AN INVESTIGATION OF THE INTEGRATION OF INFORMATION COMMUNICATION TECHNOLOGY IN TEACHING OF SCIENCE SUBJECTS AT THE NAMIBIAN COLLEGE OF OPEN LEARNING

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Abstract

Technology has become a vital tool in teaching and learning, realising a paradigm of learner centred instruction for diverse learners. The use and integration of ICT into education, which is the focus of this study, is stated as one of the five distinct development areas in the use of ICT (MoE, 2005). In order to meet the requirements of Level 2 according to ICT policy for education, NAMCOL adopted a strategy to enhance ICT integration in teaching to this effect. NAMCOL invested resources in establishing computer laboratories at selected tuition centres. Against this background, the study investigated how the Science tutors integrated ICT in their teaching at the NAMCOL centres, the tutors' perception of ICT and the main barriers for integrating ICT in teaching at NAMCOL centres.

The study was guided by Rogers' theory of diffusion and adopted a qualitative case study design to investigate the integration of ICT in Science teaching at NAMCOL centres as well as the perceptions of the Science tutors of ICT integration. Four NAMCOL centres which met the criteria of purposive sampling were selected to participate in this study. Semi- structured interviews and observations were the research tools used in the study. Data were analysed by coding and classifying the data into meaningful themes and patterns.

The findings revealed the availability of infrastructures at NAMCOL centres and that the Science tutors and Head of Centres at the studied centres had positive perceptions towards the integration of ICT. The barriers that hindered the integration of ICT were identified. The study found that the majority of the Science tutors were confident in

using computers for personal purposes and basic functional practices. The study found that Science tutors lacked the pedagogical ICT skills.

The study recommends, among others, that capacity building with a focus on ICT pedagogy to be provided to Science tutors to ensure that they confidently integrate ICT in the teaching of Science. In addition, the centres should be equipped with the appropriate Science software to facilitate the integration process.

Finally, the study will provide NAMCOL management and tutors with research-based information and evaluation of the ICT-based environment in terms of perceived effectiveness and the quality of teaching to those learners studying Science for future strategic planning.

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List of acronyms and abbreviations

AVU	African Virtual University
Becta	British Educational Communications and Technology Agency
CD	Compact Disc
DVD	Digital Versatile Disc
Email	Electronic mail
ETSIP	Education and Training Sector Improvement Programme
GeSCI	Global e-School and Community Initiative
HoC	Head of Centre
ICDL	International Computer Driver's Licence
ICT	Information and Communication Technologies
IEA	International Association for Evaluation of Educational Achievement
MS Word	Microsoft Word
MoE	Ministry of Education
NAMCOL	Namibian College of Open Learning
NETSSC	National Education Technology Service and Support Centre
NOLNet	Namibia Open Learning Network Trust
NSSC	Namibia Senior Secondary Certificate
SADC	Southern African Development Community
SITES	Second Information Technology Education Study
TRC	Teacher Resource Centre
TV	Television
UNAM	University of Namibia
UNESCO	United Nations Educational, Scientific and Cultural Organization

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Dedication

This work is dedicated to my grandmother, Kuku Fiina Panduleni Simeon and her two strong-willed daughters, Meme Nuusiku Johannes and Meme Suama Ndengu for their unfailing love, support and prayers.

Declarations

I, Ndeshimona L. Afunde, declare hereby that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

Signature …….…… Date……..
Ndeshimona L. Afunde

CHAPTER 1: INTRODUCTION

1.1 Introduction

This chapter introduces the study on the tutors' skills and perceptions on the integration of Information and Communication Technology (ICT) into the teaching of science subjects at the Namibia College of Open Learning (NAMCOL). A brief background of the study and NAMCOL is presented, leading to the statement of the problem, significance of the study, limitations and a brief synopsis of the literature review.

1.2 Background to the study

The demand for ICT literacy in Namibia is increasing, because both employers and employees have realised that ICT enhances efficiency. The Government and organisations are training or sending their employees for training to enhance their ICT skills. During the 2011 academic year, 379 people enrolled with the Computer Based Learning Centres at NAMCOL to enhance their computer skills (NAMCOL, 2012).

It is generally agreed that people who have access to information and knowledge have a competitive advantage wherever they may find themselves (Gakuu & Kidombo, 2010). Information and Communication Technology (ICT) has become one promising way of accessing information and, therefore, enables people to compete effectively. Bush and Mott (2009) argues that when ICT is used appropriately, it helps to expand access to education, strengthen relevance of education to the workplace, and raise the quality of education by making the teaching and learning process more engaging and

active. These are in line with the goals of the ICT policy on Education in Namibia which aims, among others, to broaden access to quality education (MoE, 2005).

Tinio (2002) defines Information and Communication Technology (ICT) as a diverse set of technological tools and resources used to communicate, create, disseminate, store and manage information. Information and communication technology integration has been recognised as using computers to learn, rather than learning to use computers (UNESCO/COL, 2004). According to Wachira and Keengwe (2010), integration of technology means incorporating technology and technology-based practices into all aspects of teaching and learning. Iipinge (2010) describes ICT integration as the use of ICT tools in the teaching and learning of a subject matter. For the purpose of this study ICT integration will mean the use of computer and related tools in the teaching and learning of subject content.

The Ministry of Education (MoE) has implemented the ICT policy for education in order to enhance the use and development of ICT in the teaching and learning environment (MoE, 2005). The policy stipulates that schools offering secondary education are expected to be at least at minimum Level 2 of the five levels of ICT development in the educational institutions. The criteria for Level 2 expect secondary schools, among others, to:

- have computers accessible to all teaching staff and Internet connectivity;
- have teachers who are able to use the Internet, e-mail and word processors;
- enable learners to spend at least one hour every two weeks on the computer;
- have teachers who are able to download and create learning materials; and
- integrate the use of technology in the teaching and learning situation.

The use and integration of ICT into education, which is the focus of this study, is stated as one of the five distinct development areas in the use of ICT (MoE, 2005). The development of the ICT policy and the recent initiatives of increasing investment in ICT facilities are a proof that the Namibian Government acknowledges the importance of ICT in education.

The Namibian College of Open Learning (NAMCOL) is a state funded educational institution, which provides educational opportunities for adults and out-of-school youth through open and distance learning modes. Secondary education subjects that are offered at the college follow the same syllabi as in conventional schools. According to the national curriculum, Science subjects include Physical Science, Biology, Agriculture and Life Science (MoE, 2010). However, NAMCOL offers Physical Science, Agriculture and Biology only as Science subjects for the Namibia Senior Secondary Certificate Ordinary level (NSSCO). The focus of this study was therefore the NSSCO Science subjects at NAMCOL. For the purpose of this study, Science subjects refer to NSSCO Physical Science and Biology. Learners' enrolment into the Science subjects has increased over the past years. About 10 574 learners were enrolled for Biology and Physical Science at Ordinary level in 2013, compared to 9 060 learners recorded in 2011 (NAMCOL, 2013).

As additional learner support initiatives to enhance the teaching and learning in selected subjects such as Science, NAMCOL has developed interactive web-based, radio and video lessons. These initiatives were funded by UNESCO and the Ministry of Education. In addition, over 10 computer laboratories were set up in various towns in the country. The college received an international award from the Commonwealth

of Learning for the development of innovative e-learning lessons during the 4th Commonwealth Pan-African Forum in 2006 held in Ochorio, Jamaica (NAMCOL, 2007).

For the past two years, NAMCOL has trained tutors on how to access and utilise web-based lessons. Tutors were also trained on how to retrieve information from the Internet and develop their own teaching materials. In a study conducted amongst student teachers at the College of Education campuses in Namibia by Iipinge (2010), 75% of the respondents indicated that "ICT is providing individualised learning, providing current information, making research possible, making learning easier and making lessons fun and enjoyable" (p. 208). Most of these student teachers are now practicing teachers and it is assumed that some are recruited as tutors at NAMCOL centres. It is against this background that this study was aimed at determining the extent to which Information and Communication Technology (ICT) has been integrated into the teaching of Science subjects at the NAMCOL centres.

1.3 Statement of the research problem

During the 2011-2012 academic year, NAMCOL spent over N$ 1.4 million in producing e-lessons, radio and television lessons and establishing computer labs in various towns in the country (NAMCOL, 2012). Because of its inputs described above, there is an expectation by NAMCOL management and staff for the use of ICT in the teaching and learning of the subjects at NAMCOL centres. Although NAMCOL has invested considerable resources in setting up computer centres and development of e-learning materials, including the recently launched Open Education Resources (OER), no research has been done to investigate the integration of ICT into teaching and

learning of science subjects at the centres. This study, therefore, was conducted to investigate how teachers integrated ICT into the teaching of Science subjects and the challenges they experienced with its usage at NAMCOL centres.

Murphy (2006) raises the question of knowledge gaps in the research on integration of ICT into Science education. Al-Zaidiyeen, Mei and Fook (2010) conducted a quantitative research in Jordanian schools, which is a developing country like Namibia, to investigate the attitudes of teachers towards the use ICT in the classrooms. The findings revealed that teachers have a low level of ICT use and hold positive attitudes towards ICT. Al-Zaiyeen et al. (2010) recommended future studies to consider qualitative studies such as classroom observation and in-depth interview to investigate ICT integration by teachers, which is what this study has done.

As such, there is limited research done on the integration of ICT into the teaching of Science subjects, especially through a distance teaching mode, in Namibia. This study, therefore, aims to fill this gap by investigating the levels of ICT integration into the teaching of Science subjects.

1.4 Research questions

The following were the questions of the study:

1. How do NAMCOL tutors integrate and use ICT in their tutoring of Science subjects?
2. How do tutors and heads of centres at selected NAMCOL centres perceive the integration of ICT into the teaching of Science subjects?

3. What challenges impede the integration of ICT into the teaching of Science subjects at the selected NAMCOL centres and what can be done?

1.5 Significance of the study

In its quest to enhance the teaching and learning of Science subjects, NAMCOL has developed and introduced a number of ICT tools into the teaching and learning of these subjects. The study aimed to provide the classification of tutors and head of centres at NAMCOL in terms of ICT use and integration in the teaching of Science subjects. Such a study will provide NAMCOL management and tutors with research-based information and evaluation of the ICT-based environment in terms of perceived effectiveness and the quality of teaching to those learners studying Science (Bingimlas, 2010).

The study further identifies elements that contribute to the integration of ICT in the Science classroom as well as the elements that may act as barriers to the effective use of ICT in the classrooms.

Similar studies have been done in conventional schools as well as at the teacher training institutions, but this is the first study of its kind to investigate the integration of ICT into Science education at NAMCOL, which is an open and distance learning institution. It is hoped that the outcome will inform policy and decision making as well as justify the investment made in the provision of ICT in education at NAMCOL.

1.6 Scope of the study

The study was conducted at four NAMCOL centres, namely; Yetu Yama, Ongwediva, Rundu and Otjiwarongo. These four centres were purposively selected because they offer NSSCO science subjects and have computer laboratories on their premises. A total of 8 science tutors and 4 heads of centres (HoCs) participated in the study.

1.7 Limitations of the study

NAMCOL has over 100 tuition centres across the country (NAMCOL, 2013). This study was confined to four centres that had computer labs on the premises, and the likelihood of being able to generalise the findings of the study to other similar institutions would be limited. Responses were dependent on the participants' ability and willingness to reflect honestly on their perceptions of ICT integration and its use at the four NAMCOL centres. The study cannot be generalised to all NAMCOL centres across the country, as only four NAMCOL centres are at the core of this study.

1.8 Definition of terms

For the purpose of this study, the following operational concepts and terms are defined as follows:

Heads of Centres: The head teachers who are managing the NAMCOL tutorial centres (NAMCOL, 2011).

Information and Communication Technology (ICT): This is an umbrella term that describes a diverse set of technological tools and resources used to communicate, and to create, disseminate, store and manage information (Tinio, 2002). These technologies

include, among others, computers and network hardware and software, mobile phones, faxes and broadcasting technology such as radio, television and interactive whiteboards (MoE, 2005, p. 4).

Integration of ICT: Incorporating technology and technology-based practices into all aspects of teaching and learning (Wachira & Keengwe, 2010).

Namibia Senior Secondary Certificate Ordinary (NSSCO): This is the school-leaving, externally accredited examination, taken by Grade 12 learners in Namibia (MoE, 2010).

Science subjects: These include Physical Science and Biology at NSSCO level (MoE, 2010).

NAMCOL Centre: A centre where NAMCOL tutorials take place, e.g., Yetu Yama (NAMCOL, 2011).

Tutor: This refers to teachers at the NAMCOL tuition centres.

1.9 Summary

This chapter gave an introduction to the background of the study as well as a short general overview of initiatives of ICT integration in Namibia and the efforts NAMCOL has made with regard to the use of ICT in teaching and learning activities. Further, the chapter presented the statement of the problem, research questions, significance of the study, limitations of the study, and the definition of terms. The next chapter provides a review of literature and theoretical framework on which this study was based.

CHAPTER 2: LITERATURE REVIEW

"While education unlocks the door to development, increasingly it is information technologies that can unlock the door to education"

(Kofi Annan, United Nations, 2003)

2.1 Introduction

Research has shown that education is a vital component for attaining developmental goals. However, ICT can play a major role to improve the accessibility and quality of education as summarised by the former United Nation Secretary General above. This chapter presents a review of literature both globally and nationally on ICT use and integration in teaching and learning. It reviews ICT initiatives by the Government of Namibia and NAMCOL since the adoption of the ICT Policy for Education. Literature on the identified factors affecting ICT integration into teaching and learning of Science is summarised. Rogers' diffusion of innovation framework is particularly suited for this study on diffusion of ICT and is therefore discussed.

2.2 An overview of global and national initiatives of ICT integration into teaching and learning

This section presents the development that has been done with regard to the integration of ICT in the developed and developing countries. After having presented the development in Namibia a specific focus has been given to NAMCOL because this is where data will be collected.

2.2.1 Overview of the ICT initiatives in the developed countries

Globally, the number of computers and Internet connections in secondary schools has greatly increased in the last few years (Hennessy, Ruthven & Brindley, 2005). Hennessy et al. further report that government initiatives such as the Virtual Agency in Japan, SchoolNet in Sweden and Learning Scheme in the UK helped to increase the prominence of ICT. These initiatives included extensive training plans for all teachers in using ICT in the teaching and learning of subjects. Literature also indicates that even though ICT is generally available, it is underused and poorly integrated in the classroom (Bingimlas, 2010; Becta, 2004). It is found that teacher training is essential if teachers are to effectively use ICT in teaching and learning (Bingimlas, 2010). According to Adam, Butcher, Tusubira and Sibthorpe (2011, p. 20), the dominant schools of thought regarding ICT integration are divided. On the one hand, there are those that focus on whether teachers need ICT literacy skills, without considering how those skills will be applied pedagogically. On the other hand, there are those that focus on whether ICT should be deployed in a manner that equips teachers with ICT literacy skills and, at the same time, shows teachers how to use these skills to plan lessons and use technology for teaching and learning.

The emergence of Open Educational Resources (OER) and Web 2.0 platforms are some significant ICT development initiatives that happened at a global level. OER refers to educational resources that are freely available for use by educators and learners without payment of royalties or licence fees (Adam et al., 2011). Users may re-use and adapt OER materials to best fit their needs. This gives teachers and learners enormous opportunities to creatively become developers of their own teaching

materials. The Commonwealth of Learning (COL) spearheaded an initiative where participants from various countries were trained and commissioned to develop OER for secondary school subjects. Namibia also took part in this initiative (NAMCOL, 2011).

2.2.2 Overview of ICT integration in Africa

Many governments have realised the benefits that ICT offers and therefore have developed national ICT policies. Farrell and Isaacs (2007) compiled a report based on the findings of the survey which was conducted in 53 countries and focused on the use of ICT in education in Africa. The survey was initiated by Information for Development Programme, a donor partner housed at the World Bank. According to ICT in Education in Africa Survey Reports as recorded in Farrell and Isaacs (2007) out of the 53 countries surveyed, 36 countries had ICT policies in place, in 12 countries the policy was still underdevelopment and no development was done in 5 countries.

However, Adam et al. (2011) reports that some countries in Africa do not have relevant policies that complement the ICT development, for example, telecommunications policies or associated budgetary allocations that support such development. They further state that countries such as Angola and the Democratic Republic of Congo have national ICT policies, but there are no policies that make specific reference to ICT in education in these countries (Adam et al., 2011). Howie (2009) said most discussion on ICT policies in developing countries were conducted from the context of developed country with good infrastructure and therefore there are gaps between policies and the

practice in the classrooms. Teachers should participate in the design of professional development programmes related ICT policy in education (Kozma, 2008).

Despite lack of policies, governments have recognised the importance of ICT for the development of their nations. This was observed by Farrell and Isaacs (2007) who say that most countries in Africa have made some investment in developing the teachers' capacity to use ICT in teaching and learning. NEPAD's e-School is an initiative launched in 2003 to serve all the schools in Africa (African Union, 2008). This initiative emanated from the belief that it is through intervention in schools that the digital divide can be bridged quickly. Its main objective, among others, is to provide teachers with ICT skills that will enable them to use ICT as a tool to enhance teaching and learning.

Further, in 2006, the African Virtual University (AVU), in partnership with the African Development Bank and others, established a teacher education project in some African countries, with the aim of integrating ICT in Mathematics and Science Education (African Union, 2008). That was done to improve the quality of teachers and enhance their capacity in the use of ICT in the teaching and learning of these subjects.

In addition, increased investment in ICT has been observed by institutions of learning such as schools, universities and vocational centres because that makes them attractive to students, parents and donors. A study by Howie and Blignaut (2009) aimed at analysing the implementation and usage of ICT in secondary schools in developing countries found that remarkable strides were made in providing computers and internet access to schools, however South Africa does not yet provide universal ICT access in

education with more than half of the schools not having access to computers. The majority of the developing countries put more focus on ICT resources and some capacity building. Howie and Blignaut (2009) state that there are few ICT initiatives that is successful in enabling teachers to integrate ICT into the curriculum.

Finally, Ainley, Enger and Searle (cited in Hatlevik & Arnseth, 2012) stated that there is little understanding of the way in which ICT is used in schools and classrooms around the world. Similarly in a secondary data analysis study done by Howie (2010) which used data collected by International Association for Evaluation of Educational Achievement (IEA), for the Second Information Technology in Education Studies (SITES) 2006, Howie revealed that it was difficult to find literature on the implementation of ICT in education in South Africa. The available research is predominantly policy documents and the intention of Government (Howie, 2010). Therefore more research is required to identify how teachers use ICT in schools.

2.2.3 Overview of the ICT policy for education in Namibia

Over the past years, there has been a growth in the Information and Communication Technology (ICT) infrastructure in the country. The telecommunication switching and transmission network was digitalised in 1999 with a state of the art underground fibre-optic cabling which improves access to advanced technologies and applications. Namibia's technology (ICT) infrastructure is rated among the best in Africa (IST-Africa, n.d). However, according to the World Economic Forum Global Information Technology report (2013-2014), Namibia ranks 111 out of 144 economies using the Networked Readiness Index (NRI). The NRI "aims to measure the ability of countries

to leverage information and communication technologies for improved competitiveness and wellbeing" (p.17). Even though the country is commended for having good telecommunication infrastructure, a lot still needs to be done to ensure that the majority of the community benefits from the developments in ICT.

In addition to efforts to employ ICT infrastructure in the country, the Ministry of Education (MoE) has also brought about greater emphasis on ICT in education. The MoE developed the ICT Policy for Education in 1995, which was revised in 2000. In 2004, the policy was revised and updated to reflect the developments in pedagogy, research, technology, and partnerships in the education sector. The policy was finally launched in 2005.

The development of an ICT policy in education is seen to be crucial as ICT plays an important role in preparing individuals in school for the workplace. The then Minister of Basic Education, Hon John Mutorwa in his foreword in the ICT Policy for Education, states that ICT provides advantages in the delivery of equitable, quality education, "thereby providing an opportunity to improve the lives of our people" (MoE, 2005). This concurs with former UN Secretary General, Kofi Annan's statement of ICT providing access to education at the beginning of this chapter.

According to the ICT Policy for Education (MoE, 2005), ICTs have a crucial role to play in the Namibian education system; whether directly as a subject or indirectly as a tool to support and enhance the effectiveness of teaching and learning. Therefore, all teachers are expected to make use of ICTs in their teaching. The policy further spells out its objectives with the aim of using of ICT to improve the quality of teaching and

learning in schools, colleges, universities, vocational centres and adult education centres. These objectives are summarised below (MoE, 2005, p. 4):

- To produce ICT literate citizens;
- To produce people capable of working and participating in the new economies and societies arising from ICT and related developments;
- To leverage ICT to assist and facilitate learning for the benefit of all learners and teachers across the curriculum;
- To improve the efficiency of educational administration and management at every level from the classroom, school library, through the school and on to the sector as a whole;
- To broaden access to quality educational services for learners at all levels of the education system; and
- To set specific criteria and targets to help classify and categorise the different development levels of using ICT in education.

The policy has five development levels with specific goals which are used to measure progress in the implementation of ICT in education. Schools with the secondary education phase are expected to be at least at Level 2 of the five levels of ICT development in educational institutions. The criteria for Level 2 expect secondary schools, among others, to:

- have computers accessible to all teaching staff and Internet connectivity;
- have teachers who are able to use the Internet, e-mail and word processor;
- enable students to spend at least one hour every two weeks on the computer;

- have teachers who are able to download and create learning materials; and
- integrate the use of technology in the teaching and learning situation (MoE, 2005, p. 7).

2.2.4 Overview of initiatives of ICT integration in secondary schools in Namibia

The ICT Steering Committee, established after the launch of the ICT Policy in Education, is responsible for the coordination of all ICT projects and initiatives in education (MoE, 2005). The Education and Training Sector Improvement Plan (ETSIP) in Namibia was developed with the main aims of, among others, improving the quality of general education and improving access to ICT to enhance education. In 2006, Tech!Na, an implementation strategy based on the ICT Policy in Education, was launched. Tech!Na represents the Ministry of Education‘s ICT section of ETSIP. The main goals of Tech!Na are (Isaacs, cited in UNESCO, 2011):

- to equip educational institutions with hardware, software, connectivity, content and technical support; and
- to educate administrators, teachers and learners in ICT literacy and ICT integration skills across the curriculum.

SchoolNet Namibia, a non-profit association, was established in the year 2000. Its main objective was to provide Internet access, computers technology and training to all secondary schools in Namibia (SchoolNet-Namibia, n.d). SchoolNet provided a peer to peer training by volunteers to learners and teachers in schools. They sourced computer equipment from donor and private sectors locally and internationally, which

they refurbished and installed for Internet use in schools at a reduced rate. Around 350 schools benefited from the activities of SchoolNet (SchoolNet Namibia, n.d)

The Namibia Open Learning Network Trust (NOLNet) e-Learning Centre was established to coordinate the e-learning activities of all the partners, which include all the public and state-funded open distance learning educational bodies in the country. Staff members from the partner institutions have been trained on content development. The NoLNet e-Learning committee continues to provide e-learning expertise and training to partner institutions (NoLNet, 2014).

The Ministry of Education, in conjunction with the National Training Authority, developed a national ICT literacy certification, which includes foundation, intermediate and advanced levels. This ICT literacy certification is done by the Namibian Qualification Authority. To this effect, the MoE entered into an agreement with institutions such as NAMCOL, which offered International Computer Driver's License (ICDL) training for teachers (NAMCOL, 2010). In a study conducted by Ngololo (2010) on the evaluation of the implementation of ICT Policy in Education in the rural junior secondary in Namibia by Ngololo (2010), it is recorded that 352 teachers obtained the ICDL certificates throughout this agreements.

In addition to the abovementioned initiatives, the National Education Technology Service Support (NETTS) Centre was established as a component of the ICT in Education Implementation framework. The main function of the NETTS Centre is to provide the sourcing, refurbishing, installation and support of ICT in all educational institutions in Namibia (Isaacs, cited in UNESCO, 2013). Furthermore, the MoE, in

partnership with Telecom Namibia established XNET, which provides affordable and reliable bandwidth connectivity to all educational institutions.

A study carried out by the MoE and UNESCO revealed that Namibia has good telecommunications infrastructure and some expertise in the use of ICT for education, including open and distance learning, e-learning, educational broadcasting and blended learning. However, these have not been extensively used for teacher education and training (MoE, 2013). In line with the findings by Howie (2010) in Section 2.2.2 according to Ngololo (2010) the information on the implementation of ICT in secondary schools in Namibia is also not well documented. For that reason this study is aimed at documenting the implementation of ICT in NAMCOL NSSCO Science at secondary level.

2.2.5 ICT initiatives by NAMCOL

According to its Strategic Objective 8 on the expansion of ICT infrastructure, in its efforts to narrow the technological divide NAMCOL established 13 computer-based learning centres across the country to offer IT related courses and provide support to its learners (NAMCOL, 2013). These computer centres are managed by computer facilitators. NAMCOL learners are encouraged to use these computers, which have Internet connection for learning purposes at no cost. ICDL is offered at these centres to the general public at a reasonable fee of N$ 3,350.00 for the full package, which includes a training manual, training on all seven modules, a skills logbook and testing (NAMCOL, 2013).

Interactive e-learning lessons in Science and other subjects were developed with the support of UNESCO and put on CD-ROMs that were distributed to learners (NAMCOL, 2009). Learners with access to computers can engage the e-lessons on the CD-ROM at their own time and pace, which should help them to understand the subject topic better. For the past two years, the programme developers at the college have trained tutors on how to access and utilise the web based lessons. Tutors were also trained on how to retrieve information from the Internet and develop their own teaching materials (NAMCOL, 2012).

Through the Commonwealth of Learning (COL) initiative, NAMCOL developed OER materials in five of the Junior Secondary Certificate level on the Moodle platform. In 2013, the college went into partnership with Notemaster, a learning management system platform (NAMCOL, 2013). Learners and tutors in Windhoek, Otjiwarongo, Rundu and Ongwediva are trained on how to access the platform. Tutors and programme developers who are in Windhoek are currently developing interactive subject content, which will be put on the Notemaster platform, and learners are expected to access the platform and engage the subject content. Learners may post questions or engage in discussions on the platform, which will be guided by an appointed subject teacher. For the Notemaster project, the college has acquired additional computers, which have been put in the resource centres for use (NAMCOL, 2014).

NAMCOL has developed video lessons in Mathematics, Physical Science and Life Science on topics that are perceived as challenging to the learners. These lessons are broadcast on the Namibia Broadcasting Corporation (NBC), the national television

channel (NAMCOL, 2009, 2012). The lessons are also put on DVDs and distributed to NAMCOL centres and to conventional schools on request. Some practical experiments in Biology and Physical Science were also captured on DVD (NAMCOL, 2010). The challenge is the lack of availability of DVD players at most of the centres. In addition, 190 radio lessons were developed, recorded and broadcast on NBC national radio, UNAM radio, Ohangwena community radio, Karas community radio, Radio Live and Base FM (NAMCOL, 2013). The radio lessons focus on topics that are deemed challenging in the various topics. The expansion of ICT for teaching and learning purposes is one of the strategic objectives of the college (NAMCOL, 2011). This information is relevant to the reader to understand what has already been done at NAMCOL.

2.3 Use and integration of ICT in teaching Science subjects

The uses of ICT in education as found in literature are relevant globally and can serve as a reference for both developed and developing countries. Tinio (2002) notes that there is so much information in the knowledge-based era and, according to him, the people who will cope best will be those who have skills on how to retrieve information fast and efficiently. He further argues that education is supposed to equip learners with skills on how to retrieve information. In addition Ziphora (2003) argues that there is therefore an increased demand placed on educational institutions to use ICT to teach the skills and knowledge that students need for the 21st century.

Moreover, Watson and Watson (2011) state that, when ICT is used appropriately, it will help expand access to education, strengthen the relevance of education to all dynamics of life, and raise the quality of education by making the teaching and learning

process more engaging and instructive. Parents also believe that using computers may increase their children's academic achievement and future job opportunities (Stock & Fishman, 2010). Therefore, they are willing to either buy computers or pay additional fees for computer lessons at school. Teachers play an important role in ensuring that the learners acquire the appropriate skills to use ICT effectively. However, the teachers will not be able to impart the necessary skills unless they receive intensive training. The acquisition of computers and ICT equipment should always be accompanied by training of the users (Aryatuha, 2007). Farrell and Isaacs (2007) reported that some of the ways in which ICT need to be integrated by the teachers are being able to design and adapt content materials to suit student needs, to search and manage information.

Learners have to deal with abstract Science concepts such as the invisible sub-atomic particles in nuclear Physics, composition of DNA, circulation of substances in plants. The effective use of ICT can deal with some of these challenges and improve the teaching and learning of Science. Tchombe, Maiga, Toure, Mbangwana, Diarra and Karsenti (2008, p. 13) emphasise that "using ICTs for learning does improve learning capacity and makes the learners focus on the process for acquiring knowledge and at the same time the content of knowledge." According to them, learners are using ICTs to create knowledge and develop scientific skills within and beyond formal learning contexts. Effective use of ICTs in schools is most helpful for the teachers and learners. Learners who have access to technologies can easily communicate with other learners and their teachers when experiencing some difficulties during their studies. This way of interaction stimulates both their Science subject content knowledge and cognitive development (Tchombe et al., 2008).

Bingimlas (2009) stresses the importance of using ICTs in Science classrooms as it provides opportunities for learners to learn how to use technology to communicate and interact with others in an information era. In the teaching of Science, ICTs enable learners to collect Science information and browse various resources to complete their practical investigations, assignments and promote learner-centred interactions. Learning resources such as images, notes and videos encourage communication and collaboration among the learners in Science teaching (Bingimlas, 2009). According to Bingimlas (2009, p. 237), Internet access "allows teachers to help students to become experts in searching for information rather than receiving facts." Simulations are also used to explain and demonstrate systems that are hard to comprehend or experiments which cannot be carried out in the classroom; for example, the flow of blood through the heart can be shown on video clips or computer models. ICT can also be used in different ways in school activities as outlined by Osborne and Hennessy (2003, p. 4):

- tools for data capture, processing and interpretation – data logging systems, databases and spreadsheets, graphing tools, modelling environments;
- multimedia software for simulation of processes and carrying out 'virtual experiments'; publishing and presentation tools.

ICT can be used for assessment, Raikes and Harding in Daper (2011) recorded that ICT assessment has the following benefits: lower administrative cost, allow instant scoring and feedback and increased adaptation to individual learner characteristics. In the study conducted by Daper (2011) with selected Grade 8 science teachers in South Africa it was found that ICT use for assessment was very low, most teachers used the traditional written tests. A study conducted in high schools with long exposure to ICT

in California revealed that the use of ICT is not widespread and that teachers are simply using ICT to do what they have always been doing (Hennessy, Ruthven & Brindley, 2005). A suggestion was given by teachers that if the ICTs were in the classrooms, they would use them more frequently as part of the subject and that would increase their confidence. Daper (2011) found that the following ICT resources were the most used by the teachers who participated in his study (Daper, 2011, p.135):

- Equipment and hands-on materials (slide projectors, electronic calculators, laboratory equipment) - 30% of the respondents;
- Exercise software – 17% of the respondents;
- Digital resources (dictionaries, encyclopaedia) – 13% of the respondents.

Daper's finding further revealed that the use of learning management systems (e.g. web-based environment), simulations, multimedia production and data logging tools were the least used. The study conducted in northern Namibia by Ngololo (2010), found that the usage of ICT for pedagogical use was very low and Science teachers performed the most basic tasks when using ICT in teaching such as making notes on overhead projector and exploring Encarta, and no advanced skills were observed.

Expediting and enhancing work production may offer release from laborious manual processes, such as drawings and calculations, and more time for thinking, discussion and interpretation. ICT can contribute to solving educational problems in developing countries such as the shortage of instructional materials, the high pupil-teacher ratio and high dropout rates. This problem could be addressed by the integration of ICT in the classroom, because a study by Wells (1998) found that children enjoy learning

using technology. Open and distance learning methods, which have traditionally been used to reach learners who are unable to attend conventional schools, can be improved through ICTs. According to Hennessy, Harrison and Wamakote (2010b) teachers need to be trained to use ICT effectively and creatively in the classroom. They further suggest that the significant supports for the integration of ICT into teaching are Initial Teacher Education and Continuing Professional Development. This information will be used to understand how tutors use and integrate ICT in teaching.

2.4 Perceptions of teachers towards the use and integration of ICT

Perception is defined as a "belief or option, often held by many people and based on appearance" (Plante & Beattie, 2004, p. 24). However, this researcher view perceptions as referring to the tutors and HOCs' beliefs, attitudes and opinions towards ICT implementation in teaching. Albirini (2006) suggest that the successful implementation of ICT in education mainly depends on the attitudes of the teachers, who will ultimately determine how they are used in the classroom. Teachers who have a positive attitude towards ICT feel more comfortable to incorporate it in their teaching. Roger (2003) said that the attitude of people towards ICT plays an important role in its adoption.

Albirini conducted a study in Syria to determine the attitude of teachers towards ICT in teaching English. The findings in Albirini's study revealed that most teachers were positive about the relative advantage of computers as an educational tool. It further found that the majority of respondents indicated that computers suit their learners' learning preferences, however they said class time is too limited for computer use. A study conducted in Nigeria revealed that teachers are interested and willing to integrate

ICT into their teaching and learning situations (Hennessy et al., 2010a). They believe that ICT makes teaching and learning easier and enjoyable. However, literature further shows that although there is interest among the teachers, it is hampered by lack of skills and confidence in the use of ICT in the classroom (Bingimlas, 2009; Iipinge, 2010; Becta, 2004). Many teachers do not consider themselves to be well skilled in using ICT and feel anxious about using it in front of a class of children who perhaps know more than they do. In a related study (Bradley & Russell, cited in Becta, 2004, p. 8), it was found that the common causes of fear of using ICT are "getting stuck and not knowing what to do next" and "not understanding the computer jargon and the messages it gives."

The participating teachers in a study conducted by Ang'ondi (2013) in Kenya believed that they were good prior to ICT and so there was no need for extra work of using ICT. A study by Ward and Parr (2010) has found that teachers who do not see the benefit of technology such as improved learners' understanding of the subject or increased efficiency in administrative tasks, are hesitant to integrate ICT. Cox, Preston and Cox (1999) noted that teachers who perceived technology to be useful for their teaching and personal work were the regular users of ICT and have developed confidence in using it. Therefore, authorities need to create awareness towards ICT among teachers through pre-service and in-service training. Peer motivation and coaching has been reported to be effective in creating interest and awareness of the benefit of ICT integration in the classroom.

The successful integration of ICT requires dramatic changes in classroom organisation and management. Therefore, teachers need to develop new teaching approaches and

new ideas about their authority in the classroom (Kerr, cited in Hennessy, Ruthven & Brindley, 2005). The use of ICTs by teachers helps to make the lessons more interesting, more motivating and more enjoyable for the learners (Lim & Khine, 2006). This information will be used to understand the perceptions of tutors on the use and integrate ICT in teaching.

2.5 Challenges in integrating ICT

Using ICTs in teaching and learning is a complex exercise and in the process of using ICTs, one could encounter a number of challenges (Bingimlas, 2009). Schoepp (2005) refers to these challenges as "barriers". A barrier is defined as "any condition that makes it difficult to make progress or to achieve an object" (WordNet, cited in Schoepp 2005, p. 2). The Global e- Schools and Communities Initiative (GeSci) (2009), in its annual report, recorded that integrating ICT into teaching and learning is among the most challenging aspects of their work with partners. This is evidence that integrating ICT into teaching and learning is not an easy task. "Dormant computer labs, untrained teachers and irrelevant curricula in the developing world bear evidence to the need for full integration of ICT into teaching and learning." The problems and barriers with respect to ICT integration by teachers stem from several sources including inadequate initial training, insufficient motivation, absence of technical support, lack of confidence, lack of time, a school administration that does not embrace ICT usage, lack of administrative support, etc. (Bingimlas, 2009; Becta, 2004).

Some authors classify the barriers into two groups. Snoeyink and Ertmer (2001) classify the barriers into external or first-order barriers (which relate to limited resources, lack of time, lack of technical support and technical problems) and internal

or second-order barriers (which relate to the teachers' attitudes to ICT such as lack of confidence, resistance to change, negative attitudes, lack of time due to organisation and no perception of benefits). On the other hand, Becta (2004) classifies them according to whether the barriers relate to the teacher or to the school. These barriers are explained in more detail in the following subsections:

2.5.1 Lack of teacher confidence

This is a major hindrance that is preventing most of the teachers from using ICTs in their classrooms. Teachers regard themselves as knowledgeable people. Therefore, they are reluctant to take risks on something that they have limited knowledge and experience in because of fear of failure (Bingimlas, 2009). A study conducted among some secondary school teachers in Kenya revealed that many teachers felt that they were not knowledgeable to use ICT competently and that they lacked the skills to manage an ICT integrated lesson effectively (Ang'ondi, 2013). Similarly, a study in Namibia with junior secondary teachers found that the teachers' confidence in the use of ICT and their confidence in the pedagogical use of ICT were low (Ngololo, 2010). Lack of teachers' knowledge of ICTs makes them feel nervous and uncomfortable to use technologies in their teaching classrooms. This view concurs with a survey by Becta (2004), which found that the issue of lack of confidence attracted the most response (21.2%) from those who took part in the study on barriers. Therefore, in the pursuit to increase the use of ICT by teachers, the issue of confidence needs to be addressed.

2.5.2 Lack of teacher competence

Poor proficiency in the use of ICT is another factor that discourages teachers from making use of ICTs in the classroom (Kachepa & Batchaeva, 2008). In developing countries, lack of technological competence is a main barrier for the adoption of ICT in the classroom, while in developed countries it is rather the pedagogical competence (Bingimlas, 2009). In his study Albirini (2006) found that 43.3% of the participants had no computer competence, 39.5% had little, 16.6% had moderate competence and 0.6% of the participants possessed much computer competence. Teachers need to get adequate training in order to achieve high levels of competence and become confident in using ICT in the classroom (Becta, 2004). Authors suggest that the first stage of training should focus on the basic operations of technology and software applications, and once teachers have acquired the basic skills, only then should they move on to pedagogical training (Becta, 2004).

2.5.3 Resistance and negative attitude

Integrating ICT in education requires change of teaching styles, and educators react differently to change some teachers require more time to gain experience with computers (Naicker, 2011). A study by Albirini (2006) revealed that the success of technology use in education largely depends on the teachers attitudes towards ICT use. According to studies, teachers with negative computer attitudes were less skilled in computer use and therefore less likely to adapt to technology than those who were positive attitudes (Harrison & Rainer, cited in Al-Zaidiyeen, Mei & Fook, 2010). One key area of teachers' attitudes towards the use of ICT is their understanding of the

benefits that ICT integration has for their teaching and learning (Becta, 2004). According to Emprica (cited in Bingimlas, 2009, p. 238), "teachers who are not using new technology such as computers in the classroom are still of the opinion that the use of ICT has no benefits or unclear benefits." Bingimlas (2009) states that resistance to change is caused by discouraging factors such as lack of leadership support, technical support, teacher expertise, or time for planning. The low involvement of management and their lack of awareness of ICT issues can create apathy and resistance towards the integration of ICT in the institution (Iipinge; 2010).

2.5.4 Poor training opportunities

Wachira and Keengwe (2010) recorded that the lack of teacher training in acquiring appropriate ICT skills, is one of the reasons for the lack of ICT integration in teaching. They further indicated that ICT training had been generic, skills are learned in isolation and did not help teachers to learn subject content-specific ways of ICT integration. The traditional, one-off, topic-led in-service workshops do not develop and change the teachers' ICT pedagogical practice (Farrell & Isaacs, 2007). ICT skills should be learned with a real task in mind, such as database and modelling to be used for Science and Mathematics. The lack of trained teachers and the low levels of teachers' ICT knowledge and skills have been identified as major barriers to ICT integration into schools in many African countries (Hennessy, Onguko, Harrison, Ang'ondi, Namalefe, Naseem & Wamakote, 2010a). The Namibian Government offered free ICDL training courses to teachers. The training was more on how to use computers for administrative work and not how to use them in classrooms to enhance teaching and learning. Importantly, teachers were supposed to be trained on pedagogical integration

of ICT into education rather than simply training them on how to use computers in general. It is notable that increasing investment in technology infrastructure has not been matched by investment of time and resources to develop new ways of teaching with ICT. Albirini (2006) said often investment is done in the latest technologies without considering the needs and interests of the teachers.

Teachers are the key stakeholders in curriculum implementation and integrating computers in schools. They should be involved in all stages of the implementation and be assured of its relevant advantage and compatibility of the innovation (Rogers, 2003). They therefore need to be trained properly in the use and integration of computers into teaching and learning. Research by Bowker, Hennessy, Dawe & Deaney; Zwart, Wubbels, Bergen & Bolhuis (cited in Hennessy et al. 2010b, p.46), has shown that one of the best way to train teachers is continuing professional development programme which use " local professional communities, encourages ongoing peer learning by teachers of similar subjects and age groups and supports reflective classroom practice."

When properly trained, the teachers' ability to use and integrate ICT to support teaching and learning might improve.

2.5.5 Lack of access

Sime and Priestly (2005) found that teachers who have access to computers at home were more likely to use them in the classroom, because those teachers had time and greater opportunities to practice with computers at home and become more confident in using them. According to Albirini (2006) home was the place where teachers have

frequent access to computers, in his study 57% of the respondents had access at home and 33% had access at school. Studies have shown that even in technology-rich schools, teachers still do not integrate ICT in their classrooms because of where they are located (Schoepp, 2005). This shows that abundant access to technology will not lead to increased use of ICT in the classroom. In a comparative study by Blignaut, Hinostroza, Els and Brun (2010) comparing the ICT in education policy and development in education between South Africa and Chile, it was revealed that both countries concentrated computers in the laboratories instead of in the classrooms for easier access to the teachers and learners. Similarly a study by Iipinge (2010) found that the computers at the College of Education in Namibia are located in the computer lab. As a result, students have limited access to the computers because, whenever they need to use them, they are locked up. The organisation of the school, which includes timetabling, can also be a limiting factor to access.

2.5.6 Lack of incentives

Lack of encouragement and motivation from the school leadership and management has a negative impact on teaching and learning. Therefore, teachers need to be motivated and supported to gain ICT skills and be well informed about the usefulness of the ICT in teaching and learning. They should be provided with relevant ICT information through programmes and trainings at the school level. The decisions about purchasing of hardware, software, speed of processing and Internet access are left for "those who understand this thing"; most of them are technical people. Thus, the purchasing of ICT related stuff and the layout of the rooms are often made on the basis of technical specifications rather than educational purposes, and subject teachers feel

alienated (Watson, 2001 p. 257). Subject teachers should be consulted to give input on ICT related matters for them to take ownership and be motivated to integrate ICT into their teaching.

2.5.7 Lack of time

Teachers sometimes do not have the time to fully prepare and research materials. Therefore, they are unable to use the technology optimally (Becta, 2004). Sufficient time will allow teachers to use ICT to explore Internet websites, or look for various aspects of educational software that will expand their teaching strategies and enhance their learners' conceptual understanding (Bingimlas, 2009). Teachers may show willingness to take on ICT, but their existing timetable is loaded with curriculum and policy demands (Watson, 2001) and there is no time to try new ideas such as ICT integration. Due to time constraints, teachers keep teaching from the textbooks and using the traditional teaching strategies.

As claimed by Bingimlas (2009), the importance of ICTs in the future of education cannot be underrated. Therefore, identifying the possible barriers to the integration of ICT in schools would be an important step in improving the quality of teaching and learning.

2.5.8 Leadership

The National ICT Policy in Education expects the school managers to manage finance, physical and human resources effectively. This includes the management of all ICT related matters (MoE, 2005). The findings in the study conducted by Ngololo (2010)

revealed that principals as school managers were not exposed to any training courses to guide them on managing ICT related issues, even though they continue to encourage the teachers to use ICT in the classrooms.

According to Iipinge (2010), ICT champions are people who can lead and motivate others on ICT integration at their respective institutions. The early adopters according to Rogers (2003) are opinion leaders and they adopt the use and integration of ICT in education relatively early. At any institution in general, there are some teachers who use ICT regularly in teaching of subject matters. These people may serve as champions and inspire other colleagues to start using ICT more often. Institutions such as NAMCOL should provide opportunities for champions e.g. early adopters to share with other colleagues the benefit of ICT use and integration.

2.6 Theoretical framework: Rogers' theory

Given the literature presented above, this study has adopted the theory on diffusion of innovation by Rogers to inform the theoretical framework for the study (Rogers, 2003). According to Medlin and Parisot (cited in Sahin, 2006), Rogers' diffusion of innovations theory is the most appropriate for investigating the adoption of technology in higher education and in any educational environment settings. Sahin further stated that Rogers used the words "technology" and "innovation" synonymously. Since Rogers use the terms technology and innovation interchangeably the diffusion of innovation framework suited the studies on diffusion of ICT (Albirini, 2006).

Rogers' theory of diffusion of innovation was used in a study by Surendra (2001) who conducted a quantitative research to examine the diffusion factors proposed by Rogers

(1995) and other sources to predict the acceptance of Web technology by staff members of a college. He found that the diffusion factors, Rogers' attributes of innovations, are useful predictors of the adoption of innovation (Sahin, 2006).

2.6.1 Brief discussion on diffusion of innovation

Rogers (1995, p. 10) defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system." An innovation is a new idea or practice, in this case ICT, for a targeted group of people, such as Science teachers.

This theory includes the innovation-decision process, innovation characteristics, adopter characteristics and opinion leadership. Rogers' innovation-decision process states that the adoption of innovation tends to occur through the following five stages (Rogers, 1995, p. 161):

- Knowledge - first gaining knowledge of an innovation;
- Persuasion - becoming interested in the innovation and form an attitude toward the innovation. "The formation of a favourable or unfavourable attitude toward an innovation does not always lead directly or indirectly to an adoption or rejection" (Rogers, 2003, p. 176);
- Decision - making a decision to either adopt or reject the innovation. While adoption refers to "full use of an innovation as the best course of action available," rejection means "not to adopt an innovation" (Rogers, 2003, p. 177);
- Implementation - making use of the new practice or innovation; and
- Confirmation - continuing to use the innovation.

Most studies concerning diffusion of ICT in developing countries mainly focused on the first two stages which are knowledge and attitude (Albirini, 2006). Research questions 1 & 2 of this study will focus on the tutors' perception and implementation of ICT integration.

Rogers (2003) identified the following five main characteristics of innovations which can speed up its adoption: relative advantage, compatibility, complexity, trialability and observability. Rogers (2003) stated that relative advantage is when an innovation is perceived to be better than what it supersedes. He further stated that "compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (p. 15). Rogers (2003) defined observability as "the degree to which the results of an innovation are visible to others" (p. 16). Role modelling is the key motivational factor in the adoption and diffusion of technology. Innovations with more relative advantage, compatibility, trialability, greater observability and less complexity are more likely to diffuse (Smith & Findeis, 2013). Sooknanan (cited in Albirini, 2006) conducted a study in Trinidad found that the relative advantage, compatibility and observability were significantly related to the teachers' attitude and perception towards ICT.

Rogers (2003) further defined the adopter categories as "the classifications of members of a social system on the basis of innovativeness" (p. 22). This classification includes innovators, early adopters, early majority, late majority and laggards. The adoption growth usually begins relatively slow when a small number of leaders adopts the innovation and then exponential growth follows when other people copy the

innovation. Some people accept innovation more quickly than others. The bell curve in Figure 2.1 below illustrates the categories of innovativeness.

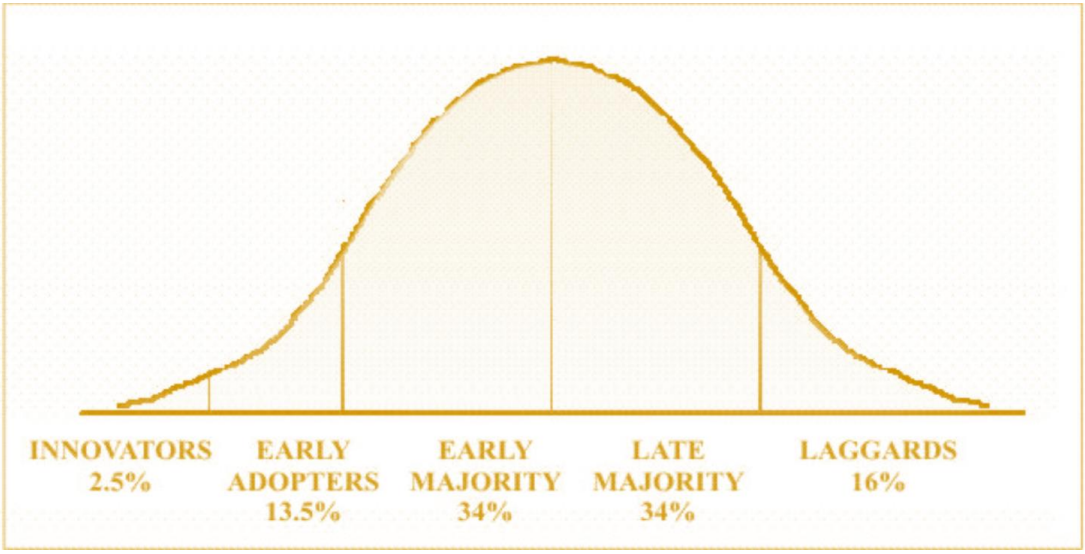

Figure 2.1: Rogers' categories of Innovativeness

Source: Rogers (2003)

The innovators, according to Rogers (2003), are usually venturesome, risk takers, technologically inclined, can cope with a high degree of uncertainty and are internally motivated. Rogers stated that innovators are the gatekeepers bringing the innovation in from outside and may not be respected by their peers because of their daring attitude.

The second group, the early adopters, are normally respectable, more integrated into the local social system than the innovators. They are opinion leaders, make cautious innovation decisions, and are internally motivated. Rogers (2003) said that since the early adopters are integrated in the social system, other members come to them to get information about the innovation.

Figure 2.1 shows the early majority adopts the innovation just before the other half of their peers adopts it. Rogers (2003) claimed that the early majority group is cautious in adopting an innovation and they are neither the first nor the last to adopt it. Thus,

their innovation decision usually takes more time than the innovators and early adopters and they are externally motivated.

The late majority includes 34% of all members of the social system who wait until most of their colleagues adopt the innovation. They are externally motived, who adopt the innovation for economic and peer pressure reasons, and not for usefulness (Rogers, 2003). The laggards are traditional, the last group to adopt, their point of reference is the past, they have limited resources and they are unwilling to take risks (Parker 1996). Their resources are limited and so they must be relatively certain that a new idea will not fail before they can afford to adopt (Sahin, 2006).

2.6.2 How the theory of diffusion was used in this study

The researcher analysed the possible influences of the adoption of ICT, which include the attributes of innovation in the teaching of Science at NAMCOL centres. The attributes of innovation as stated by Rogers are relevant to the adoption of ICT in schools. The tutors who have mastered the integration of ICT could be seen as change agents, because they have to demonstrate and give pedagogical training to others. Support before and after training boosts the confidence of the teachers.

The research questions on the use and integration of ICT by the tutors in the teaching of science enabled the researcher to classify the tutors according to Rogers' categories of innovativeness. The attributes of innovations, i.e., relative advantage, compatibility, complexity, trialability and observability in relation to the findings of the study were used to determine the degree of ICT adoption as well as the perception of the tutors towards ICT in the teaching of Science (Iipinge, 2010). Tutors should see the benefit

of the innovation in order to encourage the use and integration of ICT. Tutors need to be trained to avoid the rejection of the innovation due to its complexity. The stages of Rogers' theory are relevant to this study because the characteristics of each level would be used to classify the level of innovation of the tutors.

2.7 Summary

The literature reviewed in this chapter presented the initiatives of ICT integration globally and also in Africa. The chapter provided a brief overview of the ICT initiatives related to secondary education in Namibia. An attempt in this chapter was also made to answer the following questions in the literature review: i) how do tutors use and integrate ICT in secondary education; ii) what are the teachers' perceptions on the use of ICT in the teaching of Science; and iii) what are the barriers in the integration of ICT. The theory on diffusion of innovation as the framework to this study has also been discussed. The next chapter describes the research methodology that was employed in this study to collect and analyse data.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology applied in the study, such as research design, population, sampling procedures, data collection instruments, data analysis and ethical considerations.

3.2 Research design

This study was designed as a descriptive multiple case study employing qualitative research approaches to collect data. Four NAMCOL centres situated in different political regions have been selected. Interviews and observations were used as research instruments. De Vos, Strydom, Fouche and Delport (2011) state that qualitative researchers collect data at the site where participants experience the problem under study. They further said researchers collect data through examining of documents, observing behaviour and interviewing of participants.

Based on the above characteristics, the researcher found the qualitative research approach to be appropriate because it is used to describe the specific phenomenon, in this case, the level of ICT integration and the real life context in which each of the Science tutors work. Furthermore, a collective evaluation of all the cases is done.

3.3 Population

The population for this study was tutors who taught either NSSCO Physical Science or Biology, or both at the selected NAMCOL tutorial centres. The selected centres were located in different political regions of Namibia and they were: Keetmanshoop

TRC in Karas Region, Yetu Yama Tutorial Centre, Katutura in Khomas Region, NAMCOL Otjiwarongo in Otjozondjupa Region, NAMCOL Ongwediva in Oshana Region and NAMCOL Rundu in Kavango Region. In total, there were 10 tutors who taught NSSCO Physical Science and Biology subjects at the five centres and five heads of centres (one at each centre). For the purpose of this study, the researcher referred to the centres according to the town in which they were located, e.g. Windhoek, Ongwediva, Otjiwarongo, Rundu and Keetmanshoop.

3.4 Sample and sampling procedure

According to Gay, Mills and Airasian (2009), there are no definite rules that specify the correct number of participants in qualitative research. They further state that qualitative research can be carried out with one or as many as 60 participants. A purposeful criterion sampling method was used for this study to select eight tutors who taught Namibia Senior Secondary Certificate Ordinary (NSSCO) Biology and/or Physical Science subjects at the following centres: Yetu Yama Tutorial centre, NAMCOL Otjiwarongo, NAMCOL Ongwediva and NAMCOL Rundu. The selected tutors had taught for at least one year at the respective NAMCOL centre. The four centres were also purposively selected for the study, based on characteristics that would address the objectives of the study as outlined in Chapter 1. The Keetmanshoop centre was not selected or the actual study because it had been used for the pilot study. These five centres (including Keetmanshoop) were the only NAMCOL centres that offered NSSCO Science subjects, and had computer labs on their premises at the time of this study.

The Science tutors were chosen because the focus of the study was on the integration of ICT into Science subjects and, as such, they were suitable participants for the study. The heads of centres (HoCs) were selected due to the leadership positions they held at the centres, as they could provide rich information, which could be used to address the research questions.

The selected NAMCOL centres were given name codes C1-C4. The tutors were named T1.1 to T4.2 where the first number represented the centre and the second number represented the individual tutor. For example, T3.2 meant the second tutor at centre C3. Similarly, the codes for the participating HoCs were HoC1-HoC4. Table 3.1 lists the codes of the participants and the centres, and also the number of learners at each participating centre.

Table 3.1: Codes of participants

Centre Code	Science Tutor Code	Head of Centre Code	No. of NSSC Learners at the Centre
C1	T1.1 T1.2	HoC1	80
C2	T2.1 T2.2	HoC2	41
C3	T3.1 T3.2	HoC3	54
C4	T4.1 T4.2	HoC4	104

3.5 Pilot study

A pilot study was carried out to confirm the validity and reliability of the interview questions and observation checklist as research instruments. The pilot study was conducted with three respondents at the NAMCOL Keetmanshoop centre. NAMCOL Keetmanshoop centre was not selected to participate in the main study, since it was used for pilot study. The participants were the head of centre, a Biology tutor and a Physical Science tutor. According to Gay et al. (2009, p. 116), a pilot study is a "small-scale trial of a study conducted before the full-scale study." The authors likened the pilot study to a dress rehearsal, which is meant to identify any problems and suggest possible improvements to the research tools and procedures. The participants of the pilot study had similar features to the population of the main study. The piloting of the research tools enabled the researcher to refine the research tools.

3.6 Research instruments and data collection procedure

The research instruments used in this study were semi-structures interview guides and observation checklists. These instruments are explained in detail in the following subsections.

3.6.1 Interviews

Interviews were conducted with three participants at each of the four selected centres, which included the Physical Science tutor, the Biology tutor and the head of centre who managed the centre. Interviews can provide information that cannot be accessed through observation and, in this study, interviews were used to get clarification on

information derived from the observations, as recommended by Gay et al. (2009). The tutors were interviewed after observing their lessons.

All the interviews were scheduled with the relevant participants during May to August 2014. These interviews were done on an individual basis, with a total of twelve participants. The interviews were conducted at comfortable locations of the participants' choice. The 30-45 minute interviews were conducted face-to-face and upon the participants' consent. Audio-recording was also done using an MP3 device. The researcher took notes during the interviews.

Rubin and Rubin (cited in Mouton, 2001) describes qualitative interviews as the active participation of the interviewer and the importance of giving the interviewee a voice. Questions for interviews were semi-structured with open-ended prompts, for participants to be able to raise other relevant issues related to the study (Mouton, 2001). The interview questions for the Science tutors were aimed at finding answers to research questions regarding how ICT was integrated in the teaching of Science, tutors' perceptions regarding barriers that hindered the integration of ICT into Science education, and what strategies might be introduced to enhance the integration of ICT into the teaching of Science subjects (see Appendix E). The questionnaire for the HoCs (Appendix D) focused more on leadership of the centre, professional development and technical support provided to the Science tutors with regard to the integration of ICT.

3.6.2 Observations

During observations, a record of events was kept based on the observation checklist that included the layout of the room, types of ICTs available, technical support and

interaction with technology by learners during the teaching process (see Appendix F). The observations were done during normal class hours, from 14h30 to 18h30. The researcher observed the tutors in their natural environment, which was the classroom. The centre's daily timetable was followed during the observations in order not to cause any lesson disruption. Two lessons were observed at each of the four NAMCOL centres, bringing the total of observed lessons to 8. The subjects observed were Physical Science and Biology. The observations were conducted to find out how the centres integrated ICT into Science teaching and to verify whether the findings of the interviews corresponded with the real classroom practice. During the lesson observations, the researcher made comprehensive field notes throughout the observation period. As Bogdan and Biklen (2007) assert, field notes are written accounts of what the researcher sees, hears, experiences and thinks during the data collection period.

3.7 Data analysis

The analysis of data for this study was based on qualitative principles and techniques. Qualitative data analysis begins from the initial interaction with the participants, contrary to the quantitative data analysis where it is left until all data is collected (de Vos et al., 2011). Write-ups of notes made in the field were done immediately to take advantage of stimulated recall on reading the notes. Data from field notes and observations were typed in the Microsoft Word programme. The recorded interviews were also transcribed in Microsoft Word. The researcher followed the guidelines of Gay et al. (2009, p. 449) for analysing qualitative data, which are "examining the data in depth, organizing, categorizing, synthesizing and writing about the data". The first

process was to code and classify data into meaningful themes and patterns. As to determine at what level of innovation these tutors are, they would be measured based on the characteristics of each level as per Rogers' (2003) theory of innovation.

3.8 Ethical considerations

The researcher obtained a permission letter from the University of Namibia to conduct the study (Appendix A). An application letter was written to the Director of NAMCOL at the end of January 2014, requesting permission to collect data at NAMCOL centres (Appendix B), which was subsequently granted to the researcher (Appendix C).

Before the data collection, the researcher explained to the participants that their participation in the research was voluntary and that they could withdraw at any time should they feel uncomfortable to continue. The identities of the research participants were not revealed; pseudo name were assigned to all participants. Participants were assured that all information disclosed during the study would be treated with strict confidentiality and would only be used for the purpose of this study. Given the fact that the researcher was a full time NAMCOL employee at the time of the study, she was fully aware that this could influence how participants responded to the questions. The researcher made sure that this did not happen by being consistent in asking questions. The information collected through observations was therefore useful in validating information collected through interviews.

3.9 Summary

This chapter has provided a description of the research design used in this study. A multiple case study approach was used for the study. The purposive criterion sampling

procedure used for the selection of centres and participants were discussed in this chapter. The research instruments used were interviews and classroom observations. The sample in this study consisted of eight Science tutors and four HoCs from four NAMCOL centres. A pilot study was conducted with similar participants to check the validity and reliability of the research instruments. The next chapter presents the findings from the four centres studied.

CHAPTER 4: PRESENTATION AND ANALYSIS OF DATA

4.1 Introduction

In this chapter, the researcher presents the findings of this study and analyses the data in line with the research questions that guided the study. The data are presented in accordance with the following topics/themes:

- Biographical information of Science tutors and HoCs;
- ICT infrastructure at NAMCOL centres;
- How do tutors use and integrate ICT in teaching science subjects;
- HoCs' and Science tutors' perceptions on the use and integration of ICT in teaching;
- Constraints that hindered the use and integration of ICT in teaching Science subjects;
- The ICT integration strategies and practices in teaching and learning.

4.2 General information about the participants

This section of the study provides the responses from Science tutors as collected through interviews, observations and document analysis. This general information is important as it might have influenced the responses of the participants.

4.2.1 Biographical information of the participants

This section of the study provides the responses from Science tutors as collected through interviews, observations and document analysis. At the time of this study,

eight tutors were responsible for teaching the NSSCO Science subjects at the four NAMCOL centres selected for the study. The eight Science tutors were interviewed, two from each of the four participating centres: Ongwediva, Rundu, Yetu Yama and Otjiwarongo.

Among the tutors interviewed, 4 were teaching NSSCO Physical Science, while the other 4 were teaching Biology. Tutor T3.1 taught more than one subject (Physical Science and Mathematics). In addition, four HoCs were interviewed, one from each centre. Tutors were asked to indicate their age, gender and years of teaching experience as presented in Table 4.1.

Table 4.1: Age, gender and teaching experience of Science tutors

Centre	**C1**		**C2**		**C3**		**C4**		
Tutor	T1.1	T1.2	T2.1	T2.2	T3.1	T3.2	T4.1	T4.2	**Summary**
Age	20-29	30-39	40-49	30-39	20-29	20-29	30-39	50-59	≤ 39=6 ≥ 40=2
Gender	Male	Female	Male	Male	Female	Female	Male	Male	Male=5 Female=3
Teaching experience	9	14	13	14	8	4	3	20 +	

As shown in Table 4.1 the highly represented age groups of the Science tutors were 20-29 and 30-39, with three tutors in each age group. Most Science tutors (six out of 8) were therefore between 20-39 years of age. From the six tutors, three were female and the other three male. The age groups of between 40-49 and 51 - 60 years had only one of the participants each. This finding suggests that there is a new generation of Science tutors at NAMCOL centres. Centre C3 had the youngest tutors with the lowest combined years of teaching experience. Among the 8 respondents 4 of them had

teaching experience below 10 years and the remaining 4 had teaching experience between 13-20 years.

4.2.2 Biographical information of Head of Centres

The Science tutors and HoCs were asked to indicate their age, gender, number of years as HoC and availability of computer at home. Table 4.2 summarise the HoC responses.

Table 4.2: HoCs age, gender, years of experience and availability of computer

Centre	**C1**	**C2**	**C3**	**C4**	
HoC	HoC1	HoC2	HoC3	HoC4	**Summary**
Age	30-39	30-39	40-49	40-49	≤39 =2 ≥40 =2
Gender	Female	Female	Male	Female	Male=1 Female=3
Number of years as Head	2	1	2	6	min=1 max=6
Availability of computer at home	Yes	Yes	Yes	Yes	Yes=4

Table 4.2 above shows that the majority of the Head of Centres who took part in the study were female. Two of the HoCs ranged from 30-39 years of age, while the other two were in the 40-49 age group. The study shows that the majority of the Science tutors were male, on the contrary, the majority of the HoCs interviewed were female, with only one male serving as Head of Centre.

4.2.3 Science tutors' computer competencies

The Science tutors were asked to reflect on how they obtained skills in the use of ICT. Four out of eight tutors indicated that they obtained their ICT skills as at a university or college as part of the requirements for their qualifications. Table 4.3 below reflects

the tutors' responses. Only two tutors have undertaken self-initiated part-time training to acquire and improve their ICT skills. Six of the tutors indicated that they attended workshops about use of ICT, however tutor T1.1, T2.1 and T4.2 said they received a workshop once from NAMCOL on how to integrate internet in lesson preparations and presentations.

Table 4.3: ICT training of tutors

Centre	**C1**		**C2**		**C3**		**C4**	
Tutor	T1.1	T1.2	T2.1	T2.2	T3.1	T3.2	T4.1	T4.2
1. Formal, as part of main course at college/university	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
2. Self-initiated part-time training	Yes	-	Yes	-	-	-	-	-
3. Workshops	Yes	Yes	Yes	-	-	Yes	Yes	Yes
4. Teaching self on the job	Yes	-	Yes	-	Yes	-	-	Yes

The majority (7 out of 8) of the tutors indicated that they had confidence in the general use of computers and could manage with no assistance. One tutor who reported to have access to computer at home and is stationed at a well-resourced centre, revealed that he was not very comfortable with ICT and would need help should he use it in the classroom. The confidence of tutors in the general use of ICT was not evident in four tutors during observations. Tutor 3.1 affirmed that the lack of ICT skills was not the reason why tutors did not integrate ICT into teaching Science subjects when she said:

> *"I think most of us who are teaching (80% or 90%) are young tutors and we have been trained ICT already at universities and colleges. We are very flexible. It is just time…… that is actually limiting us that we do not*

make that sacrifice to go the extra mile. But the skill is there" (T3.1, 19 May 2014).

4.2.4 Access to computers at home by Science tutors

When asked whether they had a computer at home, the responses of the Science tutors were as follows:

Table 4.4: Access to computers by Science tutors

Centre	**C1**		**C2**		**C3**		**C4**		
Tutor	T1.1	T1.2	T2.1	T2.2	T3.1	T3.2	T4.1	T4.2	**Summary**
Computer at home	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes=7 No=1
Access to computers at centre	Yes	Yes	No	No	No	No	No	No	Yes=2 No=6

The responses of the Science tutors' access to computers at home are summarised in the pie chart below.

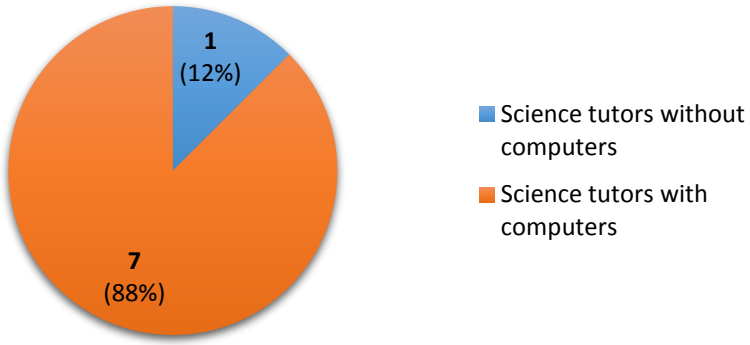

Figure 4.1: Tutors' access to computers at home (N=8)

Figure 4.1 shows that seven out of eight Science tutors owned computers and used them at times for Science related activities after hours. All the interviewed HoC

indicated that they had their own laptops. They reported that they used computers to write reports and letters and to search for information on the Internet.

4.2.5 Access to computers at NAMCOL centres by Science tutors

Tutors were asked whether they had access to computers at NAMCOL centres. Figure 4.4 below summarise the number of tutors with or without access to computers at NAMCOL centres.

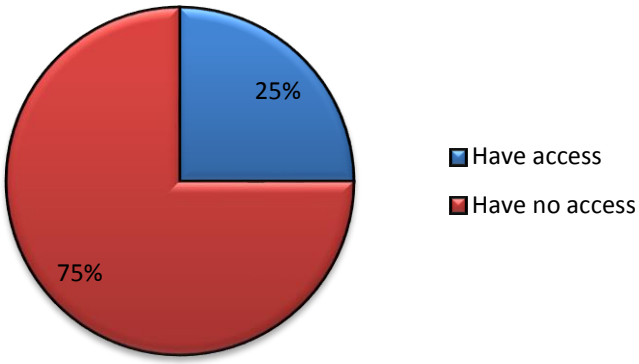

Figure 4.2: Tutors' access to computers at NAMCOL centres

As shown in table 4.4 and Figure 4.4 only 2 of eight interviewed Science tutors had access to computers at the NAMCOL centres. HoC at centre C4 said there was a desktop in the office and that tutors were welcome to use that computer, however the Science tutors at that centre stated that they do not have access to computers at the centre. HoC1 and HoC2 indicated that the Science tutors had access to the computers at the centre when they wished to use them. In addition, all the HoCs reported that tutors were also allowed to use the computers in the administrative office for a few minutes, provided the staff members at the specific centre were not busy at the time.

4.3 ICT infrastructure at NAMCOL centres

The presence of appropriate hardware and software is a pre-requisite for the use of ICT in teaching and learning (Tearle & Katene, 2005). At the time of the study, the number of computers found in the four NAMCOL centres ranged from 23 to 60 Intel core I5, LED 22 inch computers (Table 4.4). Centres C1 and C4 had the most computers. All the centres reported the availability of MS-Office 2010 application suite with the MS-Windows 7 operating system. All the centres received computers and software from NAMCOL Head Office, which is responsible for the acquisition and distribution of all Information technology items (NAMCOL, 2013).

Table 4.5: State of computers in computer labs

Centre	C1	C2	C3	C4
Number of computers in the lab	49	25	25	60
Number of computer labs	2	1	1	2
Number of working computers in the lab	49	23	25	60
Number of computers connected to the Internet	49	23	23	55

4.3.1 Location of computers

Computers were located mostly in computer labs, few in the resource centres and some in administration offices (see Table 4.6 below). The location became important in determining who used the computers and when they did so. At the time of the visit at the centres, only two centres, C1 and C4 had computer boxes installed in the classrooms. The computers in the resource centre at centre C3 were not ready for use. Five computers were found in the foyer of the reception area for use by learners and tutors at Centre C1.

Table 4.6: Location of computers

NAMCOL Centre	C1	C2	C3	C4
Number of computers in computer labs	49	25	25	60
Number of computers in administration offices	12	4	5	6
Number of computers in resource centres	3	0	8	6
Number of computers in office of HoC	0	0	0	1
Number of computers in classrooms	2	0	0	4
Number of computers in reception area	5	0	0	0
Total	**71**	**29**	**38**	**77**

4.3.2 Peripheral devices

Most of the computers at the centres had CD ROM drives. Other useful peripheral devices present in all the centres were printers, scanners, digital cameras and data projectors. All four centres had data projectors and white boards mounted in the classrooms. Centre C4 had an interactive whiteboard which was not connected but instead used as a data projector screen at times.

4.4 The use and integration of ICT in teaching Science subjects at NAMCOL centres

4.4.1 How do tutors use and integrate ICT in teaching science

Table 4.7 summarises Science tutors' responses to the question on how they used and integrated ICT in the teaching of the subjects.

Table 4.7: Use of ICT by tutors

Activities used for ICT integration	Tutors who participated in the activity
• Downloading worksheets and running copies for all learners	T4.1 T1.2 T3.2
• Presentations of lessons	T2.1 T2.2
• CDs with questions on each topic	T4.2
• Project graphs, sketches, diagrams	T2.1 T4.1
• Searching for information on Internet	T1.1 T1.2 T3.2 T2.1 T4.1 T4.2
• DVDs with demonstration of experiments	T4.1
• Downloading videos on experiments that could not be carried out practically, and projecting them on the screen	T1.1 T2.1 T4.1

The majority (6 out of 8) of the tutors searched for information on the Internet for teaching purposes. Tutors accessed internet at home or their cell phones to gather information on certain topics. On the prompt question whether the tutors use internet during the lessons, all six said no, because there was no internet connection in the classrooms. However, tutor (T1.2) added that she used cell phone to look for a definition of words during the lessons.

Three of the tutors cited the downloading of videos to demonstrate experiments which they could not carry out in class. Tutor T1.1 stated that in his free time, he developed CDs with self-instructional content on Physical Science topics which are perceived as difficult by the learners. As a result, he had CDs on 20% of the NSSCO Physical Science subject content. If one reflects on this statement in connection with Rogers's (2003) innovation categories this tutor is referring to adopters in the early adopter

category who are, according to Rogers, usually venturesome, risk takers, technologically inclined, can cope with a high degree of uncertainty and are internally motivated.

Tutors T1.1 and T2.1 reported that they often brought their laptops to class to show simulations for experiments that they could not do in the class. HoC1 and HoC2 confirmed that the two tutors (T1.1 and T2.1) were regular users of ICT in their teaching. During the visit, the researcher observed Tutor T2.1 using a laptop and projecting some subject content on the screen. The researcher noted that the listing of computer and projector in the lesson plans of T1.1 and T2.1. Tutor T2.2 without access to computer at home stated that he used ICT for presentations which he does not very often.

Tutor T4.2, admitted not to have strong ICT skills, however he indicated that he downloaded past examination papers, which he photocopied and distributed to all learners. On the day of observation, the researcher found tutor T4.2 busy with a worksheet of past examination questions related to an experiment on respiration. This confirmed the engagement of the tutor in the activity as reflected in Table 4.7.

The HoC and Regional Manager confirmed that tutor T1.1 used ICT very often. On the day of observation, T3.2 tried to use own laptop and the data projector in the class, but after almost 12 minutes of trying to connect the equipment with the assistance of the HoC, they failed and gave up. During observation, only 2 tutors were observed using ICT in the classroom. According to the lesson plans of the tutors, the researcher

only found evidence in tutors T1.1 and T2.1 of ICT use and integration in the classroom.

Most tutors (5 out of 8) seemed confident in their general use of ICT for personal or non-teaching use. Only tutors T1.1 and T2.1 based at centre HoC1 and HoC2 respectively, felt confident to use ICT in a lesson and tutor T4.2 who is based at a well-resourced centre HoC4 reported limited use of ICT in general.

4.4.2 Reasons for the use of ICT in teaching

Tutors were asked to give reasons why they used ICT in their teaching. The reasons given were not restricted to usage at NAMCOL centres only. Each tutor gave a reason, including the one who earlier indicated limited use of ICT. The responses are reduced to statements in Table 4.8 with the frequency, indicating how many times they were mentioned.

Table 4.8: Main reasons for using ICT in teaching

Main reason for using ICT in teaching (N=17)	Frequency
1. Presentation is not time consuming like when writing on the board.	2
2. To improve learners' understanding and have good results in the end.	2
3. To research on more information on Internet about the subject topics.	3
4. To get more ideas on teaching styles, methods and skills.	2
5. View demonstration of experiments.	4
6. To improve lesson preparation.	2
7. To network with other subject experts.	2

Showing the demonstration of experiments was most frequently mentioned by tutors as a reason for the use of ICT in their teaching. The use of the Internet to acquire more

information about the subject content was the second highest reason given for the use of ICT.

4.4.3 Ways in which tutors use ICT in teaching

Tutors were asked to highlight ways in which they had used ICT in the teaching and learning of Science in the last twelve months at NAMCOL centres. Table 4.9 summarises the responses.

Table 4.9: ICT activities in the past 12 months

ICT used	Topic/Activity	Tutor
CD, laptop & data projector	Reactivity series and the extraction of the metals: projected a chemical reaction in words then learners were asked to write equation and balance	T2.1
CD slides used laptop and data projector	Heart slides show the structures of the heart Magnetism	T2.2 T4.1
Cellphone and internet	Used cellphones of both tutors and learners to find explanation of terms and concepts that were found difficult to understand.	T1.2
Simulation video clips from internet	Radiation, e.g. the infrared, how the mouse operates, how the TV remote operates, how the car remotes operates because they use infrared.	T1.1
Internet, video clips, data projector	Used on the topic Cathode Ray Oscilloscope also known as CRO	T.1 T4.1

The ICT activities listed by the tutors included the use of CDs, video, Internet, laptops, cell phones, data projectors. These are all common equipment and applications that can support teaching. As shown in Table 4.9 five tutors referred to topics which they

had taught with the aid of ICT within the last 12 months. The Physical Science tutors could refer with more ease to topics where ICT was used compared to the Biology tutors, because according to Table 4.9 five of the activities listed were by the Physical Science tutors compared to two by the Biology tutors.

4.5 Perceptions on the use and integration of ICT in teaching and learning

The perceptions of the Science tutors and HoCs on the use and integration of ICT in teaching were sought. A cross analysis was done to present the positive and negative perceptions expressed by the HoCs and Science tutors. The results are shown in the following subsections.

4.5.1 Perceptions of the heads of centres

All the interviewed HoCs regarded the integration of ICT into teaching and learning as very important. One of the long serving participants said:

> *"The world is moving towards ICT and there is a great need to move along, otherwise NAMCOL will be left behind, but there should be training. If you look at this generation, like all these learners here, they do have cell phones and all these gadgets with Internet, I do not see any reason why it cannot be used for learning in the classroom"* (HoC3, 18 May 2014).

Another participant with 10 years teaching experience said:

> *"I had some software that I got from the previous school that I was teaching. For me to encourage one of my tutors, I gave the software to*

the Biology tutor and he liked it. He's using it in his class. ICT makes topics very clear. It enables learners to "see" things, such as how the blood flows" (HoC2, 2 July 2014).

Based on these statements, one can clearly see that the HoC2 entrusted to manage the NAMCOL centre was willing to advocate for the integration of ICT at the centres, by sharing the subject software with the tutor.

4.5.2 Perceptions of the Science tutors

Seven of the Science tutors viewed ICT integration favourably. The tutors regarded ICT as a tool that enhances the teaching and learning of Science as stated that:

*"Integration of ICT makes the understanding of subject content easier and better than the theoretical part and learners may find lessons more interesting with ICT rather than teaching in the traditional way" (*T1.1,19 July 2014).

The quotes in Table 4.10 provide the actual positive statements made by the Science tutors on the use and integration of ICT.

Table 4.10: Tutors' positive perceptions on the integration of ICT

Tutors with related expression	Expressions reflecting positive perceptions made by the tutors
T2.1	Yeah…. it will improve learners' results as I have observed at my school.
T1.1,T2.1,T4.1	ICT integration is a great advantage because it just broadens the knowledge.
T1.1,T1.2,T2.1, T2.2, T3.2, T4.1	The practical is also demonstrated through ICT, so it equips a learner on an advanced level through technology.
T1.1, T2.1,T3.2	I think NAMCOL is moving in the right direction by introducing ICT into the classrooms, because in this modern world, no one wants to write on the chalkboard.
T2.1, T3.1	These things (*tutor pointing at the data projector mounted in the ceiling*), are the right standard compared to any part of the world.
T1.2,T2.2, T4.2	It is actually a good thing, but then the issue is now the resources are not yet enough for all the centres.
T1.2, T2.2, T4.1	Learners may find lessons more interesting with ICT rather than teaching in the traditional way.
T.2.1, T3.1	ICT integration is definitely the way to go.
T1.1, T3.1, T3.2	The world is changing in that direction of using ICT everywhere.
T3.2, T1.1	Education is becoming; digital, education is becoming very much integrated into software.
T1.2, T3.1, T4.1	The world is changing. Technology, the phones we are getting and all these things will force education to use ICT in the classrooms.
T1.1. T2.2	So it's a step in the right direction.

The majority of the tutors have a positive perception towards ICT in education. The demonstration of science experiments seemed to be one the main reason why tutors perceive ICT to be relevant and beneficial in their teaching. Tutors expressed appreciation that NAMCOL installed data projectors in the classroom and believe more are still to come.

4.5.3 Concerns expressed as perceptions on ICT integration by heads of centres and tutors

Tutors and HoCs expressed some concerns with regard to the use and integration of ICT at the NAMCOL centres. The tutors expressed some concerns alongside their positive perceptions. However, they stressed that their positive perceptions outweighed their negative perceptions. Four themes emerged from the concerns raised which are: lack of skills, time management, infrastructure and need for assistance. The concerns raised are summarised in Table 4.11 were classified into two categories, namely; human resource related and lack of facilities and summarised in Table 4.11.

Table 4.11: Categories of concerns expressed by tutors and heads of centres

Concerns expressed as perceptions by HoCs and tutors four themes emerged: lack of skills, time management, infrastructure and assistance
1. Tutors do not have the know-how to handle such equipment. 2. There is not enough time to use all this equipment. 3. There should equipped personnel to assist with ICT in the classroom. 4. Acquire enough facilities such as computers and science software at NAMCOL centres.

The tutors' concerns were due to the compatibility of ICT to their current practice, hence all HoCs and 4 of the interviewed tutors raised a concern that even though there was equipment at the centres, NAMCOL did not train the tutors on how to use the computers, designing of web lessons, and data projectors effectively for teaching.

4.5.4 Perceptions of tutors on whether ICT can help learners to learn Science

Tutors were asked to express their views on whether ICTs helped the learners to learn. All the tutors indicated that ICT could help learners to learn Science. The following are selected quotes from the tutors to support the claim:

> *"ICT helps the learners very much to understand work more easily than the theoretical part because when they use the ICT, it is more like they are doing things on their own. They get more excited. They tend to get clarity and ideas how to solve a problem. It also helps them to gain more knowledge and ideas. I don't know how I must stress this one"* (T2.1, 3 July 2014).

> *"One of the education theories said people learn better by observing. ICT provides a platform to learn through observing, especially visual information like videos. Yes, ICT is the way to go" (*T1.2, 19 July 2014).

> *"Yes it can, but it all depends on how eager the learners are to learn how the ICT operates. Like I have seen some of the learners at this centre; I usually find them in the hall. Some of them are even on the Internet doing research on the different topics of the subjects that they are being taught. So, that way I think it helps them a lot. I saw even the computer lab sometimes is availed to them, they go on Internet; they look for the answers that they need. So, it's actually good for them"* (HoC1, 18 July 2014).

Another tutor said that learners got very excited and confident when they were taught using ICT, because most of the time learners only used their imagination if teachers did not show the pictures. She further added that:

> *"They actually like it. And they actually enjoy it with the slide showing and everything. It's actually good, it even stimulates their interest. They are always eager to see what is on for the next day because they want to see what you have prepared for them"* (T2.1, 3 July 2014).

Tutors' positive responses were most about the relative advantage of ICT in teaching and learning. Six tutors expressed that ICT will enable them to demonstrate science practical which otherwise cannot be carried out due to shortage of materials or its complexity. Tutors at all the centres stated that ICT integration will enable learners to enjoy learning and help them broaden their knowledge.

4.6 Leadership at centres on the use of ICT

Asked whether promoting the integration of ICT into the teaching of Science was a priority and how they monitored the use of ICT at the centres, the HoCs centres responded as presented in Table 4.12.

Table 4.12: Opinions of HoCs on the promotion and monitoring of ICT integration

Head of Centre	Statements on whether promotion of ICT was a priority	Statements on how HoC monitored the use of ICT in teaching
HoC1	I find it helpful.	I go around to class, if I don't go there, then when they bring in their lesson plans I make sure I check. Our Regional Manager talked to them in our first meeting with the tutors that we should make use of ICT.
HoC2	I had some software that I got from the previous school that I was teaching. I gave them to some of my tutors.	When they are preparing lesson plans. I also do class visits. Physical Science tutors always indicate in the lesson plan.
HoC3	No, it is not a priority for one good reason that there are no facilities which would support that. Especially during teaching, maybe tutors could encourage learners to go to computer labs. There are data projectors in the class rooms, but without computers. I say it will be good to look into the possibility of providing laptops in the classrooms whereby tutors can just come and use them there.	No use of ICT
HoC4	Yes…, it is a priority, but the space is limited at the centre. Right now, integration is not a priority, even though in Science ICT is important to explain the content.	I go to class every day and when tutors use laptops and data projectors I like to sit in the class to observe.

According to the above statements, three of the HoCs cited that the promotion of ICT was a priority at their centres. One of the HoCs went to the extent of availing subject related software to tutors at the centre. HoCs monitored the use of ICT during class

visits and two (HoC1 and HoC2) also checked lesson plans. Only two of the interviewed HoCs confirmed that tutors who were regular users of the ICT also reflected the ICT activities in their lesson plans.

4.7 Challenges hindering ICT integration into teaching of Science at NAMCOL

Even though seven of the interviewed tutors expressed positively on the potential of using ICT in the teaching and learning of Science, their use and integration of ICT in teaching was low. The data analysed revealed a very low level of ICT use by the tutors. Only two of them, i.e., tutors T1.1 and T2.1, made use of ICT often as was confirmed by the HoCs. The factors in the following subsections were indicated as challenges that hindered the integration of ICT into the teaching and learning of Science at NAMCOL centres.

4.7.1 Lack of time

Lack of sufficient time was mentioned as one of the reasons why ICT was not integrated into teaching by the tutors at NAMCOL centres. In particular, five of the tutors indicated that the time they had to spend with NAMCOL learners was very limited and did not allow them to incorporate the use of ICT. This was also supported by half of the HoCs. One of the tutors said the following during the interviews:

> "*… you only have that one hour of meeting that group and the next hour the other person has to come in, so there is not much time to make use of such facilities"* (T1.2, 19 July 2014).

Other four tutors said that they did not have the time to prepare the slides and search for the appropriate information. In addition, some tutors said locating and the setting up the laptops and other equipment required time and all these caused tutors to rather not use them. Two of the interviewed tutors regarded the use of ICT teaching as an additional load to their allocated time as reflected in the statement by tutor

> *"It's the time, because sometimes we have workloads already at school and you come to NAMCOL and you just focus on the theoretical and not go the extra mile by using ICT* "(T3.1, 19 May 2014).

4.7.2 Negative attitudes

Two of the interviewed HoCs alluded to the fact that tutors were working part-time for NAMCOL and some had an attitude of not wanting to go the extra-mile and carry out additional tasks during teaching. One of the tutors said:

> *"Even though there are CDs and computers available, they do not care to use them for teaching because they just aim to finish the syllabi as expected"* (T2.1, 3 July 2014).

4.7.3 Lack of information

Most of the tutors (6) and HoCs (3) admitted that they were aware that the computer labs at their centres were mainly for the training of customers who enrolled for ICDL. Three of HoCs were not aware that the centres had laptops that could be booked for use in the classrooms. The majority (6) of tutors and HoCs had no idea that NAMCOL produced interactive Physical Science lessons for use by the public. Asked about other

peripheral devices, 3 of the interviewees were not aware of the scanners and digital cameras available at the centres. Further, the centres did not have a policy on how the computer labs were to be used and for what purpose by the tutors and learners at the secondary education level.

4.7.4 Lack of ICT competency

Tutors stated lack of pedagogical ICT skills as one of the barriers to ICT integration into the teaching and learning situations as said:

> "*… some of the colleagues do not have the knowhow to get information and load it up on the computer so that you can make a slide show for the learners* (HoC3, 18 May 2014).

On the question whether they had received any ICT related training which enabled them to integrate ICT, only two tutors responded that they received training sometime - 3 years ago. They said that during the training, NAMCOL staff trained them on how to search for relevant information, develop slides, insert clips from Internet and create links on the slides.

4.7.5 Lack of facilities

All the eight tutors and four HoCs who participated in the study indicated that they appreciated that NAMCOL installed data projectors in the classrooms at the participating centres, but there were no computers in the classrooms to operate the projectors at 2 (50%) of the studied centres. Those rooms with computers required tutors to first go around looking for the keyboard and mouse, which resulted in time

wastage. As a result, the use of the projectors was low at the time of the survey. Another tutor stated that even though they had laptops, they were not allowed to use the Internet connection at NAMCOL centres. All the centres were equipped with printers and photocopy machines and two of the tutors mentioned that many times there was a shortage of papers.

4.7.6 Lack of technical support

Four of the participants stated that they received technical support from the computer lab facilitator. However, two of the tutors, all at the same centre, strongly stated that they had no technical support at the centre. For example, on the day of observation, the researcher found tutor T3.1 struggling to set up the laptop in order to project her presentation. Even with the assistance of the HoC, it could not work. According to another tutor at C4, the IT experts were reluctant to assist with technical problems. According to him, this was not peculiar to NAMCOL centres, but the same reluctance was also found at his full time job as a teacher. The same tutor reported that the IT technical person, on two different occasions when called to attend to the laptop that could not work with the mounted data projector, made a statement such as, “figure it out yourself, I am not a teacher; …send an e-mail to ask for assistance”. He said that from the time of these encounters, he had either tried to fix the technical problems himself and if he failed, he would just go on with his lesson without using the ICT. However, a tutor at the same centre reflected that he always received technical support whenever he requested it.

4.7.7 Lack of access

Four tutors strongly complained that there were no computers in the classrooms, even though there were data projectors. They had to bring their own laptops and not everyone was in possession of a laptop. One of the HoCs welcomed this research, saying that it was good that such a study was being conducted because they could air their opinions for NAMCOL management to take note. The HoC was of the opinion that NAMCOL management instilled fear in the tutors and HoCs towards the use of the facilities. The HoC stated that statements such as "… if anything happens to that (projector, Science equipment), you will pay" were often made by the managers.

The same sentiment was expressed by the tutors who said that even though there were computers in their class rooms, they were required to book for the keyboard and mouse from the administrative staff. That was time consuming and, should the equipment break, they were required to pay. Such statements, according to them, discouraged tutors from using the equipment at the centres.

The lack of directives that spell out compulsory time slots for each class group in the computer lab was indicated by the HoCs and tutors as a contributing factor hindering access. Tutors claimed that they had to depend on the moods of the computer lab facilitators to allow them access to the computers. The majority (6 tutors and 3 HoC) of the participants were strongly of the opinion that the impression portrayed at the centres was that "the computer lab is only available for ICDL lessons."

The lack of appropriate Science software which could be used by both tutors and learners discouraged the integration of ICT at the centres as demonstrated. One of the Physical Science tutors suggested that NAMCOL must acquire the Encarta software.

4.8 Recommended strategies and practices to enhance the use and integration of ICT

The participants were asked to suggest best strategies and practices that could be implemented to enhance the use and integration of ICT into teaching at the NAMCOL centres. The following were suggested: partnerships with nearby schools for use of the facilities by all NAMCOL learners, equipping classrooms with ICT equipment, providing continuous training and issuing policy directives on the use of computer labs. These are explained in the subsections below:

4.8.1 Form partnerships with schools

According to the tutors, who are also teachers in conventional schools, some schools had equipped computer labs, printers and other ICT facilities. Most of the NAMCOL centres were hosted at these schools. Therefore, the tutors suggested that NAMCOL should get into partnership agreements with these schools so that their tutors and learners could have access to those facilities. NAMCOL could be required to pay a minimal fee for maintenance and use of the facilities.

4.8.2 Equip classroom facilities with ICT equipment

One of the participants strongly suggested that all the classrooms on NAMCOL premises should be equipped with a data projector and computer and everything

needed for the use of the equipment. He said that tutors should just come with a memory stick, insert it and start with the lessons. That way, no time would be wasted. It was suggested that NAMCOL should visit other institutions such as UNAM to learn how they manage the computer facilities in the classrooms. Another tutor said:

> *"…buy projectors which take memory sticks for all the NAMCOL centres and then it will be easier because the tutors will only need to bring a memory stick to class. The college should consider such projectors for all its centres"* (T4.2, 31 July 2014).

In addition, tutors suggested that there was a need to acquire subject specific software for all the key subjects.

4.8.3 Provide training

Some tutors suggested that NAMCOL should contract the services of those teachers who used and integrated ICT successfully in their subject teaching to train other tutors. As stated earlier by one of the tutors, most tutors were computer literate, but they needed training on the pedagogical use of ICT. Tutors used PowerPoint presentations to teach in the traditional lecturing way, and they regarded that as learner centred. HoCs and tutors said that learners also needed to be trained on how to use computers and cell phones for learning as quoted below:

> *"…regular training or, maybe, workshops on the different subjects, for instance if it is a Biology workshop, then they can show us how exactly Biology can be integrated with ICT"* (T2.2, 3 July 2014).

"Show the learners how cell phones can be very good learning tools; show them how to access science related sites on Internet using cell phones" (T4.1, 31 July).

4.8.4 Draw up and enforce policy directives

There is a need for a policy to direct that all centres have a timetable which includes one lesson per week for each subject in the computer lab. The subject tutor, with the assistance of the computer centre facilitator, would then use ICT in delivering lessons. Tutor T1.2 recommended that assignments should be set in such a way that learners would be required to use ICT in order to complete the assignments.

4.9 Summary

This chapter has presented the findings on the perceptions, how tutors integrate ICT and barriers on the use and integration of ICT at the four NAMCOL centres. The data were collected through interviews, observations and document analysis. The next chapter discusses the findings presented in this chapter.

CHAPTER 5: DISCUSSION OF FINDINGS

5.1 Introduction

This chapter discusses the main findings of this study. The discussion is presented according to the following main research questions: How do NAMCOL tutors currently integrate and use ICT in their tutoring of Science subjects?; How do tutors at NAMCOL centres perceive the integration of ICT into the teaching of Science subjects?; and What challenges impede the integration of ICT into the teaching of Science subjects at NAMCOL centres and what can be done?

5.2 How do tutors use and integrate ICT in the teaching of Science

This research question was aimed to investigate the levels of ICT use by the Science tutors at NAMCOL centres. The study revealed that although tutors generally expressed positive attitudes towards the integration of ICT into teaching, such integration was mainly limited to the use of PowerPoint, word processing and searching of information from the Internet. This finding is the same as found by Ngololo (2010) that teachers performed basic tasks when using ICT. Science tutors in this study agreed using the internet mainly to research on topics to compliment information in the textbook. This was done elsewhere since the Internet at NAMCOL centres could not be accessed with personal laptops and it was not easy to use the computers at the centres. Unfortunately Science tutors in this study were not utilising the benefit of internet activities by engaging in small group activities with internet information which promote critical thinking and help learners to construct their own knowledge.

The data in Table 4.10 shows that the tutors had an understanding and appeared to have used ICT for teaching purposes either at NAMCOL or in their conventional schools. The Physical Science tutors, however, could refer with more ease to topics in which ICT was used and integrated, compared to the Biology tutors. Viewing of the science experiments was the most mentioned reason for the use of ICT by tutors as one of them put it: "*Seeing is believing and ICT gives that platform to view experiments that cannot be carried out in class*." This statement is in support of the findings of Wells (2007), who reported that the use of ICT is used to demonstrate processes which are hard to comprehend.

These findings were in line with Rogers' Attributes of innovation (2003) in terms of relative advantage. The tutors use the innovation with more advantage and which improve their tasks in the classroom and are compatible to the situation at the centres and less complex to use. Such as video clips demonstrating difficult experiments and internet for gaining more subject knowledge. Tutors shy away from innovations which are complex and rather opt to use what they feel confident with. During observation, one of the tutors brought her own personal laptop to use in class. However, she was not able to connect it and there was no technical support available for her. According to literature, technical support should be readily available if tutors are to integrate ICT successfully into their lessons (Sicilia, 2005).

Three of the tutors (T2.2, T3.1 & T3.2) indicated that they did not use ICT for their teaching at NAMCOL centres. One of the reasons given for the lack of ICT usage was the limited time in which tutors were required to complete the syllabi. Six of the eight tutors said that they were under pressure from management to achieve good grades

with the group of learners. Therefore, completion of the syllabi (Bingimlas, 2009) seemed to enjoy priority rather than integration of ICT.

Tutors T3.1 and T3.2 who did not specifically use ICT at the NAMCOL centres claimed that they had a computer lab at their conventional schools, which they used on a regular basis. When asked why they did not share the same practice at the NAMCOL centre, they cited that at NAMCOL, the time was very limited. There were no computers allocated to the classrooms at their centre and they were not provided with appropriate subject software.

Although the tutors had access to computers, either through their own laptops or the installed PCs at the two centres, only two of the Science tutors used ICT in the classroom during teaching every week. The regular users were T1.1 and T2.1 both were male and Physical science tutors. They are in the age groups 20-29 and 40-49 respectively. This finding revealed that age is not much of a deterring factor. This finding is contrary to the findings by Russell, Bebell. O'Dwyer & O'Connor (2003) they found that older teachers frequently use ICT in the classroom than the younger teachers who are highly skilled. Rusell et al. (2003) stated that the younger teachers focused more on the use of ICT instead incorporating it in their teaching.

Two of the tutors said that they used ICT once every two weeks or once in a month at NAMCOL, especially video clips demonstrating Science experiments as shown in Table 4.10. These findings are in line with Rogers' theory of diffusion of innovations (2003), which states that adoption growth usually begins relatively slow when a small number of leaders adopt the innovation and then exponential growth follows when

other people accept the innovation. The two tutors who used and integrated ICT regularly in their teaching could be regarded as leaders and change agents who could be used to demonstrate the advantages of ICT integration and train the other tutors on pedagogical integration of ICT.

It is interesting to note that at one of the centres with installed PCs, one tutor indicated regular use of the laptop and mounted data projector, which was confirmed by the HoC, while tutor T1.2 at the same centre indicated not to use ICT. This suggests that it is not necessarily the availability or lack of ICT infrastructure at centres that determine tutors' use of ICT. This is also in line with the findings by Bingimlas (2010). According to Rogers Innovation decision (2003) tutor T1.2 who does not use ICT has passed the knowledge and persuasion stages however she is yet to decide to adopt innovation, while T.1.1 who is a regular user had moved to the implementation stage. It can also be attributed to Rogers' (2003) finding that individuals accept innovation differently; some people accept more quickly than others as represented by the bell curve illustrating Rogers' innovation categories. Even though all the centres had computer labs, none of the tutors reported to have taken their learners into the computer lab for a Physical Science or Biology lesson. The computer labs had been in existence for more than 3-10 years at these centres. To some extent the majority of the tutors reflected some level of information management as they were able to use internet as a search tool to supplement the subject content.

The findings of the study provided little evidence of the use of ICT for assessment. Tutors indicated the use of internet to search and download past examination question which were used as drill exercise in the classroom. The lack of connectivity in the

classrooms prevented the tutors from using computers for assessment and take advantage of the benefits ICT related assessment which are instant feedback (Daper, 2011).

Tutors T1.1 and T2.1 were regular users of ICT, according to Rogers' categories they will be classified as early adopters. T1.1 developed CD with hyperlinks and clips demonstrating topics perceived to be difficult. Tutor T2.1 developed a series of PowerPoint presentations. The other six tutors have information on ICT and had confidence in ICT however their level of integration was low. This finding support the finding by Ngololo (2010) that ICT use for pedagogical purpose was low.

5.3 Tutors' perceptions on the use and integration of ICT in the teaching of Science

The perceptions of the Science tutors and HoCs could have an impact on the integration of ICT into the teaching situation (Watson, 1998). Seven of the eight Science tutors gave a positive perception on the use and integration of ICT in teaching. They were of the opinion that ICT could improve teaching and learning of science in schools. This finding supports the study by Hennessy et al. (2010a), which found that most teachers in Nigeria were interested and willing to integrate ICT into their teaching activities. The positive perception of the tutors is evidence that the tutors already started with Rogers' Innovation decision process (Rogers, 2003). The tutors had knowledge about ICT and most were persuaded and decided to use and integrate ICT in their teaching. According to Rogers' innovation decision stages, the tutors have passed the Knowledge stage → Persuasion stage, and are to move to the Decision stage (Rogers, 2003).

It was clear from the findings in this study that the tutors perceived ICT as a tool that could help them to teach and make concepts clearer to the learners. They were of the opinion that the integration of ICT provided alternative teaching methods that made teaching and learning fun for both teachers and learners. The majority of the tutors agreed that the use of ICT in the classroom motivates learners to use ICT for learning, which is also in line with the findings of a study conducted by Iipinge (2010).

Researchers believe that the use and integration of ICT in education depends on the attitude and perception of the teachers towards technology (Albirini, Teo and Huang in Al-Zaidiyeen et al., 2010). According to Al-Zaidiyeen (2010) the extent to which ICT is used in the teaching and learning process depends on the attitude of the teachers. Based on the tutors' positive statements in this study, it is fairly safe to assume that given the necessary training and adequate access to ICT, the participants can embrace the use and integration of ICT into the classrooms moving towards the decision, implementation and confirmation stages of Rogers' Innovation theory (Roger, 2003), which at the end may perhaps inspire others to use and integrated ICT more often in their teaching. The four HoCs and seven out of eight of Science tutors interviewed could be regarded as ICT champions. According to Iipinge (2010), ICT champions are people who can lead and motivate others on ICT integration at their respective institutions.

The tutors expressed concerns on the integration of ICT into the teaching of Science at NAMCOL centres. The concerns expressed as perceptions appeared to be influenced by various factors, such as lack of access to facilities and lack of ICT related skills. Four themes emerged from the raised concerns, i.e., lack of adequate skills, time

management, infrastructure and the need for assistance as reflected in Table 4.11. While the number of ICT facilities at the NAMCOL centres is increasing, it seems that skills upgrading for tutors with regard to supporting teaching with ICT has not been at the same pace as the provision of technology. Literature advised that the availability of computers and ICT equipment should be accompanied by training of the users (Aryatuha, 2007). Even though the tutors displayed a positive attitude towards the integration of ICT into teaching, many did not use it frequently in the classroom.

When asked whether learners responded favourably when ICT was being used, all the tutors in the study responded that ICT was helping learners to learn. A study by Moila (2006) confirmed that the teachers' ICT tools usage impacts directly on learners' ICT tools usage. This is also supported by the views of the tutors in this study that their use of ICT motivated learners to use ICT. The views given by the tutors were also in support of a study by Wells (2007), who found that learners enjoy learning using technology.

A tutor at centre C2 stated that with ICT, learners were able to view Science apparatus through videos or simulations from the Internet. One of the tutors shared informally with the researcher that during his secondary education, he never knew how a test tube looked like, even though his secondary level teachers taught about it, until he went to university in the late 1980s. To him, with the dawn of ICT, learners are in a position to view and get a better understanding of subject concepts. This makes work easier and brings reality to the classroom in the absence of the appropriate Science equipment for experiments.

5.4 Challenges that hinder ICT integration into the teaching of Science subjects

The third research question looked at the challenges that impede the integration of ICT into the teaching of Science subjects at NAMCOL centres. Two important revelations emerged from this study. Firstly, all the centres studied were equipped with ICT facilities and Internet connectivity, and seven out of the eight tutors studied had computers at home. Secondly, most of the tutors had a positive perception towards the use and integration of ICT into teaching. Notwithstanding all these, the question remains: what prevents the tutors from using and integrating ICT into their teaching situations?

Although tutors identified the positive aspects of integrating ICT into the teaching of Science, they also identified some barriers to the use and integration of ICT as presented in Chapter 4. The findings of this study show that the tutors had numerous challenges or barriers that hindered such integration. The main challenges identified relate to lack of time, lack of information, lack of ICT competency, lack of facilities, lack of access and lack of technical support.

Lack of technical know-how was one of the most mentioned barriers by the tutors. Interestingly, among the eight tutors, only one admitted that he was not confident with the use of ICT in the classroom and would need help. However, all the other participants claimed that it was "other" tutors and teachers in general who lacked skills, and that hampered them from using ICT. It appeared as though tutors did not want to reveal that they lacked skills in using ICT effectively for teaching and only wanted to refer to others as the ones who lacked skills. There may be a need to provide regular training to all the Science tutors on pedagogical ICT approaches.

Four of the tutors received computer-related training during their pre-service training. Even though 50% of the tutors indicated that they had received pre-service training on ICT, they seemed not to have used ICT effectively. This was because the training that they received focused more on usage of basic software (PowerPoint, word processing, Excel, etc.) and did not address the pedagogical aspects required to use ICT effectively for teaching and learning of the subject content. When one analyses the National ICT Policy for Education, it is silent about the professional development of teachers, which includes pedagogical ICT skill training (Ngololo, 2010). It is believed that teachers who acquire pedagogical skills on ICT integration will ensure effective integration in teaching and learning (Becta, 2004). Training of teachers should focus on ICT pedagogical skills and not just computer skills to ensure effective ICT integration in the teaching of Science (Beka, 2013).

One of the tutors and one HoC received in-service training on how to develop interactive lessons. Most of those tutors who received training on the development of interactive e-lessons were not with NAMCOL anymore. Therefore, there is a need for such trainings to be offered every year, if possible.

Significant time is needed with regard to the planning as well as the technical aspects in the initial stages of the effective integration of ICT. The study revealed that most tutors who had the ICT technical skills did not use ICT for teaching regularly due to lack of time. Tutors further reported that the preparation of the slides required time, which they did not have. In terms of Rogers (2003) adoption categories the innovators and the early adopters of ICT will put in this extra time without any rewards or incentives from the institutions. The innovators and early adopters are internally

motivated and willing to try out new technology. As for the late adopters the incentives are important, which can include peer influence and recognition. The issue of time has been mentioned in other studies (Becta, 2004; Iipinge, 2010) as a limiting factor for ICT use and integration. The tutors cited that the time they had with the learners at NAMCOL centres was limited, and much time would be wasted while trying to get and set up equipment. Bingimlas (2010) stated that the lack of time could be due to different factors, such as busy schedules and too many classes. This could be true for the NAMCOL tutors, who are also employed fulltime in the conventional schools.

These tutors teach in the morning at the conventional schools and, after school, they continue with teaching at NAMCOL centres. Tutors regarded integration of ICT as an additional work load to their teaching, as one tutor at a well-resourced centre mentioned that: '…*we have workloads already at school and you come to NAMCOL and you just focus on the theoretical and not go the extra mile by using ICT* (T3.1). This perception might deter the adoption of ICT integration at the centres as tutors will always think that it is their choice to integrate or not because it is not a requirement. In addition, during the visit at the centre, one HoC made it clear that the tutors at the centre had some afternoon tasks at their schools and therefore could not be at the NAMCOL centre for very long. As warned by Bingimlas (2009), even if there are facilities at the centre, if the tutors do not have the time, they will not make use of the available facilities. The early adopters will go the extra mile however, as for the late adopters the incentives are important, which can include peer influence and recognition in the form of rewards (Rogers, 2003).

Another challenge that was identified as a barrier to the integration of ICT was access to ICT facilities. The barriers related to access included lack of facilities at the centres, lack of Science software, lack of Internet and lack of access to computer labs. NAMCOL management provided the centres with computers as reported in Table 4.5. The majority of the computers were located in the computer labs and tutors and learners had limited access to them. At centre C4, there were PCs in the classrooms. However, the mouse and keyboards were kept by the administrator and required to be signed out. This created a barrier, as the tutors were not in a position to step into the classroom and use ICT right away.

Another issue reflected by the findings was that tutors and HoCs did not have information as to what facilities and services at the centres were available to them. Only two out the eight Science tutors were aware of the Science DVDs with the practical experiments. The interactive e-lessons for which NAMCOL scooped the COL award were not known by the participants.

Two of the centres had no computers in the classrooms at the time of the study, and tutors regarded that as a reason why they did not integrate ICT into the teaching situations. The lack of appropriate Science software at the centres was also another barrier to ICT integration. It must be pointed out that according to the ICT Policy for Education, institutions with the secondary education phase are expected to be at least at Level 2 (MoE, 2005). The criteria for Level 2 expect institutions, among others, to:

- have computers accessible to all teaching staff and Internet connectivity;
- have teachers who are able to use the Internet, e-mail and word processor;

- enable students to spend at least one hour every two weeks on the computer;
- have teachers who are able to download and create learning materials; and
- integrate the use of technology in the teaching and learning situation (p.7).

NAMCOL centres have functional computers and stable internet connectivity however, the tutors' access to these resources is limited. Although limited access to ICT at the centre and inadequate pedagogical training did not influence the tutors' positive perception but it contributed to the low use and integration of ICT in the teaching. Given the level of accessibility and availability of the resources at the centres, the researcher is of the opinion that the studied NAMCOL centres are yet to meet the expectations of the ICT Policy Level 2.

5.5 Classification of the Science tutors as per Rogers' theory of innovation

Based on the discussion and findings of tutors and HoCs who participated in this study, the following classification as per Rogers' theory of innovation can be made:

T1.1 & T2.1

> These two tutors used ICT regularly. T1.1 developed interactive CD with subject topics perceived to be difficult. T2.1 invested time to produce presentations for each subject topic without expecting rewards from the institution. Both are interested in bettering the quality of their teaching. According to Rogers' innovation theory the innovators and early adopters commit to time investment because they are internally motivated and hardly expect any incentives. Peers may approach them for advice on the adoption of ICT. For these reasons T1.1 and T2.1 are classified as early adopters. These

people have the potential to serve as ICT champions at a later stage. They just need to be provided with good leadership skills as the theory recommends.

T1.2, T3.1, T3.2, T4.1 & T4.2

According to Rogers' innovation decision (2003), all these tutors have obtained knowledge about ICT in education. They have knowledge on the benefits of the ICT in education. These tutors are at different levels of know-how to use the innovation, therefore, some only use the computers for basic functions such as presentation or searching additional information on the internet occasionally. The tutors opt to use what they feel confident with, therefore the general and pedagogical use of ICT in the classroom is low amongst them. Various reasons were given as reasons by tutors who have not adopted ICT in teaching, ranging from lack of time, lack of skills and lack of computers and software in the classrooms. The tutors are having a positive perception towards ICT use and integration however they have not adopted the innovation into the classroom. The researcher found it is not easy to classify this group. Hence the researcher is of the opinion that these group could be in the late adopters and laggards (Rogers, 2003).

5.6 Summary

This chapter discussed the main findings of this study within the framework of the research questions. The next chapter summarises the findings of this study, concludes the study and provides recommendations to improve the integration of ICT into the teaching of Science subjects at the studied NAMCOL centres.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents a summary of the research findings, draws conclusions from the findings and makes recommendations based on the findings.

6.2 Summary

The purpose of this study was to investigate the integration of Information and Communication Technology (ICT) into the teaching of NSSC Science subjects at the Namibia College of Open Learning (NAMCOL). The main objective of the study was to determine the how tutors integrate ICT into the teaching of Science subjects at the NAMCOL centres that have computer labs. Specifically, the study gathered information on the following research questions: 1) How do NAMCOL tutors currently use and integrate ICT in their tutoring of science subjects?; 2) How do tutors at the selected NAMCOL centres perceive the integration of ICT into the teaching of Science subjects?; and 3) What challenges impede the integration of ICT into the teaching of Science subjects at the selected NAMCOL centres and what can be done?

The study employed a research qualitative design where interviews and observations were used to collect data from the participants in the study. The sample of the study was eight Science tutors out of a population of ten and four HoCs, who represented a population of 100% at the four selected NAMCOL centres. The tutors at the four NAMCOL centres were purposively selected based on the criteria outlined in Chapter 3. The Science tutors and HoCs were also purposively selected.

The study found that NAMCOL has supplied 23-60 computers to the studied centres for learners' use. All the centres had printers and scanners and the classrooms had mounted data projectors with a screen. Local area network connectivity was available to enhance Internet access at the centres. The study found that there is a general level of satisfaction with the ICT infrastructure at the centres although the satisfaction levels vary amongst tutors and HoC, especially with regard to computer access at the centres.

The study also found that the majority of the Science tutors (7) and all the HoCs had a strong positive perception about the potential of ICT use in Science teaching and learning. The Science tutors were of the opinion that the integration of ICT made teaching easier and enabled them to make subject content clearer to the learners. This is an attribute of Rogers' (2003) theory of innovation that relative advantage, which is explained as the degree to which an innovation is perceived as being better than what it supersedes. The tutors regarded the integration of ICT as making teaching easier, which may contribute to the rate of adoption of ICT in teaching. The study further confirmed the finding of Wells (2007) that learners appear to enjoy lessons where ICT is being used.

It was clear from the findings that the tutors perceived ICT as a tool that could help them to teach and make concepts clearer to the learners. They were of the opinion that the integration of ICT provided alternative teaching methods, which made teaching and learning fun for both teachers and learners.

Although the results clearly indicate that the tutors are quite aware of the possible benefits of the integration of ICTs to enhance the quality of teaching and learning

practice, this does not seem to have led to increasing ICT use to ensure effective integration. Only two out of the eight used ICT regularly in the classroom. Tutors used ICT to download past examination questions, to download video clips to demonstrate Science experiments, as well as to present lessons. The study confirmed that the tutors' use of ICT was mainly limited to functional practice, e.g. Internet to download past examination questions, download video clips to demonstrate Science experiments, as well as to present lessons, word processing, PowerPoint and Excel (Bialobrzeska & Cohen, 2005). The basic use of ICT by the tutors support the findings of a study conducted in northern Namibia by Ngololo (2010), which found that Science teachers performed the most basic tasks when using ICT in teaching, and no advanced skills were observed. The majority of tutors use ICT for personal matters and not much for Science teaching related issues. This research has also established that training of tutors should focus on ICT pedagogical skills and not just on computer skills.

Finally, the findings in this study indicated that tutors experienced challenges in the integration of ICT in the teaching of science at NAMCOL centres. These challenges included lack of time, lack of access to computers and Internet connection, lack of adequate training in ICT pedagogy, lack of Science software, lack of technical support and lack of clear ICT policy and integration guidelines at the centres. The tutors further revealed lack of sufficient information about the availability of ICT facilities at the centres. Ridgeway and Passey (cited in Tearl, 2005) are of the opinion that overcoming one barrier to ICT integration into education does not mean success; rather, it means facing another more interesting and more challenging barrier. This means that, as one challenge is being overcome, new challenges are emerging. For example, as

NAMCOL management increase the supply of ICT infrastructure to the centres, tutors develop a better understanding of what they want to do with the ICT (Tearl, 2005). Therefore, new challenges are experienced.

6.3 Conclusions

It is widely understood and considered that the availability of Information and Communication Technology (ICT) in schools can help teachers to teach and learners to learn more effectively. ICT has a crucial role to play in the Namibian education system, whether as a subject or as a tool to support and enhance the effectiveness of teaching and learning.

As can be seen from the study, ICT is not yet widely integrated into Science teaching by the majority of the tutors at NAMCOL centres. This is an indication that very few tutors are in the early adopters category, while the majority of tutors are at the late majority of Rogers' adoption categories. There are a lot of contributing factors that lead to non-integration, such as lack of policy on the use of ICT and lack of appropriate tools. These can be viewed as attributing factors that make it difficult to adopt ICT as per Rogers' theory. It is important to distinct the adopter categories and each group's characteristic in planning strategies to accommodate all the types of adopters in terms of staff development, support and incentives (Donovan, 1998).

However, with the majority of the tutors in the study having shown a strong positive perception towards the integration of ICT into teaching, this can serve as a springboard to management to introduce projects that will enable tutors to acquire pedagogical ICT

skills and implement them for the benefit of the learners. In return, these tutors can serve as ICT champions at NAMCOL centres.

6.4 Recommendations

The theory on diffusion of innovation by Rogers (2003) provided the conceptual framework for this study and forms the basis of the proposed recommendations. Rogers' attributes of innovation innovations as discussed in Chapter 2, namely; relative advantage, compatibility, complexity, trialability, and observability determine the speed at which an innovation is adopted. NAMCOL should consider these attributes when ICT teaching learning activities are developed (Iipinge, 2010). Rogers (2003) claimed that people will only adopt an innovation which they perceive to be of relative advantage to the existing practice. The findings of the study indicated that the majority of the tutors are aware of the benefit of ICT integration in teaching.

Therefore, the following recommendations emanating from the study are meant to enhance the integration of ICT into teaching at NAMCOL centres.

1. There is need to develop and implement strategies on increased ICT use at NAMCOL centres. Monitoring and evaluation should be done to ensure ICT utilisation.
2. Head of Centres should request the increased use and integration of ICT in the teaching of Science at NAMCOL centres that will gradually change the attitude of the tutors if it is done alongside support and training. NAMCOL should install computers in all the classrooms that have data projectors. The more an

innovation is tried the faster its adoption according to Rogers' attributes of innovation (Rogers, 2003).

3. NAMCOL management should acquire specific Science subject software and load it onto the computers at all the centres.
4. Technical support must be readily available, and all tutors and HoCs should be trained so that they obtain troubleshooting skills to enable them to handle basic technical problems.
5. NAMCOL management should determine peak hours of computer lab usage at the centres and ensure that the same infrastructure is optimally used for teaching and learning.
6. Learners should be given assignments that require them to use and integrate ICT.
7. NAMCOL should provide in-service training and capacity building for tutors on a continuous basis in order to help them acquire ICT and 21st century skills on emerging technologies. The training should focus on ICT pedagogies rather than just computer skills.
8. NAMCOL should develop an ICT policy that spells out resource allocation, time scheduling of computer labs and access rules. This should be communicated to all tutors and learners.
9. Management should regularly inform and update tutors and learners on availability of ICT equipment.
10. Science tutors and learners should take advantage of the resources offered at NAMCOL centres, for example, using the Internet and computer labs.

11. Science tutors who use ICT need to be supported and encouraged continuously in order to enhance ICT integration.
12. Tutors should be encouraged to engage in self-training on ICT integration into teaching.

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Appendices

APPENDIX A: PERMISSION LETTER FROM UNAM

UNIVERSITY OF NAMIBIA

Private Bag 13301, 340 Mandume Ndemufayo Avenue, Pionerspark, Windhoek, Namibia

The School of Postgraduate Studies
P.Bag13301
Windhoek, Namibia
Tel: 2063523

E-mail: cshaimemanya@unam.na

Date: 23/09/2013.

TO WHOM IT MAY CONCERN

RE: RESEARCH PERMISSION LETTER

1. This letter serves to inform that student: Ms. AFUNDE N.L (Student number: 9400784[illegible]) is a registered student in the Department of MATHS, SCIENCE & TECH ED at the University of Namibia. His/her research proposal was reviewed and successfully met the University of Namibia requirements.
2. The purpose of this letter is to kindly notify you that the student has been granted permission to carry out postgraduate studies research. The School of Post Graduate Studies has approved the research to be carried out by the student for purposes of fulfilling the requirements of the degree being pursued.
3. The proposal adheres to ethical principles.

Thank you so much in advance and many regards.

Yours truly,

Name of Main Supervisor: DR. S.M. IIPINGE

Signed: ----------

Dr. C. N.S. Shaimemanya

Signed: ----------

Director: School of Postgraduate Studies

APPENDIX B: LETTER REQUESTING TO CONDUCT RESEARCH

N.L. Afunde
P O Box 23756
Windhoek

20 January 2014

Mr H.V. Murangi
Director
Namibian College of Open Learning
Private Bag 15008
Katutura

Dear Mr Murangi,

Permission to undertake research at NAMCOL centres

In fulfilment of my Master of Education (Science) degree with University of Namibia, I am seeking your permission to carry out research at six selected NAMCOL centres across the country. My thesis focuses on the integration of Information and Communication Technology (ICT) in the teaching and learning of science. The respondents would be the Learner record administrator, NSSCO Physical Science and Biology tutor, the Head of Centre and the Computer facilitators.

With the number of computers that have found their way into your centres, I am sure you will be interested to know the extent to which centres are using the new technologies. Best practices will hopefully be identified and the experiences disseminated for the benefit of other centres.

The study is not concerned with the evaluation of any individual tutor, learner or the centre. Information will therefore be presented in such a manner that confidentiality is maintained.

If you have any queries about the project, please feel free to contact my supervisor, Dr Sacky Iipinge at the University of Namibia. His e-mail address is smiipinge@unam.na.

I thank you.

Ndeshimona L. Afunde

APPENDIX C: PERMISSION LETTER FROM NAMCOL

NAMCOL

Private Bag 15008, Katutura, Windhoek
Tel: + 264-61-320 5111, Fax: + 264-61-216 987
www.namcol.com.na

04 March 2014

Ms. Ndeshi Afunde
P.O. Box 23756
WINDHOEK

Dear Ms. Afunde

RE: REQUEST TO CONDUCT YOUR RESEARCH AT NAMCOL CENTRES

Your letter dated 20 January 2014 concerning the above subject matter is hereby acknowledged with gratitude.

Given the above, I have the pleasure to inform you that NAMCOL has considered your request to conduct your mini thesis/project work on NAMCOL Centres. You are further requested to submit the final research to NAMCOL for record purposes.

I trust that you will find the above in order.

Yours sincerely,

HEROLDT V. MURANGI
DIRECTOR

NAMCOL
DIRECTOR'S OFFICE
04 -03- 2014
PRIVATE BAG 15008
KATUTURA, WINDHOEK
NAMIBIA COLLEGE OF OPEN LEARNING

APPENDIX D: INTERVIEW GUIDE FOR HEAD OF CENTRE

This interview is designed as an instrument to solicit relevant information for a Masters study programme and will be conducted for this purpose only. This centre has been selected to participate in this project to provide information on the integration of ICT in the teaching and learning of NSCCO science subjects. **All the information will be treated with strict confidentiality.**

For the purpose of this study ICT *refers to computers and related software and peripheral devices*.

1. Name of Centre:

2. What is your age group: a. 20-29 b. 30-39 c. 40-49 d. 50-59 e. 60+

   Gender: □ Male □ Female

3. How many learners do you have at your centre?

4. How long have you been the Head of Centre?

5. How many science tutors do you have for JSC and NSSCO respectively?

6. Do science tutors have access to computers at the NAMCOL centre?

7. How many functioning computers do you have at the centre?

8. Do your tutors integrate ICT in their teaching? Elaborate.

9. Is promoting the integration of ICT in the teaching and learning process a priority for your centre leadership?

10. How do you monitor the use and integration of ICT in the teaching and learning process at your centre?

11. What are the challenges that hinder the integration of ICT in teaching of science at your NAMCOL centre?

12. How do you overcome these challenges?
13. In the past 2-3 years, has your centre organised some workshops to demonstrate the use of ICT to support teaching and learning activities?
14. How do you encourage tutors at your centre to integrate ICT in their lessons?
15. What support do you offer to your science tutors on the integration of ICT in the classrooms? (*Any professional development related to the integration of ICT in teaching? Is there pedagogical support available?*).
16. What is the extent to which technical support is available to science tutors when integrating ICT into teaching?
17. What strategies and practices do you think may be employed that could enhance the integration of ICT in teaching at the NAMCOL centres?
18. What are your general perceptions for the integration of ICT in the teaching of science subjects at your centre?

Thank you

APPENDIX E: INTERVIEW GUIDE FOR SCIENCE TUTOR

This interview is designed as an instrument to solicit relevant information for a Master study programme and will be conducted for this purpose only. This centre has been selected to participate in this project to provide information on the integration of ICT in the teaching and learning of NSCCO science subjects. All the information will be treated with strict confidentiality. **All the information will be treated with strict confidentiality.**

For the purpose of this study ICT *refers to computers and related software and peripheral devices.*

1. Name of Centre:

2. What is your age group: a. 20-29 b. 30-39 c. 40-49 d. 50-59 e. 60+

   Gender: □ Male □ Female

3. Which science subject do you teach and how many learners do you have in your class?

4. How long have you been teaching NSSCO science subject?

5. Do you have access to computers at your centre?

6. Do you have access to computers at home?

7. Do you have access to computers at the NAMCOL centre?

8. How do you use and integrate ICT into the science subjects?

9. How do the learners respond when you use and integrate ICT in the teaching of science subject?

10. In what way does ICT facilitate your teaching?

11. Do you think ICT can help learners to learn science? If so, how can it help the learners to learn?

12. Would you highlight some ways in which you have used computers and related ICT devices in the teaching and learning of science in the past 12 months. It

would be helpful if you could cite specific lesson topics or tasks your students performed. (Evidence such as lesson plans, etc., to be collected).

13. What do you regard as your strongest reason in using and integrating ICTs in the teaching of science?
14. What are the challenges that hinder the integration of ICT in teaching of science at NAMCOL?
15. How do you overcome these challenges?
16. What support does NAMCOL offer to tutors on the integration of ICT in the classrooms? (Any professional development related to the integration of ICT in teaching? Is there pedagogical support available?).
17. What is the extent to which technical support is available to tutors when integrating ICT into teaching?
18. What strategies and practices do you think may be employed that could enhance the integration of ICT into teaching at the NAMCOL centres?
19. What are your general perceptions for the integration of ICT into the teaching of Science subjects at NAMCOL centres?

APPENDIX F: OBSERVATION CHECKLIST FOR THE CENTRE

1. Physical features

1.1 How big is the computer lab?

a. small b. medium c. big

1.2 What are the learners' sitting arrangements?

a. rows b. circle c. other (*specify)* ……

1.3 What is the condition of the computers?

a. clean and functional b. not functional

1.4 How many science tutors are at the centre?

1.5 How many computers are there?

1.6 What other ICT facilities are available at the centre?

a. Printer b. Data projector c. Internet

d. Scanner e. Digital camera f. CD-Rom writer

g. CD-Rom h. Other (*specify*) …….

1.7 Number of operational computers:

1.8 How many computers are connected to the Internet and printer?

1.9 Are there any science software programmes available?

a. Yes b. No. If yes, which software ……

2. Does the tutor use technology that is relevant to the subject a. Yes b. No

3. Does the tutor integrate Internet into the teaching activities?

4. Does the tutor provide opportunities for learners to use ICT in their learning activities?

a. Yes b. No

If yes, how?.....

5. Does the tutor have skills in the selection of appropriate ICT software and related ICT devices?

a. Yes b. No

If yes, elaborate ……

6. Does the tutor allow learners to use computers for their learning?

a. Yes b. No

If yes, how ……

7. Does the tutor allow learners to give feedback on their projects using computers?

a. Yes b. No

8. What is the level of the technical support provided?

a. good b. fair c. poor d. difficult to judge/find