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Master of Education – Research Report

How are Science Teachers Integrating Information and Communication Technologies into their teaching?

A Study of a South African and a British School



Research report submitted to the School of Education,
Faculty of the Humanities,
University of the Witwatersrand, Johannesburg,
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for the degree of Masters in Education
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Supervisor: Dr Donovan Lawrence

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ABSTRACT

In this study the teaching methodologies or pedagogy implemented by Science teachers pertaining to ICT integration in two independent schools, where technology resources is ample was explored. One being in Johannesburg, South Africa and referred to in this report as 'The South African School' and the other being in England, the United Kingdom and referred to in this report as 'The England School'. Through the means of lesson observations, a questionnaire and informal conversational interviews with the Science teachers, in a small scale, qualitative study, the data was analysed for possible trends. It was discovered that all ten participant teachers are skilled in the technical use of ICT but not in the pedagogical use of ICT. Teachers are mainly using ICT to enhance their existing traditional pedagogy, and not in the true sense of ICT use for collaboration and project based learning in line with a constructivist learning theory. The two groups of teachers were found to have contrasting barriers i.e. the South African teachers have time to implement ICTs, but the main reason for not implementing ICTs as much as they would like to are due to inadequate equipment in terms of an unreliable internet connection and lack of support. The England teachers, who have no barriers imposing on their use of ICT, have no time in their busy schedules to plan lessons with ICT integration. Conclusions are drawn as to how the Science teachers integrate ICT into their teaching and recommendations are proposed as to how these teachers can be assisted to overcome these hurdles in order to promote a more effective ICT experience. In this report, it is suggested that implementing an intranet into their pedagogy shall prove to be effective in teaching Science. This is a 'virtual learning environment' (VLE) which provides a platform on which collaboration in various ways can take place. It is a set of tools that enable teachers, learners and schools to raise standards through collaboration and communication which is the key to successful ICT integration and implementation.

DECLARATION

I, Sofiah Essop, know and accept that plagiarism (i.e., to use another's work and to pretend that it is one's own) is wrong. Consequently, I declare that

- The following report is my own work.
- I have correctly acknowledged all direct quotations **and** paraphrased ideas. **In addition** I have provided a complete, alphabetized reference list, as required by the APA method of referencing (described in the student handbook).
- I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I failed to acknowledge the source of the ideas or words in my writing.
- This project is being submitted to the University of the Witwatersrand, Johannesburg, for the degree of *Master of Education*. It has not been submitted before for any degree or exam at any other university.

Sofiah Essop _____

Name of candidate Signature of candidate

20th day of August 2013

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[1] School name has been changed due to ethical reasons

[2] School name has been changed due to ethical reasons

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ABBREVIATIONS & DEFINITIONS

BECTA British Educational Communications and Technology Agency

Blog An online place where a blogger can write about their lives, and their personal stories which are compelling and bring return visitors. However, bloggers also discuss politics, media, government, and technology and some have distinguished themselves as a force for honesty and polital action.

CAI Computer Aided Instruction

DfEE Department for Employment and Education (in the UK)

ICT Information and Communication Technology

Web 1.0 Online tools to find information and use it (with proper citations) to write reports using a Word Processor or Powerpoint. No interactions with the text based information. Known as the 'read only web'.

Web 2.0 Online tools that allow for interactivity with content. People can also create and share their own content in real time. Others are social in nature and promote self expression, such as community networks, blogs, wikis, and photo and video sharing sites.

Wiki Wikis allow readers to collaborate with others in writing it and adding, editing and changing the Web page's content at any time. Its ease of use makes a Wiki an effective tool for collaborative authoring. (The most well known wiki is Wikipedia).

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CHAPTER 1 - INTRODUCTION

Information, Communication and Technology deals with information literacy, or the ability to participate in the information society with the ability to access, evaluate and create knowledge. This is a research project based on analysing the pedagogy implemented by Science teachers through their integration of ICT for Science teaching. It has been conducted in two independent schools, one being in South Africa and one being in England. Both schools are adequately resourced in terms of technology. I critically examined aspects of computer based learning and established why it is used in Science education. Importantly, the aim of the study is to investigate how (pedagogy) ICTs are being implemented and integrated by Science teachers. Pedagogy refers to the method and practice of teaching. I also established why Science teachers are not implementing a particular tool or tools in their lessons. Are the reasons for using ICT in Science teaching the same or different within the two schools? The factors influencing the use of ICT in Science teaching have been compared.

It is important to clarify going forth that the term 'Science' is used to encapsulate all the Sciences taught at high school level i.e. Natural Science, Life Science and Physical Science.

1.1 Background

E-Learning is learning supported by digital electronic tools and media. Web-based learning entails utilising the internet and internet resources for teaching and learning. When compared to for example CD-ROM learning which is a pre-loaded learning program onto a CD, the benefit of Web-based learning stems from the fact that access to the content is easy and requires no distribution of physical materials.

Computer technology can be used to support the teaching and learning processes. People involved in education are taking advantage of the emergence of computer technology. Nowadays, we have several approaches as to how computer technology can be used in education such as by using CD-ROM and or web-based learning and even mobile learning which is learning that occurs when the learner is not at a fixed location and utilises portable technologies for example mobile phones. The most popular according to Hargis (2000) is web-based learning. There are many reasons why educators are using the internet in education. Some of the reasons include a higher fairness of access whereby schools are equipped with enough computers with internet for all learners. There

is an infinite resource in terms of the World Wide Web and if learners are taught to use these resources wisely, it will be beneficial for them. Learners are also then active or dynamic participants in their own learning whereby they can use the internet to research about a specific subject taught in the Science class. There is also the motivational influence of authentic learning activities whereby learners become deeply involved in solving a real world problem. Learner's inquiry and cooperative learning is also enhanced in this way as each learner has a specific role and duty to fulfil in order to provide a solution for the whole group (Hargis, 2000).

This research is positioned within the already large empirical knowledge base of ICT use in education, and came about because of my personal interest and experience in Science education and my passion for ICT implementation and integration. However, this research aims to fill a gap in the research on the actual pedagogy implemented by teachers in ICT integration in the Science classroom. To provide clarity, there is a need to describe and understand the teaching methods that Science teachers are utilising in terms of technology use in order to teach Science; and the reasons for their specific methods.

1.2 Rationale for the Study

The experiences of Science teachers' uses of ICT in contexts where resources are unlimited are valuable to inform the current and developing knowledge base in this area of research. How and why Science teachers use ICT may assist in filling some of the gaps in knowledge which relate specifically to the Science classroom. In addition to contributing to the knowledge base in this area of research, understanding the value that this use of ICT offers to Science teaching and learning will allow me to make a significant contribution to pedagogic implications surrounding ICT implementation and integration in my school of employment. It is important to understand the links between the complex issues faced by teachers which determine how they are able to use ICTs when teaching. These complex issues include factors like time constraints that teachers face and lack of support for ICT implementation.

An important element for the rationale of this study is that 'The South African School' and 'The England School' are more or less equally resourced, but situated in a developing and developed country leads to the notion and expectation that the way they use ICT, the reasons for ICT use and the specific ICT experiences will differ. This is because people have a perception that an

independent school in a developed country will utilise more ICTs and in a sophisticated manner as compared to an independent school in a developing country.

1.3 Aim of the Research

In this study I aim to investigate the manner in which the Science teachers in an independent school in South Africa and an independent school in England utilise ICT for Science teaching. The reason for choosing these two schools in two different countries is because England is thought to be far more advanced than South Africa in terms of being a developed country. Science education begins in school and hence this study will provide an understanding into what goes on in the Science classroom in terms of technology integration in two independent high schools that are approximately equally resourced. Specifically the pedagogy, the methods and practice of teaching was examined.

1.4 Research Problem

South African Science teachers support the call for a technological orientated curriculum. Very little is being done to achieve this goal in most classrooms. Without the whole hearted cooperation of teachers, classroom practices are unlikely to change. It goes without saying that if the changes are radical, new and unfamiliar to the teachers then they need support in trying to implement them. Efforts from tertiary educators to provide teachers with assistance by means of courses are doomed to failure if they merely transmit to the teachers the advisors suggested ‘recipe for success’ using a ‘tips for teachers’ approach. No matter how enthusiastically teachers receive such advice they seldom return to their classrooms and practise it. This has been evident from my own teaching practice.

It is vital that teachers plan and develop innovative classroom activities to use in their teaching, that they become self sufficient in coping with and planning for change, because such self initiated activities are more likely to be implemented in the classroom than are ideas passed on to teachers by a third party.

1.5 Research Questions

Current thinking about ICT in education suggests that while traditionally important pedagogical practices are still dominant in Science education, ICTs contributes to innovative pedagogical practices (Voogt, 2009). More effective teaching and learning would require a move away from a predominantly teacher-centred and lecture style pedagogy to a more learner-centred and activity-based pedagogy in line with current thinking about how children learn. More efficient teaching and learning would require better curriculum coverage through access to high quality digital learning materials and more enjoyable teaching and learning would require an increase in learner participation in Science lessons.

The main research question is *how are Science teachers' integrating ICTs into their teaching?*
As a way of ascertaining that ICTs adds to teaching and learning in a South African classroom and an England classroom, the main research question was operationalised by various sub questions. The diagram below provides the main and sub-questions of this research.

How are Science teachers' integrating ICTs into their teaching?

***Which* tools are being used?**

***When* are ICT tools used?**
The frequency of ICT use will be observed here.

***Why* use ICT?**
Here the teachers' reasons for integrating ICTs in their lessons were investigated. Their preferences of ICT tools and the reasons for using particular tools were examined.

***How* are the tools being used?**
The factors that enable ICT use as well as the barriers of acceptance of ICTs as a teaching tool were examined.

Figure 1. *The main question and sub-questions pertaining to the overall research question i.e. how are Science teachers integrating ICTs into their teaching?*

In my analysis I identified patterns or trends of similarities or differences in the data in the integration of ICT.

1.6 Scope of the Research

This research takes place in an independent high school in Johannesburg, South Africa to an independent high school in England, The United Kingdom. It will focus only in the Science department of both schools and the teachers are the only focus. Both schools have a wealth of ICT resources. The schools have been chosen in this way, as this research does not investigate the impact of the presence of ICT in the Science classroom. It aims to investigate the pedagogy implemented by the Science teachers in terms of ICT use and hence there are already adequate forms of ICT present i.e. computers with internet, i-pads, data projectors, smart phones and smart boards. The research has been conducted over a two week period in both schools i.e. July in South Africa and December in England. The exact same research methods have been utilised in both schools in order for the investigation to be fair and to achieve a fair comparison. There are no learners included in this study; however, the teacher perceptions of learner attitudes are included in the questionnaire.

1.7 Research Methods

The approach of this study is a small scale qualitative study. The methods utilised include lesson observations, informal conversational interviews and a questionnaire. The reasons for choosing these methods are due to the ease it allowed for the data collection. Teachers are exceptionally busy and these methods allowed for the least possible disruption of lessons. The specific techniques and the reasons thereof are detailed in chapter 3 of this report.

In this introductory chapter, an introduction and background of the scope of the research have been provided. The research problems as well as secondary research questions have been posed. The significance of this study has been discussed in the form of a rationale. The subsequent chapter is a literature review in which detailed analysis of the current trends and debates in the field are discussed. To finalise this chapter, the possible barriers that teachers may face when accessing ICTs has been discussed.

CHAPTER 2 - LITERATURE REVIEW

This chapter begins by defining the concept ICT as it is used in this study, and then discusses technologies as used in education from a perspective of the Science classroom. It also examines some of the current and emerging technologies used in education, reviewing the literature on the role of ICT in Science education. The chapter looks at current empirical research into the obstacles teachers face in the use of ICT. Lastly the theoretical framework underpinning this study is examined i.e. Gardner's theory of multiple intelligences, Vygotsky's theory of Constructivism, and Siemens theory of Connectivism. The purpose of this chapter is to provide an in-depth review of literature relevant to the above.

2.1 Introduction

It is important to provide a clear description and definition of ICT. Web 2.0 is all about free new tools such as blogs, wikis, photo and video sharing, and social networking that people are talking about and that many are using already. What do they mean for education? These tools are changing how people, including our learners, interact with the world. The changing nature of information and the new ways our learners understand and make sense of the world signal that we need new strategies and new tools for teaching and learning. The challenges of this century require that learners be adaptable and analytical, and that they have the skills to identify and use the best tools in a rapidly changing environment. In spite of all the hype, technology has not yet changed schools very much. With Web 1.0 learners could find information online and use it (with proper citations) to write reports using a word processor or PowerPoint. They could show their work to peers in class and parents at home and store it in portfolios. Now they can write directly in a blog and get immediate feedback from peers and others who could be anywhere in the world. They can collaborate with peers near and far online. Evidently there is a need for teachers to harness new tools for learners. We live in a wired, globalised world in which communication and collaboration are possible at any moment in time. So what does this mean for teaching and learning? As educational leaders, we should understand changes in technology and how they reflect changes in the world around us.

Research on implementation of ICT in schools now seems to have moved from a strong technology-based focus e.g. on registering number of computers and amount of time spent using ICT in schools, towards a focus on **how** technology best can be exploited to promote learning. A review of studies conducted in a range of subjects in primary and secondary education showed a strong relationship between ways in which ICT was used and attainment outcomes (Cox & Marshall, 2007), suggesting that the crucial component in the use of ICT in learning and teaching is **the teacher and his/her pedagogical approaches**. Cox *et al.*, (2007) argue that the most effective uses of ICT are those in which the teacher and the software can challenge learners understanding and thinking, either through whole-class discussions, using an interactive whiteboard or through individual or paired work on a computer. Both whole class and individual work can be equally effective if the teacher has the skills to organise and stimulate the ICT-based activity. I believe that teachers need a range of examples on how to effectively utilise ICT in their teaching and this research aims to investigate some the currents trends in ICT integration in the Science classroom.

2.2 History of Information and Communication Technology (ICT) in Science Education

According to Murdock (2004) the history of technology in the classroom dates back to 1951 when television was used in the United States primary schools. In 1958, the National Defence Education Act of the U.S brought some new technology into schools, but primarily in vocational education. The 1960's saw some growth in the usage of technology in the classroom in the United States as more money was being set aside for that purpose. For example, in 1963 the Vocational Education Act was passed with more money supporting the use of technology in schools. With the manufacture of the first personal computers by International Business Machines (IBM) in the 1980's, drill and practice, computer-assisted instruction (CAI) gained acceptance in schools; and the first educational drill and practice programs were then developed for personal computers. The 1990's saw the development of multimedia PCs and simulations, educational databases and other types of CAI programs being produced on CD-ROM disks, many with animation and sound (Murdock, 2004). There was proliferation of web pages as the Internet and the World Wide Web began to gain ground. Many schools in the U.S started introducing graphics and multimedia tools for the delivery of information and instruction using the Internet. During this time more educational software were being packaged in CDs and DVDs (Murdock, 2004).

There is little available in the literature about the history and development of computers in the classroom in Africa. South Africa witnessed an increase in the use of technology in the classroom following the government's White Paper in 2004 titled 'Transforming learning and teaching through information and communication technologies'. The Department of Education set a framework for the collaboration of government and the private sector in the provision of ICTs in education through the white paper (Department of Education, 2004). The Department of Education believes that ICTs have the potential to improve the quality of education and training due to its high access of fairness, but it does not take into account the mindset of the teachers and their existing teaching practices.

2.3 Overview of ICT tools

According to Prensky (2003), learners need to feel motivated in order to learn. "A motivated learner cannot be stopped", he says. Ghani, Hamim & Ishak (2007) adds that one of the most difficult subjects to learn and understand is Science. Prensky (2003) says that learners are highly stimulated but educators are not equipped with the motivational skills that learners need.

Computer games

According to Prensky (2003), learners have an interest in **computer games**. Learners are fully engaged and attentive while playing a computer game. Computer games allow for goal seeking and reaching and learners are determined to accomplish the goal of the game. This attitude needs to be harnessed towards school work. Teachers need to utilise teaching methods that allow their learners to be interested, competitive, cooperative, results orientated and actively seeking information and solutions. 'Digital game based learning' is the answer according to Prensky. There is a need to merge the content of learning and the motivation of computer games in order for children to learn.

Siemens (2004) agrees with Prensky (2003) that children today are growing up immersed in digital technology. The 'short attention span' criticism of teachers is a foregone analysis because children can focus on computer games, which they find more interesting for multi-hour bursts, so surely if their lessons were interesting they would be able to focus on it just as easily. Also, it is not just boys, but girls, as well as learners from diversified ethnic and social backgrounds who are

increasingly attracted to computer games. Evidently this form of motivation needs to be harnessed for better use.

Some of the advantages of digital games based learning as reported by Prensky (2003) are that children can now spread their attention over a wide and varying range of events. Their multi-tasking and parallel processing skills are heightened. Children are better at taking in information and applying it to make a decision quickly. Computer games provide learning opportunities which allow learners to want to learn and discover new things. They are capable of understanding multimedia, have better reading skills and learning by 'connectivism[3]' which is collaborating over networks (Siemens, 2004).

Computer based learning

In San Diego in the United States (U.S), a 2 year, $2, 24 million dollar project was implemented called "Enhancing Science education through technology". (San Diego Unified School District, 2006). The aim was to integrate technology into grade 7 and 8 Science classrooms[4]. The goal was to expand learner engagement with each other in terms of the current Science topic and learning opportunities, which computer based learning offers. A program was implemented which was based on scientific inquiry which is an important aspect of the subject. Teachers incorporated the use of technology into educational activities with the aim of simulating the way that a scientist would use technology in his or her work. By technology, computer based learning is at the fore front. The project proved to be successful and the schools continued to implement Science enhancement activities through the project.

According to Ghani *et al.,* (2007), computer aided and web based learning, are used by schools around the world. The reasons for computer based learning being the popular choice is due to a high fairness of access whereby schools are fully equipped with computers with internet for all learners to use. There is also an infinite resource of information available on the World Wide Web and if learners are taught how to use these resources wisely, it can be beneficial to them. Learners also then become active and dynamic participants in their own learning because they have access

[3] George Siemens, who is considered as the precursor of Connectivism defines his theory as a learning theory for the digital age (Siemens, 2004). It is based on the premise that knowledge exists in the world rather than simply in the head of an individual.

[4] General Education and Training Certificate phase in South Africa (GETC).

to computers which results in them exploring various content online. The motivational influence of authentic learning activities results in learners becoming involved in their work and working hard to accomplish a given task. Learner enquiry skills and cooperative learning is automatically achieved when learners have to participate in authentic learning activities whereby each learner has a specific role and duty to fulfil for the sake of the entire group and the problem being solved. Inquiry-based learning is a learning process through questions generated from the interests, curiosities, and perspectives or experiences of the learner. When investigations grow from our own questions, curiosities, and experiences, learning is a motivating process that is intrinsically enjoyable. Cooperative learning involves structuring classes around small groups that work together in such a way that each group member's success is dependent on the group's success.

In Science education in particular, computers can be used to acquire and display experimental data, to analyse video-taped phenomena digitally or to even mathematically model systems. Many natural phenomena can be explained by teachers using computers, or experiments can be shown that cannot be set out in the confines of a high school laboratory.

Ghani *e*t *al.,* (2007), in accordance with Prensky (2003) agree that computers motivate learners. Not only can computers enhance, extend and reinforce their learning in Science, but it also helps to challenge learners and help them to apply Science in their real life which is an important learning outcome[5] stipulated in the national curriculum statement of South Africa.

A study was conducted in Malaysia in 2007 whereby the efficiency and effectiveness of web based learning was examined in Science education. Just as in South Africa, children learn Science in primary school and then go on to learn specialisations such as Biology, Physics and Chemistry in secondary school. In Malaysia Science is considered difficult. This is a perception among South African schools as well. According to Ghani *et al.,* (2007) some of the reasons that attribute to this attitude / perception are,

> "The major factors as to why students do not like Science is that teachers use an outdated learning method. Teachers are used to a traditional method of teaching: giving information and students receive information. It is one way communication".
>
> (Ghani, Hamim & Ishak, 2007, Pg 2)

[5] Learning Outcome 3: Science, society and the environment

At this point researchers (Ghani *et al.,* 2007, Prensky, 2003 and Siemens, 2004) have established that computer based learning is the way forward. But we also know that there are some great conventional approaches to teaching Science. Other than the fact that many learners are bored and demotivated to learn Science, what is it about conventional approaches that are resulting in web based approaches being the popular choice for learners?

In previous years, teachers explain the content by using an experiment in labs. Science labs were built to provide an appropriate learning environment for students, location of resources as well as other environmental aspects such as lighting and temperature. Normally, teachers would explain concepts in the classroom and then, learners would attend the lab session to conduct the experiments themselves. This is referring to the transferral of the factual information between teacher and learners. For this conventional education, learners depend on teachers.

But, today, technology has gained status in education because of its prevalence; its promise to provide low cost education; it may help some people to participate more easily, to learn more effectively, and to enjoy learning (Palmieri, 1997). In a web-based approach, the internet provides students with a choice of how, when, and where they want to participate in the learning experience. It can lead to learners focusing on tasks for longer periods; content previously found boring is now more interesting, learners are more eager to participate in and contribute to discussions and ask more questions. Kruse, (2004) stated that web-based education yields additional benefits, among them:

> "Access is available anytime, anywhere, around the globe. Students always have access to a potentially educational web-site anytime, anywhere as long as they have a computer with an internet connection.
>
> Content is easily updated. This is perhaps the single biggest benefit to web-based learning".
>
> (Kruse, 2004, Pg 1)

In Malaysia, in order to attract students to Science, the government introduced what they called "E-tuition" (Ghani *et al.,* 2007). The focus of this was to change the style of the conventional 'boring' lesson to an exciting style of delivering Science content. This was designed with the aim of taking advantage of the use of technology in Science education. E-tuition is a web based e-learning system designed to assist everyone involved, this includes teachers, learners and parents,

and to enhance their active involvement in Science. It was also designed with the hope of attracting learners to this otherwise exciting subject, by providing an efficient way of teaching it.

Computer simulation and Laboratory activities

Laboratory activities can increase the interest and the abilities of the learners for Science. Although the laboratory has a very important place in Science education, it has some limits and problems about its use. The main problems according to Tamir (1978) are as follows:

- The laboratory activities are expensive as they are carried out and arranged with equipment.
- It takes too much planning time for the teachers to apply it.
- Checking the learners as a large class becomes difficult.

In the cases where the laboratory study is not done to the extent that it is desired to be, technological devices like models used in the process of education instruction can be utilised.

Computer simulation is a popular choice for experiments that cannot be conducted due to the confines of a high school laboratory, as suggested by De Jong (1991). In one way or another, simulations of real-time environments have been used as a tool for teaching in many areas and disciplines. This has been the case especially where pedagogical practice in real time environments carries too high a risk. Simulations are the transfers of the events with specific limitations in daily life to the computer medium. Computer based learning is the closest one to the laboratory medium and offers learner interaction. Simulations help the learners to form their own cognitive models about events and processes. Simulations also offer opportunities for easily observing the events that occur too slowly or too fast in the lab. Experiments that are very dangerous and expensive to perform can be done by simulation instead.

Computer based learning by way of simulation programs makes the concepts and processes more concrete and helps the learners to understand more easily the relationship between them and as a result of this, more permanent and valuable learning is achieved.

In Science, a huge amount of the subject matter is the practical aspect or conducting of experiments in a laboratory. Bayrak, Kanli & Ingec, (2007), in their paper stress the importance of having laboratory sessions in Science education. They compared the effects of computer based

learning and laboratory based learning. They conducted their investigations on grade 9 students based on the topic of 'Electric Circuits'.

At the end of their study a significant difference was not determined between the effect of lab based learning on student success and the effect of computer simulation based learning. Thus, as a result of research for the learner's academic success it can be said that computer simulation based physics learning is as effective as lab based physics learning.

> "The physics software simulations having the necessary qualities about electrical circuits offer an opportunity for the students to study at a virtual environment and increase the academic successes of the students as if they studied at a real lab environment".
>
> (Bayrak, Kanli & Ingec,, 2007, Pg. 20)

Computer based testing

If teachers want to keep up with the fast paced nature of computer based learning, computer based testing should be carried out. Here the responses are electronically recorded, assessed, or both. Computer based testing is particularly well suited to tests consisting of multiple-choice questions, which can be assessed automatically thus reducing labour and costs. It enables teachers to author, deliver, and report on surveys, quizzes, tests and exams. The internet provides many opportunities for learning, and assessment can be done online with automatic marking that reduces the amount of time that the teacher spends marking. The design of the assessment may take longer, but if the task is used in years to come, then it saves teachers time in the long run.

Online discussion forum

An online discussion forum is a site where people can hold conversations in the form of posted messages. It can be subject specific which makes it a focused discussion. One of the biggest complaints from parents and learners is the lack of communication from teachers. A 'user discussion forum' is a shared space on the Web. The discussion forums provide a common 'meeting' place for learners to contribute information. Content is presented as a collection of threaded messages. The threaded presentation puts messages on the same topic together and indicates response messages with indentation, allowing readers to follow discussions topic by topic. Of course there are dangers that come to mind especially when dealing with teenagers as

personal attacks etc. may be made on a public space and this needs to be dealt with in a manner as it would be dealt with if it had to occur on the playground.

Field trips

According to Falk & Dierking (1997), field trips are often the activities that students remember best, long after the course is finished. A study on the impact of school field trips established that, even after years had elapsed, nearly 100% of the individuals could relate at least one thing they learned during a school field trip, and most could relate three or more things. Many scientists were inspired to study Science by the field trips they took with secondary school classes. Thus the trip becomes an opportunity to connect the question-asking to the question-answering, exposing the process of 'doing Science' as not just learning scientific facts. On the other hand, Kisiel (2005) says that although teachers may report that a primary reason for including the field trip experience is to support what they are teaching in class, studies suggest that this curriculum connection is sometimes quite weak. To complicate matters, high school teachers are apprehensive about taking their learners outside of the school building. The concern often relates to control, not curriculum. Once again, computer based learning in the form of virtual field trips could solve many of the problems faced by Science teachers today. A virtual field trip is a guided exploration through the World Wide Web that organises a collection of pre-screened, thematically based web pages into a structured online learning experience (Foley, 2003). It is an inter-related collection of images, supporting text and/or other media, delivered electronically via the World Wide Web, in a format that can be professionally presented to relate the essence of a visit to a time or place. The virtual experience becomes a unique part of the participants' life experience.

While there is no significant research into the use virtual field trips, Stansbury (2013), offers an online article titled 'Ten of the Best Virtual Field Trips'. It has been well received by teachers as documented in the comments on the website.

Social networking sites

Social networking sites have great educational value if used correctly. This is a web site that enables users to create public profiles within that web site and form relationships with other users of the same web site who access their profile. Social networking sites can be used to describe community-based web sites, online discussions forums, and other social spaces online.

A group can be formed that allows learners and teachers to interact with scientific content. It also creates a record of threaded messages so learners can refer back to a particular conversation if need be. Also, it allows the teacher who sets up the page to upload pictures relevant to the Science topic at hand and, it allows for learners to get to know one another better. More so for the quieter learners who tend not to interact as much in class. While there is no significant research into the use of this tool in Science education, there have been developments of web sites specifically created for school learners (Malinson, 2011). 'Obami' as described and created by Malinson is a social learning network that provides a communication and learning platform for teachers, learners and their parents. It combines networking tools with comprehensive learning management tools, all from within a safe environment – it is intended in large part for children.

2.4 Literature that do not support the effectiveness of ICT

There is still debate on the question of whether ICT has made significant impact or not on learners' achievement. Many research findings (Prensky, 2003; Ghani *et al*., 2007; Hargis, 2000; Kozma, 2003) report that there is significant impact while other studies (Oppenheimer, 1997; Voogt, 2009) show that ICT does not have much significant impact on students' achievement in Science. This disparity may be due to assumptions that many research studies make and the degree of reliability and validity of some of the research methods used (Cox & Marshall, 2007). Though many research work claim that ICT is effective in the teaching and learning of Science concepts, the work cited below did not find any significant difference between students taught with Computer Aided Instruction (CAI) (experimental group) and those who used the traditional method of instruction (control group). Hsu & Thomas, (2002) conducted research on 117 students divided into three groups (with-log group, the without-log group and the control group) and reported that there were no significant differences on post-test scores of the three groups. They found that the follow-up interview reveals that although there were no significant differences in achievement levels, the students in the experimental group report that the simulation used supported their learning because they could complete the given exercises on time.

Bayrak *et al.,* (2007), stress the importance of having laboratory sessions in Science education. They compared the effects of computer based learning and laboratory based learning. They conducted their investigations on grade 9 students based on the topic of 'Electric Circuits'. At the end of their study a significant difference was not determined between the effect of lab based learning on student success and the effect of computer simulation based learning.

2.5 Obstacles to the use of technology in teaching

This section is included in the literature review because of one of the research questions which examines the factors that impede the use of technology in teaching even though various research suggests that implementing ICT is effective in teaching. Information and Communication Technology (ICT) play a very important role in teaching but they have not been effectively incorporated into teaching in South Africa as a result of the following factors identified in the literature. The aim is to see if the outcome of this study will be consistent with these factors.

1. *Teachers' perceptions*[6] *about the significance of computers*: some teachers do not see computers and technology to be of any significant use or having any significant impact on learning and therefore do not see the need to incorporate them into their instruction. BECTA[7] ICT Research (2003) also identified this barrier to the use of ICT in their review of what research says about barriers to the use of ICT in teaching.

2. *Teachers' attitudes*[8]: teachers' attitudes to the use of technology can be obstacles because if a teacher does not have a positive attitude to the use of ICT, he is not encouraged or disposed to using it in his teaching and does not spend the necessary time required in incorporating it into his teaching. Fabry & Higgs, (1997) classified attitudes into three groups: self-confidence with ICT, perceived relevance of ICT, and innovativeness. Closely related to the teachers' attitudes is their resistance to change. Many teachers do not want to leave their comfort zone. If the Science teachers in this study are not adequately trained, then this could result in a negative attitude. However, attaining training is a personal decision.

Fabry *et al.*, (1997) identified resistance to change as one of the obstacles to technology usage in instruction. Some teachers are not easily adaptable to change because they simply want to continue with their traditional or 'long-standing pedagogical methods' of teaching even when it is generally perceived and reported in literature that ICT has significant impact on learning. Teachers do not know what the change holds for them so they simply stick to their traditional methods of

[6] Perceptions: This is something one can change and develop. It includes senses, feelings, ideas, thoughts and theories. It is the ability to understand the difference between concepts.

[7] British Educational Communications and Technology Agency

[8] Attitudes: This is a learned tendency to evaluate things in a certain way. This can include evaluations of people, issues, objects or events. Such evaluations are often positive or negative, but they can also be uncertain at times.

teaching. BECTA ICT Research (2003) identified factors such as fear of embarrassment when using computers and fear of losing professional status which may cause anxiety and stress for the teacher when using technology.

3. *Teachers' training*: teachers do not have the requisite training to be able to use technology in their classroom. BECTA ICT Research (2003) identified time and training as major obstacles to technology usage in instruction. Many pre-service teacher training courses do not prepare teachers to incorporate technology in their teaching. If the Science teachers in this study do not have adequate training in the use of technology they might find it difficult to commit any more time to doing personal training and for preparing ICT resources for lessons.

4. *Cost*: a major obstacle to the use of technology in instruction is the cost involved in procuring the technology – hardware, software, installation, services, etc. Maintenance involved in the technology is also an issue here. Only a few schools (especially in Africa) can afford the technology compared to the Western and Asian countries. For example, Oppenheimer (1997) reported that New Jersey spent $10 million on classroom computers. Not many school districts or education departments can afford such a budget on computers alone. This factor results in a shortage of equipment. The Science teachers in this study teach in independent schools whereby, if a justification for a certain technology is provided to management, the chances of acquiring it are high.

5. *Choice of technology*: there are so many technologies available, especially software, that teachers find it difficult to choose the one that is appropriate for their classroom. As noted above, the time required making choices between available technologies and adapting this technology to their instruction is enormous. The time to do this, many teachers claim, is not available. Fabry *et al.*, (1997) reported that teachers ranked time among the barriers inhibiting the integration of computers to teaching. The Science teachers in this study are also extremely busy people. Meeting the demands of an independent school can be challenging.

6. *Access to computers*: Fabry *et al*., (1997) reported that Apple Computers started a project called Apple Classrooms of Tomorrow as far back as 1985. In spite of this, access to computers is still an issue. Fabry *et al*., (1997) noted that access involves locating the proper amount and right types of technology where teachers and students can effectively use them. If teachers have access to the internet and other resources within and outside the school then they may be able to locate relevant

materials for teaching. Also, some of the technology resources that are accessible are not appropriate for use in the classroom. The two schools in this study are adequately resourced with computers and internet.

7. *Learners' technology skill*: the learners' technology skill could also constitute an obstacle. Many learners especially in the rural areas and disadvantaged schools do not possess the necessary skills to use technology therefore the teacher needs to train them in using the technology before actually using it for the lesson. The learners's in the participating schools are exposed to technology and have access to it. The majority are equipped with basic skills that are taught in school.

8. *Obsolete equipment*: BECTA ICT Research (2003) identified the outdated software and hardware as one of the obstacles to the use of technology in teaching. In a field that much of one's knowledge and available hardware and software resources become obsolete before you have mastered the use of the technology, then this factor is a major obstacle. It is an unpleasant experience to acquire expensive technology and later on find that it becomes obsolete after a few years.

9. *Demographics*: Literature such as Van Braak (2001) indicates that age and gender affect the rate of use of technology in instruction. It is reported here that males seem to be more involved in computing and have more favourable attitudes towards technology than females.

10. *Organisation constraints*: The organisation in which one works can affect a teacher's interest or motivation to use technology in instruction. For example, if the management shows commitment to the use of technology and encourages the teachers to integrate technology in their teaching, the teachers are likely to use technology in teaching. Van Braak (2001) notes that teachers cannot use technology if they lack training, time and support. If the organisation or management provides some form of support to the teachers such as organising training programmes, and providing the enabling environment, teachers are more likely to incorporate technology into teaching.

2.6 Old Tools vs. New Tools

Will computers 'seduce' us into using them to do things we can do more effectively with traditional teaching technologies? According to Kahn (1985), the 'romance' of computers can lead to a suspension of judgement about how useful they actually are. Traditional teaching technologies, including practical laboratory work, demonstrations, worksheets, slides, films, audio and video tapes, exposition with chalk and board and class discussions, have all been refined by generations of teachers into effective ways of teaching the content and skills defined by the various Science curricula. It is not necessary likely, or desirable for computers to replace this diversity. Computers do some things that other technologies cannot do, and sometimes do the same things but in more effective ways. But there will be many occasions when using the traditional technologies will mean teaching quicker and better. The teacher has to make critical judgements about the effectiveness of different methods for teaching different items in the Science curriculum; we should not be persuaded into trying to make the computer the replacement for everything.

2.7 Theoretical framework

There are three existing theories underpinning this study. Gardner's (1987) theory of Multiple Intelligences is an applicable one and the reason being is due to it taking into account different learning styles that ICT use pertains to. Constructivism is a learning theory that allows for learners to collaborate and utilise existing knowledge in order to learn. This is in line with the definition of ICT use established earlier. Connectivism is a learning theory that allows for learners to connect using networks in order to learn and hence it is applicable to this study. These three theories are further elaborated upon below.

Gardner (1993) believes that we have **multiple intelligences**, rather than a general intelligence that underlies performance in all tasks. The use of ICT is an approach that can adhere to the different intelligences, due to the variety of lessons it allows for. It is often argued that Gardner's notion of multiple intelligences helps teachers to create more personalised and diversified instructional experiences.

> "Humans have evolved over thousands or millions of years into different kinds of problem solvers and problem finders as well, and you have to understand that process if you want to figure out how people learn and how they develop and what they can and can't do."
>
> (Gardner, 1987, Pg. 27)

He also suggests that different cultures highlight certain intelligences & minimise others. Gardner (1987) concludes that the cumulative evidence points to seven distinct intelligences. He believes these develop differently in different people due to both heredity and training. He believes that all need to be measured to provide a truly global assessment of intelligence.

A strong point of this theory is that it helps to explain the variety of individual differences in different types of mental performance. There are criticisms to the theory which include: are these intelligences or just 'abilities'? (And what is the difference?). It does not explain why some people are more intelligent than others. These 'intelligences' are not all essential for successful adaptation as theorised by Piaget (Wertsch & Tulviste, 1996). Ultimately there is not really much hard scientific evidence.

> "It is hard to teach one intelligence; what if there are seven? It is hard to enough to teach even when anything can be taught; what to do if there are distinct limits and strong constraints on human cognition and learning"?
>
> (Gardner, 1993, Pg. xxiii)

This theory has however been met with a strongly positive response from many.

According to Kornhaber (2001), the theory validates teachers' everyday experience. Learners think and learn in many different ways. It also provides teachers with a conceptual framework for organising and reflecting on curriculum, assessment and pedagogical practices. In turn, this has led many teachers to develop new approaches that might better meet the needs of the range of learners in their classrooms.

All seven intelligences are needed to live life well. Teachers, therefore, need to attend to all intelligences. As Kornhaber (2001) has noted it involves teachers opting 'for depth over breadth'. Understanding entails taking knowledge gained in one setting and using it in another.

Sternberg's (1985) 'triarchic model' have shared Gardner's dislike of such standard intelligence theory. However, in contrast to Gardner, Sternberg does not look strongly at the particular

material that the person is processing. Instead he looks to what he calls the 'componential, experiential and contextual facets' of intelligence. A further set of criticisms centre on the specific intelligences that Howard Gardner identified. For example, it can be argued that musical intelligence and bodily-kinaesthetic intelligence are better approached as talents (they do not normally need to adapt to life demands).

The theory states that all seven intelligences are needed to productively function in society. Teachers, therefore, should think of all intelligences as equally important. This is in great contrast to traditional education systems which typically place a strong emphasis on the development and use of verbal and mathematical intelligences. Thus, the Theory of Multiple Intelligences implies that teachers should recognise and teach to a broader range of talents and skills.

Lazear (1992) says that all students will come into the classroom with different sets of developed intelligences. This means that each child will have his own unique set of intellectual strengths and weaknesses. These sets determine how easy (or difficult) it is for a student to learn information when it is presented in a particular manner. This is commonly referred to as a learning style. Many learning styles can be found within one classroom. Therefore, it is impossible, as well as impractical, for a teacher to accommodate every lesson to all of the learning styles found within the classroom. Nevertheless the teacher can show learners how to use their more developed intelligences to assist in the understanding of a subject.

As the education system has stressed the importance of developing mathematical and linguistic intelligences, it often bases learner success only on the measured skills in those two intelligences. As a supporter of Gardner's Theory of Multiple Intelligences, I believe that this emphasis is unfair. Children, whose musical intelligences are highly developed, for example, may be overlooked for gifted programs or may be placed in a special education class because they do not have the required maths or language test marks. Teachers must seek to assess their learners' learning in ways which will give an accurate overview of their strengths and weaknesses.

Gardner says,

> "I also feel that the problem is not a lack of resources, either human or technological, but rather a lack of will. Nowadays, there is a tremendous pressure to treat everyone in the same way, to give them the same curricula and to subject them all to the same quick tests."
>
> (Gardner, 1987, Pg. 33-34)

While there may be some significant questions and issues around Howard Gardner's notion of Multiple Intelligences, it still has had utility in education. It helps me as a teacher to question my work and it encourages me to look beyond the narrow confines of the dominant discourses of skilling, curriculum, and testing. Most importantly for this study, it ascertains to the use of ICT as ICTs allow for a diverse array of lessons which will pertain to the Multiple Intelligences explained above. It provides for the linguistic, musical, logical- mathematical, spatial, bodily-kinaesthetic, interpersonal and intrapersonal intelligence.

Constructivism views learning as a process in which the learner actively constructs or generates new ideas or concepts based upon current and past knowledge. With a constructivist approach to learning, learners build on what they already know and what they learn. Rather than providing didactic instruction and expecting learners to repeat facts on a test, teachers encourage learners to think about what they already know about a topic, search for new information, and collaborate with others to solve realistic problems and derive new understanding.

Using Web tools helps the process along. Learners are able to do more research, find information they would never encounter without Web access, and collaborate to create a product that shows both a priori and new information are combined to become knowledge. Using Web 2.0 tools such as wikis allows learners to collaborate on creating a document that displays what they have learnt. They can illustrate with photos and videos, use an interesting presentation format, and engage the audience to think about what they have seen.

Project based learning is a constructivist approach that encourages learning in depth by allowing learners to use inquiry-based methods to engage with issues and questions that are rich, real and relevant to their lives. It emphasizes learning activities that are long-term, interdisciplinary, and learner-centred. Learners form a learning community that focuses on critical thinking. Project based learning allows for alternative approaches that address learners' individual differences, variations in learning styles, intelligences, and abilities and disabilities (linked to Gardner's theory).

Web-based tools add the ability to communicate and collaborate with the world outside the classroom easily at no cost beyond the technology. Because the Web has almost limitless information, learners need strategies to find what they are looking for. Achieving the goal of having learners learn deeply rather than broadly can happen.

Constructivism is undoubtedly a major theoretical influence in contemporary Science education. Some would say it is *the* major influence (Matthews, 2000). Constructivism is used frequently by Science teachers lately as it is used increasingly as a theoretical rationale for research and teaching. Constructivism is an epistemology, a theory used to explain how we know what we know. Knowledge is 'out there', residing in books, independent of a thinking being. Science is then conceptualized as a search for truths, a means of discovering theories, laws and principles associated with reality. Using computers entails active learning, and this change in practice will eventually foster a shift in society's beliefs toward a more constructivist view of education. In other words, computers and other technology should not be viewed as 'add ons', but as tools which are an integral part of a child's learning experience.

In a technology rich environment one must remember that the educational focus is on learning and instructional goals instead of the technology itself, because technology is merely tools or vehicles for delivering instruction. It is not what equipment is used, but **how** the equipment is used which makes it relevant to a constructivist classroom (Matusevich, 1995).

The capacity to form connections between sources of information, and thereby create useful information patterns, is required to learn in our knowledge economy. A Constructivist perspective and a **Connectivist** perspective both try to come to terms with an increasing body of knowledge, sitting at our fingertips. Both perspectives agree that the rote learning of facts is becoming less important in school and especially in Science. Constructivists believe that learners will need the skills to construct understandings of new knowledge. Connectivists believe that they will need the skills to connect with new knowledge (Siemens, 2004).

George Siemens' (2004) theory of Connectivism is an approach to learning that also considers technology as a key factor. Including technology and connection-making as learning activities begins to move learning theories into a digital age.

Siemens believes that learning and knowledge rests in diversity of opinions; learning is a process of connecting specialised nodes or information sources; the capacity to know more is more critical than what is currently known; nurturing and maintaining connections is needed to facilitate continual learning; the ability to see connections between fields, ideas, and concepts is a core skill; and decision-making is itself a learning process.

Siemens points out that using technology and making connections are linked. Combining connectivism with constructivist methods in the classroom offers learners an opportunity to gain 21st century skills. Siemens (2004) highlights the trends:

- Many learners will move into a variety of different, possibly unrelated fields over the course of their lifetime.
- Informal learning is a significant aspect of our learning experience. Formal education no longer comprises the majority of our learning. Learning now occurs in a variety of ways – through communities of practice, personal networks, and through completion of work related-tasks.
- Technology is altering our brains. The tools we use define and shape our thinking.
- The organisation and the individual are both learning organisms. Increased attention to knowledge management highlights the need for a theory that attempts to explain the link between individual and organisational learning.
- Many of the processes previously handled by learning theories (especially in cognitive information processing) can now be off-loaded to, or supported by, technology.
- Know-how and know-what are being supplemented with know-where (the understanding of where to find knowledge needed).

With this theory the role for technology is an obvious one. Computers can be used in many ways in teaching Science. Learners use computers to acquire and display experimental data, to digitally analyse videotaped phenomena, and to mathematically model systems. Teachers use computers to explain the concept of phenomena and to show experiment to students. Computers may help both, learners and teachers. Computer use can motivate learners and can enhance, extend or reinforce their learning in Science. Computers can also help teachers in demonstrating concepts, challenge learners and help them to apply Science in their daily life.

My theoretical rationale going into this research is one that emphasises the use of computer based learning in the Science classroom. Children come into high school with enthusiasm and eagerness to do and learn Science, only to lose interest quickly due to too much factual content. From my own experiences as a Science teacher in the field of Natural Science and Life Science, using computers is a necessity as children value the learning experience.

These are 21st century learners who differ from learners in the past in that they are technologically advanced in terms of computer use and we have to modify our teaching to accommodate them.

Technology needs to be kept up with if we want to develop scientists for the future or children will simply lose interest in a fascinating subject.

In this chapter, a clear definition of ICT was established. It is the use of technology for learning to occur through collaboration. The various ICT tools that can be implemented into the Science classroom were discussed i.e. computer games, computer based learning including web learning, computer simulation, computer based testing, online discussion forum, laboratory activities and virtual field trips. Literature that does not support ICT use and the obstacles to the use of ICT in teaching was examined. The chapter was concluded by providing an analysis of the theories underpinning this study. In the following chapter i.e. the research design and methodology, an analysis of the research process has been provided.

CHAPTER 3 - RESEARCH DESIGN AND METHODOLOGY

This chapter presents and justifies the research design and specific research methods chosen. The lesson observations, the teacher questionnaire and the informal conversational interviews are designed to paint the landscape of pedagogical orientations of the Science teachers. This is done as a way of understanding how the pedagogical orientation of the Science teachers influence their pedagogical use of ICT and provides the context for further data analysis.

This research is designed to answer the main question: How are Science teachers implementing and integrating ICTs into their teaching. In this chapter, I aim to provide an argument for my pragmatic approach to the research design as well as for my choice of a small scale qualitative research design. I also outline the specific research methods chosen and provide a justification for doing so. I provide an account for the data I shall gather and how that data shall be managed and analysed. Where appropriate, I shall discuss the limitations inherent in this research design and my choice of data collection strategies, as well as factors which enhance this research credibility.

3.1 Research Perspective

The research paradigm for this project is qualitative and interpretative in nature. This is because it is small scale research. There is also personal involvement on my part being a Science teacher for over 6 years. From my perspective, **teachers' pedagogies and pedagogical reasoning influence their pedagogical use of ICT.** Hence in this study, I am not interested too much on 'what' ICT are being implemented and integrated into Science classrooms, but more on 'how' are ICT being used for teaching and learning to occur. My view is that without a good understanding of how learning occurs, it would be difficult for a Science teacher or any teacher for that matter to use technology effectively to support the learning process. ICT in itself do not support learning but only when integrated into a learning environment is the full potential realised. That is my main objective, to find out how are Science teachers integrating ICT into their lessons for teaching and learning to occur and to then draw a comparison between the factors influencing ICT integration in terms of the similarities and differences. I shall examine:

The types of ICT used – this is the tools that the two schools implement which may be within web 1.0[9] and web 2.0[10] tools.
The motivation for using these tools – here I shall investigate why the teachers utilise the chosen tools.
How exactly the ICT tools are integrated into the Science content as well as the subject in terms of creating networks i.e. the social learning that takes place via online networks.
The attitudes towards ICT by the Science teachers – here I shall examine the level of willingness, enthusiasm or despondency towards ICT by the Science teachers.

3.2 Research Design

The research method I used is a small scale qualitative survey. This is useful in establishing what are the implications surrounding the implementation of computer based teaching in Science Education.

3.2.1 Why qualitative research?

This study has been conducted using qualitative research as this is an inquiry in which I collect data in a face-to-face situation by interacting with the Science teachers in their settings. Qualitative research has allowed me, the researcher to describe and analyse the Science teachers' individual and collective social actions, beliefs, thoughts and perceptions in terms of integrating ICT into their teaching. This allowed me to interpret phenomena in terms of meanings that these two particular groups of Science teachers assign to them. This qualitative research is important to me as ultimately it is hoped to lead to improvement of educational practice, illumination of social issues and action stimulus in my current school which is one of the two schools in this research.

[9] Web 1.0 is the "read-only web." The early web allowed us to search for information and read it. There was very little in the way of user interaction or content contribution. The goal for a website was to establish an online presence and make their information available to anyone at any time.

[10] Web 2.0 requires that users be able to interact with one another or contribute content.

3.2.2 The Qualitative Strategies

- **Participant observation**

> "Qualitative field observations are detailed descriptive recording, presented as field notes of events, people, actions and objects in setting."
>
> (McMillan & Schumacher, 2006, Pg. 359)

During a two week period, I observed various lessons of the participant Science teachers. I did not partake in the lessons as this was necessary in order to obtain acceptance of my presence even though I was unobtrusive. Classroom observation with a focus on teaching was my objective. I directly observed and recorded the methodology implemented particularly using ICT in whatever mode it was being used in for that particular lesson. Even though I conducted participant observation, there were informal conversations with the participant teachers in terms of scheduling my presence in their lessons.

- **Informal Conversational Interviews**

I could not foresee the ICT being implemented (if any) for a particular lesson; hence the conversations pre and post a lesson were informal conversational interviews.

It is important to note that qualitative interviews took the form of informal conversational interviews as described by McMillan *et al.,* (2006). Here, my questions emerged from the immediate context and were asked in the natural course of events; there was no predetermination of question topics or phrasing. Informal conversations are an integral part of participant observation.

- **Supplementary to Field Observations**

In order to corroborate my initial findings on ICT implementation and integration into Science teaching, I supplemented my research with participant Science teacher questionnaires.

Participant questionnaires – one of the advantages of this method of research is that the questionnaires can be given personally to the participant teachers. I as the researcher was able to distribute the questionnaires personally to all teachers and it was anticipated that this would result in a high response from the teachers. The use of open-ended questions allowed the participant teachers to be self expressive through the use of their own words. It was hoped that the

questionnaires yield meaningful information because the actual feelings of the participants emerge, making it possible to validate their responses and gain insight into their reasoning.

However, questionnaires have disadvantages in that if a question is unclear then the participant could skip that question but since I handed out and collected the questionnaires while I was a daily presence in both schools, this was avoided. When I handed out the questionnaires I informed participants to verbalise with me any need for clarification.

The two schools were chosen based on being independent and approximately equally resourced. The same questionnaire was handed out to all ten of the Science teachers in both schools (5 teachers per school). This allowed for a fair comparison. This questionnaire was handed out towards the end of the study i.e. the two week period, so as to not prompt the Science teachers into using ICTs in their lessons for the sake of my presence as a researcher in their school. The purpose of the questionnaire was to generate some statistical comparisons between the two schools and to compare the opinions of the teachers i.e. are they similar, different or in direct contrast.

3.3 Development, Validation and Pilot of Questionnaire

According to Gay (1981) the questionnaire should be as attractive and brief, and as easy to respond to, as possible. In designing and developing the questionnaire, I, the researcher considered the following criteria:

- Included unstructured questions which the responder had to complete, giving them freedom of response. This permits greater depth of response and may permit insight into the reasons for responses.
- Tried to keep the questions short to encourage respondents to respond by avoiding spending too much time reading.
- Had to be as easy to answer as possible because:
  - -the question should mean the same thing to everyone
  - -the question should be one that respondents will be willing to answer.
- Used follow-up questions (yes or no, explain). This makes it easier for respondents to answer a given question and improves the quality of data received.

There was a rationale for asking each question in order to answer the research questions. Table 1 lists the questions asked and provides the rationale for each question.

A **pilot** study is a rehearsal where a study is conducted and the results are analyzed. The purpose of a pilot study, even a small-scale pilot study, is to help refine procedures such as effectiveness of the questionnaire and in trying out analysis techniques. However, the larger the scope of the pilot study, the more like the real study it is, the more likely it is that potential problems such as uncontrolled variables and insufficient data processing routines will be identified.

In order to check and ensure **rigour** in this research, the questionnaire was piloted by seven teachers, from another independent school in Johannesburg, who were not included in the main study. These teachers checked if the wording of the questions were clear, understandable and whether the instructions for answering the questions were also clear. The results obtained from this pilot study were used to inform changes in language and the layout of the questions.

This review of the questionnaire was important to check that the wordings of the questions are clear and brief. Questions also needed to be carefully worded so that respondents can easily understand what is being asked. Therefore, an example of a good questionnaire would be that which Davidson described as; *"clear, unambiguous and uniformly workable. Its design must minimize potential errors from respondents.... and coders* (Davidson cited by Cohen and Manion, 1994: 93).

Below are the questions in the questionnaire together with a rationale for asking each question.

Table 1. *Participant Teacher Questionnaire and Rationale*

Question		Reason For Asking
1.	How long have you been teaching in the Science field including your career at this school?	These questions assist with setting the scene and creating a holistic view of the department. It creates a profile of each participant teacher.
2.	How old are you?	
3.	What learning area or subject methodology or specific area of Science are you currently teaching?	
4.	Do you have a computer that you can easily access at home?	
5.	Do you have any professional training in the use of ICTs?	
5.1	If yes, elaborate briefly.	
6.	Are you comfortable / confident with your ICT skills?	
7.	Do you use ICTs in your lessons?	

8.	Do you feel that ICT's can be implemented to enhance your teaching and your students' learning?	It is important to ask this in a direct way as there are teachers who believe solely in traditional teacher-centred teaching. While this may be true as these teachers may still achieve the results they want, it is important to know this as 21st century learners need activity based learning which ICT implementation entail.
8.1	If yes, how and why? If no, why not?	
9.	Briefly list the reasons (if any) that hinder you from implementing ICTs in your teaching.	As these schools are well resourced, I think it would prove to be fascinating to discover the reasons that would hinder a teacher here from implementing ICTs. One of the reasons I predict is time constraints and lack of skills.
10.	Are you aware of the many advantages of social networking sites e.g. Facebook, Twitter etc for educational purposes in Science.	Social networks are also being used by teachers and learners as a communication tool. Because many learners are already using a wide range of social networking sites, teachers have begun to familiarise themselves with this trend and are now using it to their advantage. Teachers and professors are doing everything from creating chat-room forums and groups to extend classroom discussion to posting assignments, tests and quizzes, to assisting with homework outside of the classroom setting. Social networks are also being used to foster teacher-parent communication. These sites make it possible and more convenient for parents to ask questions and voice concerns without having to meet face-to-face. Many might see these sites as dangerous and the safety of their learners compromised not realizing that through education, this can be prevented.
10.1	If yes, elaborate on how you think these tools can be used in Science education.	
11.	Teacher 'Technophobia' is common in schools. Do you think some of the teachers in this Science department display this?	Technophobia is the fear or dislike of advanced technology or complex devices, especially computers. The new technologies conflict with established beliefs, such as the personal values of simplicity and modest lifestyles. As technologies become increasingly complex and difficult to
11.1	If yes / no, why do you think this is the case?	

12.	Do you display 'Technophobia'?	understand, people are more likely to harbor anxieties relating to their use of modern technologies.
12.1	If yes / no, why do you feel this way?	
13.	Do you think that younger teachers are better equipped than others in terms of their ICT skills in this school?	It is often a generalisation that technology is better handled by the youth. In fact, some older people are under this impression and associate technology with youth only and do not even attempt to try it out for themselves.
13.1	If yes / no, state your reasons.	
14.	Does this school have an ICT expert who is designated to assist staff with ICT implementation specifically into their lesson?	Often, teachers would like to utilise ICTs but they simply do not have the time to prepare such lessons. This is due to other commitments and administration obligations that teachers are faced with. Also, teachers feel at ease knowing that an expert is available.
14.1	If no, if you or the Science department were provided with an ICT expert, would you be open to implementing ICT's more often in your Science lessons?	
15.	Do you think your students enjoy / would enjoy being taught using ICTs?	This ascertains the knowledge that the teacher has of his/her learners. Also, it would be interesting to note if a teacher does not implement ICTs yet believes his/her learners would enjoy it.

- **Conceptual research**

Here an analysis of the national policy documents on ICT integration into schools for both countries was conducted. South Africa produced a White paper on e-education (Department of Education, 2004). This paper, produced by the Department of Education aimed largely to lead to South Africa's social transformation by implementing technology in all schools. The government planned on doing this in phases but it proved to be unsuccessful in most of Johannesburg's public schools. Only 40% of the provinces' public schools have somewhat implemented ICTs this according to a report by Rasool (2011). The Department for Employment and Education (DfEE) in the UK produced a document called the National Grid which outlines a strategy for ICT implementation into all public schools. The resources were provided, however pedagogical strategies were not (DfEE, 1997).

3.4 Data Analysis

The information gathered from the various research strategies has been sorted and arranged to assist with interpretation such that the questionnaires were collated and summarised regarding some of the yes/no questions and presented in bar graphs. Opinions or comments of the questions have been presented in tables accompanying the bar graphs. The data was used to build up a comparison discussion of ICT implementation and integration by the Science teachers. One strategy as outlined by McMillan *et al*., (2006) that was used is open coding. This is the process of dividing data into parts by a classification system. The purpose of dividing data into parts is so that I as the researcher could rearrange or recognise the data in order to work with it. During the coding process, responses can be put into common and meaningful themes that emerge. This came mainly from the informal conversational interviews.

3.5 Ultimate goal

Ultimately I aim to create a list of factors that impact on the successful integration of ICTs. I shall place these factors into a hierarchy and it can be utilised by teachers who are keen on implementing and integrating ICTs or for teachers who want to begin. More importantly, the findings of this study will explain why the admirable goals of the White paper on e-Education in South Africa have been problematic to implement in practice. The ideas of policy and practice always go together. There are therefore two ways of doing policy analysis: analysing "policy from the perspective of practice" or to analyse "practice from the perspective of policy" (Jones, 2003) because one can never assume practice on the ground from the formal policy that is developed.

e-Education policy goal

> *"*Every South African learner in the general and further education and training bands will be ICT capable (that is, use ICTs confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and to be full participants in the global community) by 2013".
>
> (DOE, 2004, Pg. 17)

As a Science teacher in an independent school that is adequately resourced, I know that this goal has not been achieved. Hence, the findings of this study aims to have a wider impact. There is a need to ascertain the reasons as to why the White paper goals were not implemented in South

Africa. It is already evident that resources alone do not solve the problem of successful ICT integration into the Science classroom.

3.6 Ethical Considerations

Cohen & Manion (1994) believe that researchers ought to find a balance between the demands placed on them as professionals in pursuit of truth, and their subjects' rights and values which are potentially threatened by research. McMillan *et al*., (2006) point out that ethics deal with beliefs about what is right and wrong, proper or improper, good or bad. There are guidelines to what is ethically correct in research and this should be considered important. Here, I provide an account of the ethical considerations that were taken into account.

- A participant information sheet (Appendix A) was provided to the principals' of both schools explaining in detail what this research entails. It was a requirement for the principals' to sign the consent form (Appendix B) allowing me into their schools during the period of time as stipulated in the sheet.

- The same information sheet was also addressed to the Science teachers and they too had to provide consent (Appendix C) for my individual research strategies. To avoid the tediousness of creating a separate form for each research strategy, I have created tick boxes for the teachers to grant me consent for only (if not all) the strategies that they are most comfortable with. This sheet explicitly outlines the anonymity of the research and that if they choose to participate; it will be on a voluntary basis.

- It is important to note that the South African school is a non-governmental school and hence no GDE (Gauteng Department of Education) authorisation is required.

- Also, very importantly, no children were utilised in the research process at all and hence ethical considerations with regards to minors were not considered.

To summarise the key point from this chapter, it is important to note that teachers' pedagogies and pedagogical reasoning influence their pedagogical use of ICT and this is what this study aims to investigate within the Science classroom. Going forth into the next chapter i.e. research data, analysis and interpretation, the results of the study are presented and analysed.

CHAPTER 4 – RESEARCH DATA, ANALYSIS AND INTERPRETATION

In this chapter, the data of the participants of the study have been described and a demographic table or breakdown of their age, number of years teaching and specific area of Science are provided. This chapter provides an analysis of the qualitative data collected from 'The South African' school and 'The England School' Science teachers, in classrooms with ample resources to show how these teachers use ICT when they teach Science.

4.1 Introduction

Teachers use of ICT in teaching Science lies at the core of this study. Both internationally and for the purpose of this study, the key concern driving policy and research interest in the integration of ICT in education is the premise that ICT is important for bringing changes to the classroom teaching and learning, to develop students 21st century skills (Law & Chow 2008). These skills include the ability of graduating students to become lifelong learners within a context of collaborative inquiry, and the ability to work and learn from experts and peers in a connected global community, referred to as 21st century skills. Understanding how Science teachers use ICT will allow an assessment of the extent to which 21st century skills are being realised in classrooms.

The qualitative data from the lesson observations, informal conversations with the teachers and the teacher questionnaire responses were integrated to address themes around teachers' use of ICT in Science. The combined data provides evidence of the limited extent to which South African and England Science teachers in general are able to effectively incorporate 21st century pedagogical practices in their teaching. The observed teacher practice together with the teacher responses provided evidence that the sample Science teachers showed a predominantly traditional orientation in their teaching practice. Even when they were able to adopt ICT in their practice, their ICT-using pedagogical orientations remained predominantly traditional. However, it is important to note that the sample teachers' use of Web 1.0 tools in the classroom is dominant but little or no Web 2.0 tools are being used. The collaborative inquiry approach was utilised once by a South African teacher whereby learners worked in small groups, utilising the internet, in order to accomplish a task. There was no group work done in the ten lessons observed in the school in England. However, on two occasions, learners used iPads for interactivity based tasks, but this was carried out by each individual.

ICTs can be used to supplement, enrich and reinforce the existing curriculum. This study highlighted that teachers utilise their own personal experience and interest in computer technology to capitalise on the potential of technology to take learners beyond the curriculum. It needs to be used for project based learning, in a sophisticated and innovative way. Unfortunately, even though all the sample teachers acknowledge this, they are unable to produce such innovative tasks for their learners due to various barriers that are presented later in section 4.12.

In classrooms where access to technology resources is not limited, it is assumed that teachers engage in a common set of innovative pedagogical practices. It is assumed that the ICT supported practices allow learners to work with each other on collaborative projects which cut across subject areas, and allow teachers in the same school to collaborate with each other. This is assumed because when most people see the unlimited technology present in a school, it is thought that it is being utilised by teachers and learners. There may even be instances of innovative ICT use whereby teachers and learners collaborate with others outside the classroom involving scientists, professors or business people (Kozma, 2003). However, in this small scale qualitative study, this was not observed.

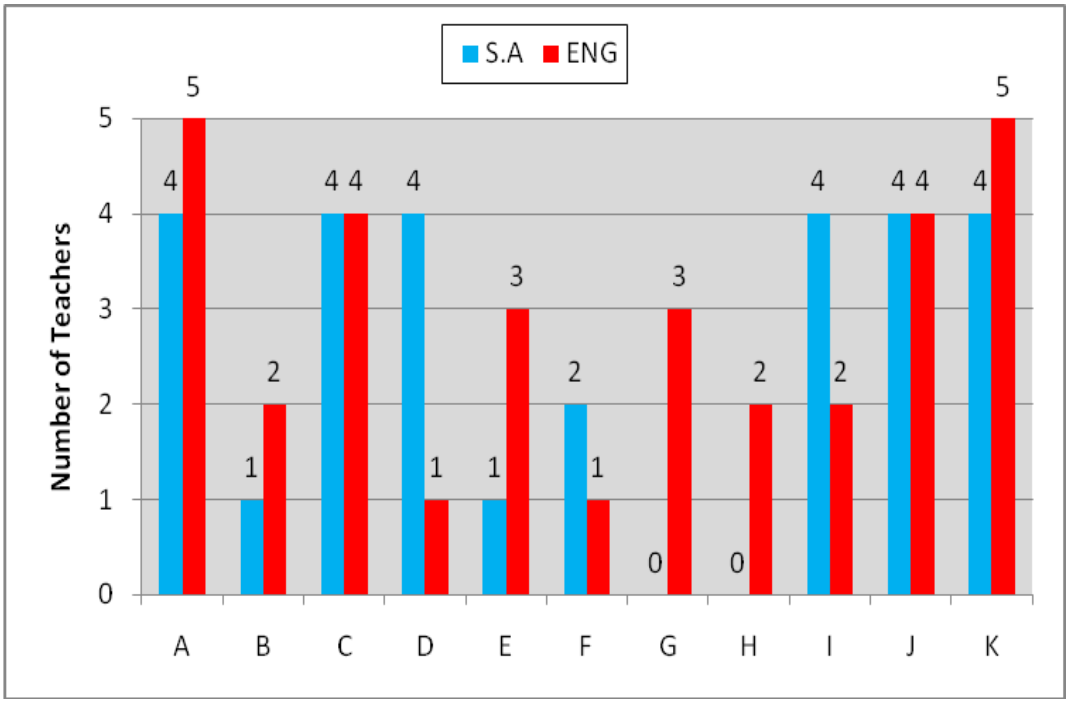
4.2 Science Teacher Profiles

Firstly, I have tabulated the profiles of the participant Science teachers. 5 teachers participated from each school across various areas of Science i.e. Physics, Chemistry and Life Science (biology). Each teacher was observed teaching twice randomly and not within the same week. This resulted in 10 lesson observations per school. The researcher achieved this by obtaining the timetables of all the participant teachers. The lessons were observed at random in order to not tempt the participant teachers to prepare a highly technological lesson due to my presence. All questionnaires were handed back to me except for one in the South African School (teacher 5 in table 2). The minimum number of years teaching is 4 years (teacher 5 in the England School in table 2). The maximum number of years is 38 years (teacher 1 in the South African School in table 2).

Participant Science teacher Profiles				
		How long have you been teaching in the Science field including your career at this school? (yrs)	**How old are you? (yrs)**	**What learning area or subject methodology or specific area of Science are you currently teaching?**
South Africa	**1**	38	55	Physical Science
	2	6	31	Physical Science & Natural Science
	3	8	29	Natural Science & Physical Science
	4	15	39	Life Sciences
	5	-	-	Life Sciences
England	**1**	22	49	Chemistry
	2	30	53	Physical Science
	3	17	38	Biology
	4	9	32	Chemistry
	5	4	37	Physical Science

Table 2. *Summary of the Science Teachers profiles in both schools*

The graph below is a summary of the number of teachers who answered 'Yes' to the questions A to K in the Questionnaire. The questions are presented below the graph.



A Do you have a computer that you can easily access at home?
B Do you have any professional training in the use of ICTs?
C Do you feel that ICTs can be implemented to enhance your teaching and your students' learning?
D Are you aware of the many advantages of social networking sites e.g. Facebook, Twitter etc. for educational purposes in Science.
E Teacher 'Technophobia' is common in schools. Do you think some of the teachers in this Science department display this?
F Do you display 'Technophobia'?
G Do you think that younger teachers are better equipped than others in terms of their ICT skills in this school?
H Does this school have an ICT expert who is designated to assist staff with ICT implementation specifically into their lesson?
I If you or the Science department were provided with an ICT expert, would you be open to implementing ICTs more often in your Science lessons?
J Does management at your school encourage staff to implement ICTs in their lessons?
K Do you think your students enjoy being taught using ICTs?

Figure 2. *The number of teachers who responded with YES answers to the questions A - K. (South African teachers compared to England teachers)*

4.3 Accessibility to resources

Question A – Do you have a computer that you can easily access at home?

People who have full access to computers become confident in their use. In 1997 – 1998, in the UK, the DfEE[11] Multimedia Portables for Teachers Pilot provided over 1100 teachers with a portable lap top with an internet cable. The evaluation of the project concludes: 'the portables have made a transformative difference to the teachers, at a personal and professional level' (BECTA, 1998).

The personal possession of a computer may well be the single most important factor enabling a teacher to integrate ICT into their professional practice. In the UK, secondary school teachers in management positions felt that they under-used computers because of lack of time to become familiar with them. It is too simplistic to construe this lack of time as lack of interest or motivation (Leask, 2001). The portables for teachers study showed that given the equipment, and crucially the chance to take it home and learn about it in their own time, teachers made rapid gains in skills. They also acquired commitment and enthusiasm. The study data supported the view that those teachers who have their own computers are more likely to know how to use them with learners. Tim Brighouse, Chief Education Officer for Birmingham, who had been one of the advocates of the policy of helping teachers to buy their own equipment said:

> "The bread would come back buttered if teachers used ICT in the home because people get intrigued by the possibilities technology offers."
>
> (Brighouse, 1999, Pg. 27)

In this study, all the sample teachers are in possession of a computer. However, it did not concur with the notion discussed above. From the conversations and lesson observations, the Science teachers' use of their lap tops is mainly for administrative purposes, emails, or projections (PowerPoint or YouTube videos). This is due to the teachers not being skilled in the use if ICT for collaborative or project based learning (Table 3.)

One of the key areas where a considerable amount of money was spent on the San Diego, US project (San Diego Unified School District, 2006), was on the hiring of expert educators in this

[11] Department for Education and Employment

field which they referred to as "project resource teachers". Six months of the 2 year project was spent first on putting the correct measures in place for teaching and learning to occur. This is a direct contrast to Goveia & Soule (2003), who stress in their paper that learners, administrators and teachers do not need professional training to start or continue using computers. They feel that it is a waste of time and money and it can be learnt by one self through personal endeavours with a computer. Either way, in this study all the teachers acknowledge the need of a computer at home and in the classroom as it is a necessity in order to work efficiently, for example, administrative work, setting of tests and exams and general preparation for their Science lessons.

> "Exposure to a lap top makes me use it. If something is put to your disposal, then you must use it."
>
> (S.A Teacher 3)

4.4 Teacher ICT Competence

There are a number of factors which influence the ways teachers use ICT and can be used to predict differences between teachers who successfully integrated computer technology from those who do not. Some of these are extrinsic factors such as access to resources and school environment, while others are intrinsic, such as teachers personal ICT competence and their atittudes and beliefs to teaching with technology.

A teachers technical and pedagogical ICT competence is a key factor in whether or not a teacher uses ICT in their practice (Law *et al*., 2008). Science teachers were asked to indicate how they perceived their level of competence in the general and pedagogical use of ICT. The results are presented in figure 2.

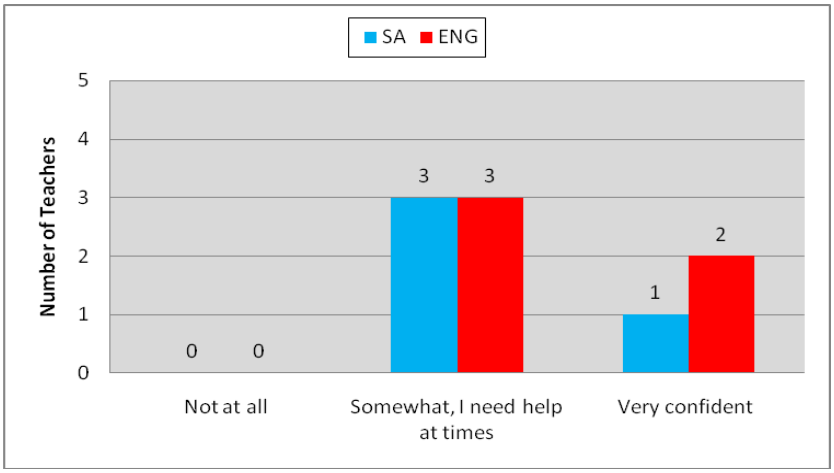


Figure 3. *South African and England teacher responses to the question: Are you comfortable/confident with your ICT skills?*

Question B - Do you have any professional training in the use of ICT's?

In order to implement ICTs it is important for these Science teachers to ensure that their computer skills are very good. They must be comfortable and confident with their basic computer skills and basic web technologies. Teachers should be able to create and manipulate documents (formatting, copying, pasting, attaching and retrieving them). They must have a desire to learn new software applications. And obviously, having the right computer to support the software is important.

After conducting the three research strategies it is apparent that the sample Science teachers are most confident in their Web 1.0 abilities i.e. word processing, filing electronic documents, email, and presentation software i.e. PowerPoint. Teachers are unaware of actual methods that can be used to prepare collaborative lessons using ICT. This is due to their lack of professional training. Teachers believe that they are ICT skilled but this is only a self perceived general ICT competence rather than pedagogical ICT competence. This was affirmed in table 3 whereby teachers contradicted their responses. All the teachers indicated that they are somewhat to very confident with their ICT skills (figure 3), however, this is a false sense of belief as 3 out of the 10 teachers indicated having received professional training, but this is training in the use of Web 1.0 tools which many young people learn on their own.

Professional Training in the use of ICT's?		
		Teacher responses
South Africa	**1**	
	2	
	3	
	4	Have attended numerous courses and am currently being trained using the iPad.
	5	
England	**1**	No formal qualification but having run the ICT department and been responsible for moving ICT use forward, I have put on many training sessions for other staff. I have also been involved with professional discussion groups and involved with a national project to see how ICT can best be used to enhance chemistry teaching.
	2	Took courses in basic programming many years ago. Courses in using excel, Access etc. Also taught teachers to use computers in 1990's.
	3	
	4	Courses on the use of Internet resources, Interactive Whiteboard, visualisers, CPS system (all INSET).
	5	

Table 3. *Summary of the Science teachers' responses to the type of professional training they have received*

4.5 Teachers use of ICT

Question C - Do you feel that ICTs can be implemented to enhance your teaching and your students' learning?

The way computers perform their tasks are a rich source of analogy for understanding other phenomena. It is not only what computers do that make them so important in Science; it is also what they are! Because computers exist, we can use them as an aid to thinking about the real world. There are some natural phenomena we can understand better by using the computer as a source of contrasts, comparisons and analogies. The ways computers handle information, the process of storing, manipulating and retrieving data, and the evolving vocabulary that describes all these operations, have become part of the intellectual resources of Science. Our ability to describe and think about scientific problems is that much greater because we have a wider range of words and images to think about them in.

Do you feel that ICTSs can be implemented to enhance your teaching and your students' learning?		
		Teacher responses
South Africa	**1**	Where appropriate, especially to illustrate everyday application of concepts.
	2	Use ICT for simulations and some demonstrations of practical's that needs resources that are not available in the school.
	3	To provide simulations and demonstrations. For research by teacher and learners for projects.
	4	The old chalk and talk method is essential at times but our learners have different methods of learning. Some are more visual and the videos etc. help them grasp some difficult concepts.
	5	-
England	**1**	This requires long term planning and support especially making sure key staff in each department has enough time to continue to move things forward AND widespread sharing of good ideas and the resources produced.
	2	It is very useful to demonstrate a wide range of models.
	3	Through direct participation by the students – active learning. Particularly useful for students who are visual learners.
	4	No, because is usually serves as a distraction rather than an aid to learning.
	5	In Physics some concepts can be simulated well on ICT. Pupils respond to up to date technology.

Table 4. *Summary of the teacher responses to their feelings on ICT use for teaching and learning*

There is a 'flip' side to this discussion. The teachers in this study agree that implementing ICTs in their Science lessons would enhance their lessons as well as their student learning (Table 4). Cuban (1996) disagrees with this. He says that there are exaggerated claims for what new technologies can do and that reformers too often ignore the main purpose of schooling, the real social organisation of schools, and the pressing daily realities of teaching. He feels that 'techno-reformers' deeply interested in making teaching and learning more engaging and productive, forget the fact that teachers , not policy makers or administrators, stand at the crossroads of these conflicting goals and are being asked to do the impossible.

> "I have little interest in terms of designing lessons with ICT incorporation for interactivity as this takes too much time, which teachers do not have here. Learners get easily distracted by other things online when sitting behind a computer and easily detract from learning about the task at hand. I am bogged down by admin work which is extremely time consuming. i.e. writing personal comments for each learner I teach for the end of term report. Traditional teaching methods are better; the odd YouTube video works well."
>
> (England Teacher 2)

The use of these technologies requires careful expenditure of a teacher's time and energy. Time that teachers do not have. Cuban (1996) indicates that providing more machines, software, technical assistance and training to teachers will not solve the technology dilemma. He says that as long as techno-minded policy-makers blame the teachers, ignore the teachers' larger roles in the schools, and then expect them to rectify the problem, their dream of computerised classrooms will never come to pass. Figure 4 shows that the South African teachers use ICTs weekly and the England teacher use ICTs daily. However, as mentioned, it is not used for teaching and learning to occur in a collaborative manner in line with Constructivism.

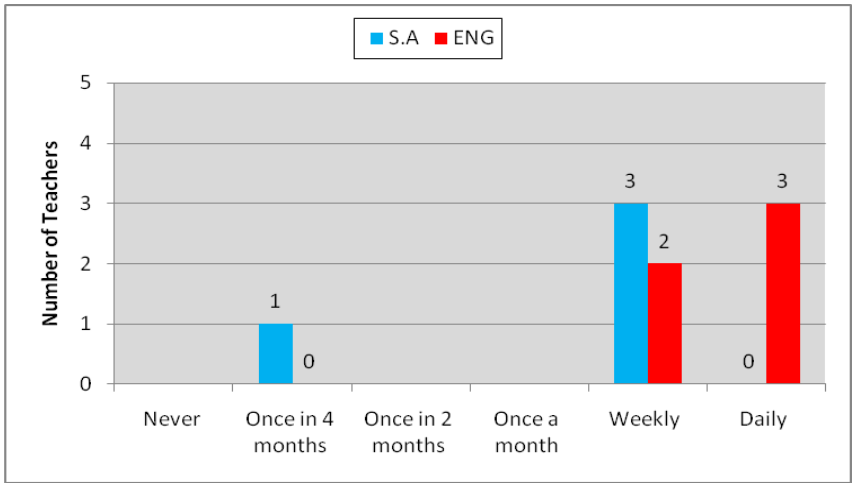


Figure 4. *South African and England teacher responses to the question: Do you use ICTs in your lessons?*

Question K - Do you think your students enjoy being taught using ICTs?

Clearly there are implications for the increasing use of new Information and Communication Technologies in schools. If learning is taking place on the web then learners have access to a wide range of teaching and learning resources in their local library, community centre, Cyber café and many other places. Learners have always had access to forms of expertise other than their teachers but now younger learners are rapidly becoming powerful users of the web, sometimes for trivial uses, but often finding extremely useful information to support projects or schoolwork often to the embarrassment of their teacher. They may also be producing their own websites when, at the same time, their teachers have still not made any significant use of the web for teaching purposes, if they are using computers at all (Leask, 2001).

Do you think your students enjoy being taught using ICTs?		
		Teacher responses
South Africa	**1**	Where appropriate, students are interested. If done for the sake of using I.T, students easily lose interest, bored.
	2	They seem to pay more attention when they use ICT's. It is exciting to them.
	3	Something different. Appeals to their interests. Interacts with them at their level of socialising.
	4	I guess they are able to "see" and experience what they are taught instead of just listening to the teacher. It is also more "fun" and different from a usual lesson
	5	
England	**1**	They see lessons as more up to date and relevant to them if technology is used in class (even though much of what is taught may be the same for the last 100 years!!). They can also see value in anything that make lessons seem more fun, more engaging and therefore more effective.
	2	Need variety for stimuli.
	3	They are able to have some control of the lesson, especially if use SMART software and other interactive software. With Science, being able to visualise a process, rather than just being told about it, can make all the difference to a student's understanding and enjoyment.
	4	It serves as fun distraction from real learning.
	5	They enjoy using lap tops as an alternative to books from time to time.

Table 5. *Summary of the teacher responses on their perception of their learners feelings of ICT use*

> "I prefer I.T over traditional methods. It keeps learners interactive. It is visual, manipulative and captures attention. Children can concentrate for long periods."
>
> (S.A Teacher 3)

Gardner says,

> "I also feel that the problem is not a lack of resources, either human or technological, but rather a lack of will. Nowadays, there is a tremendous pressure to treat everyone in the same way, to give them the same curricula and to subject them all to the same quick tests."
>
> (Gardner, 1987, Pg. 33-34)

While there may be some significant questions and issues around Howard Gardner's notion of Multiple Intelligences, it still has had utility in education. It helps me as a teacher to question my work and it encourages me to look beyond the narrow confines of the dominant discourses of skilling, curriculum, and testing. Most importantly for this study, it ascertains to the use of ICT as ICTs allow for a diverse array of lessons which will pertain to Multiple Intelligences. It provides for the linguistic, musical, logical- mathematical, spatial, bodily-kinaesthetic, interpersonal and intrapersonal intelligence. In table 5, it can be seen that the teachers acknowledge this theory and

its importance. England teacher 2 comments that ICTs provides a variety of stimuli. However, this acknowledgment did not mean that the teachers were implementing ICT in a manner conducive to learner enquiry and collaborative learning.

4.6 Simulations

Can computers help learners understand a methodology of Science which consists of a cycle of a model, prediction and data? Among the ideas that learners find difficult are: What exactly is a model? How does a model generate predictions? Why is a prediction only a prediction if it is in some way testable? What is the importance for the model of the agreement between the prediction and the data and how does all this lead to a further development of the original model? Certainly computer simulations are unequivocally representations of models. There should be no confusion as to what is the simulation and what is the reality. For one thing, the simulation is clearly inside the computer! A computer simulation therefore helps learners conceptualise what a model is. That the model is also an anology is also clear (Kahn, 1985).

> "ICT's good for showing learners' real generators and the workings of it e.g. Eskom turbines. It is great for concepts that seem weird and abstract. It can reduce some concepts e.g. iron filing field (around a magnet). Not be used to teach concepts. Can be used only for applications related to South African life, and at the end of a topic. Conceptual knowledge is best taught using traditional methods."
>
> (S.A Teacher 1)

Computer simulations also help learners see that models generate predictions. A simulation represents a system which is undergoing change in some way. The simulation generates numbers which represent the 'state' of the system at successive moments. These numbers are predictions, because an actual experiment should produce similar numbers if the same variables are physically measured under the specific conditions. The computer simulation is therefore predicting, with greater or lesser success, how the 'real world' system behaves.

> "Some concepts are abstract. ICTs provide a visual which is important. It is easier to relate objects to concepts."
>
> (S.A Teacher 2)

Based on the finding of this research, all the teachers agree that utilising simulations is useful in teaching Science. It was used in the observed lessons to teach the process of digestion to Grade 9 learners, the workings of a turbine to Grade 11 learners and the process of plant fertilisation to Grade 12 learners. As indicated in table 5, the teachers do think that their learners enjoy being taught using ICTs as the visual aspect pertains to their learners. This is in line with the learning theory of Multiple Intelligences particularly the linguistic and visual aspect.

4.7 Laboratory Work

It would be an unhappy consequence of the ability of the computer to simulate experiments, if the use of computers led to an elimination or reduction of practical laboratory work in the Science curriculum. While some simulations lend themselves to this sort of misuse, most teachers would feel that replacing actual experiments with computer simulations would impoverish rather than enrich the student's experience of Science.

> "Equipment and hands on is important in Science. ICTs cannot achieve the same goals."
>
> (S.A Teacher 1)

> "Simulation can never replace hands on."
>
> (S.A Teacher 2)

> "I enjoy hands on practical work over ICT use. Even though I would like to create lessons implementing ICTs, I do not have the time to do so. There is simply no time and space in the work week to do so. Learners can be quite unruly at times, and it distracts them even more from the real learning that needs to take place. I admit to not utilising the Smart Board to its full potential, and I play YouTube videos appropriate to the lesson topic now and then."
>
> (England Teacher 4)

Does this mean that it is never justifiable to perform an 'experiment' with a computer, if that experiment can be done by students in the laboratory? Simulated laboratory experiments offer a solution to one of the most intractable problems of routine laboratory work: how to give the learner some control over the choice of experimental procedures. In most laboratory experiments, the learner is provided with the apparatus and a worksheet which tells him or her what to do. There is no opportunity for the learner to make any contribution to the experimental design.

Unless it is project work, the learner is not expected to make any decisions, just to follow instructions. Scientific creativity, if any is required, is limited to interpretation of results. Computer simulations can be used to make up for this deficiency. Learners can alter the experimental design and try out experimental conditions different from the ones they actually used in the real experiments. Alternatively, learners can try out different simulated conditions and experimental configurations before deciding how to do the actual experiment. In either case the learner participates in one of the most important activities that a scientist does: devising workable ways to test the predictions of a scientific model.

The findings of this research have shown that the teachers do not allow for much creativity from their learners in terms of experimental design. They provide their learners with the practical work and the learners simply follow the instructions. The teachers are not using a Constructivist approach. This would form an ideal time to do so, whereby learners can be given the theory required for a particular experiment, but the actual methodology can be devised by themselves. Enquiry based learning is a constructivist approach that encourages learning in depth by allowing learners to use inquiry-based methods to engage with issues and questions that are rich, real and relevant to their lives. It emphasizes learning activities that are long-term, interdisciplinary, and learner-centred. Learners form a learning community that focuses on critical thinking. Project based learning allows for alternative approaches that address learners' individual differences, variations in learning styles, intelligences, and abilities and disabilities (linked to Gardner's theory).

4.8 Things computers cannot do

Leask (2001) elaborates on some of the limitations of ICTs but also provides ways to overcome these. Computers will not make every learner understand every idea. But computers can help us to get through to more learners, because they offer the teacher an additional teaching strategy, one which may be the only successful strategy for a particular learner. The greater the range of available strategies, the more successfully a teacher can deal with the diversity of abilities and learning styles in a group of learners. ICTs can even reduce the number of those learners who, for different reasons, end up labelled as 'could do better'. All of us, as learners, have experienced that moment is a class, or that line in a book, where there was some logical jump we just did not follow at all. Something obvious to the teacher or writer was missing in our own thinking. Such moments

can be distressing and, if they cannot be bridged, devastating. ICTs provide an additional way of communicating ideas and information, and may make those occasions rarer.

ICTs will not always be able to make clear what it is the teacher wants. Confusions in the minds of learners about teacher expectations always exist. It is never easy for a teacher to clarify in his or her mind every single teaching goal (and sub goal), and then communicate them to every learner. And it is the business of clarification, for which the teacher needs detachment and time for reflection that is likely to get lost among more urgent priorities when meeting the demands of children and classes on a daily basis. But computer programs attempt to do only a small number of things, so that their use should help clarify for teachers and learners at least some of the teacher's expectations. Teachers who buy education software will have to make deliberate decisions during the process of selecting the programs they buy. They will have to think about what any commercially available program claims to do, and how that matches the needs of their Science curriculum. The result is that when teachers use a computer program in a class, they have usually decided what it is they want that very specific element in the lesson to accomplish. And learners will be able to see a little better what the teacher wants.

ICTs will not stop some learners being bored at least some of the time. It is a rare moment in any class when someone is not consciously waiting for something more exciting and interesting to happen. Even with ICTs there are bound to be some bored learners. And even with the best technology there are occasional disasters: a monitor that won't work, a program that does not load or a class brought to a complete halt by a 'bug' in the program you never discovered until that moment. We have all suffered the anguish and embarrassment of those times when nothing goes right and the audience become relentless, then bored and finally starts to entertain itself. But when a computer program with exciting sound and graphics is an extra activity in a practical session or a class is shown a vivid and instant demonstration of some key point on a larger classroom monitor, then it is difficult for even the most alienated learner not to become involved. Change of pace, active learner participation and electronic pyrotechnics are all a great help against the insidiousness of boredom.

ICTs will not make all activities in a class productive at all times. But many valuable skills, strategies and world models are acquired through the use of ICTs, independently of those planned by the teacher. When learners are sitting entering data or doing any of the other routine tasks which using a computer requires they are learning that operations must be carried out in a specific

sequence in order to produce a result. These and other related skills equip the learners to participate easily and unselfconsciously in a high-technology society.

ICTs will not magically make badly organised classes more coherent. But teachers who have to make deliberate decisions as to where and how to use particular programs must also look at their total material. And having and using ICTs will almost certainly get teachers talking to each other about what they are doing, which software seems to work best, and what they hope to get out of using them. ICTs may not solve all the problems of organisation and communication in the classroom, but they are definitely a powerful stimulus to thinking about teaching.

The findings of this research show that one South African and one English teacher agree that ICTs are not always conducive to learning.

> Learners can be quite unruly at times, and it distracts them even more from the real learning that needs to take place. I admit to not utilising the Smart Board to its full potential, and I play YouTube videos appropriate to the lesson topic now and then."
>
> (England Teacher 4)

> Not be used to teach concepts. Can be used only for applications related to South African life, and at the end of a topic. Conceptual knowledge is best taught using traditional methods."
>
> (S.A Teacher 1)

4.9 Social Networking

Are you aware of the many advantages of social networking sites e.g. Facebook, Twitter etc for educational purposes in Science.		
		Teacher responses
South Africa	**1**	As a support in terms of communication of homework, tasks, deadlines etc.
	2	Transmitting scientific information including modern research.
	3	Research, Communication, Presentations.
	4	I have created a Facebook group where discussions on various topics are done simultaneously. This works very well especially for the learners who are more shy.
	5	-
England	**1**	Yes, this has been something discussed at a number of conferences, exhibitions and discussion groups I have been part of. Twitter – a good of effectively blogging interesting things you have found that keen and able students may like to look at: websites, books, YouTube videos. Facebook – potential for societies and groups of interested pupils. Not used at this school for this yet.
	2	
	3	Don't think Facebook and Twitter are appropriate for educational purposes due to access of personal data.
	4	
	5	

Table 6. *Summary of teacher responses elaborating on how they think Social Networking tools can be used in Science education.*

Question D - Are you aware of the many advantages of social networking sites e.g. Facebook, Twitter etc. for educational purposes in Science.

South African teacher 4 mentioned using the social networking site, *Facebook* to communicate with the learners (Table 6). According to Aragon (2003) and Lester (2005), blogs are an excellent medium for informal, yet constructive chat to take place. Participants can fill in personal information about them, upload pictures and write in comments regarding their thoughts about Science. They can also comment on other participant's blog comments and this creates a great social interaction. This is a form of asynchronous chat. The teacher must also contribute to the blogs with frequent feedback to individuals. This allows the learners to feel heard by their teacher. Teachers can also use this space to share personal stories and experiences which will allow students to view them as a real person.

The findings of this study agree with this however, only one teacher indicated that he/she uses this form of interaction for Science education learning. This ties in with the learning theory underpinning this study i.e. Connectivism. However, only one teaching using this tool is not a fair indication of its value. The theory of Connectivism is an approach to learning that considers

technology as a key factor. Including technology and connection-making as learning activities begins to move learning theories into a digital age. Using technology and making connections are linked. Combining Connectivism with Constructivist methods in the classroom offers learners an opportunity to gain 21st century skills. The organisation and the individual are both learning organisms. Increased attention to knowledge management highlights the need for a theory that attempts to explain the link between individual and organisational learning.

A discussion group on relevant topics is used by one of the Science teachers (Table 6). Aragon (2003) and Lester (2005) indicate the need to create a space for discussions to take place e.g. discussion boards. Teachers can direct learners to an online discussion board that allows them to interact with respect to Science material. It can also have a feature that allows them to upload and send other articles that they may have found interesting. The teacher must also participate and contribute to discussions. However, teachers must have a sense of timing to not always reply immediately as this gives other learners an opportunity to comment first.

4.10 Attitudes and Beliefs

Looking at ICTs in society, whether from an economic, political, cultural or educational point of view, means looking beyond just the physical technology and also beyond the impact of the physical technology on society and the practices it generates. It also means looking at how humans in society relate to and act on the technology – how and why they act on society with the technology so as to change society and the world around them.

For ICTs to be integrated into teaching and learning (the action), the role of teachers becomes a key lever and teacher technology actions are strongly shaped by their beliefs in the field of Educational Technology. Ertmer (2006) calls this "the final frontier" of technology integration. Constructing knowledge in teachers helps to shape their beliefs but the reason why teachers act in a certain way also goes beyond their knowledge. Teachers do not always practice what they preach and this is very much the case with respect to ICTs. This has been the case of the participant teachers in this research. Why do some teachers embrace technology so enthusiastically and integrate it into their teaching? Why are others so resistant to change? Why do many teachers have positive beliefs about the role of technology and also hold progressive pedagogical beliefs and yet do not integrate technology?

> "I believe that ICT should not be used simply for the sake of using it. There must be a purpose and a goal that needs to be accomplished. There must be learning taking place."
>
> (England Teacher 1)

The teachers in this research believe that their existing teaching methodology accomplishes the required goals. The curriculum goals are met and their learners are prepared for the final examinations. The teachers know that their existing methods are fine because they also achieve the required results from their learners as is a requirement from independent schools. So the belief is, why should they alter their methodology and pedagogy and spend time consuming hours re-developing lessons when at the end of it all, the same goals are met.

Question E - Teacher 'Technophobia' is common in schools. Do you think some of the teachers in this Science department display this?

Teacher beliefs are significant determinants in explaining why they adopt computers in the classroom (Van Braak, 2008). Even when resources, support, teacher skill and a favourable policy environment are present, high level technology use remains surprisingly low. In these cases, it may be that additional barriers, specifically related to teachers pedagogical beliefs may affect the level of ICT integration.

As indicated in figure 2, two South African and one English teacher display 'technophobia'. The context for many of the South African teachers attempting to assimilate ICT into their practice has been lack of appropriate equipment, training and time to evaluate new applications. Coupled with uncertainties about genuine pedagogical purposes for ICT, these reasons have caused some teachers to remain wary of ICT. The unreliability of school equipment, the expense of repairs and a lack of technical support have been additional problems (as experienced mainly by the South African teachers). Even though the comments from the South African teachers presented in table 7, show that they are keen and eager to utilise ICTs, there is a sense of uncertainty and reluctance presence. Words such as, "they are always **trying** to find out" or "we **realise** that it is an important tool" (table 7), indicate that ICTs in not being used in its full capacity for teaching and learning to take place.

Technophobia can be seen to be a barrier that people may experience as they fear the computer and are resistant to using ICTs because it is assumed that it is too difficult to use or because an individual's first experience with such devices may have been unpleasant. Table 8 shows that all

the teachers are aware of the positive use of ICT and none display the fear described. However, as much as the teachers would like to embrace the full use of ICTs, they are not due to the constraints mentioned.

Teacher 'Technophobia' is common in schools. Do you think some of the teachers in this Science department display this?		
		Teacher responses
South Africa	**1**	Limited historical exposure. No support.
	2	Everyone has a computer and they are always trying to find out how best they can use them.
	3	I have learnt something technological from everyone in this department.
	4	We all use this technology but some use it more often than others. We realise that this is an important tool in our teaching
	5	
England	**1**	Different teachers place varying degrees of priority as to how much they develop and use ICT in their teaching. It is mainly a matter of priority and time. All Science teachers use ICT to some extent. This has been a focus for many years in our Science department.
	2	
	3	Due to lack of experience with the software. Takes time and dedication to get to grips with new technology and time is something a lot of us don't have in Science. Inset of resources have been helpful but unless you frequently use ICT you probably don't have the desire to start now.
	4	
	5	Have their own tried and tested methods.

Table 7. *Summary of teacher responses on their thoughts as to why teachers display 'Technophobia*

Question F - Do you display 'Technophobia'?

Do you display 'Technophobia'?		
		Teacher responses
South Africa	**1**	Not enough time to spend on it, no support from colleagues who have "got it". Too much pressure to complete teaching curricula.
	2	Because I am always trying to integrate ICT into teaching.
	3	No because I make use of technology on a daily basis. Yes because I have reservations in learning new programs and equipment because of time and frustrations.
	4	I am aware of the value it has in teaching, especially the difficult concepts in Life Sciences.
	5	
England	**1**	I think ICT and technology in general can enhance teacher delivery in the classroom and also help students to learn more effectively. E.g. if they have to look up information they take greater ownership of it than if they were simply given a photocopied piece of paper.
	2	
	3	The way we educate our children has to change with the way in which they interact with their environment. 'Chalk and talk' is a thing of the past for students to remain interested and focused they need to be actively involved in their learning.
	4	I don't have the time to become comfortable with the use of ICT i.e. everyday lessons
	5	I like to embrace as much as possible and feel confident with it.

Table 8. *Summary of teacher responses as to why they might display 'Technophobia'*

4.11 Does age matter?

Question G - Do you think that younger teachers are better equipped than others in terms of their ICT skills in this school?

Figure 2 indicates that none of the South African teachers and 3 of the English teachers think that younger teachers are better equipped than others in terms of their ICT skills. Table 9 indicates the responses of the teachers with regards to this. People interact with technology on an emotional level (Kahn, 1985). Computers may not have feelings, but we certainly have feelings about computers; strong emotional responses are evoked when we sit down and make computers do things for us. What are these emotions and what is their relevance to teaching Science? Many young people are engaged emotionally and intellectually by the idea of the future and see this future very much in terms of new technologies, the 'hardware' of space, the hi-tech of sci-fi. Computers have a strong identification with this future world: using them generates an excitement among most learners. This was indicated by England teacher 1 in table 9.

South African teacher 4 in table 9 expressed that once a person starts using ICTs, he/she is more likely to continue. Young people live in a world where power and control are highly valued: most teachers, parents and adults have this power and successfully deny this power to young people. For some, computers represent an escape from the catch-22 of being constantly urged, by every device of television, film, music, poster and magazine advertisement, to seek something that they cannot have. Computers allow you to have power and control; they are expensive and powerful and yet they do what you want. As your skills increase, you find that you can make the machine do more elaborate and clever things; your sense of power and control grows. Even a beginner feels these things, and it is probably the sense of being in absolute control of a small part of the world that drives a few learners to become more skilled than most adults in using and programming computers. The relationship of a teacher and a learner is always an emotionally charged one. Teachers and learners cannot avoid bringing to the teacher-learner relationship their deep feelings from other parallel relationships, such as the parent-child relationship with its complex and inadequately described interaction of expectation, impatience, disappointment, pride and anxiety. Sometimes these feelings and emotions, evoked during teacher-learner interactions, can be made to work for the learner, sometimes they work against him or her. But computers are never impatient, never judgemental, and never moralistic; they have no sexist or racist prejudices. For some learners, learning from a computer is possible; learning from a teacher is not. There are

learners who learn things in different and more successful ways by using technology (Khan, 1985).

Do you think that younger teachers are better equipped than others in terms of their ICT skills in this school?		
		Teacher responses
South Africa	**1**	More exposure to I.T development – less technophobia. AND younger teachers do not have the financial back-up to afford latest I.T.
	2	Some old teachers know better.
	3	I see mixed abilities of technological skills in young and older people.
	4	I think that once you become aware of its uses and begin using it you are more likely to continue, irrespective of age. Some younger teachers don't use it as often as I do.
	5	
England	**1**	They are more familiar with technology having grown up with it. They also have more time and desire to play with new devices and explore online systems and sites. They also often type much quicker and have fewer worries about giving things a go. (Not so stuck in their ways).
	2	
	3	New PGCE/Bed courses have students using ICT from the outset. Younger teachers have been brought up computer literate and have no fear associated with using ICT.
	4	The time issue is the key factor at our school – we need space to think and prepare ICT resources, regardless of age.
	5	Have their own tried and tested methods.

Table 9. *Summary of teachers reasons on their feelings that younger teachers are better equipped in ICT use*

The fact that young people enjoy computers does not necessarily mean they can learn everything (or anything) with them. Some learners are ICT experts. However, Selwyn (1998) has shown that the most powerful educational applications of computers are not the ones learners tend to use at home. In order to encourage use of spreadsheets, databases, communicative links, and other genuinely educational software for most learners, the involvement of adept teachers is required. Also, being autonomous with computers (as an increasing numbers of learners are) is not always the same as knowing how to help others learn how to use them. Teachers must know how to do things with computers, but must also acquire the more complex understanding of how to ensure that computer use is educationally effective for others. The modern myth that children are better with computers than adults (especially teachers) does not take these traditional factors into account.

4.12 Obstacles to using ICT

Even when teachers recognise the importance of integrating technology into their teaching, successful implementation is often hampered by obstacles, which has been the focus of research for many years (BECTA, 2003). As outlined in section 2.5, a summary of research on this topic conducted by BECTA suggests four categories of obstacles:

Resource-related factors.
Factors associated with training, skills, knowledge and computer experience.
Attitudinal (including beliefs about teaching and learning) and personality factors.
Institutional and cultural factors (including policy).

The figure below indicates the barriers that the sample Science teachers feel hinder their use of ICT.

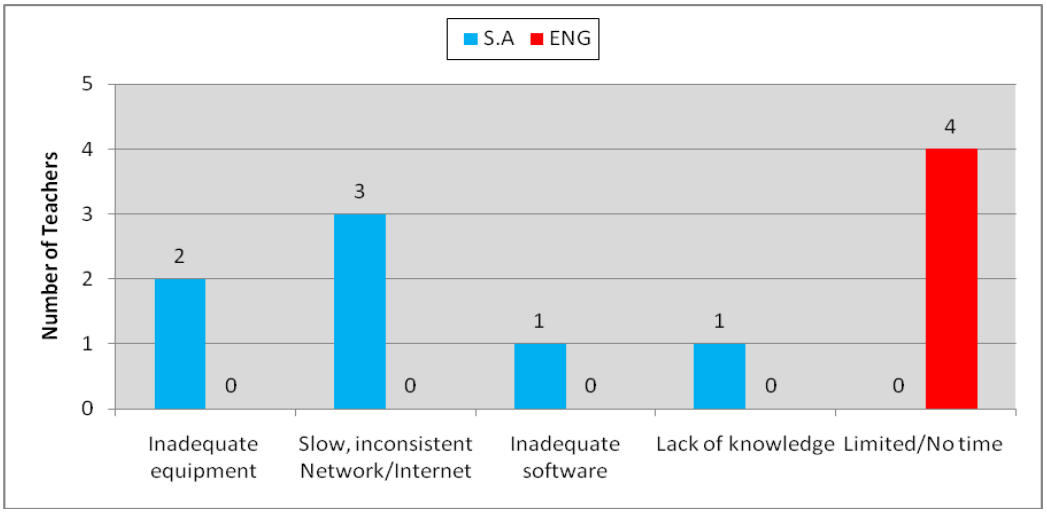


Figure 5. *South African and England teacher responses to the question: Briefly list the reasons (if any) that hinder you from implementing ICTs in your teaching.*

It is important to note again that both schools are adequately resourced. The only difference in resources is the presence of Smart Boards in the England classrooms. However, one teacher in the South African school has an e-beam. A smart board is an interactive whiteboard that uses touch detection for user input and an e-beam transforms any standard whiteboard or other surface into an interactive whiteboard. An interactive white-board is a large interactive display that connects to a computer and projector. A projector projects the computer's desktop onto the board's surface where users control the computer using a pen, finger, stylus, or other device.

Based on figure 5, it can be seen that even though the South African school is well resourced, teachers have a perception that the resources are inadequate. This is due to a lack of technical support. On the other hand, the school in England has adequate technical support but teachers do not have the time that is needed to prepare lessons for ICT implementation. Interestingly, the South African teachers did not mention time constraints. So it can be assumed that if the South African teachers are given support, they would prepare appropriate lessons using ICT and if the England teachers are given time, they would prepare lessons using ICT.

> "I acknowledges the time consuming nature of creating lessons with ICT implementation and believe that staff should be given the time to prepare this as this is what learners need in order to keep up in a global economy."
>
> (England Teacher 1)

Realistic time management:

It is a while now that anyone confidently claimed that computers would save time. Their processing speed is phenomenal, but that does not mean they decrease the time their operator spends on a given task. Tasks expand to take into account the capacity of the computer, standards rise accordingly, and time gets used at an alarming rate. We now expect computers to make presentation neater, data more comprehensive, information more accurate, layout more attractive, activities more interactive, finished products more impressive – and everything more time consuming. New tasks arise because the work is undertaken by ICT. The labyrinth of links that is the internet can seemingly absorb infinities of time. Communication generates more communication. So, there are important implications for time management when implementing ICT in the teaching profession. Teachers are used to doing a large part of their planning and administrative work at home. Home computers may streamline this, but the disadvantage is that they may come to add to demands on teacher time, but involvement with new technology inducts teachers into a learning community of users, altering attitudes and behaviour, and seems often to begin or become consolidated at home.

> "What we do alters who we are".
>
> (Zimbardo & Leippe, 1991, Pg. 84)

According to Leask (2001), who talked to teachers in the UK about their uptake and use of the internet; it was discovered that lack of time was not cited as a barrier by those with a sense of

purpose for ICT use. Teachers wishing to use ICT to support their work with classes found time to do so.

There are many reasons that hinder the teachers in this study from successfully implementing ICTs in their Science lessons. These reasons are in accordance with Butler & Sellbom (2002) who indicate the various factors that inhibit the adoption of new technology. Many factors affect the rate of adoption, including sociological, organisational, and psychological variables. A lack of school support, lack of financial support, and, most importantly, lack of time to learn new technologies as indicated by the teachers in this study; are more of the factors that impose barriers to adoption.

Reliability is one of the factors mentioned by the South African teachers in this research. Butler *et al*., (2002) says that the biggest problem with using technology for teaching is reliability. There are other problems closely akin to reliability. These include software being incompatible with school and home, mistakes by support services, software malfunctions, slow internet access, and out of date software. 'The server is down' is a major contributing factor to the reluctance of adopting technologies in the Science classroom. 'Zero breakdowns', including uninterrupted accessibility, regular system checks and repairs, and fast reliable email, is the backbone of successful ICT implementation in the Science classroom. This is something the South African teachers in this study do not have.

There are certain strategies that can curb the issue of reliability. It is important that technology staff is aware of the importance of having a reliable system especially concerning technology in the classroom. It is important that the school purchase highly reliable technologies. Schools must improve systems for checking and maintaining classroom technologies. Also, new approaches need to be implemented to assure that extremely rapid responses are made to breakdowns.

A contributing factor to non-implementation of ICTs by some of the teachers was 'the time it takes to learn to use new technologies.' Knowing how to use ICTs is an important factor in determining its adoption. According to Butler *et al*., (2002), there is a general tendency in academic culture that 'training' solves problems of 'learning'. Learning in an *ad hoc* way/manner seems more effective e.g. you happen to overhear or see a colleague doing something and you ask them to share how it is done or you learn a new skill as you need it i.e. in small pieces. No doubt training is useful for some complex systems, however, sometimes teachers have a hard time

learning to use things because of bad design: things don't work the way people expect, controls map poorly to the devices they control, or controls are hard to figure out.

However, not all teachers are innovators when it comes to technology. Many would prefer some help to learn such things as what tools to use for developing websites, or for editing graphics or digital video.

There are recommendations to simplify learning to use technology. New classroom technology setups should be tested by staff before they are installed. Classrooms should be as similar as possible in terms of the computer set up to avoid problems. It is also imperative to help staff by encouraging staff discussions about teaching, learning and technology.

Another factor that inhibits Science teachers from implementing ICTs in their lessons is the concern that technology might not really be critical for learning. One of the England teachers (table 4 and table 5, teacher 4) agreed with this. Butler *et al*., (2002) indicate that very few journals summarise the results of well run experiments on the impact of technology, and little useful scientific information is available on the Web. Which technologies used in the classroom (if any) facilitate the learning of discipline content or skills? Given the cost of technologies and the time needed to learn how to use them properly, it is important to first assess and evaluate the impact of ICTs for teaching and learning.

In order to help Science teachers determine if learning and using technology are really worth it, certain recommendations can be followed. Identify those teachers who have assessed and evaluated the impact of technologies on learning and organise a workshop, conference, or set of papers to make this information more widely available to the teachers. It is also important that Science teachers are able to assess and evaluate the impact of ICTs on learning for themselves.

In this study, the South African Science teachers indicated that there is very little support from the administration department should a problem arise. 4 of the teachers (figure 2) indicated that if adequate support was provided, they would be more open to implementing ICTs in their Science lessons. According to Butler *et al*., (2002), teachers are not satisfied with the school response to problems. Once again, teachers feel that problems are not corrected in a timely fashion. The lack of school support poses a major barrier to adoption and use of computer technology.

It is recommended that in order to improve school support for Science teachers, identify attitudes and behaviours that are seen as poor or inadequate support, and work with technology staff to reduce these. Also, a rapid response system must be in place that can deal with a wide range of problems.

4.13 ICT Tools implemented by Teachers in Lessons

The school Science curriculum is strongly influenced by what can be taught and learnt, and the way it is approached is dependent on the resources that can be made available in Science laboratories. The emphasis today is on learners doing Science for themselves, and it is now hard to conceive of Science education without the benefit of equipment and materials. The potential value of computers and technology in Science education is great, and it is today considered as essential as the microscope.

	YouTube videos	Data Projector	Desk / LapTops	Email (with learners)	Smart Board (for interactivity)	iPads	Cell phones	e-Beam
S.A	5	1	1	1	N/A	0	1	0
ENG.	3	1	2	1	2	2	1	N/A

Table 10. *Summary of ICT tools used by teachers in both schools. The numbers indicate the number of times that tool was used in a total of 10 lesson observations per school.*

In this study, YouTube proved to be the popular choice of ICT tool for the Science teachers. YouTube is best known for its free video-sharing service. People can post, comment on, tag and watch videos. While it has become an entertainment hub, YouTube is also a place where people can build or join a community that produces and shows videos about shared interests. People can upload videos and make them public or private or even integrate them on other web sites using video embeds. Viewers can create playlists of their favourites and subscribe to others' videos.

The implication for education is that learners can create thoughtful and meaningful video clips that look professional and command and audience for their work (Solomon & Schrum, 2007). Having

the simple tools available makes it easier to create and edit effective presentations. They can collaborate by uploading individual videos and editing them together into a single movie that uses the best of each clip. They can use the clips for digital storytelling and insert them into presentations and projects. If their videos are of high quality, other learners can learn from them (Solomon *et al*., 2007).

> "I prefer technology as I get bored with listening to my own voice and so my learners could be bored too. Technology supplements the lessons and provides visuals. Learners make their own videos too as they have easy access to the resources for this."
>
> (S.A Teacher 4)

In all the observed cases in this study, teachers did not make use of this tool in this manner. YouTube videos were projected for the class to watch, based on the current topic. It was used to show real life aspects of the current topic e.g. freefall from the edge of the atmosphere, for the topic of velocity and acceleration; or to demonstrate simulations e.g. fertilization of flowers, and fracking in the Karoo. Learners were shown the videos at the end of the lesson as a treat and there was no engagement with the content of the video.

Two teachers (one in SA and one in England) utilised email groups. This allowed the teacher to email extra resources to the learners or for the learners to work on a computer and email the work to the teacher. This too proved to have obstacles as indicated by one of the England School teachers.

> "I enjoy using technology but admit to not using it to its full potential as I do not have the time to prepare lessons with ICT implementation. I often get them (learners) to email me their work, but even that proves to be time consuming as many of them don't write their names of their work and then I still have to come back to find out whose work belong to who. I enjoy getting them to prepare creative presentations and posters using a computer, which I print, laminate and put up in class."
>
> (England Teacher 5)

The South African school teachers also faced problems as not all his learners had set up an email and many had not provided their email addresses as yet. This took up a lot of time in the lesson observed, as the teacher struggled to solve this.

In the England School, all the classrooms were equipped with a Smart Board. In the South African School, one classroom was equipped with an e-Beam. In the observed lessons, the Smart Board was used twice for lessons of interactivity. The e-Beam was not used. 3 out of the 5 England teachers admit to not using their Smart Boards to its full potential and using it mainly as a projector to show video clips on. This is how the e-Beam was mainly used by the South African teacher as well.

> "I do use the Smart Board for interactive lessons whereby learners can come up and move pictures around. I believe in varying my lessons from traditional teaching styles to utilising iPads. I often search for interesting Apps or websites that can be utilised in my class."
>
> (England teacher 3)

The Smart Board interactive whiteboard and e-Beam were designed to help improve learning. Combining the simplicity of a whiteboard with the power of a computer, the Smart Board interactive whiteboard lets the teacher deliver dynamic lessons, write notes in digital ink and save the work, all with the simple touch of a finger.

iPads were introduced into both schools during the time of this study. In the South African school, selected teachers were attending in school training on how to use this tool. So it was not yet implemented in lessons. In the England School, teachers were given no training but were already clued up on its use and it was implemented into Science teaching instantly. It was used in two lessons out of the ten lessons observed. It was used by learners to access interactive Applications (Apps). All learners were engaged and enjoyed the tasks. A South African teacher had this to say regarding iPads:

> "ICTs are not an everyday tool. It does have limited application. It is time consuming and iPads for example are a 'gimic'. Technology cannot replace the teacher. It is emotionless and cannot have a relationship with the learners."
>
> (S.A Teacher 1)

Two of the teachers allowed cell phone use in their lessons. One in the South African school and one in the England School. In the South African school, the teacher allowed his learners to use their cell phones to access information quickly. In the England School the teacher allowed his

learners to listen to music while working. He said that it allowed those particular learners to concentrate better (In line with Multiple Intelligence theory). It worked well, as each learner was engaged at the task at hand. This can be done when the teacher knows his learners. He knew that his learners work well in his manner.

> "I allow cell phones when working on a project because it is difficult booking the computer room and learners don't have access to the computer room."
>
> (S.A Teacher 3)

4.14 Community of Practice (School Support)

The presence of a community of practice is often considered to be an important enabling factor in supporting pedagogical innovation and change in schools. The idea underpinning this concept is that teachers work with colleagues in a school context and that the beliefs and practices of teachers are strongly influenced by the culture and practices of the school within which they operate. Four key aspects were identified in the SITES (2006) study pertaining to the presence of a community of practice pertaining to teachers, namely (i) whether there is a shared vision among teachers and the leadership in the school, (ii) whether teachers have opportunities to take part in the decision making of the school, (iii) whether there is the presence of a strong culture for professional collaboration and in the case of ICT implementation, (iv) the availability of technical, administrative and infrastructural support (Law, Pelgrum & Plump, 2008).

Question H - Does this school have an ICT expert who is designated to assist staff with ICT implementation specifically into their lesson?

Within these four aspects, among the South African teachers, the availability of technical, administrative and infrastructural support was felt most by all the participants. This perceived lack of support may be a significant contributing factor to the low ICT use by the South African Science teachers. The England School Science teachers do not encounter the above mentioned four factors, but as was discussed, time to prepare innovative lessons is not available in their schedules. The England teachers have mentioned time constraints often throughout the study and upon further interrogation of this it was found to be true due to the following reasons:

1. Teachers teach at least 4 – 6 lessons of a 6 lesson timetable. In their free lessons, they have to complete various administration requirements for the day pertaining to the learners.

2. In the afternoon, teachers are involved daily in the extra-mural programme.
3. In the evening to night, as all the teachers reside on the school property, they are involved in boarding house duties.
4. There are also lessons that take place on a Saturday morning and sports events in the afternoon.

On the other hand, the South African teachers teach 3 – 5 lessons out of a 6 lesson timetable. They are only involved in the extra-mural programme twice a week, and only one teacher resides on the school property and has boarding house duties to conduct in the evenings. But due this, this teacher has a reduced teaching timetable. Hence the South African teachers indicated that they do have time, but they do not have support.

Question I - If you or the Science department were provided with an ICT expert, would you be open to implementing ICTs more often in your Science lessons?

Research evidence from a study of Australian teachers beginning use of the internet in their work (Williams & Mckeown, 1996) showed that most of those involved benefitted from the on-line support of their colleagues. Electronic communication can allow teachers to transcend their traditional isolation within classrooms, and to begin to develop links with other professionals that allow discussion of common interest issues.

This study also suggests that the South African Science teachers as learners of ICT may find support offered by their peers or a knowledgeable other invaluable. Only 2 of the 5 England teachers thought having an expert would provide the support. This is due to again the issue of not having time in their work day to seek out this expert.

> "I don't think having an expert is the problem. Staff would not have the time to see this individual during the working week due to all their other commitments."
>
> (England Teacher 3)

Question J - Does management at your school encourage staff to implement ICTs in their lessons?

All the South African teachers agree that management encourages the use of technology and 4 out of the 5 England teachers agree. However, as discussed early on, this is not ICT in the true sense. Management encourages staff to utilise the technological tools in order to make their jobs easier, and not in the form of planning collaborative, innovative lessons. I do not think this is done on

purpose, it seems as though, teachers and management are not aware of the pedagogical uses of ICT for teaching. It is simply used as a tool to enhance existing teaching methods. Professional training is required in order for teachers to learn how to use ICT to teach Science.

4.15 Policy issues

The general nature of policy is that of a guide to action, or a framework designed to deal with problems or issues. (Kozma, 2003). In other words policies are put in place to direct and inform practice. There is always a relationship between policy and the practices it aims to put in place, but there is seldom an absolute alignment between the two and one of the purposes of policy analysis is to ascertain the relationship between the two. As Kozma indicates in a number of his writings, ICT-in-education policies have been put in place to both simultaneously address macro development challenges as well as to improve the quality of education.

Teachers are expected not only to cope with, but also implement change on a grand scale. In the UK there has been the introduction and review of the National Curriculum and the implementation of the literacy and numeracy strategies. In addition, schools, learners and teachers have been involved in technological change. A change that not only involves 'connecting the learning community', but also involves developing a range of strategies for 'learning within a connected community' (in line with Connectivism). It is argued, according to the DfEE (1997), that this degree of change is in the name of 'raising standards'.

> "The National Grid for Learning will also send a clear message, both here and internationally, that the UK tends to be among the world leaders to harness new technologies to raise educational standards..."
>
> (DfEE, 1997, Pg. 3)

I can argue, however, that standards of teaching and learning will only be raised if the various elements of change are implemented effectively at school, local and national levels. The implementation of the 'The National Grid' for learning in the UK, cannot improve standards alone. The successful integration of ICT into the curriculum will, however, have a definite impact. To achieve this, schools need to be well organised and planned. Teachers need to develop the ability to identify opportunities for ICT and develop the concept of using the technology as a tool for learning, particularly within the literacy and numeracy framework which in turn impacts on other subjects including Science.

However, in 1994, a British report titled: *Learning through Telematics*, continued the attack on the current education climate. It reported:

> "Predicting the future of technology is easy. Predicting the way in which the technology will be taken up within education is very difficult. There is a long history of hyperbole about educational technology, characterised by repeated predictions of imminent revolution in methods. Yet there is a strong resistance to change and innovation in the system as a whole. Education is a social and political system and experience should teach us that such systems are not easily changed by developments in technology".
>
> (Mayes 1994, Pg. 14)

Pachler (1999) quotes the DfEE Initial Teacher Training National Curriculum which is intended to teach teachers about 'when, when not, and how to use ICT effectively in teaching particular subjects (DfEE 1998: 17)'. He points out the dangers of the lack of pedagogical theory offered in this document (Pachler, 1999). The language of this document is didactic which militates against the constructive learning model the government wants to introduce.

It is not surprising that the British inspection body, The Office for Standards in Education, is critical of the teaching and use of ICT in schools. Resourcing in the classroom is adequate but the inspectors report for 1994/5 complains that content in general is not being taught in sufficient depth utilising ICTs across the curriculum. The DfEE's longitudinal study on learning with computers, the Impact Report (1993), finds new measurable results from computer use in schools. They concluded that, the majority of school pupils are not yet provided with opportunities to take advantage of the potential of the full range of software, a substantial amount of which is currently available in schools.

A summary of this chapter highlights the unexpected result that the Science teachers in both independent schools are not implementing ICT in a manner appropriate for learning to take place. ICT is being used to supplement their existing traditional teaching practices. It is not being used for collaboration or authentic learning tasks. The reason for this is because the teachers are not skilled in this area, and in 'The South African' school, it is due to a lack of support; in 'The England School' it is due to a lack of time. In the next chapter, conclusions are drawn and recommendations are made.

CHAPTER 5 – CONCLUSIONS

In this chapter I shall firstly provide a summary of the research results obtained. Secondly, I shall answer the initial research questions that I had set out. Thirdly, the findings of this research will be discussed in relation to the theoretical framework. And finally, I provide recommendations in terms of the initial main question of 'How are Science teachers integrating Information and Communication Technologies into their teaching?' This includes the list of factors placed in order of hierarchy that need to be taken into account for ICT implementation (as was mentioned in the research design).

5.1 Summary of the Research Data

- All the participant Science teachers agree that ICT implementation is important in the teaching of Science and it does enhance their teaching.
- All the teachers do use ICT tools in their lessons ranging from once in 4 four months to daily.
- The main hindrance for South African teachers is the lack of reliability of the internet/network as well as the lack of support from administrative staff. While England teachers have no hindering factors that will allow for successful ICT implementation, they claim that they do not have the time in their work day to plan ICT enriched lessons or the time to see the experts who can assist.
- All the South African teachers felt that social networking tools can be used for education purposes as this allows for communication. Many of their learners do already use social networking tools like Facebook and hence this needs to be capitalised on. Only one of the England teachers is aware of this tool and acknowledges its use for communication in Science.
- One teacher from each school admitted to having a fear of using technology and both these teachers attribute this to having a lack of time to become comfortable with technology.
- One South African teacher and three England teachers feel that younger teachers are better skilled with technology. They attribute this to reasons such as: more exposure to information technology (I.T) developments, they have more time and desire to play with new devices, or, new PGCE/Bed (Postgraduate Certificate in Education / Bachelor of education) courses have students using ICT from the outset.

- All the South African teachers felt that having support would result in them utilising new tools more often. The England teachers felt that even though they have the support, they do not have the time to utilise this support.
- All the teachers admit that management does encourage them to use ICT.
- All the teachers acknowledge that their learners will enjoy lessons that utilise ICT due to reasons such as: it is exciting, it appeals to their interests, interacts with them at their level, provides variety for stimuli, and visuals help with understanding scientific concepts.

5.2 Answers to the Research Questions

How are Science teachers' integrating ICTs into their teaching?

The main research question is *how are Science teachers' integrating ICTs into their teaching?* Teachers are utilising ICTs in the form of tools that enhance their lessons and enhance their traditional teaching methods. Teachers do not possess the 'know-how' for ICT implementation for collaborative learning to take place in the true sense of Constructivism and Connectivism. There are very few interactive lessons, or group work which utilises ICT. Perhaps, with the introduction of iPads into both schools, further research might discover ICT integration to an adequate level.

As a way ascertaining that ICT adds to teaching and learning in a South African classroom and an England classroom, the main research question was operationalised by sub questions:

<u>Which</u> tools are being used?

It has been established that the science teachers in this study utilise ICT tools for ease of teaching purposes. The tools used by these teachers were YouTube videos to show videos of real life situations pertaining to the current topic, data projector to project notes and diagrams, desk / laptops for learners to use the internet for browsing purposing only, email (with learners) to send and receive work, Smart Board (for interactivity) used mainly for projection purpose and very little interactivity, iPads used for individual access to Apps, cell phones used for quick access to information and an e-Beam used mainly for projection purposes.

<u>Where</u> are ICT tools used by teachers and learners?

Are the tools used by the learners in school or out of school? The tools are used by learners in school. Learners in the South African School will use their cell phones out of school to access social networking sites or to browse the internet for information on a topic. Learners in the England School have access to laptops with internet.

<u>When</u> are ICT tools used?

How frequently are ICTs being used? ICTs are being used on a daily basis by all teachers for administrative purposes but not for teaching purposes.

<u>Why</u> use ICT?

What are the teacher's reasons for integrating ICTs into their science lessons?

The participant Science teachers are using ICTs as tools due to not having professional training in the use of ICT for collaborative learning to take place. The Science teachers are using the ICT tools to keep their learners occupied, make their lessons visual for their learners and to create a sense of enjoyment for Science. It is used for aesthetic purposes.

From this study, the teachers prefer YouTube videos due to its ease of access. Teachers also prefer projecting notes and diagrams using a data projector, Smart board or the e-beam. This allows ease of teaching, and storage of work for future use. All the teachers agree that their learners enjoy ICT however one teacher in each school is not in favour of ICT use as it distracts learners and the same goal can be achieved using traditional methods.

<u>How</u> are the tools being used?

How do science teachers use ICTs? (Enabling factors)

If equipment is present 9 out of the 10 teachers are keen to learn how to use it. The teachers, who are using ICT, do enjoy the ease it provides them with in terms of projecting information and videos.

What are the barriers to acceptance of computers as a teaching method in science education?

The barriers for the South African teachers are an unreliable internet connection and lack of support and knowledge.

The England teachers on the other hand, are not short of support, have no technical failures, have no lack of resources, yet do not implement ICT to its full potential due to a lack of time to prepare lessons with ICT implementation.

The use of ICT has a low impact on teaching and learning where teachers fail to appreciate that interactivity requires a new approach to pedagogy, lesson planning and the curriculum. Some teachers reorganise the delivery of the curriculum but the majority use ICT to add or enhance their existing practices (9 out the 10 sample teachers). Teachers need to employ proactive and responsive strategies in order to guide, facilitate and support appropriate learning activities.

Science teachers need to engage with the forms of multimedia found on computers or on the web as soon as possible, otherwise learners will be redirecting their own learning or being redirected by commercial providers which may make life extremely difficult for less ICT literate teachers. We have to embrace these new technologies, examine their potential and critically determine what part they play in existing or new forms of education, schooling and teaching. Given instantaneous access to unlimited information and resources for all areas of Science, what may now be described as the role of the teacher? To answer this, Science teachers need to structure lessons and topics such that they provide direction and guidance for learning to take place. Facilitation is required by teachers whereby, yes, it will take time to prepare lessons utilising ICTs, but in the long run, it creates independently thinking learners who will learn to manage online content.

Many teachers, according to Leask (2001), are embracing new technologies and have been doing so for many years, often from personal interest, but much of the time through in-service training,

continuing professional development courses or through higher academic study. The Science teachers are concerned with what and how their learners learn. They are concerned with education rather than technology. They are not concerned with how technology improves learning but in how to improve learning through the effective and appropriate use of technology. They need to be concerned with the nature of learning rather than the nature of technology. The established curriculum is dictated by the pre-twentieth century technology of writing, printing and calculating. The real offer of educational technology is liberation from the consequences of having been restricted by these primitive tools. (Papert, 1998).

The trend in Science teaching over the last few decades has been towards emphasizing problem solving, data interpretation and experimentation. While the content of what Science teachers teach will never become negligible or arbitrary, the process (the methods used by scientists to develop predictive models and test them) are increasingly recognised as a central and vital part of what we teach. Simulations and modelling programs, databases and statistical packages, computer laboratory experiments, data collections and representation, all serve to emphasize process over content, Science as an activity over Science as a static collection of 'facts'.

ICT competence among the Science teacher is low, but teachers are competent in the technical use of ICT than in the pedagogical use of ICT. The South African teachers in this study are in possession of technology resources but despite this, lack of a reliable internet connection proved to be the greatest obstacle. A lack of administrative support coming in closely at second. It was not one that they had any control over and this provided an obvious frustration for the teachers.

5.3 Findings in Relation to the Theoretical Framework

Constructivism: is a learning theory that allows for learners to collaborate and utilise existing knowledge in order to learn. The teachers are not using a Constructivist approach. Laboratory work forms an ideal time to do so, whereby learners can be given the theory required for a particular experiment, but the actual methodology can be devised by themselves. Enquiry based learning is a constructivist approach that encourages learning in depth by allowing learners to use inquiry-based methods to engage with issues and questions that are rich, real and relevant to their lives. It emphasizes learning activities that are long-term, interdisciplinary, and learner-centred. Learners form a learning community that focuses on critical thinking. Project based learning

allows for alternative approaches that address learners' individual differences, variations in learning styles, intelligences, and abilities and disabilities (linked to Gardner's theory). Table 4 and Table 5, which indicate the teachers feelings on ICT use and the learners feelings on ICT use respectively, show that teacher centred teaching is the dominant if not the only manner in which teaching is taking place. There was no group work conducted in any manner. The reason for this was that the teachers still achieve the same outcomes and the same good results using their traditional methods.

Connectivism: is a learning theory that allows for learners to connect using networks in order to learn and hence it is applicable to this study. Only one South African teacher indicated the use of a Social Networking tool (Table 6). The capacity to form connections between sources of information, and thereby create useful information patterns, is required to learn in our knowledge economy. A Constructivist perspective and a Connectivist perspective both try to come to terms with an increasing body of knowledge, sitting at our fingertips. Both perspectives agree that the rote learning of facts is becoming less important in school and especially in Science. Constructivists believe that learners will need the skills to construct understandings of new knowledge. Connectivists believe that they will need the skills to connect with new knowledge (Siemens, 2004). Combining Connectivism with Constructivist methods in the classroom offers learners an opportunity to gain 21st century skills. This was not the aim of the Science teachers. The aim was to get though the Scientific content. Forming online groups and engaging in discussion here, was not used.

Multiple Intelligences: This theory is an applicable one and the reason being is due to it taking into account different learning styles that ICT use pertains to. In table 5, it can be seen that the teachers acknowledge this theory and its importance. England teacher 2 comments that ICTs provides a variety of stimuli. However, this acknowledgment did not mean that the teachers were implementing ICT in a manner conducive to learner enquiry and collaborative learning. The odd YouTube video was played (8 out of the 20 observed lessons), simulations were shown (in the form of YouTube videos) and cell phone use was allowed (2 out of the 20 observed lessons). This pertained to the visual and auditory aspect of the theory only. Learners were not allowed to express musical, logical-mathematical, spatial, bodily-kinaesthetic, interpersonal and intrapersonal intelligence. There was no need to allow other forms of learning as once again the ultimate goals of writing tests and exams and achieving good results were achieved. This is the main goal of the schools and this is what the parents of the learners want.

5.4 Recommendations

New technologies have a major role in developing opportunities, and facilitating the sharing of resources and content. An intranet or 'Virtual Learning Environment (VLE)' as currently being implemented in 'The England School' provides a platform on which collaboration in various ways can take place. The technology can provide a set of tools that enable teachers, learners and schools to raise standards through collaboration and communication. An on-line 'learning community' is a phrase often used to describe a community of learners who use new technologies as tools through which developing professional practice and learning.

An educational intranet, also known as a Learning Management System (LMS) (web or network based system open to approved users) can be developed on a number of different levels, therefore, existing networks can often be utilised to provide a technically simple intranet. With investment, more complex intranets can be developed to encourage and facilitate collaboration, but whatever the scale of the intranet to be developed, key decisions have to be made in relation to how the technology is to be used and in relation to the nature of learning that the intranet will support. A balance needs to be found between the type of learning community to be supported and the technologies that are available. These are discussed below.

Learning in a networked society

Learning in a networked society in line with the learning theory Connectivism. When developing an educational intranet for a school, it is important to consider the type of learning that the design of the system will promote. Some decisions will be restricted by the type of technology available to develop the system, while other decisions will reflect how content materials will be accessed, interacted with and developed. What will be the aims for users of the intranet as learners? When a user approaches the intranet, what type of activity will they be involved in? Who will be involved in developing the community? What tools will they be given?

I argue that when a user approaches an intranet they can do one of three things; browse pages of information, interact with pages of content or collaborate with other uses. A user may be involved in any number of these tasks during one session.

Browse – A user uses the technology to gain information. The activity requires the user to read information presented on the screen and take away from the information a degree of knowledge.

This activity relies on the learner being able to interpret the information effectively and to be able to draw relevant conclusions.

Interact – On this occasion, the information is developed and shaped by the user. The information retrieval process relies on the interaction of the user with the system. Key questions may be asked of the user and choices made or communicated using on-line forms. This activity involved the user directly in the learning process and requires the user to interact with the information to enable relevant conclusions to be made.

Collaborate – the learning activity relies on the user collaborating with other users, sharing information and knowledge. When a user approaches the system they are actively involved in the activity, which can only take place when users interact. Information is provided by other users. This activity involves the user directly in the learning process (Leask, 2001).

This concept can be taken further. If each activity is evaluated and the type of activity that is being promoted via the technology, I can argue that the 'Browse' activity is essentially a passive task, where the learning gains are dependent entirely on the effective interpretation by the learner of the information presented. I can argue that the last two activities encourage active tasks where the technology encourages the involvement of the user. This is in many ways a crude model as it presumes that all the activities are solitary tasks, where the learner in on their own using the system. This is perhaps one of the best ways in which to approach the development of content if assumptions have to be made regarding the effect a particular material has on learning. When developing content for an intranet, the type of content presented to learners is therefore critical if the technology is to have an impact on learning and on raising standards.

These concepts have implications for the type of community that will develop. Will users be encouraged to interact with the technology and with each other or will they be encouraged to take from the system relevant knowledge? If we imagine the intranet to be a large room, we need to consider how the room is set out and what type of content is displayed, where it is displayed and how to encourage learning to take place. An intranet that encourages users to browse for information and knowledge will encourage a relationship to develop between the user and the technology that ignores other users on the system to a great extent. The room would have no furniture, but the walls would be covered with posters of information. There would be many entrances and the room would be full of people searching for relevant information and looking at the posters to gain further understanding and knowledge. Even though the room may be full of people, it is silent as no one is encouraged to communicate with another (Leask, 2001).

An intranet that encourages users to communicate and collaborate would be similar to the room above, but, this time there would be areas of the room set aside for people to meet. When searching for relevant information, someone may guide you to a particular resource. When looking at a poster of information on a wall, users will be encouraged to turn to the person next to them and discuss the content and they may need to interact with the poster to gain full understanding of its meaning (Leask, 2001).

I could well argue that the latter argument describes an active learning community where users are encouraged to use the relevant technological tools to develop a range of skills, concepts and understandings. Learning becomes a collaborative, shared experience as advocated by constructivism.

The concept of a collaborative learning community can be difficult for teachers to achieve. Many users may wish to use the technology to share resources, often think in terms of digitising materials that already exist in paper format. While there is an obvious place for this type of content within an intranet, if the whole intranet contained materials of this nature, collaboration would be discouraged and the concept of a browsing intranet would be encouraged. Furthermore, the intranet becomes an information dissemination service to those in authority and the quality of that information provided is only as good as the group that have control over the content to be distributed. Therefore, contributions from the many, with an integrated quality control mechanism, that facilitates communication and collaboration between users of all types should be encouraged. This is how ICT's should be implemented by Science teachers.

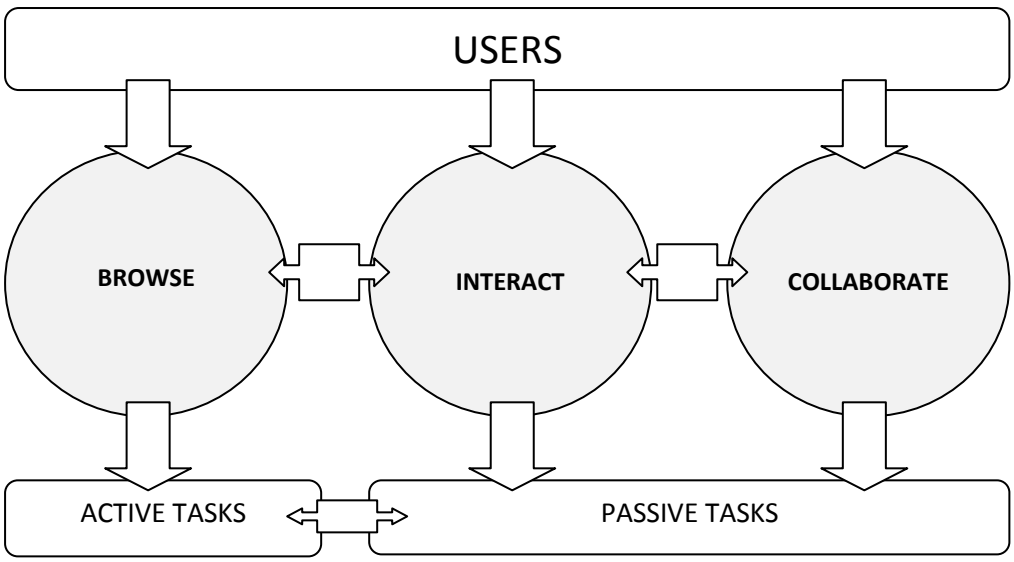


Figure 6. *Ways of using an Intranet*

Intranets can, and do, make an impact in the classroom and have enormous potential for helping to raise standards in schools. For this potential to be realised, there is a need to further develop a 'sharing culture', where the educational intranet is one of the first points of call, for relevant resources and collaborative opportunities, for teachers and learners.

5.5 Hierarchy of factors for successful ICT implementation

One of the aims of this research was to create a list of factors that impact on the successful integration of ICTs. I have placed these factors into a hierarchy and it can be utilised by teachers who are keen on implementing and integrating ICTs or for teachers who want to begin. It is based on the findings of this study.

1. Professional training

   If teachers are enthusiastic about ICT implementation, no amount of enthusiasm will prepare the teacher for successful implementation in terms of collaborative learning and the use of an intranet. Professional training is the most important requirement.

2. Reliable internet connection

   Before adequate support is even provided to teachers, in order for collaborative learning to take place, and communication, a reliable internet is a necessity. This avoids teacher frustrations.

3. Support

   The school must have a staff member designated to assist teachers instantaneously with technical or other ICT problems that arise.

4. Time

   If schools want to prepare learners for a global community in the 21st century, time needs to be set aside for departments to strategise and plan lessons with ICT implementation. Teachers can then go out into the classroom, implement, and meet again to reflect on the pedagogies implemented.

There is scope for further research into this field of ICT and Science education. In both schools, as I neared the end of my research, iPads were being implemented into teaching. The use of this could prove to be a fruitful study.

To conclude, with a final word, ten teachers allowed me into their personal space and shared their frustrations with me. However, all the teachers are motivated and have their learner's best interest at heart which was pleasing to see as a passionate Science teacher myself.

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Appendix A – Participant Information Document

Faculty of Humanities
Private Bag 3, Wits, 2050, South Africa
Fax: +27 (0) 11 717 3219
Tel: +27 (0) 11 717 3021

26 April 2012

Dear Principal and Science Teachers

The Integration of Information and Communication Technologies (ICTs) in the Teaching of Science.

I am Sofiah Essop, a *Masters in Education* (MEd) student at the University of the Witwatersrand, Johannesburg, South Africa. I am conducting research for my Masters research project and I am interested in doing this at your school.

Over the last two decades the use of ICT's has grown rapidly. It has also been shown to be successfully implemented in Science Education. But, research shows that many Science teachers are not implementing ICT's in their lessons. I aim to find out the reasons for this. If ICTs are integrated into teaching, I wish to find out more importantly, how are Science teachers implementing and integrating ICTs into their Science lessons for teaching and learning to occur. My overall objective is to investigate the teaching methods utilized in two schools, one being in South Africa and one being in England. I am personally involved in this research as a Science Educator with a passion for ICT integration into my teaching.

This shall be conducted in a small scale qualitative study by observing the teachers in your schools Science department, conducting informal conversational interviews and having a questionnaire filled out by the Science teachers. There shall be no disruption of the lessons other than my presence in the classroom.

I am inviting you to participate in this research study. The participant Science teachers' involvement would entail granting me their consent to observe their lessons, conducting informal conversations with me and to fill in my questionnaire. This study will be conducted over a period of 10 school days during the period of the 16th July 2012 to 27rd July 2012 in South Africa and during the 03rd December 2012 to the 14th December 2012 in England. I shall informally talk to the teachers with regards to which lessons I shall attend as I am unable to observe every lesson of all the participant Science teachers.

While there are no direct benefits unto participant teachers, the information gathered from this study will hopefully allow me as the researcher to bring back vital information to my current school which is in South Africa and forms one of the participant schools.

It is important to note that the participating teachers are consenting to involvement in research, and not to treatment. The participant is free to withdraw from the study at anytime without prejudice. Participation in the study is entirely voluntary; that a choice not to participate will have no adverse consequences; that should the person choose to participate, he/she may decline to answer questions and may withdraw from the study at any time. The questionnaire is both anonymous and participants will not be identified in any way. If participants do complete the questionnaire, they are also free to withdraw at any stage. All the data that will be collected will be stored at a storage facility at Wits University upon completion of the research report. The final research project will be available to your school or any of the participants, at their request.

I would be grateful if you accept my invite to participate in my research. I require an introduction with the Science Head of Department in order to facilitate my presence and introductions with the other Science teachers. I have personal involvement in this study as a Natural Science and Life Science teacher.

Please feel free to contact me or my supervisor, Dr Donovan Lawrence should there be any area that I/he can elaborate on.

Kind regards

Sofiah Essop

Wits School of Education

Tel: +2776 484 6090

sofiah2711@gmail.com

Dr Donovan Lawrence

Tel: +2711 717 3175

Donovan.Lawrence@wits.ac.za

Appendix B – Principal Consent Form

I, _____, the Principal of 'The South African School', South Africa hereby grant consent / do not grant consent for Sofiah Essop to conduct her research for the degree of *Master in Education* in Dominican Convent Schools Science Department. I have read and understand the anonymity of the research.

Thank you

_____ _____

Principal, 'The South African' School Date

PRINCIPAL CONSENT FORM

I, _____, the Principal of 'The England School' hereby grant consent / do not grant consent for Sofiah Essop to conduct her research for the degree of *Master in Education* in Stowe Schools Science Department. I have read and understand the anonymity of the research.

Thank you

_____ _____

Principal, 'The England School' School Date

Appendix C – Teacher Consent Form

I, _____a Science teacher of 'The South African School', South Africa hereby **grant consent / do not grant consent** for the research of Sofiah Essop for the degree of *Master in Education* for the following:

Please tick

Informal conversational interviews	
Grant consent	Do not grant consent

Please tick

Lesson observation	
Grant consent	Do not grant consent

Please tick

Utilise my responses in the questionnaire	
Grant consent	Do not grant consent

I have read and understand the anonymity of the research.

Thank you

_____ _____

Science Teacher, 'The South African' School Date

TEACHER CONSENT FORM

I, _____a Science teacher of 'The England School', England hereby **grant consent / do not grant consent** for the research of Sofiah Essop for the degree of *Master in Education* for the following:

Please tick

Informal conversational interviews	
Grant consent	Do not grant consent

Please tick

Lesson observation	
Grant consent	Do not grant consent

Please tick

Utilise my responses in the questionnaire	
Grant consent	Do not grant consent

I have read and understand the anonymity of the research.

Thank you

_____ _____

Science Teacher, 'The England School' School Date

Appendix D – Participant Science Teacher Questionnaire

Dear Science Teacher

Thank you so much for taking the time to fill in my questionnaire. Please answer these questions as honestly as possible. Answer the questions with regards to this school and your experiences at this school unless asked to do so otherwise. Please understand your participation is voluntary and you have the right to withdraw your questionnaire or discontinue participation at any time. Your individual privacy will be maintained in all published and written data resulting from the study.

	Question	Answer
1.	How long have you been teaching in the Science field including your career at this school?	
2.	How old are you?	
3.	What learning area or subject methodology or specific area of Science are you currently teaching?	
4.	Do you have a computer that you can easily access at home?	
5.	Do you have any professional training in the use of ICT's?	
5.1	If yes, elaborate briefly.	
6.	Are you comfortable / confident with your ICT skills?	Not at all Somewhat, I need help at times Very confident

7.	Do you use ICTs in your lessons?	Never Once in 4 months Once in 2 months Once a month Weekly Daily
8.	Do you feel that ICTS's can be implemented to enhance your teaching and your students' learning?	
8.1	If yes, how and why? If no, why not?	
9.	Briefly list the reasons (if any) that hinder you from implementing ICT's in your teaching.	
10.	Are you aware of the many advantages of social networking sites e.g. Facebook, Twitter etc for educational purposes in Science.	
10.1	If yes, elaborate on how you think these tools can be used in Science education.	
11.	Teacher 'Technophobia' is common in schools. Do you think some of the teachers in this Science department display this?	
11.1	If yes / no, why do you think this is the case?	

12.	Do you display 'Technophobia'?	
12.1	If yes / no, why do you feel this way?	
13.	Do you think that younger teachers are better equipped than others in terms of their ICT skills in this school?	
13.1	If yes / no, state your reasons.	
14.	Does this school have an ICT expert who is designated to assist staff with ICT implementation specifically into their lesson?	
14.1	If no, if you or the Science department were provided with an ICT expert, would you be open to implementing ICT's more often in your Science lessons?	
15.	Does management at your school encourage staff to implement ICTs in their lessons?	
16.	Do you think your students enjoy being taught using ICTs?	
16.1	If yes / no, why?	