICTs if the learning content is linear, uni-dimensional and well structured.

- 94.6% of the ICT requirements of all NCS subjects are classified in only three technology role categories: technology learning content (21.3%), resource tool (19.9%) and cognitive tool (53.4%). CAT and IT account for most of the 21.3% of ICT requirements in the category of technology learning content. The 19.9% of ICT requirements in the resource tool category refers to using ICTs to access information on the Internet and other electronic resources. However, with more than half of all ICT requirements in category of cognitive tool, the main focus of the NCS is on using ICTs in cognitive activities that include constructing own knowledge. This emphasis confirms the OBE/constructivist foundation of the NCS (refer Finding 4.11 in section 5.3.2(b)).

- Only 5.5% of the ICT requirements are classified in the categories of context tool, collaboration tool and productivity tool (refer Finding 4.12 in section 5.3.2(b)). Although these technology roles in learning are specified in only a few assessment standards, they are still very relevant, meaningful and appropriate in actual learning activities in learning environments.

(c) ICT requirements according to application types

The following is a summary of the findings that resulted from analysing the identified ICT requirements in terms of the categories of the typology of application types. The categories of this typology are: word processor; spreadsheet;

database; presentation graphics; productivity suite (that includes the previous four application types); Web browser; e-mail; applications for other computer-managed communication forms; Internet suite (that includes the previous three application types); multimedia/hypermedia authoring application; subject-specific application; system software and utilities; not applicable/no software; all relevant application types for the subject; and database or multimedia application with subject-related information, excluding the Internet. However, the categories of word processor, spreadsheet, database and presentation graphics are grouped together with the category of productivity suite. The same applies to the categories of Web browser, e-mail and other computer-managed communication (cmc) forms that are grouped together with the category of Internet suite. This is done because these two groups of application packages are mostly provided as a unit in the form of a suite of programs to computer users.

- The distribution of ICT requirements according to application types is as follows (refer section 5.3.2(c)):

Category	**All NCS subjects**	**NCS subjects other than CAT and IT**
Productivity suite	42.0%	45.3%
Internet suite	20.4%	22.4%
Multimedia/hypermedia authoring	6.6%	6.6%
Subject-specific application	16.9%	17.4%
System software and utilities	2.1%	0.3%
Not applicable/no software	4.1%	0.3%
All relevant application types	1.2%	0%
Database/multimedia application with subject-related information, excluding the Internet.	6.6%	7.7%

- The group of application type categories of system software and utilities, not applicable/no software and all relevant application types for the subject is mostly applicable to CAT and IT only (refer Finding 4.13 in section 5.3.2(c)).

- Almost half (48.6%) of all ICT requirements require the group of application type categories of productivity suite and multimedia/hypermedia authoring that enable learners to create cognitive constructs (refer Finding 4.14 in section 5.3.2(c)). This finding again confirms the OBE/constructivist foundation of the NCS.

- More than a quarter (27,0%) of all ICT requirements specify the use of the group of application types that consists of the Internet suite and database and multimedia applications with subject-related information. These requirements require learners to access information and/or communicate with others outside the classroom (refer Finding 4.15 in section 5.3.2(c)).

- 16.9% of all ICT requirements require the use of unique subject-specific applications that are applied in specific professions, disciplines and sciences to provide specialised functions and facilities (refer Finding 4.16 in section 5.3.2(c)). The subjects and subject-specific applications involved are as follows:

Subject	**Subject-specific application**
Accounting:	Accounting package
Agricultural Management Practices:	Farm management system
Agricultural Technology:	Process control system
Civil Technology:	Computer-aided design package
Design:	Design-specific package
Engineering Graphics and Design:	Computer-aided design package
Geography	Geographical information system
Hospitality studies	Stock control system
	Point-of-sale system
Information Technology	Programming language
Mathematical Literacy	Specialised graphing software
Mathematics	Specialised graphing software
	Dynamic geometry software
Music	Music composition software
Visual Arts	Visual arts software

This concludes the discussion of the ICT requirements of the NCS according to requirement types, technology roles in learning and application types. An analysis of the ICT requirements of individual subjects is offered in section 5.3.3, but because it is not the main focus of this study it is not included in this summary of main findings.

7.2.5 Findings relating to the research question: What are the implications of the ICT requirements of the NCS for implementation in schools?

This question is answered by listing the findings related to each of the first four research questions in separate tables and discussing their implications for implementation (refer section 6.2). These can be summarised as follows:

- Implications regarding the theoretical foundation for integrating ICTs in learning and the roles of technology in learning (refer sections 6.2.1 and 6.2.2): Educators should firstly have a fundamental understanding of the theoretical foundation and roles of technology. Secondly, they should embed their teaching and learning strategies in this foundation when implementing the ICT requirements of the NCS.

- Implications regarding the identification and classification of ICT requirements (refer section 6.2.3): Educators should firstly have a fundamental understanding of the definition and categories of ICT requirements. Secondly, they should be able to apply this definition in order to recognise and identify ICT requirements in the assessment standards of their NCS subjects.

- Implications regarding the extent and nature of the ICT requirements in the NCS (refer section 6.2.4):

    - Curriculum developers should note the problem of inconsistent recognition and uneven prescription of the use of ICTs in learning activities by the different subjects of the NCS. One way of solving this problem is to develop a clear set of guidelines for integrating the use of ICTs in the learning activities of subjects.

- Curriculum developers can use the current integration levels as bench marks for future NCS reviews.

- The question of an effective technology integration indicator and an acceptable level of technology integration in a curriculum or subject is a meaningful subject for further research.

- Curriculum developers should review the learning outcomes and assessment standards of NCS subjects against the background of the above implications to ensure that the use of ICTs in learning activities is evenly and consistently prescribed in all NCS subjects with a predetermined level of technology integration.

- Educators should be appropriately trained and supported for meaningful implementation of ICT requirements in the learning activities of their subjects.

- An ICT infrastructure that meets the collective technology needs of all subjects in a school should be installed and maintained for every school.

- Based on their ICT requirements, different subjects have different access needs for their learners – some may need full-time yearlong access to dedicated ICT facilities, some on a full-time block basis, some regular and some periodically. Appropriate access for learners to ICT facilities that comply with the collective needs of all individual subjects in a school, should be organised by providing sufficient facilities and access time in school time tables.

7.2.6 Findings relating to the research question: Which theoretical and practical guidelines in a framework of understanding can be recommended for implementing the ICT requirements of the NCS in learning?

The objective with the framework of understanding is to synthesise the findings of the research in a conceptual framework that educators can use as a context for interpreting and implementing the implications of the ICT requirements with real understanding of the fundamental issues that are at stake. It is only in a conceptual framework that the interdependence of and relationships between all factors that determine the success of technology implementations in learning become clear. Some of the factors are investigated in this research, but many are not. It is important that educators realise there are other factors not examined in this research that also contribute to the success of technology implementation in learning. The following is a summary of the key focus areas of the proposed framework of understanding:

- **Technology leadership** with its four characteristics of understanding technology, having a vision, sharing the vision, and enacting the vision

- **Curriculum integration** that includes the requirement of a technology-integrated curriculum, the ICT requirements of the NCS, and the review of the NCS

- **Staff development** that addresses the issues of training of educators, technology coordinator, and external support

- **Technology resources** that includes the issues of technology needs, technology planning and operating and maintaining the technology resources

7.3 CONCLUSIONS

From the findings described above it is clear that ICTs have a substantial presence and footprint in the NCS. 594 of its 1678 assessment standards are classified as ICT requirements. This represents an integration ratio of 35.4%. However, its integration index, which is regarded as a better indicator of technology integration in the assessment standards, is only 23.0%. Whether this value is exceptional, average or below par is a question that still needs to be answered and a meaningful subject for further research.

Both the distribution of ICT requirements according to technology roles in learning and application types confirm the OBE/constructivist foundation of the NCS. However, there is a substantial variance in the level of technology integration in the subjects of the NCS. This exposes the problem of inconsistent recognition and uneven prescription of the use of ICTs in learning activities by the different subjects. The implication of this is that subjects with low technology integration levels do not harness the full potential and value of ICTs in teaching and learning, putting themselves at a disadvantage to subjects that do. This is an issue that needs to be addressed.

7.4 RECOMMENDATIONS

The recommendations are directed at curriculum developers, educator trainers, senior management at schools and educators in classrooms. These recommendations should not be regarded as an accidental supplement, but as the fundamental message of this research for improving the future of integrating technology in learning.

7.4.1 Recommendations to curriculum developers

It is recommended that the curriculum developers of the NCS:

- take cognisance of the proposed theoretical foundation for integrating technology in learning, the roles that technology can play in learning, the requirements for a curriculum to qualify as a technology-integrated curriculum, the classification of ICT requirements of the NCS as possible ways of how ICT requirements can be incorporated in the assessment standards of subjects, and the footprint of ICTs in the current NCS;

- initiate research to determine what represents a desired level of technology integration in a curriculum, and how it can be measured;

- develop a clear set of guidelines for prescribing and integrating the use of ICTs in the learning activities of subjects' assessment standards; and

- apply the guidelines for prescribing and integrating the use of ICTs in learning when reviewing the learning outcomes and assessment standards of NCS subjects in order to ensure that technology is integrated to the same level in all subjects.

7.4.2 Recommendations to educator trainers

It is recommended that educator trainers at higher education institutions include the following in their educator training programmes:

- A theoretical foundation for integrating technology in learning, and the roles that technology play in learning

- The identification and classification of ICT requirements in the assessment standards of NCS subjects, and the footprint of ICTs in the current NCS

- Teaching strategies for integrating technology in learning activities

7.4.3 Recommendations to senior management at schools

It is recommended that senior managers at schools:

- must have a fundamental understanding of the requirements of technology leadership, the theoretical foundation for integrating technology in learning, and the roles that technology play in learning;

- should be aware of the footprint of ICTs in the current NCS, and its implications for implementation; and

- plan, manage and review the implementation of the ICT requirements of the NCS.

7.4.4 Recommendations to educators in classrooms

It is recommended that educators in classrooms:

- must have a fundamental understanding of the theoretical foundation for integrating technology in learning, the roles that technology plays in learning, the identification and classification of ICT requirements in the assessment standards of their subjects, and the footprint of ICTs in the current NCS; and

- are able to apply theoretical insights and practical knowledge and skills in developing learning events that appropriately integrate technology in learning activities in order to achieve expected learning outcomes.

7.5 LIMITATIONS

This research concentrated on the ICT requirements of the NCS that is the national curriculum for grades 10 – 12. It did not include the Revised National Curriculum Statement Grades R – 9. There is obviously a very important link between the two curricula – the learning outcomes of the latter, including technology knowledge, skills and values, represent the input requirements of the former. In other words, the technology knowledge, skills and values of learners at the end of grade 9 that become the prerequisites for implementing the ICT requirements of the NCS were not investigated in this research. What it should be is an issue that needs carefully consideration and coordination.

7.6 SUMMARY

The purpose of this chapter was to summarise the main findings of this study from a research point of view, make recommendations for curriculum developers, teacher trainers, senior management at schools and educators in classrooms, drawing a final conclusion from the research, and present an important limitation.

Lastly, it is hoped that this research contributed to an understanding of some of the factors that are essential for the successful implementation and integration of technology in learning. This research focussed mainly on a theoretical foundation for integrating technology in learning, and the footprint of technology in the subjects of the NCS. While the focus was mostly on the classroom, there are many other factors outside the classroom, even up to national level, that are just as essential for harnessing the full power and potential of technology in order to prepare our learners for working and living in the 21st century.

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ANNEXURE A

CODING AGENDA FOR THE IDENTIFICATION AND CLASSIFICATION OF THE INFORMATION AND COMMUNICATION TECHNOLOGY REQUIREMENTS OF THE NATIONAL CURRICULUM STATEMENT

1. IDENTIFICATION OF ICT REQUIREMENTS

The information and communication technology (ICT) requirements of the National Curriculum Statement (Grades 10 – 12) (NCS) are found in the **assessment standards** of the individual subjects of the NCS (refer section 5.2.1 of Chapter 5).

ICT refers primarily to education-relevant technology tools (software packages) that enable users to do specific tasks, as well as the computer and peripheral hardware required to execute these computer programs. Individual computer and peripheral components such as electronic circuit boards are excluded from this definition.

Definition of an ICT requirement: An ICT requirement is defined as any **assessment standard** in the subject statement of an NCS subject in which the use of ICT facilities in a learning activity is prescribed, implied or potentially beneficial. When deciding whether an assessment standard qualifies as an ICT requirement all clarifying and supporting evidences from the rest of the relevant subject's curriculum documentation that may relate to this particular assessment standard must be taken into consideration. In order to further explain this definition four types of ICT requirements are distinguished:

- **Prescribed and compulsory ICT requirements:** An assessment standard is a **prescribed and compulsory ICT requirement** if it meets all of the following criteria:
  - The assessment standard and/or supporting evidence from the subject's curriculum documentation that relates directly to this assessment standard explicitly prescribes the <u>compulsory</u> use of ICT facilities in learning activities.
  - The assessment standard and/or its supporting evidence contain clear ICT-related terminology such as the following:

    Concepts of ICT: *computer, computer application, computer technology, database, digital, digital design, digital media, digital techniques, digital technology, e-mail, electronic communication, electronic communication skills, electronic media, hardware, hardware concepts, information and communications technology, information system, Internet, presentation graphics, slides, software, software concepts, Web site*

    Tools of ICT - general application packages: *database package, e-mail package, multimedia/ hypermedia authoring package, presentation graphics package, Web browser, word processor, spreadsheet package*

    Tools of ICT - subject-specific application packages: *accounting package, computer-aided design package, dynamic geometry software, geographical information system, programming language*

- **Prescribed but optional ICT requirements:** An assessment standard is a **prescribed but optional ICT requirement** if it meets all of the following criteria:

- The assessment standard and/or supporting evidence from the subject's curriclum documentation that relates directly to this assessment standard explicitly prescribes the optional use of ICT facilities in learning activities.
- The assessment standard and/or its supporting evidence contain clear ICT-related terminology such as the following:

  Concepts of ICT: *computer, computer application, computer technology, database, digital, digital design, digital media, digital techniques, digital technology, e-mail, electronic communication, electronic communication skills, electronic media, hardware, hardware concepts, information and communications technology, information system, Internet, presentation graphics, software, software concepts, Web site*

  Tools of ICT - general application packages: *database package, e-mail package, multimedia/ hypermedia authoring package, presentation graphics package, Web browser, word processor, spreadsheet package*

  Tools of ICT - subject-specific application packages: *accounting package, computer-aided design package, dynamic geometry software, geographical information system, programming language*

- **Implied ICT requirements:** An assessment standard is an **implied ICT requirement** if it meets all of the following criteria:
  - It does not explicitly prescribe the use of ICT facilities in learning activities.
  - It refers to learning activities that can clearly be supported and enhanced by the use of ICT facilities.
  - The subject's curriculum documentation contains general supporting evidence and encouragement that implies ICT facilities can be used in learning activities such as those indicated in this assessment standard.
  - The assessment standard typically contains phrases that show potential for ICT use such as the following:

    access/acquire/capture/collect/obtain/organise/record/process/store data/information; post to a journal; record data; communicate/compile/create/design/develop/plan/prepare/present a(n) account/action plan/assignment/budget/business plan/diagram/document/financial statement/ graphics presentation/ inventory/journal/ledger/marketing tool/menu/organogram/recipe/report/ research instrument/statement/table/trial balance; draw a curve/Gantt chart/graph/timeline; calculate price/interest/value

  In this case the particular uses of ICT facilities in learning activities are identified and proposed by the analyst. The ICT uses must be meaningful, substantial, appropriate and not trivial.

- **Potential ICT requirements:** An assessment standard is a **potential ICT requirement** if it meets all of the following criteria:
  - It does not explicitly prescribe the use of ICT facilities in learning activities, nor does supporting evidence exist that implies the use of ICT facilities in the learning activities indicated in the assessment standard.
  - It refers to learning activities that clearly has potential to be supported and enhanced by the use of ICT facilities.

- The assessment standard typically contains phrases that show potential for ICT use such as the following:

  access/acquire/capture/collect/obtain/organise/record/process/store data/information; post to a journal; record data; communicate/compile/create/design/develop/plan/prepare/present a(n) account/action plan/assignment/budget/business plan/diagram/document/financial statement/ graphics presentation/ inventory/journal/ledger/marketing tool/menu/organogram/recipe/report/ research instrument/statement/table/trial balance; draw a curve/Gantt chart/graph/timeline; calculate price/interest/value

In this case the particular uses of ICT facilities in learning activities are identified and proposed by the analyst. The ICT uses must be meaningful, substantial, appropriate and not trivial.

Refer various examples in Section 3, Field 8.

2. RECORDING OF ICT REQUIREMENTS

Every identified ICT requirement is recorded systematically as a database record consisting of 9 fields. Fields 1-6 represent the **identification details** of an ICT requirement.

Field 1: ID		**Field definition:** Database record number of the ICT requirement.	
Code	**Code definition**	**Coding rules**	**Examples**
N	Database record number	The records of the ICT requirements are automatically numbered consecutively from 1 by the database system.	N = 1, 2, 3, etc.

Field 2: Subject	**Field definition:** The NCS subjects to which the ICT requirements belong.
Code	**Code definition**
S01	Accounting
S02	Agricultural Management Practises
S03	Agricultural Sciences
S04	Agricultural Technology
S05	Business Studies
S06	Civil Technology
S07	Computer Applications Technology
S08	Consumer Studies
S09	Dance Studies
S10	Design
S11	Dramatic Arts
S12	Economics
S13	Electrical Technology
S14	Engineering Graphics & Design

S15	Geography
S16	History
S17	Hospitality Studies
S18	Information Technology
S19	Languages - First Additional Language
S20	Languages - Home Language
S21	Languages - Second Additional Language
S22	Life Orientation
S23	Life Sciences
S24	Mathematical Literacy
S25	Mathematics
S26	Mechanical Technology
S27	Music
S28	Physical Science
S29	Religion Studies
S30	Tourism
S31	Visual Arts

Field 3: Reference		**Field definition:** Bibliographical reference of where the ICT requirement can be found.	
Code	**Code definition**	**Coding rules**	**Examples**
DOE yyyyxx:pp	Bibliographical reference of where the ICT requirement can be found	Use the same reference method as in the Bibliography, except substitute DOE for Department of Education.	DOE2003k:18 This example refers to the Geography subject statement, page 18.

Field 4: AS number		**Field definition:** Number of the assessment standard that is identified as an ICT requirement.	
Code	**Code definition**	**Coding rules**	**Examples**
aa.bb.cc	Number of the assessment standard	aa = grade (i.e. 10, 11 or 12) bb = learning outcome number cc = assessment standard numbered according to horisontal level	10.1.4 This example refers to grade 10, learning outcome 1 and assessment standard 4.

Field 5: ICT requirement		**Field definition:** An ICT requirement is defined as any **assessment standard** in the subject statement of an NCS subject in which the use of ICT facilities in a learning activity is prescribed, implied or potentially beneficial.	
Code	**Code definition**	**Coding rules**	**Examples**
Passage of text – no actual codes	Same as field definition	*1.* Refer section 1 above for a description of the process of identifying ICT requirements. *2.* Always consider all clarifying and supporting evidences from the subject's curriculum documentation when deciding whether a particular assessment standard is an ICT requirement.	Agricultural Management Practices assessment standard 10.4.4. *"Apply and use basic information technology skills to enhance production enterprises."*

Field 6: Notes		**Field definition:** Notes that include supporting evidence from a subject's curriculum documentation that confirms and supports an assessment standard to qualify as an ICT requirement, as wel as any interpretations regarding the identification and classification of the ICT requirement made by the analyst.	
Code	**Code definition**	**Coding rules**	**Examples**
Descrip-tive notes – no actual codes	Same as field definition	Notes should include: 1. An indication of the type of supporting evidence (DSE = direct supporting evidence, GSE = general supporting evidence, NSE = no supporting evidence) 2. Reference(s) of the supporting evidence 3. Description/summary of the supporting evidence 4. Interpretations (IP) made in identifying and classifying the ICT requirement	Accounting assessment standard number 11.1.7 *"Perform elementary VAT calculations"*. **Notes** NSE IP: that a spreadsheet can be used beneficially to support and enhance the learning activity of calculating VAT required by this AS.

3. CLASSIFICATION OF ICT REQUIREMENTS

All ICT requirements are classified according to the categories of one deductive typology and two inductive typologies. These **classification details** are recorded in fields 7-9 of the database records. Examples of ICT requirements classified in all of the categories are provided with the supporting evidence and interpretations recorded in the "Notes" field.

Field 7: Deductive typology: Technology role		**Field definition:** Technology role refers to the role that ICT plays in learning. This typology has seven categories: **technology learning content**; **didactic tool**; **context tool**; **resource tool**; **cognitive tool**; **collaboration tool**; and **productivity tool**. An ICT requirement may have a broad scope that allows for more than one clear technology role. This means that it could be classified in more than one category.	
Code	**Code definition**	**Coding rules**	**Examples**
TR1	Technology learning content	1. Use this code for ICT requirements in which the technology itself is the learning content, i.e. learners are primarily required to acquire knowledge, skills and values about ICTs. 2. ICT requirements from the subjects Computer Applications Technology and Information Technology all fall into this category.	Computer Applications Technology assessment standard 10.1.2 "*Install, configure and use input and output devices."* **Notes** DSE: Refer MOTIVATION FOR ALL COMPUTER APPLICATIONS TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: that device driver software (as part of utilities) is a prescribed and compulsory tool that can be used for the learning activities of installing, configuring and using devices required by this AS.
TR2	Didactic tool	Use this code for ICT requirements that refer to a technology use that apply behaviourist learning principles to teach by transmitting knowledge embedded in computer programs to learners who assimilate it.	(This category of technology uses in learning refers to traditional behaviourist computer-assisted learning programs in modes such as tutorials, drill and practice and educational games. No such cases were found in the NCS documentation for all 31 subjects.)
TR3	Context tool	Use this code for ICT requirements that refer to the use of technology for providing an environment or space that: describes the context of a problem; presents and/or simulates the problem; and allows manipulation and exploration of and interaction with the problem.	Physical Science assessment standard 10.2.3 *"Apply scientific knowledge in familiar, simple contexts".* **Notes** GSE: The subject has six knowledge/main content areas, including "Electricity and magnetism" (DOE2003w:11). These are applicable to all three Los (DOE2003w:34). It also puts a special emphasis on the use of relevant contexts in teaching the main content areas (DOE2003w:34).

			DOE2003w:50 as part of LO3 identifies "information technologies" and "digital (e-) communications" as possible contexts for teaching "electricity and magnetism". However, this SE is linked to this AS of LO2 because it refers specifically to contexts, and because the main content areas and the use of contexts in teaching it apply to all LOs. IP: that a Web browser and multimedia packages with relevant information can be used beneficially to support and enhance the learning activity of accessing contextual information as anchor/background for scientific applications required by this AS.
TR4	Resource tool	Use this code for ICT requirements that refer to the use of technology for getting access to resources that provide information related to the learning problem/task/topic.	Geography assessment standard 10.1.2 *"Acquire information from fieldwork and a variety of other sources".* **Notes** NSE IP: that spreadsheet and database packages can be used beneficially to support and enhance the learning activity of systematically recording of information (DOE2003k:10) required by this AS.
TR5	Cognitive tool	Use this code for ICT requirements that refer to technology uses that enhance, extend and amplify learners' cognitive powers and abilities during own knowledge construction by engaging them in cognitive operations that they would not otherwise have been capable of. Such learning activities result in a 'cognitive product' such as a new understanding of a concept, an articulation of this new understanding, a presentation of what has been learned, and a new, revised or extended personal knowledge structure.	Accounting assessment standard 11.1.2 *"Within the accounting cycle, record the unique information of a partnership and a club".* **Notes** DSE: DOE2008a:29 confirm the prescribed but optional use of an accounting package as part of the CASS component only. IP: that an accounting package is a prescribed but optional tool that can be used for the learning activity of recording the unique information required by this AS.
TR6	Collaboration tool	Use this code for ICT require-ments that refer to the use of technology for facilitating knowledge construction by:	Computer Applications Technology assessment standard 10.2.8 *"Demonstrate understanding of a variety of communication modes and tools".*

		enabling communication and collaboration with others; supporting discourse among members of learning communities; and facilitating consensus building among such members.	**Notes** DSE: Refer MOTIVATION FOR ALL COMPUTER APPLICATIONS TECH-NOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: that Web browser, e-mail and other cmc communication packages are prescribed and compulsory tools that can be used for the learning activities of communicating required by this AS.
TR7	Productivity tool	Use this code for ICT requirements that refer to the use of technology to provide productivity support in inauthentic labour that is incidental to authentic learning.	Life Sciences assessment standard 12.1.2.2 *"Manipulate data in the investigation to reveal patterns."* **Notes** Refer NOTE ON ASSESSMENT STANDARD NUMBERING CONVENTION in Outcome 11.1.1.2, record ID 422. DSE: DOE2008u:38 indicates computer software and Internet programs as optional resources for this AS. IP: that a spreadsheet package is a prescri-bed but optional tool for the learning activity of manipulating data required by this AS.

Field 8: Inductive typology 1: Requirement type		**Field definition:** Requirement type refers to types of ICT requirements distinguished according to authority levels. This typology has four categories: **prescribed and compulsory ICT requirements**; **prescribed but optional ICT requirements**; **implied ICT requirements;** and **potential ICT requirements**. An ICT requirement should be classified in only one of them.	
Code	**Code definition**	**Coding rules**	**Examples**
RT1	Prescribed and compulsory ICT requirement	Use this category for ICT requirements that comply with the description of prescribed and compulsory ICT requirements given in section 1.	Computer Applications Technology assessment standard 10.2.2 *"Enter, edit and format text, numerical data and graphics using basic techniques in a word processing programme."* **Notes** DSE: Refer MOTIVATION FOR ALL COM-PUTER APPLICATIONS TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: word processor is indicated.

RT2	Prescribed but optional ICT requirement	Use this category for ICT requirements that comply with the description of prescribed but optional ICT requirements given in section 1.	Accounting assessment standard 11.1.2 *"Within the accounting cycle, record the unique information of a partnership and a club".* **Notes** DSE: DOE2008a:29 confirm the prescribed but optional use of an accounting package as part of the CASS component only. IP: that an accounting package is a prescribed but optional tool that can be used for the learning activity of recording the unique information required by this AS.
RT3	Implied ICT requirement	Use this category for ICT requirements that comply with the description of implied ICT requirements given in section 1.	Economics assessment standard 10.2.1 *"Explain the market as a phenomenon and make use of graphs to illustrate the establishment of prices and quantities".* **Notes** GSE: DOE2008l:17 confirms in general that computers can be used while working in the classroom, doing homework or conducting research. IP: that a spreadsheet package can be used beneficially to support and enhance the learning activity of drawing graphs to illustrate the establishment of prices and quantities required by this AS.
RT4	Potential ICT requirement	Use this category for ICT requirements that comply with the description of potential ICT requirements given in section 1.	Accounting assessment standard 11.1.7 *"Perform elementary VAT calculations."* **Notes** NSE IP: that a spreadsheet can be used beneficially to support and enhance the learning activity of calculating VAT required by this AS.

Field 9: Inductive typology 2: Application type	**Field definition:** Application type refers to the type of software package (technology tool) that enables a user to create a product (e.g. document, spreadsheet, graph, presentation slide, report, diagram, multimedia production, computer program, etc.) or perform an action (e.g. do calculations, record a transaction, send and receive a message, publish and retrieve information, download a file, etc.). This typology has 16 categories. More than one application type can be indicated for an ICT requirement.

Code	Code definition	Coding rules	Examples
AT1	Word processor	Use this category for ICT requirements in which the use of a word processor is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a word processor.	Business Studies assessment standard 10.2.1 *"Design and use a research instrument to assess the needs and wants in an identified environment".* **Notes** NSE IP: that a word processor or spreadsheet can be used beneficially to support and enhance the learning activities of designing a research instrument such as a questionnaire (DOE2003d:26) required by this AS.
AT2	Spreadsheet	Use this category for ICT requirements in which the use of a spreadsheet is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a spreadsheet.	Business Studies assessment standard 10.2.1 *"Design and use a research instrument to assess the needs and wants in an identified environment".* **Notes** NSE IP: that a word processor or spreadsheet can be used beneficially to support and enhance the learning activities of designing a research instrument such as a questionnaire (DOE2003d:26) required by this AS.
AT3	Database	Use this category for ICT requirements in which the use of a data base is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a data base.	Computer Applications Technology assessment standard 11.2.4 *"Create a single table data source and generate simple forms, queries and reports using a database programme".* **Notes** DSE: Refer MOTIVATION FOR ALL COMPUTER APPLICATIONS TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: a database is indicated.

AT4	Presentation graphics	Use this category for ICT requirements in which the use of a presentation graphics package is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a presentation graphics package.	Dance Studies assessment standard 10.1.4 *"Demonstrate an ability to design materials to promote a dance performance."* **Notes** NSE IP: that a word processor and/or presentation graphics package can be used beneficially to support and enhance the learning activity of designing posters and flyers for dance performances (DOE2003g:24 & DOE2008i:18) required by this AS.
AT5	Productivity suite that includes AT1, AT2, AT3 and AT4	Use this category for ICT requirements in which the use of more than two packages of the productivity suite is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of more than two packages of the productivity suite.	Computer Applications Technology assessment standard 10.3.3 *"Present and communicate information in electronic formats".* **Notes** DSE: Refer MOTIVATION FOR ALL COM-PUTER APPLICATIONS TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: DOE2008g:40 confirms word processing, spreadsheet, database and presentations graphics packages are prescribed and compulsory tools that can be used for the learning activities of presenting and commu-nicating information required by this AS.
AT6	Web browser (navigator)	Use this category for ICT requirements in which the use of a Web browser is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a Web browser.	Agricultural Sciences assessment standard 10.1.2 *"Collect, organise, process and evaluate this collected information in order to solve problems through responsible decision-making using effective communication".* **Notes** GSE : DOE2008af:13 confirms the Internet as a possible resource, while DOE2008c:11,13,26-28 indicates that learners should be able to: observe, access, process and record data accurately; communicate through verbal, non-verbal and symbolic language forms; and do presentations. IP: that Web browser, word processor, spreadsheet, database and presentation

			packages can be used beneficially to support and enhance the learning activities of observing, accessing, processing, recording and presenting information required by this AS.
AT7	E-mail application	Use this category for ICT requirements in which the use of an e-mail package is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of an e-mail package.	Information Technology assessment standard 10.2.2 *"Make efficient use of e-mail (including attachments, digital signatures, address books) as a means of communication".* **Notes** DSE: Refer MOTIVATION FOR ALL INFORMATION TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 229. IP: that an e-mail package is a prescribed and compulsory tool that can be used for the learning activities of using e-mail required by this AS.
AT8	Applications for other computer-managed communication forms	Use this category for ICT requirements in which the use of packages for other computer-managed communication forms such as online chat, discussion forum/board and mailing list/user group is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of such packages.	Information Technology assessment standard 11.2.3 *"Find additional information about a problem with some software by posting to a discussion board or user group".* **Notes** DSE: Refer MOTIVATION FOR ALL INFORMATION TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 229. IP: that a cmc package is a prescribed and compulsory tool that can be used for the learning activities required by this AS.
AT9	Internet suite that includes AT6, AT7 and AT8	Use this category for ICT requirements in which the use of more than two packages of the Internet suite is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of more than two packages of the Internet suite.	Information Technology assessment standard 12.3.10 *"Comment critically on the social, political, economic and other consequences of search engines and group communications".* **Notes** DSE: Refer MOTIVATION FOR ALL INFORMATION TECHNOLOGY ASSESSMENT STANDARDS TO BE

			CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 229. IP: that Web browser and cmc packages are prescribed and compulsory tools that can be used for the learning activity of using search engines and group communication required by this AS.
AT10	Multimedia/ hypermedia authoring application	Use this category for ICT requirements in which the use of a multimedia/hypermedia authoring package is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a multimedia/ hypermedia authoring package to create Web pages or multimedia programs.	Computer Applications Technology assessment standard 11.3.2 *"Organise, record and summarise information in appropriate electronic formats".* **Notes** DSE: Refer MOTIVATION FOR ALL COMPUTER APPLICATIONS TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: SE DOE2008g:40 confirms the use of word processing, spreadsheet, database and Web authoring packages as prescribed and compulsory tools that can be used for the learning activities of extracting and recording information required by this AS.
AT11	Subject-specific application	Use this category for ICT requirements in which the use of a subject-specific application is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of a subject-specific application (e.g. accounting package, computer-aided design package, geographical information system, programming language).	Accounting assessment standard 10.1.2 *"Within the context of the accounting cycle, identify and complete source documents, record the information in the subsidiary journals (books of first entry), post to the ledgers and draw up the trial balance of a sole trader manually and/or by using an accounting package".* **Notes** DSE: DOE2008a:29 and DOE2008ad:11,19&21 confirm the prescribed but optional use of an accounting package or spreadsheet as part of the CASS component only. IP: that accounting and spreadsheet packages are prescribed but optional tools that can be used for the learning activities required by this AS.

AT13	System software and utilities	Use this category for ICT requirements in which the use of system software (e.g. operating system) or utilities (e.g. anti-virus software) is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of system software (e.g. operating system) or utilities (e.g. anti-virus software).	Information Technology assessment standard 10.1.11 *"Identify the functions of various types of operating system".* **Notes** DSE: Refer MOTIVATION FOR ALL INFORMATION TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 229. IP: that operating systems (e.g. Windows) are prescribed and compulsory tools that can be used for the learning activities required by this AS.
AT14	Not applicable/ no software	Use this category for ICT requirements in which no software/computer programs are involved.	Information Technology assessment standard 10.1.17 *"State and discuss the implications of the latest computer technologies".* **Notes** DSE: Refer MOTIVATION FOR ALL INFORMATION TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 229. IP: that no software is involved.
AT15	All relevant application types for the subject	Use this category for ICT requirements that refer to all the relevant application types for a subject.	Information Technology assessment standard 10.1.13 *"Distinguish between different types of files by their extensions or applications types".* **Notes** DSE: Refer MOTIVATION FOR ALL INFORMATION TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 229. IP: that all software used in IT are prescribed and compulsory tools that can be used for the learning activities required by this AS.

AT16	Database or multimedia application with subject-related information, excluding the Internet.	Use this category for ICT requirements in which the use of a database or electronic multimedia resource with subject-related information (e.g. electronic reference works, library catalogues, electronic encyclopedia) is prescribed or that refers to learning activities that can clearly be supported and enhanced by the use of such a package.	Computer Applications Technology assessment standard 10.3.1 *“Use technologies to locate and collect specific data using relevant methods”.* **Notes** DSE: Refer MOTIVATION FOR ALL COMPUTER APPLICATIONS TECHNOLOGY ASSESSMENT STANDARDS TO BE CONSIDERED AS PRESCRIBED AND COMPULSORY ICT REQUIREMENTS in outcome 10.1.1, record ID 61. IP: DOE2008g:39 confirms the use of a Web browser or electronic reference work as prescribed and compulsory tools that can be used for the learning activities of finding information required by this AS.

COMPLETE RECORDS OF THE ICT REQUIREMENTS OF THE SUBJECT GEOGRAPHY

A total of 594 ICT requirements were identified in the assessment standards of the 31 subjects of the NCS, and recorded using the database design explained in section 5.2.4 of Chapter 5. The complete records of the ICT requirements of the subject Geography are displayed below as an example. The database report of all subjects' ICT requirements covers 128 pages in small print, and is considered too comprehensive to be included in the research report (refer Annexure C for a scaled-down version of the full report).

AS number = Assessment Standard number

ID = Identification number (record number)

TR = Technology Role

RT = Requirement Type

AT = Application Type

AS number	ID	Reference	Requirement	Notes	TR	RT	AT
10.1.2	197	DOE2003k:18	Acquire information from fieldwork and a variety of other sources.	NSE IP: that spreadsheet and database packages can be used beneficially to support and enhance the learning activity of systematically recording of information (DOE2003k:10) required by this AS.	TR7	RT4	AT2,AT3
10.1.3	200	DOE2003k:18	Organise information graphically, pictorially and diagrammatically.	NSE IP: that a word processor and spreadsheet can be used beneficially to support and enhance the learning activity of organising information in visual or graphical froms such as graphs, diagrams and tables (DOE2003k:10) required by this AS.	TR5	RT4	AT1,AT2
10.1.4	203	DOE2003k:18	Analyse information obtained from a variety of sources.	DSE: DOE2003k:26&34, DOE2008o:37 and DOE2008ar:21 confirm that the GIS is part of Grade 10 content. DOE2003k:10 confirms that the use of a database and GIS is included in this AS for synthesing information into meaningful interpretations. It also confirms the use of statistical methods to analyse information in this AS. IP: that spreadsheet, database and GIS packages are prescribed and compulsory tools that can be used for the learning activities of accessing and analysing information required by this AS.	TR5	RT1	AT2,AT3,AT11
10.1.5	206	DOE2003k:18	Report findings in oral and/or written form.	NSE IP: that word processor and presentation graphics packages can be used beneficially to support and enhance the learning activity of reporting findings required by this AS.	TR5	RT4	AT1,AT4

11.1.1	195	DOE2003k:19	Plan and structure a project or enquiry process.	NSE IP: that word processor and/or spreadsheet packages can be used beneficially to support and enhance the learning activity of planning a project required by this AS.	TR5	RT4	AT1,AT2
11.1.2	198	DOE2003k:19	Acquire a variety of information from relevant primary and secondary sources which include fieldwork.	NSE IP: that spreadsheet and database packages can be used beneficially to support and enhance the learning activity of systematically recording of information (DOE2003k:10) required by this AS.	TR7	RT4	AT2,AT3
11.1.3	201	DOE2003k:19	Classify the acquired information according to different categories.	NSE IP: that a word processor and spreadsheet can be used beneficially to support and enhance the learning activity of classifying information in visual or graphical froms such as graphs, diagrams and tables (DOE2003k:10) required by this AS.	TR5	RT4	AT1,AT2
11.1.4	204	DOE2003k:19	Analyse information obtained from a variety of sources - including fieldwork data, 1:50 000 topographical maps, orthophoto maps and statistics.	DSE: DOE2003k:28&35, DOE2008o:41 and DOE2008ar:21-22 confirm that the GIS is part of Grade 11 content. DOE2003k:10 confirms that the use of a database and GIS is included in this AS for synthesing information into meaningful interpretations. It also confirms the use of statistical methods to analyse information in this AS. IP: that spreadsheet, database and GIS packages are prescribed and compulsory tools that can be used for the learning activities of accessing and analysing information required by this AS.	TR5	RT1	AT2,AT3,AT11
11.1.5	207	DOE2003k:19	Report findings in written, oral and/or illustrative form.	NSE IP: that word processor and presentation graphics packages can be used beneficially to support and enhance the learning activity of reporting findings required by this AS.	TR5	RT4	AT1,AT4
12.1.1	196	DOE2003k:19	Plan a geographical research project of limited extend in a familiar context.	NSE IP: that word processor and/or spreadsheet packages can be used beneficially to support and enhance the learning activity of planning a research project required by this AS.	TR5	RT4	AT1,AT2
12.1.2	199	DOE2003k:19	Integrate information from a variety of sources.	NSE IP: (1) that integrating information implies acquiring information first, including the systematic recording of information, and (2) that spreadsheet and database packages can be used beneficially to support and enhance the learning activity of systematically recording of information (DOE2003k:10) required by this AS.	TR7	RT4	AT2,AT3

12.1.3	202	DOE2003k:19	Compare and contrast information from a variety of sources.	NSE IP: (1) comparing and contrasting information imply classifying it in visual or graphical froms such as graphs, diagrams and tables, and (2) that a word processor and spreadsheet can be used beneficially to support and enhance the learning activity of classifying information in visual or graphical froms such as graphs, diagrams and tables (DOE2003k:10) required by this AS.	TR5	RT4	AT1,AT2
12.1.4	205	DOE2003k:19	Analyse the acquired information in order to answer the initial question.	DSE: DOE2003k:30&35 and DOE2008ar:21-22 confirm that the GIS is part of Grade 12 content. DOE2003k:10 confirms that the use of a database and GIS is included in this AS for synthesing information into meaningful interpretations. It also confirms the use of statistical methods to analyse information in this AS. IP: that spreadsheet, database and GIS packages are prescribed and compulsory tools that can be used for the learning activities of accessing and analysing information required by this AS.	TR5	RT1	AT2,AT3,AT11
12.1.5	208	DOE2003k:19	Substantiate findings in written, oral and/or illustrative form.	NSE IP: that word processor and presentation graphics packages can be used beneficially to support and enhance the learning activity of substantiating findings required by this AS.	TR5	RT4	AT1,AT4

ANNEXURE C

SUMMARY OF ALL INFORMATION AND COMMUNICATION REQUIREMENTS OF THE NATIONAL CURRICULUM STATEMENT

A total of 594 ICT requirements were identified, classified and reliability checked for the 31 subjects of the NCS, and recorded in a database (refer sections 5.2.4 and 5.2.6 of Chapter 5). The database report of all these ICT requirements in full record layout covers 128 pages in small print, and is considered too comprehensive to be included in the research report. Instead, a scaled-down version of the report that includes only the essential record fields of subject code, assessment standard number, record number, bibliographical reference and classification codes for the three relevant typologies is presented below.

Subj = Subject

AS = Assessment Standard number

ID = Identification number (record number)

TR = Technology Role

RT = Requirement Type

AT = Application Type

Subj	AS	ID	Reference	TR	RT	AT
S01	10.1.2	4	DOE2003b:12	TR5	RT2	AT2,AT11
	10.1.5	5	DOE2003b:12	TR5	RT4	AT2,AT11
	10.3.2	15	DOE2003b:16	TR5	RT2	AT2
	10.3.4	16	DOE2003b:16	TR5	RT2	AT2, AT11
	11.1.2	6	DOE2003b:13	TR5	RT2	AT11
	11.1.4	7	DOE2003b:13	TR5	RT4	AT2,AT11
	11.1.5	8	DOE2003b:13	TR5	RT4	AT2,AT11
	11.1.7	12	DOE2003b:13	TR5	RT4	AT2
	11.2.3	13	DOE2003b:15	TR5	RT2	AT2
	11.3.3	17	DOE2003b:17	TR5	RT2	AT11
	11.3.4	18	DOE2003b:17	TR5	RT2	AT11
	12.1.2	9	DOE2003b:13	TR5	RT2	AT11
	12.1.3	10	DOE2003b:13	TR5	RT2	AT11
	12.1.5	11	DOE2003b:13	TR5	RT4	AT2,AT11
	12.2.2	14	DOE2003b:15	TR5	RT4	AT2
	12.3.3	19	DOE2003b:17	TR5	RT2	AT11
	12.3.4	20	DOE2003b:17	TR5	RT4	AT2
S02	10.2.1	27	DOE2005a:16	TR5	RT1	AT2,AT3,AT6
	10.4.1	30	DOE2005a:20	TR4,TR5	RT4	AT3,AT6
	10.4.4	31	DOE2005a:20	TR4,TR5	RT1	AT2,AT3,AT6,AT11
	11.2.1	28	DOE2005a:17	TR5	RT1	AT2,AT3,AT6
	11.4.1	32	DOE2005a:21	TR4,TR5	RT4	AT3,AT6
	11.4.4	33	DOE2005a:21	TR4,TR5	RT1	AT2,AT3,AT6,AT11
	12.2.1	29	DOE2005a:17	TR5	RT1	AT2,AT3,AT6
	12.4.1	34	DOE2005a:21	TR4,TR5	RT4	AT3,AT6
	12.4.4	35	DOE2005a:21	TR4,TR5	RT1	AT2,AT3,AT6,AT11
S03	10.1.2	36	DOE2003c:16	TR4,TR5	RT3	AT5,AT6
	11.1.2	37	DOE2003c:17	TR4,TR5	RT3	AT5,AT6
	11.1.4	38	DOE2003c:17	TR4,TR5	RT1	AT5,AT9

Subj	AS	ID	Reference	TR	RT	AT
S03	12.1.2	39	Doe2003c:17	TR4,TR5	RT3	AT5,AT6
	12.2.10	565	DOE2003c:21	TR5	RT4	AT1,AT2
S04	10.2.5	40	DOE2005b:16	TR5	RT4	AT5
	10.3.7	43	DOE2005b:20	TR1	RT1	AT9
	10.4.7	46	DOE2005b:24	TR4,TR6	RT1	AT9
	10.4.9	566	DOE2005b:24	TR5,TR7	RT4	AT2
	11.2.5	41	DOE2005b:17	TR5	RT4	AT5
	11.3.7	44	DOE2005b:21	TR1	RT1	AT11
	11.4.7	47	DOE2005b:25	TR7	RT1	AT11
	11.4.9	567	DOE2005b:25	TR5,TR7	RT4	AT2
	12.2.5	42	DOE2005b:17	TR5	RT4	AT5
	12.3.7	45	DOE2005b:21	TR1	RT1	AT11
	12.4.7	48	DOE2005b:25	TR7	RT1	AT11
	12.4.9	568	DOE2005b:25	TR5,TR7	RT4	AT2
S05	10.2.1	21	DOE2003d:14	TR5	RT4	AT1,AT2
	10.2.3	22	DOE2003d:14	TR5	RT4	AT1
	10.2.6	23	DOE2003d:14	TR5	RT4	AT5
	11.2.3	24	DOE2003d:15	TR5	RT4	AT1, AT2
	11.2.6	25	DOE2003d:15	TR5	RT4	AT5
	11.3.7	639	DOE2003d:19	TR4,TR5	RT4	AT1,AT4,AT6
	12.2.6	26	DOE2003d:15	TR5	RT4	AT5
S06	10.2.5	49	DOE2005c:18	TR5	RT2	AT5
	10.3.4	52	DOE2005c:20	TR1	RT1	AT11
	10.4.4	55	DOE2005c:24	TR5	RT1	AT11
	10.4.9	58	DOE2005c:26	TR5	RT4	AT2
	11.2.5	50	DOE2005c:19	TR5	RT2	AT5
	11.3.4	53	DOE2005c:21	TR1	RT1	AT11
	11.4.4	56	DOE2005c:25	TR5	RT1	AT11
	11.4.9	59	DOE2005c:27	TR5	RT4	AT2
	12.2.5	51	DOE2005c:19	TR5	RT2	AT5
	12.3.4	54	DOE2005c:21	TR1	RT1	AT4,AT11
	12.4.4	57	DOE2005c:25	TR5	RT1	AT4,AT11
	12.4.9	60	DOE2005c:27	TR5	RT4	AT2
S07	10.1.1	61	DOE2003e:14	TR1	RT1	AT15
	10.1.2	62	DOE2003e:14	TR1	RT1	AT13
	10.1.3	63	DOE2003e:14	TR1	RT1	AT13
	10.1.4	64	DOE2003e:14	TR1	RT1	AT14
	10.1.5	65	DOE2003e:14	TR1	RT1	AT14
	10.2.1	76	DOE2003e:16	TR1	RT1	AT1,AT2
	10.2.2	77	DOE2003e:16	TR1	RT1	AT1
	10.2.3	78	DOE2003e:16	TR1	RT1	AT2
	10.2.6	79	DOE2003e:16	TR1	RT1	AT1,AT2
	10.2.7	80	DOE2003e:16	TR1	RT1	AT1,AT2
	10.2.8	81	DOE2003e:16	TR1,TR6	RT1	AT9
	10.3.1	99	DOE2003e:18	TR1,TR4	RT1	AT6,AT16
	10.3.2	100	DOE2003e:18	TR1	RT1	AT1,AT2
	10.3.3	101	DOE2003e:18	TR1,TR5	RT1	AT5

Subj	AS	ID	Reference	TR	RT	AT
S07	11.1.1	66	DOE2003e:15	TR1	RT1	AT15
	11.1.2	67	DOE2003e:15	TR1	RT1	AT13
	11.1.3	68	DOE2003e:15	TR1	RT1	AT13
	11.1.4	69	DOE2003e:15	TR1	RT1	AT14
	11.1.5	70	DOE2003e:15	TR1	RT1	AT14
	11.2.1	82	DOE2003e:17	TR1	RT1	AT5
	11.2.2	83	DOE2003e:17	TR1	RT1	AT1
	11.2.3	84	DOE2003e:17	TR1,TR5	RT1	AT2
	11.2.4	85	DOE2003e:17	TR1,TR5	RT1	AT3
	11.2.5	86	DOE2003e:17	TR1	RT1	AT4,AT10
	11.2.6	87	DOE2003e:17	TR1	RT1	AT5,AT10
	11.2.7	88	DOE2003e:17	TR1	RT1	AT5,AT10
	11.2.8	89	DOE2003e:17	TR1,TR6	RT1	AT9
	11.3.1	102	DOE2003e:19	TR1,TR4	RT1	AT6,AT16
	11.3.2	103	DOE2003e:19	TR1	RT1	AT5, AT10
	11.3.3	104	DOE2003e:19	TR1,TR5	RT1	AT5,AT10
	12.1.1	71	DOE2003e:15	TR1	RT1	AT15
	12.1.2	72	DOE2003e:15	TR1	RT1	AT15
	12.1.3	73	DOE2003e:15	TR1	RT1	AT13
	12.1.4	74	DOE2003e:15	TR1	RT1	AT14
	12.1.5	75	DOE2003e:15	TR1	RT1	AT14
	12.2.1	90	DOE2003e:17	TR1	RT1	AT5
	12.2.2	91	DOE2003e:17	TR1	RT1	AT1
	12.2.3	92	DOE2003e:17	TR1	RT1	AT2
	12.2.4	94	DOE2003e:17	TR1	RT1	AT3
	12.2.5	95	DOE2003e:17	TR1	RT1	AT4,AT10
	12.2.6	96	DOE2003e:17	TR1	RT1	AT5,AT10
	12.2.7	97	DOE2003e:17	TR1	RT1	AT5,AT10
	12.2.8	98	DOE2003e:17	TR1,TR6	RT1	AT9
	12.3.1	105	DOE2003e:19	TR1,TR4	RT1	AT6,AT16
	12.3.2	106	DOE2003e:19	TR1	RT1	AT5,AT10
	12.3.3	107	DOE2003e:19	TR1,TR5	RT1	AT5,AT10
S08	10.2.2	571	DOE2003f:16	TR4	RT2	AT6
	10.4.3	110	DOE2003f:22	TR5	RT4	AT2
	11.1.1	569	DOE2003f:15	TR4	RT2	AT6
	11.1.2	108	DOE2003f:15	TR5	RT4	AT2
	11.2.2	572	DOE2003f:17	TR4	RT2	AT6
	11.4.3	111	DOE2003f:23	TR5	RT4	AT2
	12.1.1	570	DOE2003f:15	TR4	RT2	AT6
	12.2.7	109	DOE2003f:19	TR4,TR5	RT2	AT1,AT4,AT6
	12.3.1	573	DOE2003f:21	TR4	RT2	AT6
	12.3.3	574	DOE2003f:21	TR4	RT2	AT6
	12.4.1	575	DOE2003f:23	TR5	RT4	AT5
	12.4.2	112	DOE2003f:23	TR5	RT4	AT1,AT2
	12.4.3	576	DOE2003f:23	TR5	RT4	AT2
S09	10.1.4	113	DOE2003g:14	TR5	RT4	AT1,AT4
	10.3.2	116	DOE2003g:18	TR4,TR5	RT3	AT5,AT6

Subj	AS	ID	Reference	TR	RT	AT
S09	11.1.4	114	DOE2003g:15	TR5	RT4	AT5
	11.3.2	117	DOE2003g:19	TR4,TR5	RT3	AT5,AT6
	12.1.4	115	DOE2003g:15	TR5	RT4	AT5
	12.3.2	118	DOE2003g:19	TR4,TR5	RT3	AT5,AT6
S10	10.1.1	119	DOE2003h:16	TR4,TR5	RT3	AT5,AT6,AT11
	10.2.1	122	DOE2003h:20	TR4,TR5	RT3	AT5,AT6,AT11
	10.2.3	125	DOE2003h:20	TR5	RT1	AT10,AT11
	10.2.5	128	DOE2003h:20	TR5	RT3	AT1,AT4,AT11
	10.2.6	131	DOE2003h:20	TR5	RT3	AT1,AT4,AT11
	10.2.7	134	DOE2003h:20	TR5	RT3	AT1,AT4,AT10
	10.2.8	137	DOE2003h:20	TR5	RT3	AT1,AT4,AT11
	10.3.8	140	DOE2003h:24	TR5	RT4	AT1,AT4
	11.1.1	120	DOE2003h:17	TR4,TR5	RT3	AT5,AT6,AT11
	11.2.1	123	DOE2003h:21	TR4,TR5	RT3	AT5,AT6,AT11
	11.2.3	126	DOE2003h:21	TR5	RT1	AT10,AT11
	11.2.5	129	DOE2003h:21	TR5	RT3	AT1,AT4,AT11
	11.2.6	132	DOE2003h:21	TR5	RT3	AT1,AT4,AT11
	11.2.7	135	DOE2003h:21	TR5	RT3	AT1,AT4,AT10
	11.2.8	138	DOE2003h:21	TR5	RT3	AT1,AT4,AT11
	11.3.11	577	DOE2003h:27	TR5,TR7	RT4	AT2
	11.3.5	141	DOE2003h:25	TR4	RT3	AT6
	11.3.7	145	DOE2003h:25	TR5	RT3	AT1,AT4,AT10
	11.3.8	143	DOE2003h:25	TR5	RT4	AT1,AT4
	12.1.1	121	DOE2003h:17	TR4,TR5	RT3	AT5,AT6,AT11
	12.2.1	124	DOE2003h:21	TR4,TR5	RT3	AT5,AT6,AT11
	12.2.3	127	DOE2003h:21	TR5	RT1	AT10,AT11
	12.2.5	130	DOE2003h:21	TR5	RT3	AT1,AT4,AT11
	12.2.6	133	DOE2003h:21	TR5	RT3	AT1,AT4,AT11
	12.2.7	136	DOE2003h:21	TR5	RT3	AT1,AT4,AT10
	12.2.8	139	DOE2003h:21	TR5	RT3	AT1,AT4,AT11
	12.3.13	578	DOE2003h:27	TR4,TR5	RT4	AT1,AT4,AT6
	12.3.5	142	DOE2003h:25	TR4	RT3	AT6
	12.3.8	144	DOE2003h:25	TR5	RT4	AT1,AT4
S11	10.2.4	146	DOE2003i:24	TR4,TR5	RT3	AT1,AT4,AT6,AT10
	10.4.1	152	DOE2003i:28	TR4,TR5	RT3	AT1,AT4,AT6,AT10
	11.2.4	147	DOE2003i:25	TR4,TR5	RT3	AT1,AT4,AT6,AT10
	11.2.5	149	DOE2003i:25	TR5	RT4	AT5
	11.4.1	153	DOE2003i:29	TR4,TR5	RT3	AT1,AT4,AT6,AT10
	12.2.1	148	DOE2003i:23	TR4,TR5	RT3	AT1,AT4,AT6,AT10
	12.2.5	150	DOE2003i:25	TR5	RT4	AT1
	12.3.2	151	DOE2003i:27	TR4,TR5	RT3	AT1,AT4,AT6,AT10
	12.4.1	154	DOE2003i:29	TR4,TR5	RT3	AT1,AT4,AT6,AT10
S12	10.2.1	155	DOE2003j:16	TR5	RT3	AT2
	10.2.2	156	DOE2003j:16	TR5	RT3	AT2
	10.2.3	157	DOE2003j:16	TR5	RT3	AT2
	10.4.3	580	DOE2003j:20	TR5	RT3	AT4
	10.4.4	163	DOE2003j:20	TR5	RT3	AT2

Subj	AS	ID	Reference	TR	RT	AT
S12	11.2.1	158	DOE2003j:17	TR5	RT3	AT2
	11.2.2	159	DOE2003j:17	TR5	RT3	AT2
	11.2.3	160	DOE2003j:17	TR5	RT3	AT2,AT4
	11.4.3	581	DOE2003j:20	TR5	RT3	AT4
	11.4.4	164	DOE2003j:21	TR5	RT3	AT2
	12.2.1	161	DOE2003j:17	TR5	RT3	AT2
	12.2.3	162	DOE2003j:17	TR5	RT3	AT2
	12.4.3	582	DOE2003j:20	TR5	RT3	AT4
	12.4.4	165	DOE2003j:21	TR5	RT3	AT2
S13	10.2.1	166	DOE2005d:16	TR4,TR5	RT3	AT5,AT6,AT16
	10.2.5	169	DOE2005d:16	TR5	RT2	AT5
	11.2.1	167	DOE2005d:17	TR4,TR5	RT3	AT5,AT6,AT16
	11.2.5	170	DOE2005d:17	TR5	RT2	AT5
	12.2.1	168	DOE2005d:17	TR4,TR5	RT3	AT5,AT6,AT16
	12.2.5	171	DOE2005d:17	TR5	RT2	AT5
S14	10.2.2	583	DOE2005e:16	TR4,TR5	RT1	AT2,AT6,AT11
	10.2.4	174	DOE2005e:16	TR5	RT1	AT4,AT11
	10.3.3	177	DOE2005e:18	TR1	RT1	AT5,AT11,AT13
	10.3.5	180	DOE2005e:18	TR5	RT1	AT11
	10.3.7	183	DOE2005e:18	TR5	RT4	AT4
	10.4.2	186	DOE2005e:20	TR5	RT1	AT11
	10.4.3	189	DOE2005e:20	TR5	RT1	AT11
	10.4.4	192	DOE2005e:22	TR5	RT1	AT11
	11.1.1	172	DOE2005e:15	TR1	RT1	AT14
	11.2.2	584	DOE2005e:17	TR4,TR5	RT3	AT2,AT6,AT11
	11.2.4	175	DOE2005e:17	TR5	RT1	AT4,AT11
	11.3.3	178	DOE2005e:19	TR1	RT1	AT11,AT13
	11.3.5	181	DOE2005e:19	TR5	RT1	AT11
	11.3.7	184	DOE2005e:19	TR5	RT4	AT4
	11.4.2	187	DOE2005e:21	TR5	RT1	AT11
	11.4.3	190	DOE2005e:21	TR5	RT1	AT11
	11.4.4	193	DOE2005e:23	TR5	RT1	AT11
	12.1.1	173	DOE2005e:15	TR1	RT1	AT14
	12.2.2	585	DOE2005e:17	TR4,TR5	RT3	AT2,AT6,AT11
	12.2.4	176	DOE2005e:17	TR5	RT1	AT4,AT11
	12.3.3	179	DOE2005e:19	TR1	RT1	AT11
	12.3.5	182	DOE2005e:19	TR5	RT1	AT11
	12.3.7	185	DOE2005e:19	TR5	RT4	AT4
	12.4.2	188	DOE2005e:21	TR5	RT1	AT11
	12.4.3	191	DOE2005e:21	TR5	RT1	AT11
	12.4.4	194	DOE2005e:23	TR5	RT1	AT11
S15	10.1.2	197	DOE2003k:18	TR7	RT4	AT2,AT3
	10.1.3	200	DOE2003k:18	TR5	RT4	AT1,AT2
	10.1.4	203	DOE2003k:18	TR5	RT1	AT2,AT3,AT11
	10.1.5	206	DOE2003k:18	TR5	RT4	AT1,AT4
	11.1.1	195	DOE2003k:19	TR5	RT4	AT1,AT2
	11.1.2	198	DOE2003k:19	TR7	RT4	AT2,AT3

Subj	AS	ID	Reference	TR	RT	AT
S15	11.1.3	201	DOE2003k:19	TR5	RT4	AT1,AT2
	11.1.4	204	DOE2003k:19	TR5	RT1	AT2,AT3,AT11
	11.1.5	207	DOE2003k:19	TR5	RT4	AT1,AT4
	12.1.1	196	DOE2003k:19	TR5	RT4	AT1, AT2
	12.1.2	199	DOE2003k:19	TR7	RT4	AT2,AT3
	12.1.3	202	DOE2003k:19	TR5	RT4	AT1,AT2
	12.1.4	205	DOE2003k:19	TR5	RT1	AT2,AT3,AT11
	12.1.5	208	DOE2003k:19	TR5	RT4	AT1,AT4
S16	10.1.3	209	DOE2003l:16	TR4,TR5	RT3	AT1,AT2,AT6
	10.3.1	212	DOE2003l:20	TR5	RT4	AT2
	10.3.4	215	DOE2003l:20	TR5	RT3	AT1,AT4
	11.1.3	210	DOE2003l:17	TR4	RT3	AT6,AT16
	11.3.1	213	DOE2003l:21	TR5	RT4	AT2
	11.3.4	216	DOE2003l:21	TR5	RT3	AT1,AT4
	12.1.2	211	DOE2003l:17	TR4	RT3	AT6,AT16
	12.3.1	214	DOE2003l:21	TR5	RT4	AT2
	12.3.4	217	DOE2003l:21	TR5	RT3	AT1,AT4
S17	10.3.2	586	DOE2003m:20	TR5	RT4	AT1,AT4
	10.3.4	225	DOE2003m:20	TR5	RT4	AT1
	11.3.1	219	DOE2003m:21	TR5	RT4	AT1,AT4
	11.3.2	221	DOE2003m:21	TR7	RT4	AT11
	11.3.3	223	DOE2003m:21	TR5	RT4	AT2
	11.3.4	226	DOE2003m:21	TR5	RT4	AT1
	12.1.1	218	DOE2003m:17	TR5	RT4	AT1,AT4
	12.3.1	220	DOE2003m:21	TR1	RT1	AT1,AT11
	12.3.2	222	DOE2003m:21	TR7	RT4	AT11
	12.3.3	224	DOE2003m:21	TR5	RT4	AT2
	12.3.4	227	DOE2003m:21	TR5	RT4	AT1
	12.4.1	228	DOE2003m:23	TR7	RT4	AT11
S18	10.1.1	229	DOE2003n:14	TR1	RT1	AT14
	10.1.10	237	DOE2003n:16	TR1	RT1	AT15
	10.1.11	238	DOE2003n:16	TR1	RT1	AT13
	10.1.12	239	DOE2003n:16	TR1	RT1	AT13
	10.1.13	240	DOE2003n:16	TR1	RT1	AT15
	10.1.14	241	DOE2003n:16	TR1	RT1	AT13
	10.1.16	249	DOE2003n:18	TR1	RT1	AT13
	10.1.17	250	DOE2003n:18	TR1	RT1	AT14
	10.1.2	230	DOE2003n:14	TR1	RT1	AT14
	10.1.3	231	DOE2003n:14	TR1	RT1	AT14
	10.1.5	236	DOE2003n:16	TR1	RT1	AT14
	10.2.1	254	DOE2003n:20	TR1	RT1	AT14
	10.2.2	255	DOE2003n:20	TR1,TR6	RT1	AT7
	10.2.4	256	DOE2003n:20	TR1,TR6	RT1	AT7
	10.2.5	257	DOE2003n:20	TR1,TR4	RT1	AT6
	10.2.9	258	DOE2003n:20	TR1	RT1	AT14
	10.3.1	269	DOE2003n:22	TR1	RT1	AT14
	10.3.11	281	DOE2003n:24	TR1	RT1	AT14

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S18	10.3.2	270	DOE2003n:22	TR1	RT1	AT14
	10.3.7	271	DOE2003n:22	TR1	RT1	AT14
	10.3.8	272	DOE2003n:22	TR1	RT1	AT14
	10.3.9	280	DOE2003n:24	TR1	RT1	AT14
	10.4.1	287	DOE2003n:26	TR1,TR5	RT1	AT11
	10.4.10	304	DOE2003n:28	TR1	RT1	AT11
	10.4.11	305	DOE2003n:28	TR1	RT1	AT15
	10.4.12	306	DOE2003n:28	TR1	RT1	AT11
	10.4.13	307	DOE2003n:28	TR1	RT1	AT2
	10.4.14	308	DOE2003n:28	TR1	RT1	AT15
	10.4.19	323	DOE2003n:30	TR1,TR5	RT1	AT3
	10.4.2	288	DOE2003n:26	TR1,TR5	RT1	AT2
	10.4.21	324	DOE2003n:30	TR1	RT1	AT15
	10.4.22	325	DOE2003n:30	TR1	RT1	AT15
	10.4.3	289	DOE2003n:26	TR1,TR5	RT1	AT2
	10.4.4	290	DOE2003n:26	TR1	RT1	AT11
	10.4.5	291	DOE2003n:26	TR1,TR5	RT1	AT11
	10.4.6	292	DOE2003n:26	TR1,TR5	RT1	AT3,AT10,AT11
	10.4.7	293	DOE2003n:26	TR1	RT1	AT14
	10.4.8	303	DOE2003n:28	TR1,TR5	RT1	AT1,AT2,AT4
	11.1.11	244	DOE2003n:17	TR1	RT1	AT13
	11.1.13	245	DOE2003n:17	TR1	RT1	AT13
	11.1.15	251	DOE2003n:19	TR1	RT1	AT13
	11.1.17	252	DOE2003n:19	TR1	RT1	AT14
	11.1.3	232	DOE2003n:15	TR1	RT1	AT14
	11.1.4	233	DOE2003n:15	TR1	RT1	AT13
	11.1.5	242	DOE2003n:17	TR1	RT1	AT14
	11.1.6	243	DOE2003n:17	TR1	RT1	AT14
	11.1.7	579	DOE2003n:17	TR1	RT1	AT13
	11.2.2	259	DOE2003n:21	TR1,TR6	RT1	AT9
	11.2.3	260	DOE2003n:21	TR1,TR6	RT1	AT8
	11.2.5	261	DOE2003n:21	TR1,TR4	RT1	AT6
	11.2.6	262	DOE2003n:21	TR1	RT1	AT6
	11.2.7	263	DOE2003n:21	TR1	RT1	AT9
	11.2.9	264	DOE2003n:21	TR1	RT1	AT14
	11.3.11	283	DOE2003n:25	TR1	RT1	AT14
	11.3.2	273	DOE2003n:23	TR1	RT1	AT14
	11.3.3	274	DOE2003n:23	TR1,TR4,TR5	RT1	AT1,AT4,AT6
	11.3.4	275	DOE2003n:23	TR1,TR4,TR5	RT1	AT1,AT4,AT6
	11.3.5	276	DOE2003n:23	TR1,TR4,TR5	RT1	AT1,AT4,AT6
	11.3.6	277	DOE2003n:23	TR1	RT1	AT14
	11.3.9	282	DOE2003n:25	TR1	RT1	AT14
	11.4.11	311	DOE2003n:29	TR1,TR5	RT1	AT11
	11.4.12	312	DOE2003n:29	TR1	RT1	AT11
	11.4.13	313	DOE2003n:29	TR1	RT1	AT2
	11.4.14	314	DOE2003n:29	TR1	RT1	AT11
	11.4.15	315	DOE2003n:29	TR1	RT1	AT11

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S18	11.4.16	316	DOE2003n:29	TR1	RT1	AT3,AT11
	11.4.17	326	DOE2003n:31	TR1,TR5	RT1	AT3
	11.4.2	294	DOE2003n:27	TR1,TR5	RT1	AT2
	11.4.21	327	DOE2003n:31	TR1,TR5	RT1	AT1
	11.4.3	295	DOE2003n:27	TR1,TR5	RT1	AT2
	11.4.4	296	DOE2003n:27	TR1	RT1	AT11
	11.4.5	297	DOE2003n:27	TR1,TR5	RT1	AT11
	11.4.6	298	DOE2003n:27	TR1,TR5	RT1	AT11
	11.4.7	299	DOE2003n:27	TR1	RT1	AT2,AT6
	11.4.8	309	DOE2003n:29	TR1	RT1	AT11
	11.4.9	310	DOE2003n:29	TR1	RT1	AT11
	12.1.11	248	DOE2003n:17	TR1	RT1	AT13
	12.1.17	253	DOE2003n:19	TR1	RT1	AT14
	12.1.3	234	DOE2003n:15	TR1	RT1	AT14
	12.1.4	235	DOE2003n:15	TR1	RT1	AT13
	12.1.8	246	DOE2003n:17	TR1	RT1	AT14
	12.1.9	247	DOE2003n:17	TR1	RT1	AT14
	12.2.5	265	DOE2003n:21	TR1,TR4	RT1	AT6
	12.2.6	266	DOE2003n:21	TR1	RT1	AT13
	12.2.8	267	DOE2003n:21	TR1	RT1	AT13
	12.2.9	268	DOE2003n:21	TR1	RT1	AT14
	12.3.10	285	DOE2003n:25	TR1,TR6	RT1	AT9
	12.3.11	286	DOE2003n:25	TR1	RT1	AT14
	12.3.2	278	DOE2003n:23	TR1	RT1	AT14
	12.3.6	279	DOE2003n:23	TR1,TR4,TR5	RT1	AT1,AT4,AT6
	12.3.9	284	DOE2003n:25	TR1	RT1	AT14
	12.4.11	317	DOE2003n:29	TR1	RT1	AT11
	12.4.12	318	DOE2003n:29	TR1,TR5	RT1	AT11
	12.4.13	319	DOE2003n:29	TR1	RT1	AT11
	12.4.14	320	DOE2003n:29	TR1	RT1	AT11
	12.4.15	321	DOE2003n:29	TR1	RT1	AT3,AT11
	12.4.16	322	DOE2003n:29	TR1	RT1	AT15
	12.4.17	328	DOE2003n:31	TR1	RT1	AT3,AT11
	12.4.18	329	DOE2003n:31	TR1,TR5	RT1	AT3
	12.4.19	330	DOE2003n:31	TR1,TR5	RT1	AT5,AT11
	12.4.2	300	DOE2003n:27	TR1,TR5	RT1	AT2
	12.4.20	331	DOE2003n:31	TR1	RT1	AT5
	12.4.21	332	DOE2003n:31	TR1,TR5	RT1	AT10,AT11
	12.4.23	333	DOE2003n:31	TR1,TR5	RT1	AT1
	12.4.4	301	DOE2003n:27	TR1	RT1	AT11
	12.4.6	302	DOE2003n:27	TR1,TR5	RT1	AT11
S19	10.1.2	361	DOE2003o:16	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	10.2.1	364	DOE2003o:22	TR4	RT3	AT5,AT6,AT7,AT16
	10.3.1	376	DOE2003o:32	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	10.3.2	379	DOE2003o:34	TR5	RT3	AT1,AT4,AT7,AT10
	10.3.3	382	DOE2003o:36	TR5	RT3	AT1,AT4,AT7,AT10
	10.4.1	385	DOE2003o:38	TR4,TR5	RT4	AT1,AT6,AT16

Subj	AS	ID	Reference	TR	RT	AT
S19	11.1.2	362	DOE2003o:17	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	11.2.1	365	DOE2003o:23	TR4	RT3	AT5,AT6,AT7,AT16
	11.3.1	377	DOE2003o:33	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	11.3.2	380	DOE2003o:35	TR5	RT3	AT1,AT4,AT7,AT10
	11.3.3	383	DOE2003o:37	TR5	RT3	AT1,AT4,AT7,AT10
	11.4.1	386	DOE2003o:39	TR4,TR5	RT4	AT1,AT6,AT16
	12.1.2	363	DOE2003o:17	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	12.2.1	366	DOE2003o:23	TR4	RT3	AT5,AT6,AT7,AT16
	12.3.1	378	DOE2003o:33	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	12.3.2	381	DOE2003o:35	TR5	RT3	AT1,AT4,AT7,AT10
	12.3.3	384	DOE2003o:37	TR5	RT3	AT1,AT4,AT7,AT10
	12.4.1	387	DOE2003o:39	TR4,TR5	RT4	AT1,AT6,AT16
S20	10.1.2	334	DOE2003p:16	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	10.2.1	337	DOE2003p:22	TR4	RT3	AT5,AT6,AT7,AT16
	10.3.1	349	DOE2003p:30	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	10.3.2	352	DOE2003p:32	TR5	RT3	AT1,AT4,AT7,AT10
	10.3.3	355	DOE2003p:34	TR5	RT3	AT1,AT4,AT7,AT10
	10.4.1	358	DOE2003p:36	TR4,TR5	RT4	AT1,AT6,AT16
	11.1.2	335	DOE2003p:17	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	11.2.1	338	DOE2003p:23	TR4	RT3	AT5,AT6,AT7,AT16
	11.3.1	350	DOE2003p:31	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	11.3.2	353	DOE2003p:33	TR5	RT3	AT1,AT4,AT7,AT10
	11.3.3	356	DOE2003p:35	TR5	RT3	AT1,AT4,AT7,AT10
	11.4.1	359	DOE2003p:37	TR4,TR5	RT4	AT1,AT6,AT16
	12.1.2	336	DOE2003p:17	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	12.2.1	339	DOE2003p:23	TR4	RT3	AT5,AT6,AT7,AT16
	12.3.1	351	DOE2003p:31	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	12.3.2	354	DOE2003p:33	TR5	RT3	AT1,AT4,AT7,AT10
	12.3.3	357	DOE2003p:35	TR5	RT3	AT1,AT4,AT7,AT10
	12.4.1	360	DOE2003p:37	TR4,TR5	RT4	AT1,AT6,AT16
S21	10.1.2	388	DOE2003q:16	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	10.2.1	391	DOE2003q:20	TR4	RT3	AT5,AT6,AT7,AT16
	10.3.1	403	DOE2003q:24	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	10.3.2	406	DOE2003q:26	TR5	RT3	AT1,AT4,AT7,AT10
	10.3.3	409	DOE2003q:28	TR5	RT3	AT1,AT4,AT7,AT10
	10.4.1	412	DOE2003q:30	TR4,TR5	RT4	AT1,AT6,AT16
	11.1.2	389	DOE2003q:17	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	11.2.1	392	DOE2003q:21	TR4	RT3	AT5,AT6,AT7,AT16
	11.3.1	404	DOE2003q:25	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	11.3.2	407	DOE2003q:27	TR5	RT3	AT1,AT4,AT7,AT10
	11.3.3	410	DOE2003q:29	TR5	RT3	AT1,AT4,AT7,AT10
	11.4.1	413	DOE2003q:31	TR4,TR5	RT4	AT1,AT6,AT16
	12.1.2	390	DOE2003q:17	TR4,TR5	RT2	AT5,AT6,AT7,AT10,AT16
	12.2.1	393	DOE2003q:21	TR4	RT3	AT5,AT6,AT7,AT16
	12.3.1	405	DOE2003q:25	TR4,TR5	RT3	AT5,AT6,AT7,AT10,AT16
	12.3.2	408	DOE2003q:27	TR5	RT3	AT1,AT4,AT7,AT10
	12.3.3	411	DOE2003q:29	TR5	RT3	AT1,AT4,AT7,AT10

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S21	12.4.1	414	DOE2003q:31	TR4,TR5	RT4	AT1,AT6,AT16
S22	10.3.3	591	DOE2003r:15	TR4,TR5	RT1	AT1,AT4,AT6
	10.4.2	417	DOE2003r:20	TR4,TR5	RT4	AT1,AT4,AT6
	11.1.1	587	DOE2003r:15	TR5	RT4	AT1,AT2
	11.1.3	588	DOE2003r:15	TR4,TR5	RT4	AT1,AT4,AT6
	11.3.3	415	DOE2003r:19	TR4,TR5	RT4	AT1,AT4,AT6
	11.4.2	418	DOE2003r:21	TR4,TR5	RT4	AT1,AT4,AT6
	11.4.3	420	DOE2003r:21	TR4,TR5	RT4	AT1,AT4,AT6
	12.1.3	589	DOE2003r:15	TR4,TR5	RT4	AT1,AT4,AT6
	12.1.4	590	DOE2003r:15	TR4,TR5	RT4	AT1,AT4,AT6
	12.3.3	416	DOE2003r:19	TR4,TR5	RT4	AT1,AT4,AT6
	12.4.2	419	DOE2003r:21	TR4,TR5	RT4	AT1,AT4,AT6
	12.4.3	421	DOE2003r:21	TR4,TR5	RT4	AT1,AT4,AT6
S23	10.1.2.1	424	DOE2003s:18	TR7	RT2	AT2
	10.1.2.2	427	DOE2003s:18	TR5,TR7	RT2	AT2
	10.1.3.1	431	DOE2003s:22	TR5	RT2	AT1,AT4
	10.2.1.1	434	DOE2003s:24	TR4	RT2	AT6
	11.1.1.2	422	DOE2003s:17	TR5	RT2	AT1,AT2
	11.1.2.1	425	DOE2003s:19	TR4,TR5	RT2	AT1,AT6
	11.1.2.2	428	DOE2003s:21	TR5	RT2	AT1,AT2
	11.1.3.3	432	DOE2003s:23	TR5	RT2	AT1,AT4
	11.2.1.1	435	DOE2003s:25	TR4	RT2	AT6
	11.2.3.1	437	DOE2003s:27	TR5	RT2	AT1
	12.1.1.2	423	DOE2003s:17	TR5	RT2	AT1,AT2
	12.1.2.1	426	DOE2003s:19	TR4,TR7	RT2	AT1,AT6
	12.1.2.2	429	DOE2003s:19	TR7	RT2	AT2
	12.1.2.4	430	DOE2003s:19	TR5	RT2	AT2
	12.1.3.4	433	DOE2003s:23	TR5	RT2	AT1,AT4
	12.2.1.1	436	DOE2003s:25	TR4	RT2	AT6
	12.2.3.1	438	DOE2003s:27	TR5	RT2	AT1
S24	10.2.2	439	DOE2003t:22	TR5	RT2	AT2,AT11
	10.3.3	620	DOE2003t:26	TR5	RT4	AT11
	10.3.4	621	DOE2003t:26	TR5	RT4	AT11
	10.4.1	444	DOE2003t:30	TR4,TR5	RT2	AT5,AT6
	10.4.2	447	DOE2003t:32	TR5	RT3	AT2
	10.4.3	450	DOE2003t:34	TR5	RT3	AT2
	10.4.5	625	DOE2003t:36	TR5	RT3	AT2
	10.4.6	628	DOE2003t:36	TR5	RT3	AT2,AT4
	11.2.2	440	DOE2003t:23	TR5	RT2	AT2,AT11
	11.3.3	442	DOE2003t:27	TR5	RT2	AT2,AT11
	11.3.4	622	DOE2003t:27	TR5	RT4	AT11
	11.4.1	445	DOE2003t:31	TR4,TR5	RT3	AT5,AT6
	11.4.2	448	DOE2003t:33	TR5	RT3	AT2
	11.4.3	451	DOE2003t:35	TR5	RT3	AT2
	11.4.5	626	DOE2003t:37	TR5	RT3	AT2
	11.4.6	629	DOE2003t:37	TR5	RT3	AT2
	12.2.2	441	DOE2003t:23	TR5	RT2	AT2,AT11

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S24	12.3.3	443	DOE2003t:27	TR5	RT2	AT2,AT11
	12.3.4	623	DOE2003t:27	TR5	RT4	AT11
	12.4.1	446	DOE2003t:31	TR4,TR5	RT3	AT5,AT6
	12.4.2	449	DOE2003t:33	TR5	RT3	AT2
	12.4.3	452	DOE2003t:35	TR5	RT3	AT2
	12.4.4	624	DOE2003t:35	TR5	RT3	AT2
	12.4.5	627	DOE2003t:37	TR5	RT3	AT2
S25	10.2.1	596	DOE2003u:22	TR5	RT3	AT2,AT11
	10.2.2	462	DOE2003u:22	TR5	RT2	AT2,AT11
	10.2.3	598	DOE2003u:24	TR5	RT3	AT2,AT11
	10.2.5	601	DOE2003u:26	TR5	RT3	AT2,AT11
	10.2.6	465	DOE2003u:26	TR5	RT3	AT2,AT11
	10.2.7	603	DOE2003u:28	TR5,TR7	RT3	AT2,AT11
	10.3.2	606	DOE2003u:32	TR5	RT3	AT11
	10.3.3	608	DOE2003u:34	TR5	RT3	AT2,AT11
	10.3.4	611	DOE2003u:34	TR5	RT3	AT11
	10.3.6	614	DOE2003u:36	TR5	RT3	AT11
	10.3.7	467	DOE2003u:36	TR4,TR5	RT3	AT1,AT4,AT6
	10.4.1	470	DOE2003u:38	TR5,TR7	RT3	AT2,AT11
	10.4.3	473	DOe2003u:42	TR5	RT3	AT4
	10.4.5	476	DOE2003u:42	TR4,TR5	RT3	AT5,AT6,AT11
	11.2.1	597	DOE2003u:23	TR5	RT3	AT2,AT11
	11.2.2	463	DOE2003u:23	TR5	RT2	AT2,AT11
	11.2.3	599	DOE2003u:25	TR5	RT3	AT2,AT11
	11.2.5	602	DOE2003u:27	TR5	RT3	AT2,AT11
	11.2.6	466	DOE2003u:27	TR5	RT3	AT2,AT11
	11.3.2	607	DOE2003u:33	TR5	RT3	AT11
	11.3.3	609	DOE2003u:35	TR5	RT3	AT11
	11.3.4	612	DOE2003u:35	TR5	RT3	AT11
	11.3.6	615	DOE2003u:37	TR5	RT3	AT11
	11.3.7	468	DOE2003u:37	TR4,TR5	RT3	AT1,AT4,AT6
	11.4.1	471	DOE2003u:39	TR5,TR7	RT2	AT2,AT11
	11.4.3	474	DOE2003u:43	TR5	RT3	AT4
	11.4.4	617	DOE2003u:43	TR5	RT3	AT2,AT11
	11.4.5	477	DOE2003u:43	TR4,TR5	RT3	AT5,AT6,AT11
	12.2.2	464	DOE2003u:23	TR5	RT2	AT2,AT11
	12.2.3	600	DOE2003u:25	TR5	RT3	AT2,AT11
	12.2.7	605	DOE2003u:29	TR5	RT3	AT2,AT11
	12.3.3	610	DOE2003u:35	TR5	RT3	AT11
	12.3.4	613	DOE2003u:35	TR5	RT3	AT11
	12.3.6	616	DOE2003u:37	TR5	RT3	AT11
	12.3.7	469	DOE2003u:37	TR4,TR5	RT3	AT1,AT4,AT6
	12.4.1	472	DOE2003u:39	TR5,TR7	RT2	AT2,AT11
	12.4.3	475	DOE2003u:43	TR5	RT3	AT4
	12.4.4	618	DOE2003u:43	TR5	RT3	AT2,AT11
	12.4.5	478	DOE2003u:43	TR4,TR5	RT3	AT5,AT6,AT11
S26	10.2.1	479	DOE2005f:16	TR4,TR5	RT3	AT5,AT6,AT16

Subj	AS	ID	Reference	TR	RT	AT
S26	10.2.5	482	DOE2005f:16	TR5	RT2	AT5
	11.2.1	480	DOE2005f:17	TR4,TR5	RT3	AT5,AT6,AT16
	11.2.5	483	DOE2005f:17	TR5	RT2	AT5
	12.2.1	481	DOE2005f:17	TR4,TR5	RT3	AT5,AT6,AT16
	12.2.5	484	DOE2005f:17	TR5	RT2	AT5
	12.3.8	592	DOE2005f:21	TR7	RT4	AT2
S27	10.1.5	487	DOE2003v:20	TR5	RT4	AT5
	10.2.2	489	DOE2003v:22	TR4,TR5	RT2	AT6,AT11
	10.2.3	492	DOE2003v:22	TR5	RT2	AT11
	10.3.1	495	DOE2003v:24	TR5	RT4	AT11
	10.4.2	498	DOE2003v:26	TR4	RT3	AT6,AT16
	10.4.4	593	DOE2003v:26	TR5	RT4	AT1
	11.1.4	485	DOE2003v:19	TR5	RT4	AT5
	11.1.5	488	DOE2003v:21	TR5	RT4	AT4
	11.2.2	490	DOE2003v:23	TR4,TR5	RT2	AT6,AT11
	11.2.3	493	DOE2003v:23	TR5	RT3	AT11
	11.3.1	496	DOE2003v:25	TR5	RT2	AT11
	11.4.2	499	DOE2003v:27	TR4	RT2	AT6,AT16
	11.4.3	594	DOE2003v:27	TR4,TR5	RT3	AT1,AT4,AT6,AT16
	12.1.4	486	DOE2003v:19	TR5	RT4	AT5
	12.2.2	491	DOE2003v:23	TR4,TR5	RT3	AT6,AT11
	12.2.3	494	DOE2003v:23	TR5	RT3	AT11
	12.3.2	497	DOE2003v:25	TR5	RT4	AT11
	12.4.2	500	DOE2003v:27	TR4	RT3	AT6,AT16
S28	10.1.1	501	DOE2003w:18	TR5,TR7	RT4	AT2
	10.1.2	504	DOE2003w:18	TR5	RT4	AT2
	10.1.4	507	DOE2003w:22	TR5	RT4	AT1,AT4
	10.2.3	510	DOE2003w:26	TR3	RT3	AT6,AT16
	11.1.1	502	DOE2003w:19	TR5,TR7	RT4	AT2
	11.1.2	505	DOE2003w:19	TR5	RT4	AT2
	11.1.4	508	DOE2003w:22	TR5	RT4	AT1,AT4
	11.2.3	511	DOE2003w:27	TR3	RT3	AT6,AT16
	11.3.3	637	DOE2003w:33	TR4,TR5	RT3	AT5,AT6
	12.1.1	503	DOE2003w:19	TR5,TR7	RT4	AT2
	12.1.2	506	DOE2003w:19	TR5	RT4	AT2
	12.1.4	509	DOE2003w:22	TR5	RT4	AT1,AT4
	12.2.3	512	DOE2003w:27	TR3	RT3	AT6,AT16
	12.3.1	635	DOE2003w:29	TR4,TR5	RT3	AT5,AT6
	12.3.2	636	DOE2003w:31	TR4,TR5	RT3	AT5,AT6
	12.3.3	638	DOE2003w:33	TR4,TR5	RT3	AT5,AT6
S29	10.1.3	630	DOE2005g:16	TR5	RT4	AT2
	10.4.2	513	DOE2005g:22	TR5	RT4	AT1,AT4
	10.4.3	514	DOE2005g:22	TR5	RT4	AT1,AT4
	11.4.1	515	DOE2005g:23	TR5	RT4	AT1,AT4
	11.4.2	516	DOE2005g:23	TR5	RT4	AT1,AT4
	12.3.3	517	DOE2005g:21	TR5	RT4	AT4
	12.4.1	518	DOE2005g:23	TR5	RT4	AT1,AT4

Subj	AS	ID	Reference	TR	RT	AT
S29	12.4.2	519	DOE2005g:23	TR5	RT4	AT1,AT4
S30	10.1.3	520	DOE2003x:16	TR4	RT3	AT6,AT16
	10.2.2	632	DOE2003x:18	TR4,TR5	RT3	AT1,AT4,AT6,AT16
	10.3.3	633	DOE2003x:20	TR4,TR5	RT2	AT1,AT4,AT6
	10.3.4	524	DOE2003x:20	TR4,TR5	RT2	AT2,AT6
	10.4.5	531	DOE2003x:22	TR6	RT2	AT7
	11.1.3	631	DOE2003x:17	TR4,TR5	RT3	AT1,AT4,AT6,AT16
	11.2.2	522	DOE2003x:19	TR4,TR5	RT2	AT1,AT6
	11.3.3	634	DOE2003x:21	TR4,TR5	RT2	AT1,AT4,AT6
	11.3.4	525	DOE2003x:21	TR5	RT3	AT1,AT4
	11.3.5	526	DOE2003x:21	TR7	RT3	AT2
	11.4.5	532	DOE2003x:23	TR6	RT2	AT1,AT7
	12.1.3	521	DOE2003x:17	TR4,TR5	RT2	AT1,AT4,AT6,AT16
	12.2.2	523	DOE2003x:19	TR4,TR5	RT3	AT1,AT4,AT6,AT16
	12.3.2	527	DOE2003x:21	TR4,TR5	RT2	AT1,AT2,AT6
	12.3.3	528	DOE2003x:21	TR4,TR5	RT2	AT1,AT6
	12.3.5	529	DOE2003x:21	TR7	RT3	AT2
	12.3.6	530	DOE2003x:21	TR4,TR5	RT2	AT1,AT6
	12.4.2	533	DOE2003x:23	TR5,TR7	RT3	AT1,AT2
	12.4.5	534	DOE2003x:23	TR5,TR6	RT2	AT1,AT7
S31	10.1.2	535	DOE2003y:14	TR4	RT3	AT6,AT16
	10.2.1	540	DOE2003y:16	TR5	RT3	AT11
	10.2.2	543	DOE2003y:16	TR5	RT3	AT11
	10.2.3	547	DOE2003y:16	TR5	RT3	AT1
	10.2.4	550	DOE2003y:16	TR5	RT3	AT11
	10.2.5	553	DOE2003y:16	TR5	RT3	AT11
	10.3.3	556	DOE2003y:18	TR5	RT3	AT4
	10.4.3	559	DOE2003y:20	TR4,TR5	RT3	AT1,AT6
	10.4.5	562	DOE2003y:20	TR4,TR5	RT3	AT1,AT4,AT6
	11.1.2	536	DOE2003y:15	TR4	RT3	AT6,AT16
	11.1.4	539	DOE2003y:15	TR5	RT3	AT1
	11.2.1	541	DOE2003y:17	TR5	RT3	AT11
	11.2.2	544	DOE2003y:17	TR5	RT3	AT11
	11.2.3	548	DOE2003y:17	TR5	RT3	AT1
	11.2.4	551	DOE2003y:17	TR5	RT3	AT11
	11.2.5	554	DOE2003y:17	TR5	RT3	AT11
	11.3.3	557	DOE2003y:19	TR5	RT3	AT4
	11.4.3	560	DOE2003y:21	TR4,TR5	RT3	AT1,AT6
	11.4.5	563	DOE2003y:21	TR4,TR5	RT3	AT1,AT4,AT6
	12.1.2	537	DOE2003y:15	TR4	RT3	AT6,AT16
	12.1.4	546	DOE2003y:15	TR5	RT3	AT1
	12.2.2	545	DOE2003y:17	TR5	RT3	AT11
	12.2.3	549	DOE2003y:17	TR5	RT3	AT1
	12.2.4	552	DOE2003y:17	TR5	RT3	AT11
	12.2.5	555	DOE2003y:17	TR5	RT3	AT11
	12.3.3	558	DOE2003y:19	TR5	RT3	AT4
	12.4.3	561	DOE2003y:21	TR4,TR5	RT3	AT1,AT6
	12.4.5	564	DOE2003y:21	TR4,TR5	RT3	AT1,AT4,AT6

ANNEXURE D

SUMMARY OF THE ICT REQUIREMENTS OF THE NCS ACCORDING TO REQUIREMENT TYPES

RT1 = Prescribed and compulsory ICT requirements
RT2 = Prescribed but optional ICT requirements
RT3 = Implied ICT requirements
RT4 = Potential ICT requirements
ICTRs = ICT requirements
ASs = Assessment standards
IR = Integration ratio
II = Integration index

Refer section 5.3.1 for an explanation of this summary.

			A: ICTRs according to requirement types										B: Integration			
			RT1		RT2		RT3		RT4		Total		ASs	ICTRs	IR	II
			n	%	n	%	n	%	n	%	n	%	n	n	%	%
	NCS	Gr 10	68	37.0	22	12.0	61	33.2	33	17.9	184	100	557	184	33.0	22.1
		Gr 11	70	33.7	28	13.5	68	32.7	42	20.2	208	100	569	208	36.6	23.8
		Gr12	62	30.7	29	14.4	66	32.7	45	22.3	202	100	552	202	36.6	23.2
		Total	200	33.7	79	13.3	195	32.8	120	20.2	594	100	1678	594	35.4	23.0
	NCS - (CAT + IT)	Gr 10	16	12.1	22	16.7	61	46.2	33	25.0	132	100	505	132	26.1	14.1
		Gr 11	16	10.4	28	18.2	68	44.2	42	27.3	154	100	515	154	29.9	15.8
		Gr12	16	10.3	29	18.6	66	42.3	45	28.8	156	100	506	156	30.8	16.2
		Total	48	10.9	79	17.9	195	44.1	120	27.1	442	100	1526	442	29.0	15.4
S01	Accounting	Gr 10	0	0.0	3	75.0	0	0.0	1	25.0	4	100	13	4	30.8	19.2
		Gr 11	0	0.0	4	57.1	0	0.0	3	42.9	7	100	12	7	58.3	31.3
		Gr12	0	0.0	3	50.0	0	0.0	3	50.0	6	100	13	6	46.2	23.1
		Total	0	0.0	10	58.8	0	0.0	7	41.2	17	100	38	17	44.7	24.3
S02	Agricultural Management Practices	Gr 10	2	66.7	0	0.0	0	0.0	1	33.3	3	100	13	3	23.1	17.3
		Gr 11	2	66.7	0	0.0	0	0.0	1	33.3	3	100	12	3	25.0	18.8
		Gr12	2	66.7	0	0.0	0	0.0	1	33.3	3	100	13	3	23.1	17.3
		Total	6	66.7	0	0.0	0	0.0	3	33.3	9	100	38	9	23.7	17.8
S03	Agricultural Sciences	Gr 10	0	0.0	0	0.0	1	100.0	0	0.0	1	100	17	1	5.9	2.9
		Gr 11	1	50.0	0	0.0	1	50.0	0	0.0	2	100	20	2	10.0	7.5
		Gr12	0	0.0	0	0.0	1	50.0	1	50.0	2	100	21	2	9.5	3.6
		Total	1	20.0	0	0.0	3	60.0	1	20.0	5	100	58	5	8.6	4.7
S04	Agricultural Technology	Gr 10	2	50.0	0	0.0	0	0.0	2	50.0	4	100	28	4	14.3	8.9
		Gr 11	2	50.0	0	0.0	0	0.0	2	50.0	4	100	28	4	14.3	8.9
		Gr12	2	50.0	0	0.0	0	0.0	2	50.0	4	100	28	4	14.3	8.9
		Total	6	50.0	0	0.0	0	0.0	6	50.0	12	100	84	12	14.3	8.9

			A: ICTRs according to requirement types										B: Integration			
			RT1		RT2		RT3		RT4		Total		ASs	ICTRs	IR	II
			n	%	n	%	n	%	n	%	n	%	n	n	%	%
S05	Business Studies	Gr 10	0	0.0	0	0.0	0	0.0	3	100.0	3	100	21	3	14.3	3.6
		Gr 11	0	0.0	0	0.0	0	0.0	3	100.0	3	100	20	3	15.0	3.8
		Gr12	0	0.0	0	0.0	0	0.0	1	100.0	1	100	21	1	4.8	1.2
		Total	0	0.0	0	0.0	0	0.0	7	100.0	7	100	62	7	11.3	2.8
S06	Civil Technology	Gr 10	2	50.0	1	25.0	0	0.0	1	25.0	4	100	30	4	13.3	10.0
		Gr 11	2	50.0	1	25.0	0	0.0	1	25.0	4	100	30	4	13.3	10.0
		Gr12	2	50.0	1	25.0	0	0.0	1	25.0	4	100	30	4	13.3	10.0
		Total	6	50.0	3	25.0	0	0.0	3	25.0	12	100	90	12	13.3	10.0
S07	Computer Applications Technology	Gr 10	14	100.0	0	0.0	0	0.0	0	0.0	14	100	14	14	100.0	100.0
		Gr 11	16	100.0	0	0.0	0	0.0	0	0.0	16	100	16	16	100.0	100.0
		Gr12	16	100.0	0	0.0	0	0.0	0	0.0	16	100	16	16	100.0	100.0
		Total	46	100.0	0	0.0	0	0.0	0	0.0	46	100	46	46	100.0	100.0
S08	Consumer Studies	Gr 10	0	0.0	1	50.0	0	0.0	1	50.0	2	100	14	2	14.3	7.1
		Gr 11	0	0.0	2	50.0	0	0.0	2	50.0	4	100	15	4	26.7	13.3
		Gr12	0	0.0	4	57.1	0	0.0	3	42.9	7	100	14	7	50.0	26.8
		Total	0	0.0	7	53.8	0	0.0	6	46.2	13	100	43	13	30.2	15.7
S09	Dance Studies	Gr 10	0	0.0	0	0.0	1	50.0	1	50.0	2	100	14	2	14.3	5.4
		Gr 11	0	0.0	0	0.0	1	50.0	1	50.0	2	100	14	2	14.3	5.4
		Gr12	0	0.0	0	0.0	1	50.0	1	50.0	2	100	15	2	13.3	5.0
		Total	0	0.0	0	0.0	3	50.0	3	50.0	6	100	43	6	14.0	5.2
S10	Design	Gr 10	1	12.5	0	0.0	6	75.0	1	12.5	8	100	25	8	32.0	17.0
		Gr 11	1	9.1	0	0.0	8	72.7	2	18.2	11	100	26	11	42.3	21.2
		Gr12	1	10.0	0	0.0	7	70.0	2	20.0	10	100	25	10	40.0	20.0
		Total	3	10.3	0	0.0	21	72.4	5	17.2	29	100	76	29	38.2	19.4
S11	Dramatic Arts	Gr 10	0	0.0	0	0.0	2	100.0	0	0.0	2	100	13	2	15.4	7.7
		Gr 11	0	0.0	0	0.0	2	66.7	1	33.3	3	100	16	3	18.8	7.8
		Gr12	0	0.0	0	0.0	3	75.0	1	25.0	4	100	12	4	33.3	14.6
		Total	0	0.0	0	0.0	7	77.8	2	22.2	9	100	41	9	22.0	9.8
S12	Economics	Gr 10	0	0.0	0	0.0	5	100.0	0	0.0	5	100	15	5	33.3	16.7
		Gr 11	0	0.0	0	0.0	5	100.0	0	0.0	5	100	15	5	33.3	16.7
		Gr12	0	0.0	0	0.0	4	100.0	0	0.0	4	100	15	4	26.7	13.3
		Total	0	0.0	0	0.0	14	100.0	0	0.0	14	100	45	14	31.1	15.6
S13	Electrical Technology	Gr 10	0	0.0	1	50.0	1	50.0	0	0.0	2	100	25	2	8.0	5.0
		Gr 11	0	0.0	1	50.0	1	50.0	0	0.0	2	100	26	2	7.7	4.8
		Gr12	0	0.0	1	50.0	1	50.0	0	0.0	2	100	22	2	9.1	5.7
		Total	0	0.0	3	50.0	3	50.0	0	0.0	6	100	73	6	8.2	5.1

			A: ICTRs according to requirement types										B: Integration			
			RT1		RT2		RT3		RT4		Total		ASs	ICTRs	IR	II
			n	%	n	%	n	%	n	%	n	%	n	n	%	%
S14	Engineering Graphics & Design	Gr 10	7	87.5	0	0.0	0	0.0	1	12.5	8	100	21	8	38.1	34.5
		Gr 11	7	77.8	0	0.0	1	11.1	1	11.1	9	100	21	9	42.9	36.9
		Gr12	7	77.8	0	0.0	1	11.1	1	11.1	9	100	21	9	42.9	36.9
		Total	21	80.8	0	0.0	2	7.7	3	11.5	26	100	63	26	41.3	36.1
S15	Geography	Gr 10	1	25.0	0	0.0	0	0.0	3	75.0	4	100	11	4	36.4	15.9
		Gr 11	1	20.0	0	0.0	0	0.0	4	80.0	5	100	11	5	45.5	18.2
		Gr12	1	20.0	0	0.0	0	0.0	4	80.0	5	100	11	5	45.5	18.2
		Total	3	21.4	0	0.0	0	0.0	11	78.6	14	100	33	14	42.4	17.4
S16	History	Gr 10	0	0.0	0	0.0	2	66.7	1	33.3	3	100	14	3	21.4	8.9
		Gr 11	0	0.0	0	0.0	2	66.7	1	33.3	3	100	14	3	21.4	8.9
		Gr12	0	0.0	0	0.0	2	66.7	1	33.3	3	100	14	3	21.4	8.9
		Total	0	0.0	0	0.0	6	66.7	3	33.3	9	100	42	9	21.4	8.9
S17	Hospitality Studies	Gr 10	0	0.0	0	0.0	0	0.0	2	100.0	2	100	16	2	12.5	3.1
		Gr 11	0	0.0	0	0.0	0	0.0	4	100.0	4	100	16	4	25.0	6.3
		Gr12	1	16.7	0	0.0	0	0.0	5	83.3	6	100	15	6	40.0	15.0
		Total	1	8.3	0	0.0	0	0.0	11	91.7	12	100	47	12	25.5	8.0
S18	Information Technology	Gr 10	38	100.0	0	0.0	0	0.0	0	0.0	38	100	38	38	100.0	100.0
		Gr 11	38	100.0	0	0.0	0	0.0	0	0.0	38	100	38	38	100.0	100.0
		Gr12	30	100.0	0	0.0	0	0.0	0	0.0	30	100	30	30	100.0	100.0
		Total	106	100.0	0	0.0	0	0.0	0	0.0	106	100	106	106	100.0	100.0
S19	Languages - English First Additional Language	Gr 10	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Gr 11	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Gr12	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Total	0	0.0	3	16.7	12	66.7	3	16.7	18	100	42	18	42.9	21.4
S20	Languages - English Home Language	Gr 10	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Gr 11	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Gr12	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Total	0	0.0	3	16.7	12	66.7	3	16.7	18	100	42	18	42.9	21.4
S21	Languages - English Second Additional Language	Gr 10	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Gr 11	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Gr12	0	0.0	1	16.7	4	66.7	1	16.7	6	100	14	6	42.9	21.4
		Total	0	0.0	3	16.7	12	66.7	3	16.7	18	100	42	18	42.9	21.4
S22	Life Orientation	Gr 10	1	50.0	0	0.0	0	0.0	1	50.0	2	100	16	2	12.5	7.8
		Gr 11	0	0.0	0	0.0	0	0.0	5	100.0	5	100	16	5	31.3	7.8
		Gr12	0	0.0	0	0.0	0	0.0	5	100.0	5	100	16	5	31.3	7.8
		Total	1	8.3	0	0.0	0	0.0	11	91.7	12	100	48	12	25.0	7.8

			A: ICTRs according to requirement types										B: Integration			
			RT1		RT2		RT3		RT4		Total		ASs	CTRs	R	
			n	%	n	%	n	%	n	%	n	%	n	n	%	%
S23	Life Sciences	Gr 10	0	0.0	4	100.0	0	0.0	0	0.0	4	100	13	4	30.8	23.1
		Gr 11	0	0.0	6	100.0	0	0.0	0	0.0	6	100	15	6	40.0	30.0
		Gr12	0	0.0	7	100.0	0	0.0	0	0.0	7	100	17	7	41.2	30.9
		Total	0	0.0	17	100.0	0	0.0	0	0.0	17	100	45	17	37.8	28.3
S24	Mathematical Literacy	Gr 10	0	0.0	2	25.0	4	50.0	2	25.0	8	100	17	8	47.1	23.5
		Gr 11	0	0.0	2	25.0	5	62.5	1	12.5	8	100	18	8	44.4	23.6
		Gr12	0	0.0	2	25.0	5	62.5	1	12.5	8	100	18	8	44.4	23.6
		Total	0	0.0	6	25.0	14	58.3	4	16.7	24	100	53	24	45.3	23.6
S25	Mathematics	Gr 10	0	0.0	1	7.1	13	92.9	0	0.0	14	100	24	14	58.3	30.2
		Gr 11	0	0.0	2	14.3	12	85.7	0	0.0	14	100	26	14	53.8	28.8
		Gr12	0	0.0	2	18.2	9	81.8	0	0.0	11	100	22	11	50.0	27.3
		Total	0	0.0	5	12.8	34	87.2	0	0.0	39	100	72	39	54.2	28.8
S26	Mechanical Technology	Gr 10	0	0.0	1	50.0	1	50.0	0	0.0	2	100	28	2	7.1	4.5
		Gr 11	0	0.0	1	50.0	1	50.0	0	0.0	2	100	28	2	7.1	4.5
		Gr12	0	0.0	1	33.3	1	33.3	1	33.3	3	100	28	3	10.7	5.4
		Total	0	0.0	3	42.9	3	42.9	1	14.3	7	100	84	7	8.3	4.8
S27	Music	Gr 10	0	0.0	2	33.3	1	16.7	3	50.0	6	100	16	6	37.5	17.2
		Gr 11	0	0.0	3	42.9	2	28.6	2	28.6	7	100	14	7	50.0	26.8
		Gr12	0	0.0	0	0.0	3	60.0	2	40.0	5	100	13	5	38.5	15.4
		Total	0	0.0	5	27.8	6	33.3	7	38.9	18	100	43	18	41.9	19.8
S28	Physical Science	Gr 10	0	0.0	0	0.0	1	25.0	3	75.0	4	100	10	4	40.0	12.5
		Gr 11	0	0.0	0	0.0	2	40.0	3	60.0	5	100	10	5	50.0	17.5
		Gr12	0	0.0	0	0.0	4	57.1	3	42.9	7	100	10	7	70.0	27.5
		Total	0	0.0	0	0.0	7	43.8	9	56.3	16	100	30	16	53.3	19.2
S29	Religion Studies	Gr 10	0	0.0	0	0.0	0	0.0	3	100.0	3	100	16	3	18.8	4.7
		Gr 11	0	0.0	0	0.0	0	0.0	2	100.0	2	100	15	2	13.3	3.3
		Gr12	0	0.0	0	0.0	0	0.0	3	100.0	3	100	15	3	20.0	5.0
		Total	0	0.0	0	0.0	0	0.0	8	100.0	8	100	46	8	17.4	4.3
S30	Tourism	Gr 10	0	0.0	3	60.0	2	40.0	0	0.0	5	100	16	5	31.3	20.3
		Gr 11	0	0.0	3	50.0	3	50.0	0	0.0	6	100	18	6	33.3	20.8
		Gr12	0	0.0	5	62.5	3	37.5	0	0.0	8	100	18	8	44.4	29.2
		Total	0	0.0	11	57.9	8	42.1	0	0.0	19	100	52	19	36.5	23.6
S31	Visual Arts	Gr 10	0	0.0	0	0.0	9	100.0	0	0.0	9	100	17	9	52.9	26.5
		Gr 11	0	0.0	0	0.0	10	100.0	0	0.0	10	100	17	10	58.8	29.4
		Gr12	0	0.0	0	0.0	9	100.0	0	0.0	9	100	17	9	52.9	26.5
		Total	0	0.0	0	0.0	28	100.0	0	0.0	28	100	51	28	54.9	27.5

ANNEXURE E

SUMMARY OF THE ICT REQUIREMENTS OF THE NCS ACCORDING TO TECHNOLOGY ROLES IN LEARNING

ICTRs = ICT requirements
TR1 = Technology learning content
TR2 = Didactic tool
TR3 = Context tool
TR4 = Resource tool
TR5 = Cognitive tool
TR6 = Collaboration tool
TR7 = Productivity tool

Refer section 5.3.1 for an explanation of this summary.

			ICTRs according to technology roles													
			TR1		TR3		TR4		TR5		TR6		TR7		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%
	NCS	Gr 10	55	23.4	1	0.4	43	18.3	124	52.8	5	2.1	7	3.0	235	100
		Gr 11	58	21.4	1	0.4	53	19.6	147	54.2	4	1.5	8	3.0	271	100
		Gr12	51	19.3	1	0.4	57	21.6	140	53.0	3	1.1	12	4.5	264	100
		Total	164	21.3	3	0.4	153	19.9	411	53.4	12	1.6	27	3.5	770	100
	NCS - (CAT + IT)	Gr 10	3	1.8	1	0.6	41	24.1	116	68.2	2	1.2	7	4.1	170	100
		Gr 11	4	2.0	1	0.5	48	24.5	134	68.4	1	0.5	8	4.1	196	100
		Gr12	5	2.5	1	0.5	54	26.5	131	64.2	1	0.5	12	5.9	204	100
		Total	12	2.1	3	0.5	143	25.1	381	66.8	4	0.7	27	4.7	570	100
S01	Accounting	Gr 10	0	0.0	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4	100
		Gr 11	0	0.0	0	0.0	0	0.0	7	100.0	0	0.0	0	0.0	7	100
		Gr12	0	0.0	0	0.0	0	0.0	6	100.0	0	0.0	0	0.0	6	100
		Total	0	0.0	0	0.0	0	0.0	17	100.0	0	0.0	0	0.0	17	100
S02	Agricultural Managemen t Practises	Gr 10	0	0.0	0	0.0	2	40.0	3	60.0	0	0.0	0	0.0	5	100
		Gr 11	0	0.0	0	0.0	2	40.0	3	60.0	0	0.0	0	0.0	5	100
		Gr12	0	0.0	0	0.0	2	40.0	3	60.0	0	0.0	0	0.0	5	100
		Total	0	0.0	0	0.0	6	40.0	9	60.0	0	0.0	0	0.0	15	100
S03	Agricultural Sciences	Gr 10	0	0.0	0	0.0	1	50.0	1	50.0	0	0.0	0	0.0	2	100
		Gr 11	0	0.0	0	0.0	2	50.0	2	50.0	0	0.0	0	0.0	4	100
		Gr12	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Total	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
S04	Agricultural Technology	Gr 10	1	16.7	0	0.0	1	16.7	2	33.3	1	16.7	1	16.7	6	100
		Gr 11	1	20.0	0	0.0	0	0.0	2	40.0	0	0.0	2	40.0	5	100
		Gr12	1	20.0	0	0.0	0	0.0	2	40.0	0	0.0	2	40.0	5	100
		Total	3	18.8	0	0.0	1	6.3	6	37.5	1	6.3	5	31.3	16	100
S05	Business Studies	Gr 10	0	0.0	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	3	100
		Gr 11	0	0.0	0	0.0	1	25.0	3	75.0	0	0.0	0	0.0	4	100
		Gr12	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1	100
		Total	0	0.0	0	0.0	1	12.5	7	87.5	0	0.0	0	0.0	8	100

			ICTRs according to technology roles													
			TR1		TR3		TR4		TR5		TR6		TR7		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%
S06	Civil Technology	Gr 10	1	25.0	0	0.0	0	0.0	3	75.0	0	0.0	0	0.0	4	100
		Gr 11	1	25.0	0	0.0	0	0.0	3	75.0	0	0.0	0	0.0	4	100
		Gr12	1	25.0	0	0.0	0	0.0	3	75.0	0	0.0	0	0.0	4	100
		Total	3	25.0	0	0.0	0	0.0	9	75.0	0	0.0	0	0.0	12	100
S07	Computer Applications Technology	Gr 10	14	82.4	0	0.0	1	5.9	1	5.9	1	5.9	0	0.0	17	100
		Gr 11	16	76.2	0	0.0	1	4.8	3	14.3	1	4.8	0	0.0	21	100
		Gr12	16	84.2	0	0.0	1	5.3	1	5.3	1	5.3	0	0.0	19	100
		Total	46	80.7	0	0.0	3	5.3	5	8.8	3	5.3	0	0.0	57	100
S08	Consumer Studies	Gr 10	0	0.0	0	0.0	1	50.0	1	50.0	0	0.0	0	0.0	2	100
		Gr 11	0	0.0	0	0.0	2	50.0	2	50.0	0	0.0	0	0.0	4	100
		Gr12	0	0.0	0	0.0	4	50.0	4	50.0	0	0.0	0	0.0	8	100
		Total	0	0.0	0	0.0	7	50.0	7	50.0	0	0.0	0	0.0	14	100
S09	Dance Studies	Gr 10	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr 11	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr12	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Total	0	0.0	0	0.0	3	33.3	6	66.7	0	0.0	0	0.0	9	100
S10	Design	Gr 10	0	0.0	0	0.0	2	20.0	8	80.0	0	0.0	0	0.0	10	100
		Gr 11	0	0.0	0	0.0	3	21.4	10	71.4	0	0.0	1	7.1	14	100
		Gr12	0	0.0	0	0.0	4	30.8	9	69.2	0	0.0	0	0.0	13	100
		Total	0	0.0	0	0.0	9	24.3	27	73.0	0	0.0	1	2.7	37	100
S11	Dramatic Arts	Gr 10	0	0.0	0	0.0	2	50.0	2	50.0	0	0.0	0	0.0	4	100
		Gr 11	0	0.0	0	0.0	2	40.0	3	60.0	0	0.0	0	0.0	5	100
		Gr12	0	0.0	0	0.0	3	42.9	4	57.1	0	0.0	0	0.0	7	100
		Total	0	0.0	0	0.0	7	43.8	9	56.3	0	0.0	0	0.0	16	100
S12	Economics	Gr 10	0	0.0	0	0.0	0	0.0	5	100.0	0	0.0	0	0.0	5	100
		Gr 11	0	0.0	0	0.0	0	0.0	5	100.0	0	0.0	0	0.0	5	100
		Gr12	0	0.0	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	4	100
		Total	0	0.0	0	0.0	0	0.0	14	100.0	0	0.0	0	0.0	14	100
S13	Electrical Technology	Gr 10	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr 11	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr12	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Total	0	0.0	0	0.0	3	33.3	6	66.7	0	0.0	0	0.0	9	100
S14	Engineering Graphics & Design	Gr 10	1	11.1	0	0.0	1	11.1	7	77.8	0	0.0	0	0.0	9	100
		Gr 11	2	20.0	0	0.0	1	10.0	7	70.0	0	0.0	0	0.0	10	100
		Gr12	2	20.0	0	0.0	1	10.0	7	70.0	0	0.0	0	0.0	10	100
		Total	5	17.2	0	0.0	3	10.3	21	72.4	0	0.0	0	0.0	29	100
S15	Geography	Gr 10	0	0.0	0	0.0	0	0.0	3	75.0	0	0.0	1	25.0	4	100
		Gr 11	0	0.0	0	0.0	0	0.0	4	80.0	0	0.0	1	20.0	5	100
		Gr12	0	0.0	0	0.0	0	0.0	4	80.0	0	0.0	1	20.0	5	100
		Total	0	0.0	0	0.0	0	0.0	11	78.6	0	0.0	3	21.4	14	100

			ICTRs according to technology roles													
			TR1		TR3		TR4		TR5		TR6		TR7		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%
S16	History	Gr 10	0	0.0	0	0.0	1	25.0	3	75.0	0	0.0	0	0.0	4	100
		Gr 11	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr12	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Total	0	0.0	0	0.0	3	30.0	7	70.0	0	0.0	0	0.0	10	100
S17	Hospitality Studies	Gr 10	0	0.0	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2	100
		Gr 11	0	0.0	0	0.0	0	0.0	3	75.0	0	0.0	1	25.0	4	100
		Gr12	1	16.7	0	0.0	0	0.0	3	50.0	0	0.0	2	33.3	6	100
		Total	1	8.3	0	0.0	0	0.0	8	66.7	0	0.0	3	25.0	12	100
S18	Information Technology	Gr 10	38	79.2	0	0.0	1	2.1	7	14.6	2	4.2	0	0.0	48	100
		Gr 11	38	70.4	0	0.0	4	7.4	10	18.5	2	3.7	0	0.0	54	100
		Gr12	30	73.2	0	0.0	2	4.9	8	19.5	1	2.4	0	0.0	41	100
		Total	106	74.1	0	0.0	7	4.9	25	17.5	5	3.5	0	0.0	143	100
S19	Languages - English First Additional Language	Gr 10	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr 11	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr12	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Total	0	0.0	0	0.0	12	44.4	15	55.6	0	0.0	0	0.0	27	100
S20	Languages - English Home Language	Gr 10	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr 11	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr12	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Total	0	0.0	0	0.0	12	44.4	15	55.6	0	0.0	0	0.0	27	100
S21	Languages - English Second Additional Language	Gr 10	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr 11	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr12	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Total	0	0.0	0	0.0	12	44.4	15	55.6	0	0.0	0	0.0	27	100
S22	Life Orientation	Gr 10	0	0.0	0	0.0	2	50.0	2	50.0	0	0.0	0	0.0	4	100
		Gr 11	0	0.0	0	0.0	4	44.4	5	55.6	0	0.0	0	0.0	9	100
		Gr12	0	0.0	0	0.0	5	50.0	5	50.0	0	0.0	0	0.0	10	100
		Total	0	0.0	0	0.0	11	47.8	12	52.2	0	0.0	0	0.0	23	100
S23	Life Sciences	Gr 10	0	0.0	0	0.0	1	20.0	2	40.0	0	0.0	2	40.0	5	100
		Gr 11	0	0.0	0	0.0	2	28.6	5	71.4	0	0.0	0	0.0	7	100
		Gr12	0	0.0	0	0.0	2	25.0	4	50.0	0	0.0	2	25.0	8	100
		Total	0	0.0	0	0.0	5	25.0	11	55.0	0	0.0	4	20.0	20	100
S24	Mathematical Literacy	Gr 10	0	0.0	0	0.0	1	11.1	8	88.9	0	0.0	0	0.0	9	100
		Gr 11	0	0.0	0	0.0	1	11.1	8	88.9	0	0.0	0	0.0	9	100
		Gr12	0	0.0	0	0.0	1	11.1	8	88.9	0	0.0	0	0.0	9	100
		Total	0	0.0	0	0.0	3	11.1	24	88.9	0	0.0	0	0.0	27	100
S25	Mathematics	Gr 10	0	0.0	0	0.0	2	11.1	14	77.8	0	0.0	2	11.1	18	100
		Gr 11	0	0.0	0	0.0	2	11.8	14	82.4	0	0.0	1	5.9	17	100
		Gr12	0	0.0	0	0.0	2	14.3	11	78.6	0	0.0	1	7.1	14	100
		Total	0	0.0	0	0.0	6	12.2	39	79.6	0	0.0	4	8.2	49	100

			ICTRs according to technology roles													
			TR1		TR3		TR4		TR5		TR6		TR7		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%
S26	Mechanical Technology	Gr 10	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr 11	0	0.0	0	0.0	1	33.3	2	66.7	0	0.0	0	0.0	3	100
		Gr12	0	0.0	0	0.0	1	25.0	2	50.0	0	0.0	1	25.0	4	100
		Total	0	0.0	0	0.0	3	30.0	6	60.0	0	0.0	1	10.0	10	100
S27	Music	Gr 10	0	0.0	0	0.0	2	28.6	5	71.4	0	0.0	0	0.0	7	100
		Gr 11	0	0.0	0	0.0	3	33.3	6	66.7	0	0.0	0	0.0	9	100
		Gr12	0	0.0	0	0.0	2	33.3	4	66.7	0	0.0	0	0.0	6	100
		Total	0	0.0	0	0.0	7	31.8	15	68.2	0	0.0	0	0.0	22	100
S28	Physical Science	Gr 10	0	0.0	1	20.0	0	0.0	3	60.0	0	0.0	1	20.0	5	100
		Gr 11	0	0.0	1	14.3	1	14.3	4	57.1	0	0.0	1	14.3	7	100
		Gr12	0	0.0	1	9.1	3	27.3	6	54.5	0	0.0	1	9.1	11	100
		Total	0	0.0	3	13.0	4	17.4	13	56.5	0	0.0	3	13.0	23	100
S29	Religion Studies	Gr 10	0	0.0	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	3	100
		Gr 11	0	0.0	0	0.0	0	0.0	2	100.0	0	0.0	0	0.0	2	100
		Gr12	0	0.0	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	3	100
		Total	0	0.0	0	0.0	0	0.0	8	100.0	0	0.0	0	0.0	8	100
S30	Tourism	Gr 10	0	0.0	0	0.0	4	50.0	3	37.5	1	12.5	0	0.0	8	100
		Gr 11	0	0.0	0	0.0	3	33.3	4	44.4	1	11.1	1	11.1	9	100
		Gr12	0	0.0	0	0.0	5	33.3	7	46.7	1	6.7	2	13.3	15	100
		Total	0	0.0	0	0.0	12	37.5	14	43.8	3	9.4	3	9.4	32	100
S31	Visual Arts	Gr 10	0	0.0	0	0.0	3	27.3	8	72.7	0	0.0	0	0.0	11	100
		Gr 11	0	0.0	0	0.0	3	25.0	9	75.0	0	0.0	0	0.0	12	100
		Gr12	0	0.0	0	0.0	3	27.3	8	72.7	0	0.0	0	0.0	11	100
		Total	0	0.0	0	0.0	9	26.5	25	73.5	0	0.0	0	0.0	34	100

ANNEXURE F

SUMMARY OF THE ICT REQUIREMENTS OF THE NCS ACCORDING TO APPLICATION TYPES

ICTRs = ICT requirements
AT1 = Word processor
AT2 = Spreadsheet
AT3 = Database
AT4 = Presentation graphics
AT5 = Productivity suite (AT1+AT2+AT3+AT4)
AT6 = Web browser (navigator)
AT7 = E-mail application
AT8 = Applications for other computer-managed communication forms
AT9 = Internet suite (AT6+AT7+AT8)
AT10 = Multimedia/ hypermedia authoring application
AT11 = Subject-specific application
AT13 = System software and utilities
AT14 = Not applicable (no software involved)
AT15 = All relevant application types for the subject
AT16 = Database or multimedia application with subject-related information, excluding the Internet

Refer section 5.3.1 for an explanation of this summary.

			ICTRs according to application types																	
			AT5		AT9		AT10		AT11		AT13		AT14		AT15		AT16		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
	NCS	Gr 10	117	40.6	56	19.4	17	5.9	48	16.7	7	2.4	16	5.6	7	2.4	20	6.9	288	100
		Gr 11	138	42.2	68	20.8	22	6.7	57	17.4	8	2.4	12	3.7	1	0.3	21	6.4	327	100
		Gr12	140	43.1	68	20.9	23	7.1	54	16.6	5	1.5	11	3.4	3	0.9	21	6.5	325	100
		Total	395	42.0	192	20.4	62	6.6	159	16.9	20	2.1	39	4.1	11	1.2	62	6.6	940	100
	NCS - (CAT + IT)	Gr 10	104	44.6	51	21.9	16	6.9	42	18.0	1	0.4	0	0.0	0	0.0	19	8.2	233	100
		Gr 11	119	45.4	57	21.8	17	6.5	47	17.9	1	0.4	1	0.4	0	0.0	20	7.6	262	100
		Gr12	123	45.9	63	23.5	17	6.3	44	16.4	0	0.0	1	0.4	0	0.0	20	7.5	268	100
		Total	346	45.3	171	22.4	50	6.6	133	17.4	2	0.3	2	0.3	0	0.0	59	7.7	763	100
S01	Accounting	Gr 10	4	57.1	0	0.0	0	0.0	3	42.9	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Gr 11	4	44.4	0	0.0	0	0.0	5	55.6	0	0.0	0	0.0	0	0.0	0	0.0	9	100
		Gr12	3	42.9	0	0.0	0	0.0	4	57.1	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Total	11	47.8	0	0.0	0	0.0	12	52.2	0	0.0	0	0.0	0	0.0	0	0.0	23	100
S02	Agricultural Manage-ment Prac-tises	Gr 10	3	42.9	3	42.9	0	0.0	1	14.3	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Gr 11	3	42.9	3	42.9	0	0.0	1	14.3	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Gr12	3	42.9	3	42.9	0	0.0	1	14.3	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Total	9	42.9	9	42.9	0	0.0	3	14.3	0	0.0	0	0.0	0	0.0	0	0.0	21	100
S03	Agricultural Sciences	Gr 10	1	50.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	100
		Gr 11	2	50.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr12	2	66.7	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Total	5	55.6	4	44.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	100

			ICTRs according to application types																	
			AT5		AT9		AT10		AT11		AT13		AT14		AT15		AT16		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
S04	Agricultural Technology	Gr 10	2	50.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr 11	2	50.0	0	0.0	0	0.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr12	2	50.0	0	0.0	0	0.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Total	6	50.0	2	16.7	0	0.0	4	33.3	0	0.0	0	0.0	0	0.0	0	0.0	12	100
S05	Business Studies	Gr 10	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Gr 11	3	75.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr12	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	100
		Total	7	87.5	1	12.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8	100
S06	Civil Technology	Gr 10	2	50.0	0	0.0	0	0.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr 11	2	50.0	0	0.0	0	0.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr12	4	66.7	0	0.0	0	0.0	2	33.3	0	0.0	0	0.0	0	0.0	0	0.0	6	100
		Total	8	57.1	0	0.0	0	0.0	6	42.9	0	0.0	0	0.0	0	0.0	0	0.0	14	100
S07	Computer Applica-tions Tech-nology	Gr 10	7	46.7	2	13.3	0	0.0	0	0.0	2	13.3	2	13.3	1	6.7	1	6.7	15	100
		Gr 11	9	40.9	2	9.1	5	22.7	0	0.0	2	9.1	2	9.1	1	4.5	1	4.5	22	100
		Gr12	9	40.9	2	9.1	5	22.7	0	0.0	1	4.5	2	9.1	2	9.1	1	4.5	22	100
		Total	25	42.4	6	10.2	10	16.9	0	0.0	5	8.5	6	10.2	4	6.8	3	5.1	59	100
S08	Consumer Studies	Gr 10	1	50.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	100
		Gr 11	2	50.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr12	4	50.0	4	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8	100
		Total	7	50.0	7	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	14	100
S09	Dance Studies	Gr 10	2	66.7	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Gr 11	2	66.7	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Gr12	2	66.7	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Total	6	66.7	3	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	100
S10	Design	Gr 10	7	41.2	2	11.8	2	11.8	6	35.3	0	0.0	0	0.0	0	0.0	0	0.0	17	100
		Gr 11	9	42.9	3	14.3	3	14.3	6	28.6	0	0.0	0	0.0	0	0.0	0	0.0	21	100
		Gr12	8	40.0	4	20.0	2	10.0	6	30.0	0	0.0	0	0.0	0	0.0	0	0.0	20	100
		Total	24	41.4	9	15.5	7	12.1	18	31.0	0	0.0	0	0.0	0	0.0	0	0.0	58	100
S11	Dramatic Arts	Gr 10	2	33.3	2	33.3	2	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	100
		Gr 11	3	42.9	2	28.6	2	28.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Gr12	4	40.0	3	30.0	3	30.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	100
		Total	9	39.1	7	30.4	7	30.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	23	100
S12	Economics	Gr 10	5	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	100
		Gr 11	5	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	100
		Gr12	4	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Total	14	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	14	100
S13	Electrical Techno-logy	Gr 10	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Gr 11	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Gr12	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Total	6	50.0	3	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	25.0	12	100

			ICTRs according to application types																	
			AT5		AT9		AT10		AT11		AT13		AT14		AT15		AT16		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
S14	Engin-eering Graphics & Design	Gr 10	4	30.8	1	7.7	0	0.0	7	53.8	1	7.7	0	0.0	0	0.0	0	0.0	13	100
		Gr 11	3	23.1	1	7.7	0	0.0	7	53.8	1	7.7	1	7.7	0	0.0	0	0.0	13	100
		Gr12	3	25.0	1	8.3	0	0.0	7	58.3	0	0.0	1	8.3	0	0.0	0	0.0	12	100
		Total	10	26.3	3	7.9	0	0.0	21	55.3	2	5.3	2	5.3	0	0.0	0	0.0	38	100
S15	Geography	Gr 10	4	80.0	0	0.0	0	0.0	1	20.0	0	0.0	0	0.0	0	0.0	0	0.0	5	100
		Gr 11	5	83.3	0	0.0	0	0.0	1	16.7	0	0.0	0	0.0	0	0.0	0	0.0	6	100
		Gr12	5	83.3	0	0.0	0	0.0	1	16.7	0	0.0	0	0.0	0	0.0	0	0.0	6	100
		Total	14	82.4	0	0.0	0	0.0	3	17.6	0	0.0	0	0.0	0	0.0	0	0.0	17	100
S16	History	Gr 10	3	75.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr 11	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Gr12	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Total	7	58.3	3	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	16.7	12	100
S17	Hospitality Studies	Gr 10	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	100
		Gr 11	3	75.0	0	0.0	0	0.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr12	4	57.1	0	0.0	0	0.0	3	42.9	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Total	9	69.2	0	0.0	0	0.0	4	30.8	0	0.0	0	0.0	0	0.0	0	0.0	13	100
S18	Information Technology	Gr 10	6	15.0	3	7.5	1	2.5	6	15.0	4	10.0	14	35.0	6	15.0	0	0.0	40	100
		Gr 11	10	23.3	9	20.9	0	0.0	10	23.3	5	11.6	9	20.9	0	0.0	0	0.0	43	100
		Gr12	8	22.9	3	8.6	1	2.9	10	28.6	4	11.4	8	22.9	1	2.9	0	0.0	35	100
		Total	24	20.3	15	12.7	2	1.7	26	22.0	13	11.0	31	26.3	7	5.9	0	0.0	118	100
S19	Languages - English First Additional Language	Gr 10	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Gr 11	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Gr12	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Total	18	30.0	18	30.0	12	20.0	0	0.0	0	0.0	0	0.0	0	0.0	12	20.0	60	100
S20	Languages - English Home Language	Gr 10	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Gr 11	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Gr12	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Total	18	30.0	18	30.0	12	20.0	0	0.0	0	0.0	0	0.0	0	0.0	12	20.0	60	100
S21	Languages - English Second Additional Language	Gr 10	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Gr 11	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Gr12	6	30.0	6	30.0	4	20.0	0	0.0	0	0.0	0	0.0	0	0.0	4	20.0	20	100
		Total	18	30.0	18	30.0	12	20.0	0	0.0	0	0.0	0	0.0	0	0.0	12	20.0	60	100
S22	Life Orientation	Gr 10	2	50.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr 11	5	55.6	4	44.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	100
		Gr12	5	50.0	5	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	100
		Total	12	52.2	11	47.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	23	100
S23	Life Sciences	Gr 10	3	75.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	100
		Gr 11	5	71.4	2	28.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	100
		Gr12	6	75.0	2	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8	100
		Total	14	73.7	5	26.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	19	100

			ICTRs according to application types																	
			AT5		AT9		AT10		AT11		AT13		AT14		AT15		AT16		Total	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
S24	Mathematical Literacy	Gr 10	6	60.0	1	10.0	0	0.0	3	30.0	0	0.0	0	0.0	0	0.0	0	0.0	10	100
		Gr 11	7	63.6	1	9.1	0	0.0	3	27.3	0	0.0	0	0.0	0	0.0	0	0.0	11	100
		Gr12	7	63.6	1	9.1	0	0.0	3	27.3	0	0.0	0	0.0	0	0.0	0	0.0	11	100
		Total	20	62.5	3	9.4	0	0.0	9	28.1	0	0.0	0	0.0	0	0.0	0	0.0	32	100
S25	Mathematics	Gr 10	11	44.0	2	8.0	0	0.0	12	48.0	0	0.0	0	0.0	0	0.0	0	0.0	25	100
		Gr 11	10	41.7	2	8.3	0	0.0	12	50.0	0	0.0	0	0.0	0	0.0	0	0.0	24	100
		Gr12	8	42.1	2	10.5	0	0.0	9	47.4	0	0.0	0	0.0	0	0.0	0	0.0	19	100
		Total	29	42.6	6	8.8	0	0.0	33	48.5	0	0.0	0	0.0	0	0.0	0	0.0	68	100
S26	Mechanical Technology	Gr 10	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Gr 11	2	50.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0	4	100
		Gr12	3	60.0	1	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	20.0	5	100
		Total	7	53.8	3	23.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	23.1	13	100
S27	Music	Gr 10	2	25.0	2	25.0	0	0.0	3	37.5	0	0.0	0	0.0	0	0.0	1	12.5	8	100
		Gr 11	3	27.3	3	27.3	0	0.0	3	27.3	0	0.0	0	0.0	0	0.0	2	18.2	11	100
		Gr12	1	14.3	2	28.6	0	0.0	3	42.9	0	0.0	0	0.0	0	0.0	1	14.3	7	100
		Total	6	23.1	7	26.9	0	0.0	9	34.6	0	0.0	0	0.0	0	0.0	4	15.4	26	100
S28	Physical Science	Gr 10	3	60.0	1	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	20.0	5	100
		Gr 11	4	57.1	2	28.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	14.3	7	100
		Gr12	6	54.5	4	36.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	9.1	11	100
		Total	13	56.5	7	30.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	13.0	23	100
S29	Religion Studies	Gr 10	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Gr 11	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	100
		Gr12	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	100
		Total	8	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8	100
S30	Tourism	Gr 10	3	30.0	5	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	20.0	10	100
		Gr 11	6	54.5	4	36.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	9.1	11	100
		Gr12	8	50.0	6	37.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	12.5	16	100
		Total	17	45.9	15	40.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	13.5	37	100
S31	Visual Arts	Gr 10	4	33.3	3	25.0	0	0.0	4	33.3	0	0.0	0	0.0	0	0.0	1	8.3	12	100
		Gr 11	5	38.5	3	23.1	0	0.0	4	30.8	0	0.0	0	0.0	0	0.0	1	7.7	13	100
		Gr12	5	41.7	3	25.0	0	0.0	3	25.0	0	0.0	0	0.0	0	0.0	1	8.3	12	100
		Total	14	37.8	9	24.3	0	0.0	11	29.7	0	0.0	0	0.0	0	0.0	3	8.1	37	100