AN INVESTIGATION OF ICT INTEGRATION IN THE LESOTHO SECONDARY AND HIGH SCHOOL SCIENCE CLASSROOM

By

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Submitted in accordance with the requirements for

the degree of

DOCTOR OF PHILOSOPHY IN MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION

in the subject

COMPUTING EDUCATION

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF. MR De Villiers

June 2012
I declare that AN INVESTIGATION OF ICT INTEGRATION IN THE LESOTHO SECONDARY AND HIGH SCHOOL SCIENCE CLASSROOM is my own work, and that all sources used or quoted in the study have been indicated and acknowledged by means of complete references.

__________________________   ________________
          Kalanda Kasongo       Date
Acknowledgements

First and foremost I would like to thank Jehovah, the God of all comfort and the provider of all good things, for his support throughout all my difficult days.

I wish to offer my sincerest gratitude to my supervisor Professor Ruth de Villiers, who has supported me throughout my thesis with wise guidance, patience and knowledge, at the same time allowing me to work independently. I attribute the completion of this doctoral degree to her encouragements and supportive efforts, without which this thesis would simply not have been completed. One could not wish for a better or friendlier supervisor.

In my family I have been blessed with a cheerful and understanding wife, Isabelle Kalanda and children, Jonathan, Joelly, David, Christian and Erick Kalanda.

I would like to thank the Lesotho College of Education, in particular the Rector, Dr. John Oliphant, who granted permission to use STIC resources to complete this thesis. He has also encouraged me and worked with me on a number of research papers.

I am also indebted to the contributors to the research on which this thesis is based. I am deeply grateful to them, and thank Mr. Manana Mapaka in particular for helping with the compilation of part of the quantitive data of the survey questionnaire. My thesis in its entirety has been edited by John Harris and I consider this as a major contribution. Thanks, John, keep up the good work.

Secondary and high school science teachers, principals and students, in all of the three Projects provided support by serving as participants in the studies. Teachers answered the survey questionnaire needed to conduct research and complete my thesis. I am very thankful to them all.

Finally, I thank my Brother Romain Kalanda Kassongo and his wife Charlotte Ngomba Kalanda for supporting me throughout my studies at University level and for providing a home in which to stay in my early days.
This research investigates progress in the integration of information and communication technology (ICT) into curriculum-based teaching and learning in the Lesotho secondary and high school science classroom, with the aim of establishing how effective e-learning and integration of ICT can be supported. E-learning was perceived by education stakeholders in Lesotho as an effective way to enhance teaching and learning. To this end, Lesotho embarked on three partnership projects, namely SchoolNet, Microsoft STIC and NEPAD e-School Projects.

There is a volume of research, international and regional, on e-learning and ICT integration, mainly conducted by European and American researchers. This study by an African author, therefore, fills a gap. Using a variant of action research, the author undertook six studies over four years, investigating the extent of computing infrastructure in schools and ways in which e-learning was implemented in subject-based teaching. In particular, he studied barriers to ICT implementation in Lesotho; advantages and disadvantages of combining e-learning with classroom practice; the perceptions, aptitude and skills of Lesotho science teachers and students; professional development programmes; and preparations for introducing e-learning, including infrastructural issues.

Literature studies were conducted, following which pertinent concepts from the literature were used to generate a framework of evaluation categories and criteria for addressing the research questions of this study. The criteria were translated into questions and evaluation statements for data collection instruments for the empirical studies.

Triangulation in data collection and analysis was provided by applying multiple and mixed data collection methods: questionnaires, interviews, observations and case studies, to gather data from principals, teachers and students in selected schools across the three projects and in varying regions of Lesotho.

The study identified notable progress, but determines that more remains to be done, on an ongoing basis, to support secondary and high schools in Lesotho with
implementation plans and strategies. The study concludes with guideline and recommendations for educators.
Tables of Contents

ACKNOWLEDGEMENTS

ABSTRACT

TABLES OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE ~ OVERVIEW

1.1 Introduction

1.2 Background and Problem

1.2.1 – The Lesotho Context

1.2.2 – Research Problem

1.2.3 – Potential of e-learning and ICT in education

1.3 ICT Projects in the Lesotho Educational System

1.3.1 – SchoolNet Project

1.3.2 – Microsoft School Technology Innovation Centre (STIC) Project

1.3.3 – NEPAD E-School Project

1.4 Situation in Lesotho Schools

1.4.1 – Situation in 2007

1.4.2 – Discussion

1.5 Significance and Contribution of Study

1.6 Research Objectives and Questions

1.7 Scope, Limitations and Delimiters

1.8 Research Framework

1.8.1 – Literature Reviewed

1.8.2 – Research Methodology

1.8.3 – Structure of Research

1.9 Structure of Thesis

CHAPTER TWO ~ BACKGROUND

2.1 Introduction

2.2 Forms of E-Learning

2.2.1 – Definition of E-learning

2.2.2 – Forms and Methodologies of E-learning

Tutorials

Tutorials
2.6.1 – Rationale for Integrating ICT into Education .......................................................... 37

2.6 Challenges in Using ICT for Learning ................................................................. 49

2.7 Conclusion ........................................................................................................... 54

CHAPTER THREE ~ E-LEARNING AND SCIENCE ..................................................... 56
3.1 Introduction .......................................................................................................................... 56

3.2 Learning Theories .................................................................................................................. 56
  3.2.1 – Behaviourist Orientation ............................................................................................... 57
    3.2.1.1 Behaviourism in Learning and Application to Science Education .................................. 58
  3.2.2 – Cognitive Orientation .................................................................................................. 58
    3.2.2.1 Cognitivism in Learning and Application to Science Education ....................................... 60
  3.2.3 – Constructivist Orientation .......................................................................................... 61
    3.2.3.1 Constructivism in Learning and Application to Science Education ................................. 62
  3.2.4 – Relevance of Learning Theories .................................................................................. 64
    3.2.4.1 Convergence of Constructivism and Technology .......................................................... 64
  3.2.5 – Summary of Paradigms ............................................................................................... 65

3.3 E-Learning Forms and Methods used in Science Education ............................................. 65
  3.3.1 – Appropriate technologies ............................................................................................ 66
  3.3.2 – Hypermedia-based Learning in Science ..................................................................... 66

3.4 Use of e-Learning and Technology in the Science Classrooms ....................................... 68
  3.4.1 – Theoretical Background .............................................................................................. 68
    3.4.1.1 Importance of Educational Technology ........................................................................ 68
    3.4.1.2 Methodologies of Interactive Multimedia ...................................................................... 68
    3.4.1.3 Examples of E-learning Applications for Science Education ..................................... 69
    3.4.1.4 Computing Tools used by Students ............................................................................ 72
  3.4.2 – Benefits of Technology in and Beyond the Classroom ............................................... 72

3.5 Science Teachers and E-Learning ....................................................................................... 73

3.6 Pitfalls in Implementing E-Learning Technologies in Science ......................................... 76

3.7 Conclusion ............................................................................................................................ 76

CHAPTER FOUR ~ RESEARCH DESIGN AND METHODOLOGY ............................................. 78

4.1 Introduction .......................................................................................................................... 78

4.2 Research Question and Supporting Research Questions .................................................. 79

4.3 Action Research Approach and Rationale ......................................................................... 80
  4.3.1 – Introduction ................................................................................................................ 80
  4.3.2 – Appropriateness of Action Research for this Study .................................................... 81

4.4 Qualitative and Quantitative Methods in Action Research .............................................. 82

4.5 Research Design of this Study ............................................................................................ 85
  4.5.1 – Variant of Action Research .......................................................................................... 85
  4.5.2 – The benefits of this research ...................................................................................... 89
  4.5.3 – Role of Author .............................................................................................................. 90

4.6 The Six Studies .................................................................................................................... 91
  4.6.1 – Study I: The Baseline Study ......................................................................................... 91
  4.6.2 – Study 2: Post-orientation Study ................................................................................... 92
  4.6.3 – Study 3: Comparative Study ....................................................................................... 93
  4.6.4 – Study 4: Pilot Study ..................................................................................................... 94
  4.6.5 – Study 5: Main Study .................................................................................................... 95
  4.6.6 – Study 6: Showcase Study ............................................................................................. 96
CHAPTER FIVE ~ E-LEARNING IN SCIENCE CLASSES IN LESOTHO: STUDIES 1, 2, 3 AND 4 ........................................................................................................ 108

5.1 Introduction ........................................................................................................ 108

5.2 Access to ICT in Lesotho .................................................................................... 109

5.3 Educational Context of ICT in Lesotho ............................................................... 109

5.4 SchoolNet Project and Baseline Study ............................................................... 111
  5.4.1 – SchoolNet Project ...................................................................................... 111
  5.4.2 – Study 1: Baseline Study ........................................................................... 112

5.5 Orientation and the Post-orientation Study ....................................................... 117
  5.5.1 – Orientation Sessions ................................................................................ 117
  5.5.2 – Study 2: Post-orientation Study ............................................................... 119
    5.5.2.1 Previous Experience ............................................................................. 121
    5.5.2.2 Current confidence in using technology .............................................. 122

5.6 Study 3: Comparative Study of E-Learning in Lesotho and South Africa .......... 124
  5.6.1 - Results of the comparison ........................................................................ 126
    5.6.1.1 From Lesotho schools ......................................................................... 126
    5.6.1.2 From South Africa ............................................................................. 126
    5.6.1.3 Comparative data .............................................................................. 127

5.7 Government Initiatives and Strategic Partnerships .......................................... 130
  5.7.1 – Microsoft ‘School Technology Innovation Centre’ (STIC) Project .............. 130
  5.7.2 – NEPAD E-School Project ....................................................................... 135

5.8 Impact of the Three Projects on Science Education ......................................... 136

5.9 Study 4: The Pilot Study .................................................................................... 137
  5.9.1 – The Context of the Pilot Study ................................................................ 138
  5.9.2 – Pilot Study Participants ........................................................................... 138
  5.9.3 – Physical infrastructure ........................................................................... 139
  5.9.4 – Instruments ............................................................................................ 140
    5.9.4.1 Interviews .......................................................................................... 140
    5.9.4.2 Observation ........................................................................................ 141
    5.9.4.3 Qualitative finding from the observations and interviews ................... 142
    5.9.4.4 Questionnaire Survey ......................................................................... 145
    5.9.4.5 Findings from the questionnaire survey .............................................. 146
5.10 Professional Development of Science Teachers ......................................................... 149

5.11 Conclusion .................................................................................................................. 150

CHAPTER SIX ~ DATA COLLECTION AND ANALYSIS ........................................ 151

6.1 Introduction .................................................................................................................. 151

6.2 Study 5: Main Study .................................................................................................... 153

6.3 Survey Results ............................................................................................................. 155

6.4 Interviews and Observations ....................................................................................... 191

6.5 Study 6: Showcase Study ............................................................................................ 207

6.6 Summary of Findings and Conclusion ......................................................................... 212

CHAPTER SEVEN ~ CONCLUSION ............................................................................. 214

7.1 Introduction .................................................................................................................. 214

7.2 Summary of Findings from Literature ......................................................................... 215

7.3 Summary of Findings: the Research Questions re-visited ........................................ 217

7.3.5.1 Development of ICT Policies ........................................................................... 225

7.3.5.2 Developing Professional Development Programmes for Teachers ................ 226

7.3.5.3 Developing Targets and Performance Indicators ............................................ 226

7.3.5.4 Setting up an Infrastructural Plan ................................................................. 226

7.3.5.5 Costing and Budgeting .................................................................................... 227
7.3.5.6 Advice, Training and Demonstration for teachers on how to incorporate ICT in Teaching
7.3.5.7 Collaboration among teachers in preparing ICT-mediated lessons ..................................... 227
7.3.5.8 Appointment of technical support staff ............................................................................. 227
7.3.5.9 Appointment and training of students for a 'Students' Help Desk' ..................................... 228
7.3.5.10 ICT use for other subject matter in classrooms ................................................................. 228
7.3.6 – Main Research Question .................................................................................................. 228

7.4 ICT Progress in Lesotho ........................................................................................................ 230
  7.4.1 – Progress in computing infrastructure ................................................................................. 230
  7.4.2 – Active engagement and cognitive learning ........................................................................ 231
  7.4.3 – Collaborative learning ........................................................................................................ 231
  7.4.4 – Implementation of pedagogy and learning theories ......................................................... 231
  7.4.5 – Use of higher-order thinking skills (HOTS) ..................................................................... 232
  7.4.6 – Attitude and confidence of teachers .................................................................................. 232
  7.4.7 – Relevance .......................................................................................................................... 232
  7.4.8 – Attitudes of Teachers ........................................................................................................ 233
  7.4.9 – Learner-centred approach ................................................................................................. 233

7.5 Implementation of research issues raised in previous chapters ........................................ 233
  7.5.1 – Validity and Reliability .................................................................................................... 233
  7.5.2 – Triangulation ..................................................................................................................... 234
  7.5.3 – Limitations ......................................................................................................................... 235

7.6 Recommendations .................................................................................................................. 236
  7.6.1 – Technical assistance ........................................................................................................ 236
  7.6.2 – Degradation as well as progress ..................................................................................... 236
  7.6.3 – Increased hands-on use by students ............................................................................... 236
  7.6.4 – Changed role of teachers: mentors and facilitators ......................................................... 237
  7.6.5 – Application of findings .................................................................................................... 237

7.7 Future Research ...................................................................................................................... 238

7.8 Conclusion ............................................................................................................................. 238

References ..................................................................................................................................... 241

Appendix 1: Criteria and Evaluation Statements ......................................................................... 259
Appendix 2: Criteria for Teachers and Students ............................................................................ 262
Appendix 3: Teachers’ Questionnaire (Studies 3) ......................................................................... 265
Appendix 4: Teachers’ & Stud. Interviews Protocol (Studies 1, 2 & 3) ......................................... 268
Appendix 5: Teachers’ & Student’s Interview Protocol (Main Study) ........................................... 269
Appendix 6: Principals’ Interview Protocol (Main Study) ............................................................. 271
Appendix 7: Teachers’ Questionnaire (Main Study) ..................................................................... 272
Appendix 8: Observation Sessions (All Studies) .......................................................................... 277
Appendix 9: Interview Transcript (Main Study) .......................................................................... 278
Appendix 10: Student Class Activities (Daily Log Sheet) (All Studies) ...................................... 280
List of Tables

Table 1.1: Profile of Schools – January 2007 ........................................................... 8
Table 1.2: Use of Computers in January 2007 ........................................................... 9
Table 1.3: Nature of Teachers’ Training ................................................................. 11
Table 1.4: Research Questions ................................................................................. 15
Table 2.1: Classification of E-Learning ................................................................. 28
Table 3.1: Technologies used in Science Education .................................................. 66
Table 3.2: Software used in Science Education ....................................................... 69
Table 3.3: Summary of Skills and Strategies for ICT (synthesised by the author). 75
Table 4.1: Supporting Research Questions ............................................................ 79
Table 4.2: E-Learning Implementation and Integration in Science Classrooms ...... 89
Table 4.3: Baseline Study ....................................................................................... 92
Table 4.4: Post-orientation Study .......................................................................... 93
Table 4.5: Comparative Study of South African and Lesotho Schools ................. 94
Table 4.6: Pilot Study ............................................................................................ 95
Table 4.7: Main Study .......................................................................................... 96
Table 4.8: Showcase Study ................................................................................... 97
Table 4.9: Criteria for Teachers and Students ....................................................... 98
Table 4.10: Criteria relations with Research Questions ........................................ 101
Table 4.11: Data Collection and Analysis Methods ................................................. 104
Table 5.1: Stages of E-Learning Implementation and Integration .......................... 111
Table 5.2: Profile of Schools – January 2007 ......................................................... 112
Table 5.3: Use of Computers in January 2007 ....................................................... 113
Table 5.4: Baseline Study ....................................................................................... 113
Table 5.5: Orientation Sessions ............................................................................ 119
Table 5.6: Participants trained during Orientation sessions .................................... 119
Table 5.7: Post-orientation Study .......................................................................... 120
Table 5.8: Profile of the six Schools – during the Post-orientation Study .......... 120
Table 5.9: Teachers confidence in using e-learning after workshops .................... 121
Table 5.10: E-Learning in SchoolNet Schools in mid-2007 .................................... 123
Table 5.11: Comparative Study of South Africa and Lesotho ............................... 125
Table 6.26: Questions 30, 31, 32 ................................................................. 186
Table 6.27: Motivation (Question 30) .......................................................... 186
Table 6.28: Questions 34 and 35 ................................................................. 190
Table 6.29: Participating Schools (Showcase Study) ..................................... 208
Table 7.1: Barriers and Obstacles hindering ICT use ..................................... 219
Table 7.2: Progress of E-learning (2007 – 2011) ............................................. 230
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Structure of the Research</td>
<td>19</td>
</tr>
<tr>
<td>3.1</td>
<td>Pendulum-lab developed by Colorado University</td>
<td>70</td>
</tr>
<tr>
<td>3.2</td>
<td>Orbit Simulator</td>
<td>71</td>
</tr>
<tr>
<td>3.3</td>
<td>Chemistry Simulation (Salts and Solubility)</td>
<td>71</td>
</tr>
<tr>
<td>4.1</td>
<td>De Villiers’ Action Research Model (2005a)</td>
<td>82</td>
</tr>
<tr>
<td>4.2</td>
<td>Summary of Research Design and Methods</td>
<td>84</td>
</tr>
<tr>
<td>4.3</td>
<td>Variant of Action Research</td>
<td>87</td>
</tr>
<tr>
<td>5.1a</td>
<td>Average Perceived Confidence and Skill Levels in Lesotho</td>
<td>128</td>
</tr>
<tr>
<td>5.1b</td>
<td>Average Perceived Confidence and Skill Levels in RSA</td>
<td>128</td>
</tr>
<tr>
<td>5.2</td>
<td>Lesson Preparation with PowerPoint</td>
<td>131</td>
</tr>
<tr>
<td>5.3</td>
<td>PiL Training Programme</td>
<td>133</td>
</tr>
<tr>
<td>5.4</td>
<td>Microsoft Encarta Encyclopaedia</td>
<td>134</td>
</tr>
<tr>
<td>5.5</td>
<td>Tools for a Chemistry Lesson</td>
<td>135</td>
</tr>
<tr>
<td>6.1</td>
<td>ICT Enhances Learning</td>
<td>157</td>
</tr>
<tr>
<td>6.2</td>
<td>Content with Traditional teaching</td>
<td>158</td>
</tr>
<tr>
<td>6.3</td>
<td>Improvement in learners’ attitude</td>
<td>161</td>
</tr>
<tr>
<td>6.4</td>
<td>Technology and Students’ View of World</td>
<td>161</td>
</tr>
<tr>
<td>6.5</td>
<td>E-learning and Innovation</td>
<td>163</td>
</tr>
<tr>
<td>6.6</td>
<td>Students Enjoyment of Lab Activities</td>
<td>165</td>
</tr>
<tr>
<td>6.7</td>
<td>Main Obstacles hindering ICT use in Education</td>
<td>169</td>
</tr>
<tr>
<td>6.8</td>
<td>Student’s Preparation for Presentation</td>
<td>197</td>
</tr>
<tr>
<td>6.9</td>
<td>Human Circulatory System</td>
<td>202</td>
</tr>
<tr>
<td>6.10</td>
<td>PowerPoint Presentation on Circulatory System</td>
<td>206</td>
</tr>
<tr>
<td>6.11</td>
<td>Award winner 1: Mrs Moliehi Sekese</td>
<td>207</td>
</tr>
<tr>
<td>6.12</td>
<td>Award winner 2: Mrs Lilian Ofori Assare</td>
<td>207</td>
</tr>
<tr>
<td>6.13</td>
<td>Award winners in Mombasa</td>
<td>208</td>
</tr>
<tr>
<td>6.14</td>
<td>Reproductive System</td>
<td>211</td>
</tr>
</tbody>
</table>
Chapter One ~ Overview

1.1 Introduction

Information and Communication Technology (ICT) began with the work of Charles Babbage in 1822 with his design for the so-called ‘Difference Engine’ – the very first computer. However, the advent of computing came to the fore during and after World War II, and is regarded as ‘the set of activities that facilitates the processing, transmission and display of information by electronic means’ (Roblyer, 2003: p.6). With the advent of the Internet and World Wide Web (WWW), the use of ICT has become pervasive. ICT application has spread to numerous domains, including education, where it is used in: management and administration; recording and reporting; communications; and importantly, in supporting teaching and learning activities – in which situations it is referred to as electronic learning (e-learning). Although there is an increasing consensus that e-learning via computing technology and the Internet can supplement or even replace traditional approaches when properly integrated, there is no guaranteed approach to successful integration of ICT in education systems.

Several initiatives have been aimed at improving the educational system in Lesotho, but due to economic, contextual and educational factors, such integration has been complex. This study relates to ICT integration in science education, particularly in curriculum-based activities and interaction with the subject matter. To understand the complexities, it is important to investigate aspects such as the professional development of teachers in preparation for using ICT in schools; use of e-learning in subject teaching; time allocated to the use of ICT resources; and the technological learning environments within schools. As a theoretical basis to this research, a list of criteria has been developed from the literature and applied to build the research instruments used in the pilot and main studies.

The background and problem statements that follow provide the foundation and motivation for this research.
1.2 Background and Problem

1.2.1 – The Lesotho Context

Lesotho is a landlocked country within the geographical area of the Republic of South Africa. It gained independence from Britain in 1966 (‘Government of Lesotho,’ n.d.). Lesotho has an annual per capita income of US$ 960, about R 6,600 in South African currency (Novelguide, 2010). The 2006 national census gave a de jure population of 1,876,633 with an annual growth rate of 0.08 percent (‘Government of Lesotho, Population Census 2006,’ n.d.: p.2). Lesotho is a constitutional monarchy with a democratic form of government.

Lesotho has a relatively high literacy rate and the government emphasises the strategic importance of education in the socio-economic development of the country. The country’s schools are, traditionally, mainly managed by the larger church missions, such as Roman Catholic, Anglican and the Lesotho Evangelical, while the curricula and syllabi are determined by the Ministry of Education (Government of Lesotho, n.d.). The syllabi and other educational materials are developed by the National Curriculum Development Committee, together with subject panels on which teachers serve. Primary, secondary and high schools are available throughout the country, and Maseru, the capital city, has a number of well-established international schools. In the junior classes, teachers use the Sesotho language, with English the medium of instruction in upper primary classes and in secondary schools.

1.2.2 – Research Problem

At the beginning of 2000, the Lesotho government made education compulsory and free for children between the ages of six and thirteen, starting at Grade One. This, not surprisingly, created a ripple-effect situation as the number of students proceeding to secondary and high school increased, while the number of teachers remained constant and their training and infrastructural support was unchanged in many Lesotho schools. Capacity therefore became an issue both in terms of trained teaching staff and infrastructural facilities.

Simultaneously, the need for ICT-based teaching and learning became evident. In efforts to alleviate the situation, three public-private partnership projects were
implemented to provide infrastructure and equipment and, subsequently, to offer training and professional development. These projects are introduced in Section 1.3.

In this context, the broad aims of the research are to:

1. Investigate the progress of ICT integration in the teaching and learning of science in Lesotho,
2. Identify current barriers to ICT implementation in schools,
3. Determine the pedagogic orientations and ICT familiarity of Lesotho secondary- and high school science teachers,
4. Establish how ICT is used in e-learning by science teachers in teaching or as part of students’ learning activities,
5. Ascertaining Lesotho science teachers’ perceptions of ICT integration, and
6. Determine how e-learning in Lesotho schools can be enhanced by paying attention to preparation, infrastructural issues and support for teachers and students.

The specific research questions considered in the study are listed in Section 1.6 and are in line with these aims. They are positioned in Section 1.6 rather than the present section, so as to present them after the context and local situation have been explained. The research questions are addressed throughout the study and are re-visited in Section 7.3 in the concluding chapter, where concise consolidated answers are given.

1.2.3 – Potential of e-learning and ICT in education

In the information technology revolution, ICT and e-learning have the potential to support education in general and classroom practice in particular, and to enhance teaching and learning in ways that make them more interesting and stimulating for teachers and students alike (Government of Lesotho, Vision 2020, 2001; Government of Lesotho, ICT Policy, 2005). Schools that have Internet connectivity can use forms of Web or Internet-based learning, collaborative learning, networks and online learning, and specific lessons downloaded from the Web and customised to the context. In schools with no Internet connection, such as in some of the rural regions of Lesotho, learning materials and tuition to enhance learning can be delivered via a range of technologies and software such as CD-based tutorials, computer-assisted instruction
(CAI) and computer-based testing. Some of these software applications can be purchased off the shelf.

Certain researchers have found clear links between e-learning and the attainment of required educational outcomes (Kalinga, Bagil and Trojer 2007; Lee, Brescia and Kissinger, 2009). In the context of remote regions such as in Lesotho, Kalinga, Bagil and Trojer (p.112) note that ‘Application of ICT in e-learning that is accessible in remote and rural schools will improve the performance of students ... as well as raising morale for teachers and students’. Jones (2004) and Hohlfield, Ritzhaupt and Barron (2010) refer to the important relationship between the way in which ICT is used and the resultant outcomes. Crucial components are the teachers and their pedagogic approach. Jones (2004) argues that even excellent software, reliable hardware and flexible networks, important though they may be, will have little effect on performance and attainment if teachers are not enabled, motivated, and educated to use these resources appropriately.

The advance of ICT and the policy of Lesotho’s Ministry of Information, Science and Technology (Government of Lesotho, ICT Policy, 2005), calls for the full integration of information technology into teaching in all subject areas. To this end, teachers need to be ICT-trained to become qualified and competent educators. As recently as 2005, most of the teaching force in Lesotho lacked computing skills and there was little suitable training for e-learning, which made the integration of ICT into schools a difficult and challenging task (Government of Lesotho, ICT Policy, 2005).

1.3 ICT Projects in the Lesotho Educational System

Three major projects have contributed to the advent of ICT in the Lesotho school sector: SchoolNet Lesotho, Microsoft STIC and the NEPAD e-Schools Projects, which are discussed in the following subsections and in more detail in Section 5.7. There are also certain private sector organisations that independently assist schools in making technologies accessible in the classrooms, but they are excluded from the present research. Schools that are part of the three major projects are used to obtain data for the studies that comprise this research.
1.3.1 – SchoolNet Project

Much has been achieved in the past ten years with the government and other stakeholders, such as SchoolNet, providing computers and other electronic equipment to schools. SchoolNet is a registered non-government organisation (NGO) in Lesotho dating back to 1999 when it operated as a project of the National University of Lesotho. Its role is to promote learning and teaching through the use of ICT in schools in Lesotho. It is largely an organisation of volunteers and depends on donor funds.

Aware of the issues and challenges of using ICT for educational development, SchoolNet started its own project, which it piloted in six secondary and high schools: Mohales’ Hoek, Matikoe, John Maunt, St. Agnes, Molapo and Mafeteng. Each school was initially provided with ten computers, network cabling, CD-based interactive subject-based software and the Internet. During the SchoolNet Launch Conference in February 2006 in Maseru, the Deputy Minister of Education in Lesotho, Mrs Malijane Maqelepo, opened the conference by stating that e-learning was essential for education if society was serious about achieving the stated national goal of Education for All by 2015. She suggested that the country’s strength in the ICT in Schools Project was its political will, demonstrated by the development of an educational ICT policy and continuous technical and financial support for e-learning in Lesotho schools.

However, although the SchoolNet Project provided equipment, there was no adequate professional development programme in place for educators.

1.3.2 – Microsoft School Technology Innovation Centre (STIC) Project

In 2007, the Ministry of Education and Training entered into a partnership with Microsoft to establish the School Technology Innovation Centre (STIC). This centre was established to improve and enhance teaching and learning by supporting processes and pedagogy through the innovative use of ICT in the Kingdom of Lesotho. It is intended to serve as a centre for the ‘best practice’ in teaching and learning, by showcasing and evaluating innovation in technology, processes, and electronic education pedagogy for application in schools. STIC provides an opportunity for collaboration between education stakeholders globally. It is intended to reinvigorate the teaching profession by providing powerful ICT tools to improve classroom practice.
and, importantly, by offering professional development programmes and fostering supporting skills to use these tools effectively in delivering curricula to students.

STIC works with local and national education communities to create technology, tools, programmes and solutions that facilitate the addressing of education challenges while also improving teaching and learning opportunities. STIC also organises the *Innovative Teachers Forum (ITF) Awards*. This competition acknowledges innovation and best practice by teachers in schools. It facilitates innovation workshops to ensure stakeholders have the tools and knowledge to produce, submit and share their innovative lessons and novel approaches to e-learning. Furthermore, it organises the *Innovative Students* programme to recognise the potential of students and provide them with opportunities for development.

By December 2007, fourteen Lesotho College of Education lecturers had been trained in the *Partners in Learning* (PiL) ICT Skills for Teachers programme as master trainers. These master trainers now train in-service teachers at training sessions which STIC helps coordinate. During 2008, 40 teachers from different schools in the country were identified and trained through the PiL ICT Skills for Teachers programme. Since then, more than a thousand other teachers have been trained and are now putting into practice what they learned from this programme. The year 2010 saw almost 800 teachers trained by the Microsoft PiL and NEPAD e-School programmes (See Section 1.3.3).

With support from STIC in 2009 and 2010, some six hundred pre-service and in-service teachers were involved in national, pan-African and worldwide competitions, winning a number of awards. A Showcase Study in Chapter Six presents two success stories from these competitions.

STIC provides ongoing feedback on the impact of this training to relevant authorities. It was agreed that STIC should include PiL programmes in the diploma course currently presented in the Lesotho College of Education, a teacher training college. Since 2009, all 1st-year pre-service student teachers have therefore undergone PiL training.
1.3.3 – NEPAD E-School Project

NEPAD stands for New Partnership for Africa's Development. The E-Schools initiative is a ten-year NEPAD project involving the establishment of an Africa-wide satellite network to connect all schools to the Internet, as well as to points within each country from where they can receive educational content on an on-going basis (InfoDev, 2007). It also involves ICT training of teachers and students, content and curriculum development, as well as community involvement and participation.

The Government of Lesotho officially joined the NEPAD *E-Schools Demonstration Project* in August 2005. Since then the National Implementation Agency (NIA) has been established, and a partnership between government, the private sector and development agencies’ representatives has trained a number of educators in the country in basic ICT literacy.

The NEPAD *E-Schools Demonstration Project* has been identified as a vital step for the implementation of the envisioned eventual *E-Schools Project*. Six schools from each of the participating countries, including Lesotho, have benefited from this venture by acquiring sophisticated equipment. For example, certain Lesotho secondary and high school in the capital city, Maseru, have received computers and accessories, servers, Internet, computer desks, Digital Satellite Television (DSTV), TV screens and decoder, e-curricula, e-health facilities, and trained teachers in ICT and ICT integration. All classrooms are connected to a media centre, where information from DSTV is channelled to screens in the classrooms. The *E-Schools Demonstration Project* has, however, not progressed as quickly as anticipated.

One of the major contributions of the E-Schools Project has been the provision of training to over 45 teachers by means of the *Train the Trainers’ course*.

1.4 Situation in Lesotho Schools

1.4.1 – Situation in 2007

While the basic problem addressed by this research is the general implementation of ICT to enhance teaching and learning in Lesotho’s schools, the scope of this study focuses on investigating specific aspects and forms of e-learning within a restricted
subject-matter domain, namely the teaching and learning of science at secondary and high school level in selected Lesotho schools. To set the context, this section presents a snapshot of the situation in January 2007 in selected SchoolNet schools. The year 2007 is used, as it was the year in which this study commenced.

The sample for this initial situation study, as set out in Table 1.1, comprised nine schools, including the six SchoolNet schools, three government schools and a total of 161 teachers. Schools were selected from both rural and urban areas and from demographically representative geographic locations, classified under three areas, namely Highland, Midland and Lowland, using three schools from each area. At present (2011), there are in total six schools in the SchoolNet Project; six schools in the NEPAD E-School Project; and thirty five schools in the Microsoft School Technology Innovation Centre (STIC). NEPAD schools and STIC schools were not included in the 2007 study, because the project was not fully established at that time.

<table>
<thead>
<tr>
<th>School</th>
<th>Location</th>
<th>Students</th>
<th>Teachers</th>
<th>Computers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highlands 1</td>
<td>R1</td>
<td>438</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Highlands 2</td>
<td>U1</td>
<td>866</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>Highlands 3</td>
<td>U2</td>
<td>904</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Midlands 1</td>
<td>R2</td>
<td>450</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Midlands 2</td>
<td>R3</td>
<td>300</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Midlands 3</td>
<td>U3</td>
<td>698</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Lowland 1</td>
<td>U4</td>
<td>607</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Lowland 2</td>
<td>U5</td>
<td>788</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Lowland 3</td>
<td>R4</td>
<td>85</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>5136</td>
<td>161</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 1.1: Profile of Schools - January 2007

In Table 1.1, rows representing urban schools are shaded lighter grey to distinguish them from rural schools.

Table 1.1 indicates an almost total absence of computers in rural schools, R1, R2, R3 and R4, which had only two computers for administration and two for educational purposes over the four schools. From the data in the table, ratios of students per computer were calculated as follows:
Overall: \( \frac{5136}{120} = 43 \) students/educational computer.

Urban: \( \frac{3863}{122} = 32 \)

Rural: \( \frac{1273}{2} = 637 \)

The ratio of 43 students per computer overall, was made up of 32 students per computer in urban areas and a high number of 637 students per computer in rural areas of Lesotho.

Table 1.1 covers all types of usage of computers in the schools; it was not restricted to science education or even to education. The table indicates that of the 137 computers in the schools in the sample, thirteen were used for administration. Teachers were using these computers to prepare and print letters, memos and question papers, and to record students’ results, but they were not able to use them in teaching. Only 124 computers were used for direct educational purposes.

Table 1.2 depicts the use of the 124 computers that were used in instruction and learning by teachers and students in general, and by science teachers in particular. This helps clarify the extent to which computers were used for lesson preparation, teaching and student projects.

### Table 1.2: Use of Computers in Schools – January 2007

<table>
<thead>
<tr>
<th>Edu. Computers</th>
<th>School</th>
<th>Use of Computers by:</th>
<th>All Teachers</th>
<th>Science Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Preparation</td>
<td>Students' projects</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching, e-learning tutorials, etc</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Preparation</td>
<td>Teaching, e-learning tutorials, etc</td>
</tr>
<tr>
<td>0</td>
<td>Highlands 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>35</td>
<td>Highlands 2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>Highlands 3</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Midlands 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>Midlands 2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>Midlands 3</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>Lowland 1</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>45</td>
<td>Lowland 2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>Lowland 3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>124</td>
<td>Total</td>
<td>23</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Rows representing urban schools are shaded lighter grey.
From the total of 161 teachers in Table 1.1, Table 1.2 shows that only 23 (14.3%) were using computers for lesson preparation. Nineteen of these were in urban areas and only four in rural areas. Of even more concern, only six were using computers for e-learning in the class or laboratory. This use was restricted to electronic tutorials. Among the 23 teachers, eleven (48%) were science teachers, of whom only five were using e-learning as part of their pedagogic practice, while three teachers made computers available as a support tool for students to use in their projects. Although these figures are low, it is notable that:

- Of the six who employed computers in teaching or who used e-learning tutorials, five were science teachers.
- Of the four who encouraged students to use computing tools in their projects, three were science teachers.

This confirms the decision of the author to use science teachers as participants in the study and to undertake fieldwork in the context of the science classroom. This is likely to provide the best possible sample in terms of technological aptitude and enthusiasm.

Table 1.3 gives an overview of the training undergone by teachers in the sample of schools. It relates to a timeframe slightly after that of Tables 1.1 and 1.2, but does not include the training teachers underwent during orientation sessions conducted by the author (which are elaborated in Section 5.5.1).

Due to the less-than-effective use being made of computers and the lack of training prior to the data shown in Table 1.1 and 1.2, the purpose of the orientation was to expose teachers to the benefits of technology in teaching and to train them practically on how to use technological tools to improve their students’ education.
### Table 1.3: Nature of Teachers’ Training

<table>
<thead>
<tr>
<th>School</th>
<th>All Teachers</th>
<th></th>
<th></th>
<th>Science Teachers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Duration</td>
<td>Venue</td>
<td>Level</td>
<td>Duration</td>
<td>Venue</td>
</tr>
<tr>
<td></td>
<td>BCL</td>
<td>E-L</td>
<td>&lt;6</td>
<td>6-12</td>
<td>&gt;1y</td>
<td>Lab</td>
</tr>
<tr>
<td>Highlands 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Highlands 2</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Highlands 3</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Midlands 1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Midlands 2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Midlands 3</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Lowland 1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lowland 2</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lowland 3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Rows representing urban schools are shaded lighter grey.

**Key**
- **BCL**: Basic Computer Literacy.
- **E-L**: Training with e-learning tutorials
- **Duration**:
  - <6: less than 6 Months;
  - 6-12: 6-12 months;
  - >1: more than a Year
- **Venue**:
  - Lab: Training in a Lab.
  - Class: Training in Classroom.

A total of 25 teachers were trained in basic computer literacy and only three in e-learning itself. Twenty had been trained for durations of up to six months, and six had undergone further training for up to a year. Thirteen of those trained were science teachers of whom three were trained in e-learning. In fact, all of the teachers trained in e-learning were science teachers. The figures show that much of the training was conducted in a classroom setting. 22 of the 25 teachers did their training in the classroom without students present.

### 1.4.2 – Discussion

The tables in Section 1.4.1 show that, despite computing technology being available in certain Lesotho schools for more than a decade, teachers’ use of computers, in general and in subject teaching, was very disappointing in 2007. Of 161 teachers in the participating schools, only 23 were using computers. Furthermore, the availability of computers in rural schools was almost negligible. Teachers in Lesotho face significant obstacles in integrating computers into actual classroom practice (Gaible and Burns, 2005).
To place this in perspective, certain general factors obstruct the integration of computers as a tool for teaching and learning in schools. This phenomenon is described in international literature and indicates that problems are encountered worldwide and not limited to schools in developing nations, such as Lesotho. Relevant factors are: insufficient funds; lack of qualified computer teachers; teachers’ own lack of competence in integrating computer usage into various learning areas; and the lack of well-designed curricula for teaching computer skills.

Despite the apparent impasse found by the author in the initial 2007 study on the integration of ICT into education in Lesotho, proponents both locally and abroad hold that computer technology offers educators many options for communicating, as well as facilitating and enhancing teaching and learning (Baker, 2005; Lujara, Kissaka, Trojer and Mvungi, 2007; Bingimlas, 2009). Proponents claim that e-learning makes learning easier, and that it is efficient and motivating (Davidson and Elliot, 2007; Bingimlas, 2009; Lateh and Muniandy, 2010). These authors draw support from research and reviews that show positive results and learning advantages when supplementary computer-assisted instruction is compared with traditional instruction on its own (Owen and Aworuwa, 2003; Seigel, Waldman, Atwater and Link, 2004).

Conversely, despite the rapid development of computer technology and increasing use in schools, there is a debate in many developed countries on whether or not media do indeed enhance learning (Clark, 1994; Kozma, 1994; Dawes, 2001; Lefebvre, Deaudelin and Loiselle, 2006; Lee et al. 2009; McGarr, 2009). Specific issues in this debate are the form and role of the delivery systems and instructional methods used. To ensure meaningful learning, it is necessary to understand the most suitable technologies for specific circumstances, to enhance learning and achievement of particular groups of students. Moreover, e-learning should be based on sound principles of learning theory and instructional design to effectively facilitate teaching and learning (de Villiers, 2005a). This is further addressed in Section 3.2.

The use of technologies such as Internet and Web-based learning are at an early stage in Lesotho, where many schools do not even have connectivity. Thus, while the introduction of technology in education may create opportunities or innovation,
particularly in the schools that are part of the three projects, it also gives rise to other challenges, and requires a major shift in pedagogy and practice (Laurillard, 2006).

1.5 Significance and Contribution of Study

This study is of significance to the field of education and technology as it expands the ICT knowledge base. The concept of e-learning is new to most teachers and students in secondary schools in developing countries. However, some higher education institutions in Africa which have taken up this concept, and which integrate ICT into their teaching and learning, have embraced its benefits (Mugimu, 2010). Further research that explores the benefits of ICT and examines barriers to its integration will increase awareness of technological applications and strategies for successful implementation in the African context.

The findings of this research study have a dual benefit. Firstly, there is an immediate outcome in terms of relevance to the current situation in Lesotho education. This study investigates teachers’ ICT use in schools, looking at advantages, disadvantages, and support needs, as well as barriers to ICT integration in Lesotho secondary and high schools. The findings will impact on the way ICT is used in schools in Lesotho, where it will be of direct significance for educators who want to learn more about the setting up and application of e-learning. As an immediate outcome in 2010, the preliminary findings of the Main Study of this research led to the training of more teachers (see Table 6.3 in Section 6.2), extending the training to different districts and rural schools. The interest among educators was evident from the growth in the number of schools requesting further training for principals, teachers and administrative staff. Although the application area of the research was science education, the conclusions and recommendations will be transferable to other disciplines and curricula.

Secondly, the thesis contributes to the general literature and to the body of knowledge on ICT integration in schools in African countries. Few ICT-related research studies have been conducted in Africa by Africans. In contrast, many of the studies on ICT integration in Africa have been conducted by experts from outside the continent (Kozma, 2006), who may be presenting their findings from a different perspective. Arguably, since the author is an African and an educator, he can present an African
perspective and include issues which may not be fully understood by those outside the inherent African culture.

1.6 Research Objectives and Questions

Different countries have formulated varying approaches to the integration of technology in education. Such approaches are aligned to their educational systems, as well as their pedagogic, social and economic contexts. This study is concerned with the professional development of teachers, attitudes of teachers and learners, and other aspects related to the general learning environment within the Kingdom of Lesotho, including factors that hinder pedagogically sound environments and innovative change. The focus area is the implementation of ICT to enhance teaching and learning, while the application area is science education at secondary and high school level in selected Lesotho schools. In Lesotho, secondary school covers five years, divided into two sections – three years of junior secondary and two years of high school level; thus ‘secondary school’ involves the full five-year exposure, while ‘high school’ refers to the final two years.

There is a need for localised research on e-learning, particularly on the development of guidelines for the integration of ICT in the science classrooms. Guidelines should address the creation of appropriate learning environments, and the provision of support before, during and after initial integration – the lack of which contributed to the failure of ICT integration in Lesotho’s education system during the period prior to 2007. One of the main objectives of this study is therefore to identify barriers to ICT integration, along with associated solutions, so the barriers may be replaced with structures and approaches that contribute to a conducive learning environment.

The research questions addressed in this study, following from the problem in Section 1.2.2, are listed in Table 1.4, together with references to the relevant chapter(s) in the thesis.
Table 1.4: Research Questions

<table>
<thead>
<tr>
<th>Main Research Question</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>How can effective e-Learning and integration of ICT be supported in the science classroom in Lesotho secondary and high schools?</td>
<td>1, 2, 3, 5, 6, 7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supporting Research Questions</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are barriers/obstacles to the integration of ICT in Lesotho secondary and high schools?</td>
<td>2, 5, 6</td>
</tr>
<tr>
<td>What familiarity, aptitude, skills and strategies do Lesotho secondary school science teachers and students have with the use of ICT?</td>
<td>2, 3</td>
</tr>
<tr>
<td>What advantages/disadvantages do science teachers and students perceive when integrating e-learning with established classroom practice?</td>
<td>5, 6</td>
</tr>
<tr>
<td>What preparations are required for the introduction of e-learning and how should infrastructural issues be addressed?</td>
<td>2, 3, 6, 7</td>
</tr>
<tr>
<td>What guidelines do educators need when using ICT in the science classroom?</td>
<td>2, 7</td>
</tr>
</tbody>
</table>

Chapters 2 and 3 are literature studies. They also serve to identify evaluation criteria that are converted to questions and evaluation statements for the empirical studies, which set out to answer the research questions.

1.7 Scope, Limitations and Delimiters

This study focuses primarily on the perceptions of teachers. While the author acknowledges the importance of students’ opinions on the integration of e-learning in the science classroom, he believes that this should be a separate study. This is recommended by the author in Sections 7.6.3 and 7.7 of the concluding chapter. Nevertheless, a small amount of data was collected from students as part of the research.

The thesis also focuses on the teaching and learning of science at secondary and high school level. The science disciplines are traditionally perceived as complex subjects in the school curriculum, due partly to the use of inappropriate methodologies, lack of current technologies, inadequate equipment and a shortage of creative skills among teachers. Science, as referred to in the study, comprises biology, physics and chemistry, as in the Lesotho curriculum

Delimiters: sample of schools and human participants

The empirical study is based on a small, selected, representative sample of schools, all attached to either the SchoolNet Project, NEPAD E-School Project, or schools in the Microsoft STIC Project. All participants – teachers and students – are from science
departments in the schools, and were included because they volunteered to participate. As their number is limited, generalisations cannot be made. Descriptions of technology integration in schools are restricted to the schools in the sample.

Limitation: relevance of findings

Findings of the study pinpoint issues that champions of educational technology, educational specialists, and leadership within schools in Lesotho should consider. This study is limited by definition to secondary and high schools selected from the three partnership projects in Lesotho and to science education in these schools.

Nevertheless, there may be similarities and parallels with other schools in the Southern African region, and perhaps in many other countries. The findings may be transferable to other broader, but similar, contexts.

Limitation: interpretation

This study is also delimited in the sense that the author imposes limitations on interpretations. In qualitative research ‘… researchers are part of the reality of the study, they can never be neutral’ (Bresler, 1994: 2). Thus, the author’s inherent values, biases and beliefs might also restrict his ability to extrapolate the findings in a completely objective manner, and this may be perceived as a limitation. As a researcher, the author believes educational technology and its synonyms must become integral to the teaching and learning process in Lesotho.

1.8 Research Framework

1.8.1 – Literature Reviewed

When this research project started late in 2006, the use of technology in Lesotho schools was on the increase, driven by economic and educational factors. In keeping with the action research approach outlined in Section 1.8.2 and detailed in Chapter Four, a preliminary literature review was undertaken to develop initial concepts and form a foundation for the study. This initial review identified various real and perceived barriers to ICT integration in the classroom, as well as benefits arising from educational use of ICT by schools teachers, and students.
In Chapter Two, these concepts, relating to the worth and complexities of e-learning, are reviewed in detail from literature; noting issues and precedents encountered elsewhere. The educational sector has not yet achieved maturity with regard to e-learning and this is particularly the case in Third World situations. Chapter Three probes specifically into science education. Various studies, both international and local, mentioned in Chapters Two and Three, suggest that insufficient attention has been paid to preparing teachers and students for the rapidly-changing technological environment and demonstrate that the introduction and implementation of ICT has not been optimally managed (Howie and Blignaut, 2009; Lateh and Muniandy, 2010). In particular, the research by Howie and Blignaut on the extent to which schools in South Africa are prepared to integrate ICT in Mathematics and Science classes, found that, even where significant equipment had been provided, schools are still in the early stages of integration.

1.8.2 – Research Methodology

The research design and methods are discussed in detail in Chapter Four. The main research design is a variant of action research (AR), which is extensively used as an approach that includes both qualitative and quantitative research in various social science disciplines, including education (Baskerville, 1999; Cohen, Manion and Morrison, 2005). As a longitudinal approach, it is suitable for studying an emerging field, such as educational technology, where further knowledge is required to explain phenomena and improve implementation (Charmaz, 2002; de Villiers, 2005b). AR is also characterised by a participative ethos, where the researcher practitioner plays a key rate.

AR is a pragmatic, yet systematic, research approach that, in this study, iteratively facilitates the investigation of educators’ teaching and students’ learning in the context of ICT integration in Lesotho. In action research, there is iterative data gathering, and each cycle results in responsive actions (Dick, 1997; de Villiers, 2005b). The research approach, methods and data collection techniques may be modified in the light of results from a previous cycle.

In the present research, data was collected from a variety of sources in six separate studies over a four-year period. In the variant of action research used, the six studies
varied considerably in purpose and in type of participants, and hence there was not always direct input into the next study. The studies were:

1. Baseline Study
2. Post Orientation Study
3. Comparative Study
4. Pilot Study
5. Main Study and
6. Showcase Study

In Study 6 (Main Study) and Study 5 (Pilot Study), opinions, activities, and performance were studied qualitatively and, in some cases, measured quantitatively. The qualitative data collection involved various tools, including field notes during observation of ICT-based lessons; open-ended questions in questionnaires; and face-to-face interviews with principals, teachers and students. This data was analysed using thematic analysis and a simplified grounded theory approach (Cockton, 2004; de Villiers, 2005b). The process is described in Section 4.9.

Quantitative Likert-scale data came from questionnaire surveys among teachers and students. Quantitative methods in the form of tallies and certain descriptive statistical analyses were used to process this data.

This combination and complementation of different methods of data collection and research approaches provides triangulation to this study of various aspects of human behaviour. Triangulation results in a better understanding of a subject (Cohen, Manion and Morrison, 2005). Data triangulation involves using multiple sources of data, while methodological triangulation involves using different research methods on the same objects of study. Both strategies are applied in the study.

Participants in the pilot and main studies were stakeholders from schools in the SchoolNet, STIC and E-Schools Projects. Information was collected from science teachers, principals and students in the participating schools to identify the problems experienced, the type of support needed, and characteristics of training and environments suitable for facilitating and expediting the integration of ICT into
teaching and learning. Studies were conducted on the status of e-learning in the science curriculum and of the various technologies being used.

Details of the sample of schools for the pilot and Main Study are given in Tables 5.9 and 6.3 respectively and discussed in Chapters Four, Five and Six. The participating schools include some of the schools in Table 1.1 (which portrays computer use early in 2007) and others from STIC and NEPAD schools.

1.8.3 – Structure of Research

Figure 1.1 illustrates the progression of the thesis from study objectives to the findings.
1.9 Structure of Thesis

There are seven chapters in this thesis:

1. The purpose, aims and background of the study, and the key concepts, are defined in Chapter One, together with a discussion of the three main projects aimed at integrating ICT into education. The chapter also describes the situation in Lesotho schools before the efforts by the government and stakeholders to integrate ICT in schools.

2. Chapter Two, an overview of literature, sets the background by describing different forms and methodologies of e-learning, as well as obstacles and successes of ICT integration. The chapter addresses the rationale for integrating e-learning into education. It identifies the key benefits perceived as well as challenges to integration.

3. Chapter Three provides a formulation of the theoretical framework of integration of ICT in the science classroom to inform students’ studies. It provides an overview of the main learning theories; showing their impact on teaching and learning of science. The effectiveness of media in support of education, together with the role of e-learning and educational technologies, is reviewed.

4. In Chapter Four, the research design is presented. The methodologies and techniques used to collect and analyse the data are discussed. The chapter also discusses the variant of action research used as the underlying research design and describes the composition of participants in each study.

5. Chapter Five discusses e-learning in the teaching and learning of science, with emphasis on the educational context of Lesotho. It provides a detailed report on three initiatives and partnerships signed between the Ministry of Education and Training and other stakeholders. The discussion is also informed by the author’s own experience. Findings from the first four studies are given in this chapter.

6. Findings of the Main Study, involving empirical research in nine schools used as a sample across the three projects in Lesotho, are reported and discussed in Chapter Six. To ensure the accuracy of conclusions drawn, data from questionnaires, the observations, face-to-face interviews with teachers, students and principal are
collected, analysed and triangulated. Showcases of two successful schools are also presented.

7. The research study concludes in Chapter Seven with answers to the research questions, a discussion and recommendations. The chapter argues that, for ICT to be effectively integrated into education, it must be situated in appropriate and supportive learning environments, founded on learning theories and pedagogic strategies that foster learning with technology. Moreover, the media that are used should be appropriate for the curriculum.

Through extensive empirical studies, this research presents an account of how ICT in schools and e-learning in the curriculum in Lesotho has evolved and progressed over recent years. This work should provide accumulated and useable knowledge for Lesotho education professionals and for existing and prospective adopters of ICT in schools on the African Continent.
Chapter Two ~ Background

2.1 Introduction

The purpose of this chapter is to provide an overview of literature related to the objectives outlined in Chapter One. This review was used as a basis for the research design and instrumentation (Chapter Four), as well as the development of a comprehensive framework of categories and evaluation criteria (Section 4.7).

The chapter provides a brief review of the literature on forms of e-learning (Section 2.2), aspects of ICT integration (Section 2.3) and the rationale for integration of ICT into education (Section 2.4). Section 2.5 investigates the potential benefits of ICT in education, while Section 2.6 explores challenges in using technology for learning before concluding with Section 2.7.

There has been a great deal of research on the effectiveness of ICT in education, so much so that a complete and comprehensive review of the literature is beyond the scope of this chapter. Even though many studies show that educational technology can have a positive impact on teaching and learning, other results are not convincing in the context of pedagogically complex uses of ICT and for supporting students’ higher-order thinking skills. Bloom’s model of educational objectives ‘Bloom’s Taxonomy’ (Alford, Herbert, and Frangeheim, 2006) has become the standard for classifying different levels of knowledge, namely: knowledge, comprehension, application, analysis, synthesis, and evaluation. Knowledge is considered the lowest level of learning and evaluation the highest.

2.2 Forms of E-Learning

2.2.1 – Definition of E-learning

A broad definition of e-learning, as adopted by CEDEFOP (2002: p.5), is ‘learning that is supported by information and communication technologies’. E-learning is not simply the possession of ICT skills, but primarily involves the use of various instructional formats and technological methodologies in learning, particularly the use of ‘software, the Internet, CD-ROM, online learning or any other electronic or
interactive media’ (de Villiers, 2005a p:347). This definition of e-learning is appropriate for this study, which takes a broad approach, incorporating various forms of educational technology and learning, both online and offline.

2.2.2 – Forms and Methodologies of E-learning
This section presents an overview of the evolution of e-learning and describes various forms and methodologies. In the 1950s, early computer-aided instruction platforms, such as Plato, provided educators with a programming environment to develop educational ware. These were followed by systems, such as the Time-shared, Interactive, Computer-controlled Information Television project (TICCIT), which, owing to the high costs incurred and the advent of micro-computers, was unfortunately terminated, resulting in regression in the field of instructional computing (de Villiers, 2005a).

In the early 1970s, intelligent tutoring systems (ITS) were introduced by the artificial intelligence (AI) community. They were time-intensive to develop and were, therefore, not generally introduced. During the 1980s and 1990s, CAI, in the form of tutorials and drill-and-practice software, became popular as stand-alone courseware, stored and run from diskettes on micro-computers and desktop computers (de Villiers, 2005a).

Forms and methodologies of e-learning include computer-based tutorials, hypermedia, simulation, drills and practice, learning management systems, educational games, intelligent tutoring systems, state-of-the-art interactive learning environments, problem-solving tools, Web-based learning and collaborative online environments (Alessi and Trollip, 2001; de Villiers, 2005a), some of which are overviewed in this section.

**Tutorials**

Tutorials, as instructional software used to guide students in subject-related material, present information in appropriately-sized chunks, check learning by question and answer methods, judge responses and give feedback (Alessi and Trollip, 2001). Teaching segments are alternated with question segments, giving responses with
diagnostic feedback, based on the student’s input. Examples include BioLab and MathMedia educational software packages that also exploit ‘drill and practice’ software functions.

Tutorial software is designed to teach students basic concepts and more advanced information about a subject or topic. It includes illustrations and simulations, and sometimes drill-and-practice tests. One example of tutorial software is sheppardsoftware.com, which includes information about capital cities, states, and landscapes (http://sheppardsoftware.com/Geography.htm).

**Drill-and-Practice**

A drill-and-practice system is a form of software that merely tests information and provides feedback and does not present information at the start (Alessi and Trollip, 2001). Drills provide exercises in basic skills and help students to practice and gain speed, confidence and retention. In some drills the computer stores and randomly presents practice items to support specific instructional objectives. Drills provide record-keeping facilities and different levels of difficulty, with some drills placing the student on a level according to achievement in a pre-test (de Villiers, 2005a). Drill and practice software is appropriately used in areas of basic skill mastery such as mathematical facts and processes, grammar practice, and language vocabulary. For example, the ESL trial software was designed by Merit Software to help special education students who need help in using simple, clear English. http://viking.coe.uh.edu/~ichen/ebook/et-it/drills.htm

**Simulations**

Simulations are interactive software that provide students with opportunities to simulate situations while learning (Alessi and Trollip, 2001), for example, in chemistry experiments and biological phenomena. Simulations model real-world phenomena and activities in simplified forms, by omitting details or adding features. They also serve to avoid dangerous situations, such as exposure to noxious chemicals, and allow students to manipulate situations otherwise infeasible, such as events in the solar system. Students dynamically manipulate parameters to change the situation. This control process helps them to explore situations, solve problems
and understand concepts. Simulations can be difficult for students to manage but can play a useful role in supporting advanced instruction. Examples are C\textit{rocodile-Clips} (2003) and \textit{ChemLab} (1994), which can simulate a chemistry laboratory and allow for an easy design of virtual experiments conducted by students (http://www.crocodile-clips.com/en/Crocodile_Chemistry).

\textit{Educational Games}

Educational games provide non-repetitive practice and can be used from primary school to college level (Alessi and Trollip, 2001). For example, there are adventure games for children and suitable programs can be used as simulation games in business schools. Such programs mainly serve as discovery environments and can be used in combination with both simulations and drills. These programs aim to be motivational, and are sometimes termed ‘edutainment’, with \textit{Incredible Machines} (2000) an excellent example of an educational game involving puzzle solving. It presents so-called ‘wacky’ machines designed to do specific tasks, while the student’s role is to determine where to put the missing components to make the machines work (http://www.mobygames.com/game/incredible-machine-2).

\textit{Hypermedia}

Hypermedia systems present students with a database of information and multiple means of navigation, most commonly hyperlinks, and multiple modes of presentation, such as textual, graphics, audio and video information. Hypermedia systems can be dynamic Web-based environments or CD-based environments with static content. They are flexible, with non-linear navigation, allowing students to select their own paths through the material (Alessi and Trollip, 2001). \textit{Your Digestive system} (2010) is an example of this form of e-learning methodology dealing with health education (http://kidshealth.org/kid/htbw/digestive_system.html).

\textit{Web-based learning}

Web-based instruction is teaching and learning that is supported by the features and resources of the Internet. Web-based learning is also defined as the use of the World Wide Web as a way to deliver materials and instruction for student learning. When taking into account Web-based learning, there are two categories, namely, onsite
learning and distance learning. The first is used to support traditional classroom teaching and learning. The second is used with off-site learners, with the aim not only of supporting quality learning, but also to make learning opportunities available and accessible to more students (Alessi and Trollip, 2001).

Alessi and Trollip suggest Web-based learning as an appropriate approach to teaching and learning, because, ‘Web based learning can be combined with any of these methodologies (for the web is essentially a delivery medium)’ (Alessi and Trollip, 2001, p. 12).

2.2.3 – Discussion

Each form of e-learning has an underlying philosophy to drive students’ performance. Tutorials are used in the instructional process to provide guidance and to coach students. Instruction in tutorials is activated by interactive dialogue. The system presents relevant and appropriate content, questions to be answered and judged, and feedback according to the student’s input. So-called ‘program-controlled’ tutorials are able to gauge an appropriate level of difficulty on which to place each student. For Alessi and Trollip (2001), these kinds of systems have their origins in programmed instruction and operant conditioning; they are a behavioural approach in which students are treated as passive recipients of information. The behaviourist paradigm is addressed in detail in Section 3.2.1.

An e-learning simulation is defined by Alessi and Trollip (2001: p.213) as ‘a model of some phenomenon or activity that users learn about though interaction with the simulation’. As a learning methodology, simulations are a useful way to help students manipulate variables and build mental models of phenomena and procedures to explore; this also serves to test and improve their knowledge. Alessi and Trollip consider simulations as very similar to learning in the real world. Many simulations are based on the cognitivist paradigm, discussed in Section 3.2.2.

To enhance active learning, problem-solving software is used to allow students to use the computer more actively; not as a tutor, but as a tool (Ilomäki and Ratanen, 2007). Further developments with open learning environments encourage students to explore task situations with the aim of independently acquiring knowledge while solving
problems, and improving their overall performance (Hohlfield, et. al 2010). Findings from Ilomäki and Ratanen’s study show that during the 2006-2007 school year, 85% of schools in Florida, USA used technology-enhanced media, including websites, to support pupils in communicating with families and external communities. In another approach, students use cognitive computing tools, such as commercial off-the-shelf spreadsheets and databases, to process and manipulate information. These approaches implement constructivist learning theory (see Section 3.2.3).

Technology should not be used for its own sake, but rather as a means of support. Alessi and Trollip (2001: p.6) are in favour of using computer-based instruction ‘in situations where the computer is likely to be beneficial’, while de Villiers (2005b) notes that technology is the medium and not the message.

2.2.4 – Student-Content Relationship
The use of technology in instruction and learning can be classified according to the student-content relationship. The six types listed in Table 2.1 originate from Falch’s (2004) description of four types of e-learning, which Negash, Wilcox and Emerson (2007) expanded to six types. In this table, a ‘Yes’ in the ‘Presence’ column indicates that teacher and student meet during content delivery, either physically or virtually. A ‘Yes’ in the ‘E-communication’ column indicates the availability of e-communication between teacher and student during instruction delivery, or where it is the main communication medium, with examples of the six classifications provided in the last column.
Table 2.1: Classification of E-Learning  
(Adapted from Negash, Wilcox and Emerson, 2007)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Face-to-face</td>
<td>Yes</td>
<td>No</td>
<td>PowerPoint slides; video clips; direct instruction via online textbooks; drill and practice; CAI tutorials; multimedia productions</td>
</tr>
<tr>
<td>Type 2</td>
<td>Self-learning</td>
<td>No</td>
<td>No</td>
<td>Pre-recorded course content on CD-ROMs, CAI tutorials</td>
</tr>
<tr>
<td>Type 3</td>
<td>Asynchronous</td>
<td>No</td>
<td>Yes</td>
<td>Online learning; discussion boards; e-mail and notes posted by teacher; dynamic Web-based resources</td>
</tr>
<tr>
<td>Type 4</td>
<td>Synchronous</td>
<td>No</td>
<td>Yes</td>
<td>Audio, video, chat and instant messaging, Skype</td>
</tr>
<tr>
<td>Type 5</td>
<td>Blended/Hybrid-</td>
<td>Occasional</td>
<td>Yes</td>
<td>E-mail; newsgroups; bulletin boards combined with some class-based teaching</td>
</tr>
<tr>
<td></td>
<td>asynchronous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 6</td>
<td>Blended/Hybrid-</td>
<td>Yes</td>
<td>Yes</td>
<td>Chat rooms; multi-user domains; electronic classroom lectures; video or audio conferencing</td>
</tr>
<tr>
<td></td>
<td>synchronous</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.4.1 Type 1: Face-to-face

This takes place in a face-to-face classroom setting, but is classified as e-learning because of the frequency of use of e-learning tools such as PowerPoint slides, video clips and tutorials, with multimedia to deliver content and support the process of instruction. For this type of e-learning, both instructor and student are physically present in the classroom at the time of delivery (Negash et. al, 2007). Each student or pair of students must be seated at a computer. The primary communication between student and instructor takes place in the classroom. However, many face-to-face situations also use e-learning technologies outside the classroom, for example when supplementary interactions occur between the teacher and students or between students through the use of e-mail. In a face-to-face situation, e-learning tools can be used not only for instruction, but also for content delivery. Situations where e-learning is combined with conventional classroom teaching are referred to as ‘blended learning’ and discussed further under Types 5 and 6 and in Subsection 2.3.2.1.

2.2.4.2 Type 2: Self-learning

The self-learning approach (Negash et. al., 2007) occurs where students obtain the content via media and learn on their own. There is no physical, or virtual, presence of an instructor, neither is there any electronic communication (e-communication) between the student and instructor. Instead, the student receives pre-recorded course content. Communication between the teacher, or administrator, and student is limited
to support on matters such as replacing damaged media or transferring supplementary material. Self-learning can occur in a computer laboratory or in the student’s home or workplace.

2.2.4.3 **Type 3: Asynchronous**
Teachers and students do not meet at all during content delivery; there is no physical or virtual presence of an instructor or facilitator. The teacher pre-records or uploads the learning content and students access it asynchronously at their convenience, with content delivery taking place separately from access. Communication between the teacher and students occurs *via* e-learning technologies, such as online learning, discussion boards, e-mail and notes posted by the teacher. E-communication is the main mode of contact for this form of e-learning, which may overlap with Type 2 above (Negash et. al., 2007).

2.2.4.4 **Type 4: Synchronous**
In this format the teacher and student do not meet physically, but have ‘virtual’ contact during real-time delivery. All participants are online simultaneously. E-communication is used in a technology-mediated classroom, for example, in chat sessions or computer conferencing. This methodology includes all the above technologies as well as audio, video, chat and instant messaging technologies. (Negash et. al., 2007)

2.2.4.5 **Type 5: Blended/hybrid-asynchronous**
Negash et. al. (2007) describe blended or hybrid e-learning, as situations where there is occasional contact with teachers, and content delivery takes place mainly through e-learning technologies. There are infrequent face-to-face sessions and this approach is therefore a combination of face-to-face and asynchronous e-learning. E-communication is mainly used, and there is a physical presence during face-to-face sessions but none during asynchronous delivery.

2.2.4.6 **Type 6: Blended/hybrid-synchronous**
There are similarities between this blended or hybrid form of e-communication and the asynchronous form of e-learning, in that both physical and virtual presence occur.
Face-to-face sessions in class settings alternate with virtual settings. Teachers and students meet frequently in both physical and virtual format (Negash et al., 2007).

2.3 Aspects of ICT Integration

Integrating technology into teaching and learning might seem like a new concept. However, other technologies such as television, radio, photographs and audio tapes have been used in the past. Nevertheless, with the speedy development of emerging technologies, such as Internet and the web, ICT integration has increasingly attracted the attention of educators and created new challenges to teaching and learning. In this section, we elaborate on these challenges and obstacles before describing key factors in learning with technology and concluding the section with the criteria for a successful ICT integration.

2.3.1 – Obstacles to Successful ICT Integration

When the present research commenced late in 2006, as indicated in Section 1.8, the use of technology in Lesotho schools was on the increase. However, technology-based learning was relatively new to many educators and educational managers. In Lesotho, as was previously the case internationally (Zemsky and Massy, 2004; Laurillard, 2006), practical implementation issues and obstacles to full integration were overlooked, while institutions focused on acquiring more and more computers and other equipment for schools (Kalanda and de Villiers, 2008). (This publication by the author is in Appendix 12).

Literature suggests that the educational sector has not yet achieved a level of maturity with regard to e-learning practice and this is particularly the case in third world situations (Garrison and Anderson, 2003; Zemsky and Massy, 2004; Laurillard, 2006; Howie and Blignaut, 2009). The rapid introduction of new technology, especially the Internet, in education without adequate preparation of teachers and students for the changed environment, has hampered the implementation of e-learning (Kalinga et al. 2007; Tondeur, van Keer, Van Braak and Valcke, 2008; Erixon, 2010). The study by Kalinga et al. is an African study that considers the use of an e-Learning Management System (e-LMS) for both urban and rural secondary schools in Tanzanian. Howie and Blignaut, who investigated South Africa’s readiness to integrate ICT into mathematics and science education in
secondary schools, recommend that schools should start embracing ICT as a component of teaching practice. However, various studies, both international and local, suggest that the introduction of ICT has not been managed in a way that can transform learning and teaching. Writing in 2004, Caplan (2004: p.176) considered Web-based teaching as still in its early stages but yet ‘blazing new trails in developing the essential elements and process that will lead to high-quality, active, online learning environments’.

While the introduction of technology in education may create opportunities for innovation (Lateh and Muniandy, 2010), it also gives rise to challenges and demands changes to existing processes (Laurillard, 2006). It requires a considerable shift in pedagogy and practice for educators concerned, and there is a need for research, such as this study, to contribute to the development of teaching and learning practices that conform to appropriate theoretical foundations. Schoepp (2005) refers to these challenges and difficulties as ‘barriers’ to successful engagement in ICT practices. Pelgrum (2001) classifies the obstacles into two groups: ‘material’ – referring to the lack of both hardware and software, and ‘non-material’ – including inadequate ICT knowledge and skills on the part of teachers and insufficient time to meet the additional demands of these new approaches. These issues are discussed in Sections 2.6.1 and 2.6.2 respectively.

Furthermore, teachers find it difficult to integrate technology into their teaching practices if they are not provided with good infrastructural support in the classroom and in the school. Without such foundations, they will struggle to overcome barriers to the use of educational technology (Bingimlas, 2009). Bingimlas, in a review of literature, provides a meta-analysis of relevant literature which indicates that the lack of appropriate infrastructural support and access to resources is a major barrier to e-learning in schools. Similarly, a study by Sicilia (2005) determined that technical and associated issues were major barriers to progress in the adoption of ICT. The infrastructural barriers include time spent addressing software problems; insufficient upgrading of hardware and software; inadequate Internet connectivity; and time spent repairing faulty computers and printers. Technical malfunctions and faulty equipment distract and discourage the teacher, particularly if they occur during an actual lesson. For the teaching of science, Gomes (2005) advises that ICT integration
should be supported by technical personnel or that comprehensive technical training should be scheduled for the teachers themselves. In countries such as the UK and the Netherlands, the role of technicians in supporting teachers has been recognised and implemented.

Teachers in Saudi Arabia acknowledge their desire to integrate technology in their teaching, but mention infrastructural obstacles as a serious handicap (Almohaissin, 2006). In general, recent studies identify the following as major barriers (Almohaissin, 2006; Bingimlas, 2009): lack of hardware and appropriate software; insufficient technical training; lack of suitably qualified technical personnel; and a need for ICT integration skills among educators.

Further issues arise with regard to the use of communication facilities and the associated need for reliable connectivity. Research by Biesenbach-Lucas (2003) called for further investigation into the use of asynchronous technology, cautioning that, in many cases, the use of such technology had been established with little or no consideration of the impact on learning. This warning is particularly appropriate to the African continent with its limited availability of broadband Internet facilities.

2.3.2 – Key focus in learning with Technology

2.3.2.1 Blended Learning
The combination of face-to-face instruction with technology-based learning, is referred to as blended learning (Kerres and de Witt, 2003: p.101; Osguthorpe and Graham, 2003; Negash et. al., 2007). One of the goals of blended learning is to maximise the benefits of both face-to-face and technological (online) methods. Some authors advocate the term ‘hybrid’ when referring to courses that combine face-to-face instruction with distance delivery systems (Brown, 2001; Young, 2002; Negash et. al., 2007). In the present study, the term ‘blended’ is preferred for describing educational and learning events ‘that focus on the combining together of face-to-face and technology in ways that lead to a well-balanced combination’ (Osguthorpe and Graham, 2003: p.229).
The combined solution includes several different delivery methods, such as collaboration software, Web-based courses and computer communication practices, in tandem with traditional class-based instruction. In situations where there is no Internet connectivity, the electronic component consists of CD-ROM-based drills, tutorials and simulations, as well as the use of commercial software tools such as PowerPoint presentation and Excel. The term ‘blended learning’ is also used to describe the combination of various event-based activities, as in classrooms, live synchronous e-learning and self-paced learning (Valiathan, 2002). The development of new technological delivery systems enables the integration of e-learning into traditional learning programmes.

There are multiple activities and processes involved in practically integrating ICT into the classroom. These include complete online training with precise and well-defined policies; the use of virtual laboratories; online access to, and control of, distant physical set-ups, such as physics laboratories; and working face-to-face in the classroom situation with digital controls and computer-based tools.

2.3.2.2 Communication and Collaboration between Students

Literature advocates using technology to foster learning through discussion and collaboration (Laurillard, 2002). Communication can be synchronous via chat rooms and electronic conferencing, or asynchronous by e-mail and postings on discussion boards. This, in turn, necessitates the use of the appropriate educational technology and further research into managing the implementation of communication and electronic collaboration between distributed students. (Laurillard, 2002; Biesenbach-Lucas, 2003; Mara, 2006).

2.3.2.3 Integration of Techniques, Approaches and Physical Environments

Making these different parts work together effectively is complex and challenging. The parts to be combined may include:

- the school context in which integration is to take place;
- the physical environment and the technologies themselves (Howie and Blignaut, 2009);
- technical skills of the teachers (Kalinga et al. 2007);
• technical support for installation (Zain, Atan and Idrus, 2004);
• maintenance and upgrading of hardware and software;
• pedagogic preferences and practices; and
• the skills and confidence of the students.

Literature indicates that although the traditional classroom environment, along with its conventional teaching and seating arrangements, still dominates the instructional approach, technology is now being used to teach students across curricula, using many of the ICT-based activities introduced in this chapter. The paradigm shift is occurring gradually in terms of the infrastructure and physical layout of the environment, illustrating a slow movement towards general use of technology.

Literature investigating the effect on learning of the overall layout and seating arrangements in computer laboratories and in classrooms fitted with computers, suggests that information and communication technology encourages students to ‘learn by doing’ and impacts on both the learning and teaching styles in a technology-based environments. Zandvliet and Straker (2001) found that the physical setting, computer placement and seating arrangements were often overlooked when ICT is integrated into classrooms. Swanquist (1998) suggested that comfortable classroom seating helps to improve the students’ attention span and increases their retention of information.

2.3.2.4 Open Source Technologies

This literature review identified a number of studies (Lujara et al. 2007; Lee et al. 2009) which indicate that ICT can provide rich learning environments for teachers and students. DiBona, Ockman and Stone (1999: p.4) argue with regard to the advantages of open-source when compared to proprietary commercial software, that ‘The process of discovery must be served by sharing information: enabling other scientists to go forward where one cannot; pollinating the ideas of others so that something new may grow that otherwise would not have been born’. They conclude: ‘The scientific method minimizes duplication of effort because peers will know when they are working on similar projects. Progress does not stop simply because one scientist stops working on a project’.
In another African study, Lujara et al. (2007) discuss initiatives to introduce ICT tools into certain secondary schools in Tanzania, using open source software in e-content development, to facilitate self-learning. They propose the use of ICT tools, and especially e-learning, as viable solutions to overcome a lack of conventional resources. The choice of open source (OS) software is sound, since it has certain advantages over proprietary packages: it is licence free; can be customized to suit the specific context; and it has support for sustainability.

2.3.3 – Criteria for Successful ICT Integration

2.3.3.1 Attainable Goals

A policy decision to implement and integrate ICT in schools usually requires a considerable investment in technology (Hadjithoma and Karagiorgi, 2009). Such decisions may be based on over-optimistic expectations or might assume that specific outcomes will be achieved by teachers and students. However, these decisions may fail to define the exact nature of successful ICT implementation or integration. Hence it is difficult to establish whether the venture has been successful without an initial statement of explicit objectives and expected outcomes (Miller, Martineau and Clark, 2000). The subsections following set out some criteria for successful ICT integration.

2.3.3.2 Relevance

The implementation of any ICT technology or e-learning application should be undertaken for one reason only, namely, that it is relevant and adds value to the teaching and learning experience. Hohlfield, Ritzhaupt and Barron (2010), like Newmann and Wehlage previously (1993), argue that learning, assignments and assessments must have personal value for the student outside the classroom as well, and that work produced should have an audience beyond the teacher. Therefore, for effective pedagogy to occur when ICT is integrated into the classroom, the applications should relate to real life practices. In their study, Hohlfield et al. (2010: p.393) note: ‘As schools use ICT to communicate and collaborate with families and community, they have the opportunity to address the digital divide’.

Without discerning use of ICTs, there can be unexpected, and sometimes negative, effects. Russell (1999) and Johnson and Aragon (2003) advise that when teachers
implement educational technology in a curriculum, they need to select an appropriate form or product and justify its use according to the following criteria:

1. How appropriate is the technology for the specific topic?
2. Does the technology add value to the learning experience?
3. How would use of the technology support the instructional process?

2.3.3.3 Appropriate Activities
Experienced teachers often draw from their personal experience to develop real-world educational activities. This encourages learning through active participation and leads students on to implementation and the acquisition of personal computing skills. Teachers who are less experienced, or who lack knowledge about real-world ICT practice, are less able to develop meaningful and practical learning activities which could benefit students and encourage active participation.

2.3.3.4 Attitudes and Expertise of Educators
Skills and attitudes are further considerations. Bitner and Bitner (2002), Davidson and Elliot (2007) and McGarr (2009) argue that the skills and attitudes of teachers can facilitate the effectiveness of technology integration into the curriculum, if, when teachers start developing expertise, they are prepared to share their experiences and demonstrate them to others, including their peers. Similarly, Mueller, Wood, Willoughby, Ross and Specht (2008) in their survey of 185 elementary and 204 secondary teachers’ use of computers as instructional tools in Canada, found that attitudes and beliefs have a positive impact on the successful integration of ICT in the classroom, as well as on teachers’ under-use of technology. Teachers need to be empowered by learning to use technology and, in particular, by using technologies to change their teaching paradigms and those of their peers. This is particularly challenging in rural and disadvantaged areas, where change is often difficult. Wilson-Strydom, Thomson and Hodgkingson-Williams (2005) surveyed the Intel Teach programme in South Africa to reflect on ICT integration in classrooms. In their analysis of 66 respondent teachers with regards to geographic location, they found that 44.3% of those who never implemented ICT-integrated lessons came from rural areas, 19% from townships, and 36.1% from urban areas.

In countries such as Lesotho, a further problem is the lack of role-models for the effective integration of technology into the curriculum and subject teaching.
2.3.3.5 Supportive Approaches

Bitner and Bitner (2002) propose eight factors for successful e-learning integration:

1. Teachers must be encouraged to overcome their fear of change.
2. Teachers must be trained in the basics of computer use.
3. Teachers need to learn time management skills for efficiency and productivity which, in turn, will free up time for better curriculum planning.
4. There should be pedagogical models for using computers in the classroom.
5. There should be learning models which students can follow in their search for information and the discovery of knowledge.
6. There must be a supportive environment that encourages experimentation without fear of failure.
7. It must be explained to teachers and students that they will initially experience a certain amount of frustration and turmoil in the process of change.
8. There must be on-site and ongoing technical support.

Lee et al. (2009) point out that the way ICT is integrated, impacts on the subsequent attainment of outcomes. The teachers involved and the pedagogic methods used are dominant issues in the success or lack thereof of the process. As indicated in Section 2.3.3.4, success is influenced by factors such as the knowledge, attitude, goals, skills and perceptions of the human teacher, as well as by the technology and the environment. The ultimate driving force behind the use of technology should be the goal of learning. Teachers and students should work together towards this, ensuring that the learning process is more student-centred than teacher-centred. The teacher is no longer the sole source of knowledge and wisdom while students passively absorb information (Lujara et al. 2009; Mumcu and Usluel, 2010). The role of the teacher should change from instructor to facilitator, guiding students as they actively acquire and enhance their knowledge and skills.

2.4 Rationale for Integrating ICT into Education

The general rationale for integrating ICT into education is the assumption that e-learning will introduce tangible positive changes (Maguire, 2005; Sankey and St Hill,
2005). For example, measurable improvements occurred in Grade 7 physics instruction when students had access to technology inside and outside the classroom (Kara and Karhaman, 2008). With regard to cognitive skills, Lim (2007) notes that ICT when ‘coupled with the necessary pedagogical strategies’ can ‘engage students in high-order thinking’ (p.84).

Secondly, the growing role of ICT in society, along with the pressure to adapt education to the needs of the market place, has created an urgency to integrate ICT into curriculum-based teaching. This has occurred particularly in developed countries, but the goal of change at the level of curriculum teaching is needed in Lesotho as well (Government of Lesotho, ICT Policy, 2005; Government of Lesotho, Vision-2020, 2001).

A further rationale can be drawn from the study of Lee et al. (2009), who analyzed how the overall school behaviour of tenth-grade students, as evaluated by English and Mathematic teachers and by standardised test scores in maths and reading, was related to computer use. This phenomenon was evidenced both in school work and in other activities. Their findings show that computer usage in the school situation has the potential to benefit students’ educational outcomes and general future success, especially when parents and community are involved. Further, it has also been shown that the revolutionary approach of ICT can be an effective tool for expanding educational opportunities (Bauer and Kenton, 2005; Lujara et al. 2007). Lujara et al., in their discussion of initiatives to integrate ICT tools into Tanzanian secondary schools, using open source solution for e-content development, argue that ‘The use of e-learning will be a viable solution to encounter the situation of scarce resources ... Open source has advantages compared to proprietary packages (such as) licence free and easy customisation’ (p.334).

Roblyer, Edwards and Havriluk (2004) believe the following factors provide sound reasons for using ICT in education:

1. High motivation among students to use computers;
2. The unique instructional capabilities of ICT, such as data visualisation, the visualisation of problem scenarios, and the tracking and recording of learning progress;
3. Support for innovative instructional approaches, such as collaborative
teaching and problem-based learning;
4. Increased teacher productivity; and
5. Knowledge construction by students.

For Zhao and Cziko (2001) and Tondeur et al. (2008), a major obstacle, and the
starting point for any intervention, is to improve the perception of ICT’s usefulness.
The first step involves helping teachers realise the worth of technology in instruction,
compared to current conservatism and the traditional use of chalk and board. When
they acknowledge its value, there is a decrease in resistance. Tondeur et al. (2008)
and Erixon (2010) hold that teachers in all subjects become involved in the process.
The Tondeur study notes that ‘school-related policies ... support and ICT training
(Professional Development of Teachers) has a significant effect on classrooms’
(p.212). A further advantage to educators is personal empowerment and the career
benefit of ICT skills.

The next section overviews the perceived usefulness of ICT in education in terms of
productivity, impact on students, effective pedagogy; and the learning environment.
It must be borne in mind that these benefits are mainly potential benefits. Their
actual realisation cannot be guaranteed, but is dependent on the environment and the
expertise of the human stakeholders using the technology.

2.5 Potential Benefits of ICT in Education

The belief that access to hardware and software can transform the education sector
has caused educational authorities worldwide to promote ICT literacy among
teachers and students and, consequently, to invest significantly in computers and
software for schools. However, despite the fact that many argue favourably about the
potential of ICT to transform education (Pierson, 2001; Maguire, 2005; Lujara et al.
2009; Mumcu and Usluel, 2010), there is a lack of evidence that its use definitely
enhances teaching and learning (Becker, 2000; Cuban, 2001a; Dwyer, 2003). Hence,
this section addresses potential transformation in specific areas, such as productivity,
motivational factors, the impact of ICT on students and educators; and finally,
effective pedagogy and the learning environment. All these factors can contribute to
the enhancement of teaching and learning, yet have associated complexities. This section also notes the reservation of some researchers who do not believe that the integration of ICT in education improves teaching and learning.

2.5.1 – Productivity and non-Productivity
Productivity is a common measure used in industry and business to assess the economic impact of any innovation or change in *modus operandi*. In recent times, substantial resources have been invested in technology in education, and research studies have illustrated its benefits for students and teachers. In support of measurable productivity enhancement, Hepp, Hinostroza, Laval and Rehbein (2004) contend that schools are knowledge-handling institutions and, for this reason, technologies should be fundamental management tools at all levels of an educational system, from classrooms to ministries. Kozma (2006) posits that, when successfully integrated, ICT can result in technological innovations and sharing of knowledge that can, in turn, contribute to transforming the education system; and to sustainable economic growth and social development.

Yücel, Tarman and Mete (2010), in their investigation of the stages of ICT integration among Turkish teachers, noted teachers’ feelings of inadequacy in using ICT, which was related to their level of perceived knowledge of computing and their attitudes towards using ICT in teaching and learning. They concluded that the personal ICT knowledge of teachers is the most important variable contributing to full attainment of ICT integration.

Howie and Blignaut (2009: p.361) propose that a positive and willing attitude is key to the successful application of technology in education. In their analysis of data on South Africa’s readiness to integrate ICT into mathematics and science education in secondary schools, they conclude that ‘*South Africa simply cannot afford to ignore the importance of ICT in education and its ultimate impact on the country’s well-being*’.

Computing technology holds the potential for productivity gains, in administrative and educational functions, yet in many schools computers are largely under-utilised (Cuban, 2001a; Kalanda and de Villiers, 2008). This contrasts with the corporate
world where they are extensively and intensively used to increase productivity and proficiency. In the context of developing countries, Cuban points out that some schools are achieving this, but mainly in administrative functions and for communication. For example, teachers use spreadsheets for recording data and for converting and calculating students’ marks (scores) for assessment purposes. They also use word processing packages to prepare student lists, produce tests and examinations, and develop other necessary materials. Some teachers and students use e-mail for fast communication and to improve productivity when the parties concerned are in separate locations.

Nevertheless, Cuban (2001b: p.179), writing a decade ago, contends that ‘When it comes to teacher and student productivity and transformation in teaching and learning there is little uncertainty. Both must be tagged as failures’. In certain environments, this situation has changed very little. Other researchers point out that the use of ICT in education requires more finance, more time and more effort than the traditional use of chalk and board or even the use of an overhead projector. For educators, such transformation leads to a new way of teaching, as it requires new lesson plans and new preparation methods, and, may, in the short term, make teachers less productive (Leong and Clark, 2003).

Elliott (2004) and McGarr (2009) also claim that the potential of technology in education has not been fully exploited. In international studies, changes are suggested in the infrastructure of schools and educational systems. White or black boards, chalk, pen and paper and overhead projection should be used in conjunction with computers, e-learning and the Web, as teachers and students make use of available software and hardware as supplementary media (Johnson and Liu, 2000; Pelgrum and Voogt, 2009).

There have also been efforts to reduce teaching time by encouraging teachers to replace certain bookwork exercises by using technology for practical activities such as drill-and-practice exercises. However, Cuban experienced this, too, as less than successful. In his opinion on the situation in 2001, the integration of ICTs in classrooms had not led to productivity gains in learning aspects.
2.5.2 – Motivation and Support for Educators

For successful integration of ICT in the classroom, good access to technology is a major prerequisite (McGarr, 2009). Access is, indeed, one of the greatest problems for teachers needing computers in their own classrooms. Yet even where this obstacle has been overcome, the motivation to apply ICT as an integral part of education remains a challenge.

Although Nikolova (2001: p.71), also writing a decade ago, argues that ‘ICT will have a substantial effect on what we do in schools, just as the advent of the pen and paper did in the past’, 24% of the teachers in his study lacked motivation, although they had competence or access, or even both. One of the primary purposes of this study is to determine whether the current situation in Lesotho indicates progress beyond such sentiments.

As in corporate organizations, where employee motivation is part of organizational policy, motivation for teachers and students to use ICT in the classroom is also subject to the school culture, policies and level of support. Stakeholders may be resistant to the associated changes. School authorities have the responsibility to encourage both teachers and students to accept ICT and e-learning, but must also provide infrastructural support and training (Zain, Atan and Idrus, 2004). Training of teachers should be an ongoing event, and should involve long-term professional development projects. Support may be mutually achieved by face-to-face peer groups or it can be ICT-based through web sites, chat rooms and online discussion forums.

Hayes (2007) emphasises that positive effects and benefits result for the entire school when all stakeholders are involved in the process, instead of just a few individuals. Incentives could include promotion, certification, financial benefits, training, and recognition within the school. Tangible rewards, such as these, provide so-called extrinsic motivation. In addition, intrinsic motivation can encourage and stimulate educators. Alessi and Trollip (2001) describe intrinsic motivators as the kind of motivation that comes from within a person, such as one’s personal interests and satisfaction in achievement, and they believe these are more beneficial than extrinsic motivators. According to Cotton (1995), intrinsic motivators are the internal self-esteem factors that arise when people who take pride in their work and skills, set
themselves high standards of practice. Intrinsically motivated individuals also set good standards for others. In this way, a motivated teacher can set a good example, for other teachers as well as for the students. Instruction, in turn, is intrinsically motivating if students consider it to be fun (Alessi and Trollip, 2001).

The ultimate consequence should be that the integration of computing, and increased motivation on the part of all stakeholders, become accepted means of teaching and learning and create technological learning environments that differ in positive ways from traditional instruction (Jonassen and Reeves, 1996). Although this point was made in 1996, it remains valid.

2.5.3 – ICT Impact on Students and Educators
The use of ICT in teaching and learning can change the ways that students learn, as it impacts on aspects such as teamwork, critical thinking, independent learning, concentration and cognitive processing (Pierson, 2001; Maguire, 2005; Sankey and St Hill, 2005). There is no certainty, however, that the use of educational technology improves students’ achievements.

A further relevant matter is the teacher’s attitude, and its impact on teaching.

2.5.3.1 Active engagement and cognition
When interacting actively with a computer, many students are more engaged in the learning process and pay better attention (Mugimu, 2010). The student-centred approach is one of the most significant benefits of e-learning. Other studies show that benefits go beyond technology, and also impact on pedagogic and social factors (Maguire, 2005; Mugimu, 2010).

With regards to pedagogy and cognition, students can use computers as cognitive tools and presentation tools, for example, they can manipulate scientific data on spreadsheets, store and access facts in databases, and present their work using presentation software, such as PowerPoint (de Villiers, 2005a).
2.5.3.2 **Collaboration**

To achieve full benefits, it is not only necessary for students to work together but, more importantly, that they analyse and solve problems at a computer, using cognitive skills and discovering how to approach problems in a cooperative way. Collaborative learning, which is currently encouraged in many sphere of education, can be enhanced through the use of ICT (Lim and Tay, 2003).

2.5.3.3 **Impact of ICT on Students’ Performance**

Some argue that technology demonstrates its greatest benefit if it helps students to perform better in examinations and tests. An early study by Wenglinsky (1998) on the relationship between ICT and student achievement in mathematics for Grades 4 and 8, found that the teachers in the study did not believe that technology improved academic achievement. Wenglinsky notes that not all uses of technology are beneficial, and using computers to teach low-order thinking skills relates negatively to academic achievement. On the other hand, Lateh and Muniandy (2010) in their study on ICT implementation in Grades 10 and 11 Geography in Malaysian schools, found significant gains in the achievements of students in areas that involved higher-order thinking. They argue that a ‘**Geographic Information System has the potency of sharpening the critical thinking among students**’ (p.2849).

Results from other studies reflect uncertainty on the impact of technology on student achievements. Vrasidas and Glass (2005) highlight the inconsistency, citing research studies that describe improved student achievement, while other studies indicate a contrasting negative impact. Since 1994, there has been a debate over media influence on learning. In the forefront of those who believe that media cannot influence learning has been R. E. Clark, who argues that media do not influence learning and that there is no significant difference in the end-performance of those who learned with educational technology and those who did not. On the contrary, he believes that ‘**learning is caused by the instructional methods embedded in the media presentation**’ (Clark, 1994: p.26). Clark contends that media are merely a means to convey instructional methods and content, and concludes that they do not directly influence learning. Clark challenges his critics: ‘**We need to ask whether there are other media or another set of media attributes that would yield similar learning gains**’ and adds: ‘**If a treatment can be replaced by another treatment with similar**
results, the cause of the results is in some shared (and uncontrolled) properties of both treatments’ (Clark, 1994: p.22).

In contrast to Clark, Kozma (1994) argues that media and methods are interconnected. For Kozma, both media and methods are part of the instructional design. ‘Media must be designed to give us powerful new methods and our methods must take appropriate advantage of media’s capabilities’ (Kozma, 1994: p.16). Kozma maintains that learning from media can be a complementary process, within which representations are constructed and procedures are performed, sometimes by the student and sometimes by the medium (Kozma, 1994).

While this debate continues, researchers continue to conduct studies. Most report no significant difference in learning effectiveness between technology-based and traditional classroom delivery. Researchers remain unable to state with certainty whether technology can, or will, improve the traditional ways of teaching and learning. The perceived usefulness of technology in the classroom, in terms of student performance, remains therefore an open issue.

The problem can be approached differently by questioning how one measures the success, or lack thereof, of the implementation of ICT in education. There is more to the matter than merely the difference in scores obtained when learning with or without technology. While there is limited evidence that the use of technology and e-learning improves the students’ scores per se, exposure to e-learning and interaction with technology benefits students in a much broader sense. Brown-L’Bahy (2005) proposes that educators should think in a deeper way about when, how, for whom, and under what conditions, potential benefits can be realized. Hohlfield et al. (2010) point out the holistic benefits of situated exposure to the use of technology in and beyond the classroom. Findings indicate that parental involvement in the use of computers positively impacts student achievement.

### 2.5.3.4 Impact of ICT on Teaching and Teachers

The successful application of e-learning depends to a large extent on how educators and trainers view and use ICT personally. Motivation to use ICT has been addressed in Section 2.5.2. Teachers with positive attitudes towards technology, who use it in
preparing their work professionally and efficiently, are more likely to use e-learning tools effectively to benefit students and to influence them, in turn, towards a positive approach to technology (Fullan, 2007; Erixon, 2010). At the very least, it is essential for teachers to be technologically literate.

Unfortunately, most teachers in Lesotho have been slow to embrace new pedagogic practices (Kalanda and de Villiers, 2008), although an increasing number are currently using technology in subject-based teaching, i.e. using it within the curriculum.

2.5.4 – Pedagogy and Learning Environment

The success of e-learning also depends on appropriate shifts in pedagogy, as well as content, when teachers use subject-related e-learning applications, such as tutorials and simulations related to the curricula (Mandell, Sorge and Russell, 2002). The use of ICT in education must be based on a sound pedagogic and theoretical approach to improve learning (Tomei, 2002; de Villiers, 2005a). The new approach is strengthened by a move towards the constructivist paradigm which encourages personal construction of knowledge (see Section 3.2.3), rather than simply following previous practices in a different manner. Many e-learning tutorials, however, are appropriately based on the behaviourist paradigm (see Section 3.2.1), as they guide students through well-structured subject matter. A combination of learning-theory foundations is appropriate, depending on the context and content, a point elaborated in Section 3.2.5.

Hepp et al. (2004) suggest that management and monitoring processes in schools should include in-depth reviews of teaching practices and resources, so as to:

- develop more efficient learning environments
- Strengthen the pedagogic practices of educators
- Improve learning skills and habits of students.

This should support educational change, contributing to the support of economic development and social transformation.
2.5.4.1  Active Learning

Learning with technology can occur through two contrasting approaches. Much so-called e-learning merely involves passive transmission of material to students. By contrast, active learning involves meaningful interaction with computers, which may play the role of tutor or of tool. Swan, Kratcoski and Van ‘t Hooft (2005) maintain that active and participative technology-enhanced learning can transform the educational landscape and stimulate improvements in students’ performance. E-learning provides a platform to investigate, construct and analyse information in such a manner that students do not view issues in an abstract way, but rather as part of a relevant, authentic and real world. E-learning approaches and hands-on interaction can motivate students as they engage actively and constructively in the learning process.

Lim and Tay (2003) report increased student engagement and Lim and Hang (2003) describe strengthened higher-order thinking skills when ICT tools are used. Students become more creative than in an instructor-centred environment where teachers are viewed as the sole source of knowledge. For de Villiers (2005b), creativity in instruction, in turn, fosters creativity among students.

2.5.4.2  Collaborative Learning

Collaborative learning and team work are associated with the social constructivist approach to learning (see Section 3.2.3). Some researchers believe the proper integration of ICT will encourage and lead to the development not only of active learning, but also of collaborative learning (Hepp et al. 2004). Lim and Tay (2003) maintain that ICT-enhanced learning promotes collaboration, because it can support cooperation, communication and interaction, where students learn to work with others in a team or on a joint project.

2.5.4.3  Feedback, Interactivity and Interaction

Most new technologies are interactive and support learning by hands-on involvement and by the provision of feedback. JA Hattie (cited in Velan, Jones, McNeil and Kumar (2008)) notes that diagnostic and remedial feedback, such as provided in e-learning tutorials, is a powerful influence on student achievement. Other
technologies that are highly interactive and responsive are simulations and educational games.

The Internet is an example of a tool that supplies information to teachers and students and enables them to communicate with one another. In this environment, active learning and human-computer interactivity can occur as teachers and students undertake independent research using Web 2.0 (Ebner, 2007) to discover new information, explore different issues and solve problems, leading to what Ebner terms ‘e-learning 2.0’. A further revolution is therefore taking place (O'Reilly, 2006) through a change of user behaviour due to advances in the World Wide Web. Use of educational media in different forms and environments, as discussed in Section 2.2, has expanded rapidly as learning technologies are uploaded onto the Internet. Internet users increasingly create content on the Web themselves by blogging, podcasting or using wikis, leading to the concept of Web 2.0 in which users contribute content themselves (Ebner, 2007). According to Nussbaum (2007), visits to Web 2.0 sites constituted 12% of all Web activity’ in 2007, as compared to only 2% two years previously.

Today’s students, the so-called ‘net generation’, particularly in first-world contexts, create content, are immersed in virtual networks and are connected worldwide (Lenhart and Madden, 2005; Green and Hannon, 2006). They easily generate and edit web pages using weblogs (blogs), while video sharing is normal to the daily life of many students in certain countries. As stated above, Web 2.0 supports web content creation by typical users in a ‘Read/Write Web’ (Ebner, 2007). Users load information into weblogs, podcasts, wikis, bookmarks, and popular social networking sites such as Facebook and MySpace.

In many of these technologies, teachers are ‘the migrants’ to whom the environments are unfamiliar, while the students are ‘the natives’ (Prensky, 2001 p.2). Social networking is part of daily life in certain sectors of society; many children encounter computers shortly after birth and use them from pre-school days. Teachers, in contrast, have to learn and rethink concepts and workflow to teach this generation as they face new devices, new communication structures, new types of content and also a new type of student.
Assisted by these new media interactions, animations and simulations, teachers will be able to add to the traditional learning material (Chan and Fang, 2007), so education will change even further, as traditional books can be supplemented by multimedia accumulations created by local educators and customised to the situations in their own classes.

Although the experiences described in this subsection are not typical of the Lesotho student, the creation of customised content is an instructional process that can be undertaken by those Lesotho school teachers who have been appropriately oriented and trained.

2.6 Challenges in Using ICT for Learning
Barriers may exist which can hamper the whole ICT integration process as mentioned in Section 2.3.1. If these are not identified and addressed, efforts at integration could be futile from the outset. One way to overcome such challenges is to integrate ICT into the curriculum, not the converse (Earle, 2002; Williams, 2003). It is important to identify potential obstacles and barriers, and explicitly plan and work to overcome them. These challenges are discussed under the headings: professional development; time allocation; infrastructural support, and motivation and innovative climate.

2.6.1 – Professional Development of Teachers in ICT
To determine the success or failure of any e-learning initiative, it is important to consider, among others, the views of the teacher (Tondeur et al. 2008). Teachers’ perceptions on any change or improvement in classroom practices through the use of technology will ultimately determine the extent to which effective integration of e-learning occurs. Martin (2000) highlights the role of teachers when he emphasises that, without their input and acceptance, the development of constructive educational technology projects can be retarded and even completely hindered.
2.6.1.1  Limitation

As set out in Section 2.3.1, teachers may be restricted by various obstacles. Some of these are unfamiliarity with hardware and software or computers in general; insufficient time to prepare for ICT-mediated instructions; or personal issues that are fundamentally rooted in their own beliefs about teaching and learning (Ertmer, 2005). Even competent and experienced teachers continue to struggle with practical problems they encounter in the integration process (McGarr, 2009; Howie and Blignaut, 2009).

2.6.1.2  Main Strategies

As the integration of e-learning into schools progresses, there is greater urgency to identify obstacles and formulate models to address them. Educators require support and appropriate strategies to overcome the problems. To this end, Ertmer (2001) proposes pedagogic strategies as well as technical and organizational approaches such as: initially introducing teachers to relatively simple uses of technology; engaging teachers in explicit belief exploration; and providing opportunities to examine new practices supported by different beliefs. Ertmer explains that these strategies can help teachers progress beyond initial low-level uses and should support them in the adoption of higher-level uses.

Hunter (2001) and Zhao, Pugh, Sheldon and Byers (2002) examine strategies that can be adopted to overcome contextual issues, among them, high student turnover and restricted professional development. Such strategies include:

- appointment of technical support staff,
- appointment and training of student ICT helpers,
- sufficient time for teachers to prepare for ICT-mediated lessons,
- collaboration among teachers in preparing ICT-mediated lessons,
- support provided by school leaders in addressing teachers’ ICT concerns, and
- training, demonstrations or advice for teachers on how to incorporate ICT into classroom instruction.

These studies all show how important it is that teachers buy into the use of technology to enhance the teaching environment, despite the challenges.
2.6.1.3 **Training and Other Strategies**

For Tondeur et al. (2008), a key strategy that schools should employ to overcome obstacles, is commitment to the professional development of teachers. Training has to be carefully designed and implemented to provide continuity between what is learned by teachers and what will happen in their classrooms, and to support them in transforming their practices (Zhao, et al. 2002). Based on the role of ICT, especially in complex computational subjects, such as mathematics and sciences, Adams (2005) proposes regular scheduled professional development to keep teachers up to date and aware of the need to continually improve their technological practices. Strategies to enhance the development of teachers should address technical and pedagogic aspects, such as the operation and maintenance of tools used in ICT-mediated instruction; the management of policies to implement ICT in the curriculum; and the evaluation of courseware. Note by the author: with regard to the technical and operational issues, it should not be a requirement that teachers manage them personally, but it is important that they should understand them (see recommendations in Section 2.6.3).

The professional development of teachers has traditionally been addressed by holding brief workshops, sometimes as short as one day. Teachers have criticised the lack of correlation between workshop activities and real-world classroom practices (Cohen and Ball, 1999). The programmes should be carefully designed to relate the learning context to what occurs in classrooms. The major focus should be on supporting teachers as they incorporate new approaches into their instructional practices (Hohlfield et al. 2010).

Godfrey (2001) advocates that, as well as teachers becoming conversant and competent with the multiple facets of technology, they should also gain confidence and become critical thinkers and creative users of technology. Besides needing models of best practice and relevant information, teachers should acquire personal technological expertise and support the rationale behind integrating ICT into learning. They should be able to keep up with rapid technological advances and associated changes in practice. The rate at which students master and use ICT-based learning applications should advance in a similar manner. Section 2.5.4.3 makes mention of Web 2.0 and current social networking technologies – these may well have an impact within formal education.
As education planners consider ways of overcoming the obstacles to ICT integration, they should also pay special attention to ensure that the teacher’s role changes, being not only an instructor but also becoming a facilitator, a mentor and a collaborator in learning (Mostert, 2000).

2.6.2 – Time Allocation for Teachers’ Use of ICT Resources
A major barrier to the use of ICT resources remains a lack of time (Schifter, 2002; Moser, 2007). Kalanda and de Villiers (2008) report that Lesotho teachers are concerned about the lack of time to familiarise themselves with hardware and software and to prepare the new kind of lessons. Also of concern is students’ low-level access to ICT. In his decade-old study of schools from 26 countries, Pelgrum (2001) noted that insufficient time allocation for teachers was among the top ten problems associated with e-learning integration in schools.

Teachers are given little opportunity to become accustomed to the ICT approach before they have to start managing it. Young (2004) and Davidson and Elliot (2007) advocate extensive time and opportunities for teachers’ professional development and personal curricular activities, such as discovering relevant Internet resources and creating new lessons. As the usual work allocation of a teacher does not make provision for such activities, it is advisable for authorities to implement alternative solutions. One solution could be to rearrange teaching responsibilities, or to put innovative staffing procedures into place, like using student teachers as assistants or replacement staff (Ertmer, 2001).

2.6.3 – Infrastructural Support and Technological Issues
Besides the need for professional development and additional time for professional and curricular development activities, teachers need technical, pedagogic and administrative support from their schools to effectively integrate e-learning in their lessons (Jones and Kelley, 2003; Moser, 2007). Technical issues cause problems related to both hardware and software. It is essential to provide technical support and, in particular, to troubleshoot technology-related problems so that the teachers can concentrate on didactic factors, such as preparing and conducting actual lessons (Bonk, 2001; Lee, 2001; Jones and Moller, 2002). Ideally, schools should employ
technical assistants (Marcovitz, Hamza and Farrow, 2000), or outsource hardware maintenance. Teachers not only need administrative support to manage and maintain hardware and software, but should also become knowledgeable in selecting suitable ICT materials and resources. This is the issue referred to in Section 2.6.1.3.

2.6.4 – Motivation and an Innovative Climate
The issue of educators’ motivation was addressed in Section 2.5.2. This section focuses on motivating students.

Building and maintaining motivational learning environments is challenging, and can best be achieved through efficient organisation and a climate of innovation (Oliver and Omari, 1999; O’Mahony, 2003; Mumcu and Usluel, 2010). In the study by Oliver and Omari (1999), peer-assessment activities were found to motivate and encourage student’s critical thinking and involvement in diverse solutions. The use of peer-assessment to help motivate students and to contribute to an innovative climate, also develops students’ critical thinking skills as they evaluate each others’ work.

Collaborative problem-solving activities offer a practical framework for peer-to-peer interaction and the development of these skills.

The teacher plays a different role in the classroom when students work directly on topics from the subject content, or create their own products individually or collaboratively. Here the teacher’s priority is not just to present the curriculum, but also to determine learning opportunities and select e-learning systems suitable for students and to guide them as they use these systems in the learning process.

Giving students the opportunity to choose their own activities can encourage independent learning and keep them engaged (Feldhusen, 1994). Students should be accountable for completing given activities within a certain period of time, while being free to choose when, where or how they complete the activity. It is possible to create such a learning environment only if students feel secure and accepted, and teachers acknowledge each individual student.
2.6.5 – Key findings of this literature review

Perceived Barriers to ICT Integration

- Lack of training and professional development of teachers (Section 2.6.1).
- Lack of time to prepare and obtain materials needed for lessons (Section 2.6.2).
- Poor infrastructural support with ICT equipment, which reduces the use of ICT by teachers and students (Section 2.6.3).
- Resistance to change on the part of educators, which delays ICT integration in the classroom (Section 2.6.1).

Perceived Benefits

- Productivity is enhanced when ICT is used in schools, provided that users are given access to equipment (Section 2.5.1).
- ICT use in science classes can have a positive impact on student performance (Section 2.5.3.3).
- E-learning success is associated with suitable shifts in pedagogy and content (Section 2.5.4).
- When teachers integrate ICT into the curriculum and use subject-related e-learning applications, such as tutorials and simulations, technology can benefit both teachers and students (Section 2.5.3.3). The teachers benefit, because their teaching in class is confirmed by the technology. The students gain from the new perspectives offered by the e-learning experience.

2.7 Conclusion

This chapter has provided an overview of local and international literature on factors that impact on ICT integration in teaching and learning and the effects on students. The chapter also mentions previous studies on forms of e-learning, rationale for ICT integration, perceived benefits of ICT in education, as well as obstacles and challenges in using ICT for learning. The information provided in this review has been used as a basis for the theoretical structure for this Study and the methodology described in Chapter 4.
The next chapter, a literature overview on e-learning in the science curriculum, investigates fundamental philosophies and theories of formal learning and applies them to technologically-aided teaching and learning, particularly in science. The discussion focuses on three main theoretical categories: behaviourism, cognitive theory and constructivism as theories of learning. Thereafter, attention is focussed on the use of ICT and e-learning in science education. Examples are given and specific skills used in studies in science, are defined.
Chapter Three ~ E-Learning and Science

3.1 Introduction
The use of information and communication technology (ICT) in the delivery of education has a major impact on teachers, students, schools and the community. Although there is the potential of benefits for all stakeholders as explained in Chapter Two, ICT and e-learning nevertheless pose challenges for stakeholders. These stakeholders include developers and users of systems. Questions arise about the aptitude, background, skills, approaches and familiarity of stakeholders with ICT and its integration into the science classroom (Molefe, Lemmer and Smit, 2005; Bingimlas, 2009; Blignaut, Els and Howie, 2006). These challenges raise further questions about the actual learning process, and the ability of science teachers and students to adjust to the new paradigm. This chapter therefore focuses, in particular, on the use of e-learning in the science classroom.

Chapter Two (Section 2.5) set the scene by discussing general perceptions and the impact of technology in the classroom. With this background, Section 3.2 discusses various learning theories, namely behaviourism, cognitivism and constructivism, and their respective application within science instruction and learning. Section 3.3 addresses some forms and methodologies of e-learning used in science, while Section 3.4 considers e-learning and technology in the context of the science curriculum. The current position of science teachers, their aptitude, skills, strategies and familiarity with ICT, is addressed in Section 3.5, while Section 3.6 examines certain pitfalls in implementing e-learning in the science classroom. Section 3.7 concludes with a summary of the chapter.

3.2 Learning Theories
Learning is defined by Burns (1995) as a relatively permanent change in behaviour. He attributes these changes both to observable activities and to internal processes. Burns (1995: p.99) considers that ‘Learning might not manifest itself in observable behaviour until sometime after the educational program has taken place’. Learning theories attempt to describe the way people learn, thus facilitating understanding of the complex process of learning. Alessi and Trollip (2001) describe how theories on
the ways people learn, have undergone major changes over the years. Educators should understand the theories of learning that support instruction, and should apply them optimally when using educational technology.

The three main learning theories, also termed learning paradigms, are behaviourism, cognitivism and constructivism (Alessi and Trollip, 2001; de Villiers, 2005a). These are described and compared, so as to understand their approaches and implications for learning.

3.2.1 – Behaviourist Orientation

Behaviourism, one of the earlier psychological theories on learning, was strongly dominant in the 1950s and 1960s and remains influential. This orientation originated from research, initially on animals, by psychologists such as Ivan Pavlov and B.F. Skinner (Alessi and Trollip, 2001). The behaviourist paradigm focuses on learning and behaviour in a scientific way, with three main aspects:

- Focus on observable behaviour,
- Shaping of behaviour by the environment, and
- How the learning process is reinforced by contiguity and reinforcement (Grippin and Peters, 1984).

This philosophy holds the view that everything organisms do, such as thinking and feeling, should be viewed as behaviour (Bargh and Ferguson, 2000; Ormrod, 2004).

Behaviourists maintain that phenomena operate in accordance with natural laws and that changes occur due to cause and effect. This leads to the postulation that people see and experience the world objectively, as an absolute reality, and that students should be led to perceive phenomena in the world in the same way as others. This is relevant, for example, to the laws and principles of physics and chemistry. Consequently, an important aspect of behaviourist learning theory is centred on how environmental stimuli elicit behaviour and responses. In a stimulus-response-reinforcement pattern, good behaviour is rewarded by positive reinforcement or reward, and improper behaviour is followed by negative effects (Alessi and Trollip, 2001). Alessi and Trollip (2001: p.18) argue that ‘repeatedly pairing a neutral stimulus with a natural stimulus... will cause the neutral stimulus also to elicit the
response’. Learning is therefore viewed as a passive process that occurs as an adaptation, or response, to the ‘demands’ of the environment (Jonassen, 1990: p.32). This is particularly the situation in the type of teaching and learning offered by interactive e-learning tutorials, such as those used in the science classroom.

3.2.1.1 Behaviourism in Learning and Application to Science Education

This learning theory is relatively simple to understand because it relies only on observable behaviour and postulates universal laws of behaviour. Its positive and negative reinforcement techniques can be effective both in animals and in the treatment of human psychological issues. Behaviourist theories are often applied by teachers in rewarding or punishing students’ behaviour. The weakness of this paradigm is that students may find themselves in a situation where the expected stimulus for the right response does not occur, and thus they might not respond correctly. The strength is, however, that the student can focus on a specific goal or objective and respond to the appropriate signal to achieve the given goal.

On learning in the scientific disciplines, Smith (1999) cites ‘activity’ as most important among key principles. He argues that learning is better when the student is active rather than passive. ‘Learn by doing’ is important as a guideline, because certain skills are acquired only with frequent practice. Behaviourist learning systems in science education, according to Smith, usually structure the activities by behavioural objectives, and such activities might include: collaborative group projects on a research topic; science experiments on the computer with defined outcomes; or a simple work session on mastering the periodic table. It is possible that children will share computers, which will enhance their interactions with each other.

The behaviourist paradigm is appropriate for instruction in a closed, tightly-defined domain, where questions have a single fixed answer, such as formulas in physics and the structure of chemical molecules.

3.2.2 – Cognitive Orientation
Cognitive psychology can be traced back to Plato and Aristotle. The cognitive revolution became evident in American psychology during the 1950's (Saettler, 1990).
The cognitive paradigm, unlike behaviourism, strongly emphasises non-observable mental constructs, such as the use of mind and memory in ‘human information processing’ (Alessi and Trollip, 2001: p.20). This approach attempts to describe how information enters through the senses and is perceived, encoded and stored in memory. Ideally, it is retained and used. Cognitivism proposes looking at the whole rather than its parts, and at patterns instead of isolated events (Ormrod, 2004). Changes in behaviour do occur, but they are indirect outcomes of learning. This paradigm emphasises the cognitive processes, higher-order thinking skills and mental representations constructed by students when they are actively acquiring information (Lim and Hang, 2003). Cognitivists maintain that attainment comes from the application of critical thinking skills and the understanding of essential concepts.

As a response to behaviourism, the cognitive paradigm postulates that people are different from animals, which simply respond to stimuli or the environment. Instead, humans need active participation to learn, and their actions are a consequence of thinking. Changes in human behaviour indicate what is taking place mentally.

Cognitive learning theory postulates that students collect essential resources to solve problems, and then assemble them in different ways to solve different problems. New knowledge is integrated with prior learning. Cognitive theorists see learning as the ‘acquisition or reorganization of the cognitive structures through which human process and store information’ (Good and Brophy, 1990: p.187).

Proponents of the cognitive paradigm claim that information is initially stored in short-term memory, also called working memory, and must be used or organised and stored more permanently in long-term memory; otherwise it will be forgotten (Alessi and Trollip, 2001). This process involves forming a mental model as a representation of a process, for example, how electricity flows in a circuit. The student learns reasoning processes for the accomplishment of tasks, in consistent and regular ways. A problem that occurs in some educational software designed according to cognitive principles is a lack of student activity and positive reinforcement (Mather and Goldstein, 2001).
3.2.2.1 Cognitivism in Learning and Application to Science Education

There have been major changes in the field of learning since the introduction of the formal field of instructional design. Many instructional designers ‘began to take cognitive principles into consideration’ (Alessi and Trollip, 2001: p.31). A consequence of this paradigm shift was that hybrid instructional approaches emerged, in which application of the cognitive theory of attention and perception, along with a combination of student control and program control, is reflected in certain current screen designs and interactive multimedia. Under the cognitive paradigm attention is also paid to motivational aspects. For Alessi and Trollip (2001), instructional strategies and user control are increasingly based on individual needs and differences, with the aim of fostering students’ comprehension, metacognition and recall.

Paritosh (2004) argues that many students have limited knowledge and much of what they know is implicit learning. He suggests that students learn by inducing from experience, more than by being told. Multimedia technology can assist students in both implicit and explicit modes of learning by the way that graphics, text, audio and video present visual and verbal example and rules, both situated and abstract. The prior knowledge that students bring with them to the learning experience includes informal representations and strategies. This is partial knowledge and unarticulated, so students need to learn representational syntax and semantics, perceptual knowledge, metacognitive skills; all easily presented through technology.

The cognitive paradigm is impacting on the teaching and learning of science. According to Bingimlas (2009), the use of ICT in science education expands the pedagogical resources available to science teachers. He proposes that the ease of Internet access allows teachers to help students become experts in searching for information rather than just receiving facts. This requires structured reasoning and identification of suitable keywords. Bingimlas (2009 p:236) states that the recent development toward teaching about science rather than teaching its content might require a considerable change in its ‘mode of teaching and an enhanced knowledge and understanding in teachers’.
Isman, Yaratan and Caner, 2007 also suggest that when the Internet is used in the learning of science, it can help students to acquire information whenever, wherever, and whatever they want. Furthermore it can help science teachers to design interactive environments or forums where students can be motivated and interact effectively with one another.

In the 1980's, the Cognitive and Technology Group at Vanderbilt University designed an interactive video series based on the cognitive teaching model targeting students from grade five upwards. These videos were designed not only to convey knowledge, but also to engage students in problem solving. The series commenced in the domain of mathematics, but has been expanded to twelve CDs that each present an adventure, concluding with a challenge problem. The embedded teaching approach opens up data and problem-solving models throughout the exploration involved in presenting the challenge problem.

3.2.3 – Constructivist Orientation
Constructivism is a challenge to the cognitive approach (Alessi and Trollip, 2001). Constructivist learning theory postulates that learning is an active and constructive process in which the student is personally a constructor of information. It rejects the approach of treating the student as an empty vessel into which knowledge is poured, and rather recommends that students should actively construct their own representations of reality, and should interpret knowledge instead of accepting an absolute reality as taught in behaviourism (Alessi and Trollip, 2001). The role of the teacher in the constructivist paradigm is that of entering into a discussion with the students, helping them to appreciate the meaning of the material to be learned and refine their understanding. In this situation, the educator is a facilitator rather than an instructor.

Constructivism tends to engage the student in the learning task to a much greater degree, which facilitates a deeper approach to learning and higher-order learning outcomes. Methodologies such as hypermedia, simulation, virtual reality, open-ended learning environments and, in particular, exploration of the Web, benefit students, since they allow students to conduct research and explore information independently, freely, in a non-linear way, and to apply it in their personal learning style (Alessi and
Trollip, 2001). Furthermore, they can use the self-acquired knowledge to personally generate products to demonstrate their learning.

3.2.3.1 Constructivism in Learning and Application to Science Education

Constructivists argue that educators should focus mainly on connecting facts and promoting new understanding in students. They should adapt their strategies to the responses of students and persuade students to analyse, interpret and predict information, sometimes in situations of collaborative work. Teachers should also rely on open-ended questions while promoting broad dialogue among students. Constructivism advocates the eradication of standardised assessments. As an alternative, continuous assessment and independent project work should become part of the holistic learning process and help students evaluate their own progress. The weakness is that in a case where consistency is needed, different thinking and conduct on the part of different students makes assessment complex. The strength is that students should be able to interpret numerous realities and become capable of dealing with real-life situations (Schuman, 1996).

The learning process, according to constructivists, entails ‘setting and negotiating a goal, making plans, doing research, creating materials, evaluating them, and revising’ (Alessi and Trollip, 2001: p.33). Although this was not written specifically in the context of science education, it is highly relevant to it, since science education involves project work undertaken individually or in groups. An important part of constructivist learning involves reflecting on one’s own learning and modifying one’s beliefs. Learning also enhances transfer of knowledge to other settings.

Constructivist learning theory, which entails knowledge construction based on students’ previous knowledge, is appropriate for e-learning (Harman and Koohang, 2005; Koohang, Riley, Smith and Schreurs 2009; Koohang (2009) advanced a model for e-learning environments based on constructivist learning theory. The model includes the design of learning activities; learning assessment; and it also defines the instructor’s roles.

Koohang et al. (2009) present examples of the learner-centred model used by college students to design e-learning assignments and activities. Although these examples are
from the disciplines of Information Technology and Business, they could be
customised and used for other fields of study including science education.

The Internet is a valuable tool in science education. It presents students with
numerous sources of information. At college and university, students have library
resources, but such options are not always available for primary and secondary
schools in regions such as Lesotho where resources are relatively limited. Access to
Internet tools and services can reduce such problems (Isman et al. 2007). Not only
can the Internet increase the variety of resources, it should also make the process of
gathering information faster, and more engaging. This is important for children
whose patience and span of concentration can be limited. Furthermore, resources on
the Internet come in multi-media format, including texts, graphics, videos and audio
materials.

If teachers assign collaborative projects, and require students to work in groups,
different resources can be used by different group members, resulting in a greater
variety in total. Having developed personal areas of expertise, students can share
their skills in a collaborative environment, supporting each other in constructing
knowledge. Work on computers thus allows for the deepening of individual skills, as
well as enhancing group dynamics, and developing communication skills.

Research by Craig and Van Lom (2006) in Louisiana, USA, where students took part
in a simulation game demonstrating the spread of a virus, showed the integration of
constructivist learning theory and technologies, where:

- Students voluntarily engaged with the simulation, and found it to be a
  satisfying and inspiring experience.
- Students were able to test out trial hypotheses within the simulation after
  observing particular behaviours.
- Students collaborated effectively in answering questions about their findings.
- Use of technology assisted the normal interaction between the students and
  increased, rather than replaced, the usual method of communication. Further,
  it provided appreciable support in the learning process.
3.2.4 – Relevance of Learning Theories

Researchers who hold a moderate stance on educational philosophies favour an environment which includes all three paradigms (Alessi and Trollip, 2001: p.11), incorporating behavioural, cognitive and constructivist concepts, as well as hybrids, as appropriate foundations for particular contexts and learning content. This applies not only to educational technology artefacts and e-learning environments, but also to books and other media used as educational components.

3.2.4.1 Convergence of Constructivism and Technology

Each of the three paradigms described in this section has evolved over time (Wang et al. 2006). The philosophical origin of constructivism can be traced back several decades (Larochelle, Bednarz and Garrison, 1998), and was initially applied by educators around the early 1980s. Recently, it has been very actively promoted, due probably to the advent of the Internet and Web, where the open-ended, hyperlinked nature of the environment leads itself to constructivist exploration.

Each paradigm is relevant to particular aspects of today’s changing society and technologies, and is appropriate as a foundation for certain e-learning technologies (Oliver, 1999; Hung, 2001; Hung and Nichani, 2001). When educational technology, integrated into a class situation, is founded on proper learning theory, a synergy is created that enhances learning (Branigan, 2002). If instructional design is carefully planned to include a diversity of instructional methods and various technological tools, it can help both in supporting the learning of processes that are part of the subject matter and in helping students achieve associated outcomes (Ilomäki and Rantanen, 2007; Hohlfield et al. 2010).

In particular, the natural convergence of constructivist learning theory and educational technology, when implemented in an interactive relationship, forms the foundation of a comprehensive reform system (Cicchinelli, 1999). Such educational practice can promote technology and learning theory concurrently and synergistically (Bagley and Hunter, 1992). Using technology in a constructivist way should strengthen the junction of learning theory with methods and knowledge (Trilling and Hood, 1999).
3.2.5 – Summary of Paradigms

Section 3.2 overviews the three major learning paradigms of behaviourism, cognitivism and constructivism. Each has strengths and weaknesses. Some criticisms are:

- Behavioural psychology is criticised for its lack of attention to memory, transfer of learning and motivation (Alessi and Trollip, 2001: p.37).
- Some implementations of the cognitivist paradigm can be criticised for paying inadequate attention to the principle of active learning (Alessi and Trollip, 2001: p.37). Certain cognitivist educational software is dominated by reading, watching demonstrations and listening. The principles of collaboration, communication and transfer, although mentioned by proponents of this philosophy, are not always translated into practice in the learning environments they create.
- Constructivists are criticised for their claims that certain instructivist methodologies, for example, tutorials and drills, are inappropriate (Alessi and Trollip, 2001: p.38).

Despite the limitations of each learning theory, a successful and flexible learning environment should include a combination of e-learning technologies and varied forms of educational software, such as tutorials, hypermedia and Web-based communication, representing all three learning paradigms. Alessi and Trollip (2001: p.11) note that: ‘The majority of learning psychologists, educators, and instructional designers prefer to merge various principles’.

Considering the requirements of each subject area within the discipline of science education, the environmental context, and the learning styles of individual students, the educator should use a suitable combination of available methodologies, selecting from the available educational software and multimedia products.

3.3 E-Learning Forms and Methods used in Science Education

Table 3.1 in Subsection 3.3.1 describes and tabulates some methodologies and forms of e-learning that can be used in science education, while Subsection 3.3.2 focuses on the concept of hypermedia relevant to Table 3.1.
3.3.1 – Appropriate technologies

According to Wellington (2000), the use of technology in science education incorporates the employment of common off-the-shelf software such as word-processing software, spreadsheets, desktop publishing, communication and databases. It also includes the use of simulations and multimedia to support conventional teaching. The first five applications listed by Wellington involve the use of technology as a tool, while products such as drills and multimedia tutorials represent the use of technology as a tutor. Other e-learning applications such as simulations combine the function of tutor and tool. Table 3.1 summarises various technologies, their application in science, and benefits of using them in schools.

<table>
<thead>
<tr>
<th>Educational Technology Tools</th>
<th>Application in Science</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Simulations</td>
<td>Illustrate phenomena, e.g. chemical reactions; assembly of power sources and electric circuits in physics</td>
<td>Motivation, management, cost and time; safety since students do not need to work with dangerous phenomena; simplified learning since users do not have to deal with certain real-world physical and visual manipulations</td>
</tr>
<tr>
<td>Interactive Media/ Hypermedia</td>
<td>Provide interactive tutorials, with speech, audio and video, on CDs or on the Web</td>
<td>Multimedia for multiple means of presentation: diagrams, animations and text without use of consumables for demonstration; networked structure for non-sequential access to material</td>
</tr>
<tr>
<td>Communication/ Searching</td>
<td>Research and searches to access material as needed; topics such as botanical information; biotechnology; mini-organisms; space and the solar system; etc</td>
<td>Comprehensive websites and multimedia CDs with educational material for science; multi-modal: text, images and sound; non-linear access</td>
</tr>
<tr>
<td>Word-processing</td>
<td>Enables the creation and management of textual documents comprising words, numbers and symbols</td>
<td>A tool that allows students and teachers to draft and edit text repeatedly and to collaborate in doing so; facilitates preparation of teaching material and assignments; supports students in producing projects including cooperative learning</td>
</tr>
<tr>
<td>Spreadsheets</td>
<td>Enable repetitive calculations, tables of information; modelling by manipulation of data</td>
<td>Tools that improve student motivation as they independently manipulate parameters; support lesson planning, recording of assessment, and calculations; enhance teachers’ competence and confidence</td>
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</tbody>
</table>

3.3.2 – Hypermedia-based Learning in Science

The teaching and learning of science requires additional formats over and above text. In more affluent societies, science teaching is supported by laboratories, sophisticated equipment, demonstrations, experiments and field trips. In traditionally disadvantaged communities, such facilities seldom exist, but e-learning applications
can help to compensate for this lack. When graphics, animations, audio and video are linked together electronically in a non-sequential way, the technique is often referred to as hypermedia.

Predominantly known because of the Web, hypermedia systems are presented in the form of hyperlinked ‘web pages’. The non-linear forms of information representation in this technology are similar to the knowledge storage and memory structures of human cognition (Alessi and Trollip, 2001).

Research into the use of hypermedia-based learning systems in science (Siorenta and Jimoyiannis, 2008) has led to an understanding of their contribution to the enhancement of teaching and learning. The exposure to multiple unit of information via non-linear hypertext has the potential to increase students’ metacognitive understanding of the learning task (Jacobson, Maouri, Mishra and Kolar, 1996). Likewise, situated learning is ‘one of the most substantial aspect(s) of constructivist thinking’, according to Alessi and Trollip (2001: p.33). In an effective hypermedia learning environment, students are not just readers of the text but are, in effect, more like authors and constructors of content, since they are actively constructing sets of knowledge personally required, by choosing links and associations of their choice in a significant and relevant situation (Alessi and Trollip, 2001). Hypermedia are appropriate in the context of problem-based learning, where students are actively involved and engaged in the learning task, hence facilitating higher-order learning outcomes. This is of great value in science education, where advanced learning requires students to grasp concepts, to apply knowledge and to solve problems independently.

Hypermedia implementations are not limited to the Web. They can also be used as the navigational technique for CD-based multimedia. Although CD-based content lacks the dynamicity and open-endedness of the Web, it nevertheless provides the flexibility of hyperlinked environments for students who do not have Internet connectivity, as in many Lesotho science classrooms.
3.4 Use of e-Learning and Technology in the Science Classrooms

The teaching and learning experience of science can be more effective when e-learning and technology are used to supplement traditional teaching. However, both teachers and students need to be aware of the distractions that can arise in the classroom as a result of using technology. It is important that technology is embedded in sound teaching and learning approaches to ensure the best result can be achieved (Kalinga et al. 2007), i.e., technology should be the medium and not the message (de Villiers, 2005a).

3.4.1 – Theoretical Background

3.4.1.1 Importance of Educational Technology

The use of ICT in schools, particularly in teaching science, has been a subject of much discussion in educational forums. Some studies (Culp, Honey and Mandinach, 2005; Zhou, Brouwer, Nocente and Martin, 2005) have shown that using ICT in schools can enhance teaching and help students to achieve learning outcomes. There is a general misconception regarding the learning of science, that only relatively few individuals can be proficient in science (Hapkiewicz, 1992; Hapkiewicz, 1999). A further misconception is that only males have the ability to become scientists. The truth is that students, regardless of gender, may be daunted by the challenge of abstract thinking (Kalanda and Oliphant, 2009) *(This publication by the author is also in Appendix 12)*. In this technological era, proficiency in science is highly desirable for all learners.

3.4.1.2 Methodologies of Interactive Multimedia

Alessi and Trollip (2001: p.10) review various methodologies of interactive multimedia (IMM) used to facilitate learning, including tutorials, hypermedia, drills, simulations, games, tools, open-ended learning environments, computer-based testing, and Web-based learning. These overlap with the technologies mentioned in Sections 3.3.1 and 3.3.2. Particularly relevant in science education are tutorials, simulations and drills and the use of software packages, such as databases and spreadsheets, as cognitive computing tools. Osborne and Hennessy (2003) suggest that the main forms of ICT relevant to school science activities are tools for data capture, processing and interpretation, multimedia educational software, publishing
and presentation tools, and computer projection technology. Ball (2003) mentions four ways in which e-learning applies to science education, namely as a tool, a reference source, a means of communication and a means of exploration.

Table 3.2 lists some of these forms of e-learning, giving a specific example of each.

<table>
<thead>
<tr>
<th>E-learning Software</th>
<th>Examples and their Functionality</th>
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<tbody>
<tr>
<td>Tutorials</td>
<td>Physics Tutor</td>
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<tr>
<td></td>
<td>Helps with learning physics: tests knowledge of, and ability to apply, concepts from physical science. Covers quantitative and qualitative aspects of physics.</td>
</tr>
<tr>
<td>Simulation</td>
<td>Motion Lab</td>
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<tr>
<td></td>
<td>Designed to allow students to perform lab tests at home or in a non-laboratory environment at school.</td>
</tr>
<tr>
<td>Drill</td>
<td>Spelling Words</td>
</tr>
<tr>
<td></td>
<td>Drill programs are moderately effective in producing cognitive gains.</td>
</tr>
<tr>
<td>Database</td>
<td>Access</td>
</tr>
<tr>
<td></td>
<td>Helps store, access and make sense of data results. Queries can be used to provide summaries</td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>Excel</td>
</tr>
<tr>
<td></td>
<td>Tabulation of data in a matrix; data manipulation, calculations and numerical analysis.</td>
</tr>
<tr>
<td>Presentation</td>
<td>PowerPoint</td>
</tr>
<tr>
<td></td>
<td>Aids in public presentation of findings.</td>
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</tbody>
</table>

Use of e-learning applications such as the above, offers students a bridge between concrete and abstract thinking, allowing them to study, observe and manipulate scientific phenomena and create multiple representations of concepts (La Velle, McFarlane and Brawn, 2003; Osborne and Hennessy, 2003).

3.4.1.3 Examples of E-learning Applications for Science Education

This subsection introduces some of the educational technology systems used in secondary and high school science classrooms. Figure 3.1 shows the versatile Pendulum-lab application developed by the University of Colorado. Pendulum-lab can be accessed at http://phet.colorado.edu/en/simulation/pendulum-lab. It allows for students to conduct physics experiments in advanced topics such as parametric resonances, nonlinear dynamics and chaos.
Technology can help teachers respond to students’ diverse learning styles by creating rich environments that engage students’ perceptual, visual and auditory senses. This application, with one or two pendulums, can be used to discover how the period of a basic pendulum is dependent upon the length of the string, the mass of the pendulum bob, and the amplitude of the swing. It is easy for students to measure the period using a photo-gate timer. One can vary friction and the strength of gravity, and the pendulum can be used to find the value of gravity (g) on plane X.

The second example is the Orbit Simulator, which can be accessed at http://phet.colorado.edu/sims/my-solar-system/my-solar-system_en.html. It helps students build their own system of heavenly bodies, then study the gravitational motion. Students can set initial positions, velocities and the masses of up to four bodies, and observe them orbit as displayed in Figure 3.2. Students can also determine the best fit equation (symbolic representation).
Figure 3.3 shows an example of a chemistry simulation, *Salts and Solubility*, [http://phet.colorado.edu/en/simulation/soluble-salts](http://phet.colorado.edu/en/simulation/soluble-salts) that helps students visualise compounds and determine their chemical formulae by observing ionic ratios in solutions; relating the simulation scale to real laboratory equipment through illustration and calculations; and predicting the chemical formulae of compounds with a variety of ion charge combinations. This technology helps students to manipulate variables, to explore phenomena and design experiments.
3.4.1.4 Computing Tools used by Students

Software packages, such as word processing, calculators, databases and spreadsheet tools, as well as access to the Internet, can enable students in acquiring the higher communication skills and problem-solving abilities that are essential for scientific thinking and the determination of cause and effect (Osborn and Hannessy, 2003). Schools without computers in science classrooms cannot guarantee the completeness and currency of the information used in instruction, because scientific information accumulates daily and much new information can be accessed only through the use of ICT.

The use of technologies in science classrooms can improve students’ comprehension, problem-solving processes, decision-making abilities, and cooperative learning skills (Culp et al., 2005; Zhou et al, 2005; Howie and Blignaut, 2009). Many current curricula now highlight the crucial importance of ICT and motivate educators to use technology in teaching. However, teachers need advanced training to enable them to integrate technology on a cognitive level into their teaching practices (see Section 2.6.1). Even though many educators and certain schools still resist innovation and change (Albirini, 2006; Erixon, 2010), the extent to which ICT has penetrated educational institutions is slowly, but surely, affecting both teachers and students and the way they teach and learn.

3.4.2 Benefits of Technology in and Beyond the Classroom

Osborn and Hannessy (2003: p.19) point out that technology ‘offers the opportunity to dissolve the boundaries that demarcate school science from contemporary science by facilitating access to a wide body of data’. They further suggest that the use of ICT in science classrooms can strengthen procedural knowledge (Osborn and Hannessy, 2003). Procedural knowledge is the expertise of knowing ‘how’ to do something, over and above knowing ‘what’ something is. A result of this kind of knowledge is the ability to transfer it to other situations.

Science, unlike certain other subjects, is often practical and involves real-world activities. Learning in science therefore entails ‘observing, measuring, communicating and discussing; all these aspects should be made attractive and engaging to students’ (Wellington, 2000: p.196). Presentations and activities in the
classroom should hold students’ attention (Ilomäki and Rantanen, 2007). The more that information is practised or used, according to Alessi and Trollip (2001), the better and longer it is remembered.

3.5 Science Teachers and E-Learning

Educators have been using technology in their personal work for considerable periods, for example, word processing in lesson preparation and spreadsheets for lists of marks. However, Little and Williams (2001) point out that the emphasis on ICT in actual teaching and learning of science has placed pressure on teachers to adopt it in their professional practice as well, integrating ICT into pedagogy and subject-teaching. Although most teachers now acknowledge the importance and relevance of e-learning in the teaching of science, researchers investigating teachers’ aptitudes and skills find that they continue to experience difficulties in adopting these technologies and adjusting to the rapid associated changes (Tondeur et al. 2008; Howie and Blignaut, 2009; Erixon, 2010).

The study by Erixon (2010), based on research among Swedish lower-secondary school teachers, notes that they used technology to ‘a relatively limited extent’ but they were ‘ready to develop their use of resources if available’ (p.1212). Tondeur et al. (2008: p.217), on the other hand, report that ‘poor communication between school management and the teachers’ in 53 primary schools in Belgium was a cause of inadequate development of a shared vision for ICT application in the classroom.

A study by Howie and Blignaut (2009) in South-African Grade 8 mathematics and science classes found that most schools were still in the infancy stages of ICT integration. Only 46% of mathematics and science teachers responded to the question whether they used ICT

a) once a week or more,

b) extensively during a limited period during the year, or

c) none of these.

Of these, some 16% of science teachers reported using ICT in teaching and learning activities. For integration of ICT into mathematics classrooms, the percentage was
even lower. Five percent (5%) of mathematics teachers reported using ICT once a week and 7% reported using it intensively during limited periods; while some 34% of the science teachers were not using ICT at all.

In many countries, e-learning has been part of the curriculum for little more than a decade. It is therefore understandable that teachers who qualified earlier, would have received little appropriate training and have yet to come to grips with teaching science using technology. Windschitl (2009) in his recommendations for the design of sustainable teacher preparation and professional development models in Washington, USA, identifies four sets of skills and strategies to categorise the proficiency of teachers and student teachers who are responsible for guiding young science students in schools. He argues that students and teachers should be able to:

- Understand, use, and interpret scientific explanations of the natural world
- Generate and evaluate scientific evidence and explanations
- Understand the nature and development of scientific knowledge, and
- Participate productively in scientific practices and discourse.

Windschitl further suggests that these skills and strategies should be applied in classroom activities such as content-rich inquiries and the application of scientific theory to solve real-world problems. These strategies might improve the teaching and learning of science in terms of developing scientific skills and aptitudes, as outlined in this section and summarised in Table 3.3. Most of these skills can be supported by ICT tools.
Table 3.3: Summary of Skills and Strategies required in Science (synthesised by the author)

<table>
<thead>
<tr>
<th>Skill</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observing</td>
<td>An essential skill in which students acquire information using all their senses.</td>
</tr>
<tr>
<td>Measuring</td>
<td>Concerned with comparisons conducted by reading temperatures, sizes, areas and volumes.</td>
</tr>
<tr>
<td>Communicating</td>
<td>The ability to clearly transmit a message on what has been discovered or observed using some medium (e.g. writing, speaking or drawing).</td>
</tr>
<tr>
<td>Experimenting</td>
<td>Students often experiment through trial and error. To experiment means to test by realistic investigation in a controlled fashion.</td>
</tr>
<tr>
<td>Classifying</td>
<td>Students need to recognise, sort and arrange things according to their similarities and differences.</td>
</tr>
<tr>
<td>Interpreting data</td>
<td>The ability to comprehend and interpret information collected by the student.</td>
</tr>
<tr>
<td>Making hypotheses</td>
<td>A hypothesis is a ‘conjecture’ attempting to explain a particular event, observation or a relationship, and is not a statement of fact.</td>
</tr>
<tr>
<td>Predicting</td>
<td>A deduction from the result of a reliable investigation based on regular information observed and measured.</td>
</tr>
<tr>
<td>Controlling/manipulating variables</td>
<td>To carefully control conditions that may provide a reasonable test and give credible results.</td>
</tr>
</tbody>
</table>

In the past decade, other research into learning in science (Osborn and Hannessy, 2003; Zain et al., 2004; Tondeur et al. 2008) has focused on the role of teachers. Findings show that there is frequently a problem linked to the teachers’ own lack of confidence in teaching science and their lack of fundamental scientific knowledge. Other studies established that, in some areas, the content level of the science curriculum has not been appropriate. For example, Murphy, Penuel, Means, Korbak and Whaley (2001) show that some third-level students, when doing tests designed for a lower level, were unable to correctly answer questions on certain topics.

Ponchaud (2001) indicates that a contributing factor to problems in science teaching is the fact that science teachers must prepare students for tests and ensure they are able to recall the required content knowledge. Teachers’ inaccurate use of scientific terminology and their over-emphasis on students studying to pass tests and exams at the expense of conceptual development, is further evidence of their personal lack of understanding of scientific phenomena. It also highlights their lack of preparedness for the next stage, namely the integration of e-learning in schools. In a meta-study Harlen (1997) summarises the most important findings from international studies and concludes that many of the difficulties experienced by students are related to unsatisfactory explanations provided by their teachers.
The discussion in this section shows that teachers should be properly prepared and able to help students to develop the skills described in Table 3.3. For teachers and students to successfully integrate ICT into their science teaching and learning respectively, both groups should be mentally prepared for the transformation and be adequately computer literate.

Finally, to determine whether the use of technology is effective, educators should be clear about the outcome they seek, how to measure success and how to define effectiveness. Painter (2001: p.22) poses the question: ‘What observable behaviours will indicate that technology integration is successful in this setting?’.

3.6 Pitfalls in Implementing E-Learning Technologies in Science

Section 2.3.1 in this study addressed barriers to the general use of ICT in schools; this subsection mentions particular problems in the use of ICT and e-learning in science education. There are many factors that limit the implementation of technology, especially in rural schools (Means, Penuel and Padilla, 2001: p.197), as discussed in Section 2.6. Researchers consider the various barriers to ICT integration in science classrooms (Schifter, 2002; Moser, 2007; Erixon, 2010) and argue that it is difficult to isolate and measure the effectiveness of technology use in schools.

In the general context – in science education and beyond – there are factors that contribute to the failure of technological reform in education and to the effective use of computers in schools (Kara and Kahraman, 2008). Erixon (2010) for example, notes that insufficient access to computers is one of the main contributing factors to low use of ICT in teaching. By contrast, Kara and Kahraman (2008 p:1068) suggest that because certain privileged children access so much information via visual sources like computers and televisions, it might be difficult to teach them by traditional methods. This, however, does not apply to the Lesotho situation.

3.7 Conclusion

This chapter, mainly a literature overview like the preceding chapter, discussed fundamental philosophies and theories of formal learning and applied them to
technologically-aided teaching and learning. The three main current theoretical categories: behaviourism, cognitive theory and constructivism, were considered.

The chapter also addressed general e-learning forms and methodologies used in science education, as well as e-learning and technology specifically within the science curriculum. The current position of science teachers, their aptitude, skills, strategies and familiarity with ICT was also noted. Finally, the chapter mentioned certain pitfalls in implementing e-learning in the science classroom.

This discussion leads to Chapter Four which set out the research design of this study and explains investigation of issues discussed in the literature review chapters, Chapters Two and Three.
Chapter Four ~ Research Design and Methodology

4.1 Introduction
The main purpose of this study is to investigate the progress of ICT integration in Lesotho schools and to determine how e-learning can be supported and improved. Attention is paid to the professional development and attitudes of teachers, as well as to aspects hindering sound technological environments and innovative change. The focus is on secondary and high schools and the application domain of the study is the science classroom. Science education was chosen as the domain due to the researcher’s belief that the science classroom should be at the forefront of technology.

The researcher also takes note of the literature which cautions that the mere provision of ICT to schools does not necessarily improve teaching and learning, but that the outcome depends on the way in which environments are prepared in terms of human factors as well as technological infrastructure.

In this chapter, Section 4.2 reviews the research questions, together with references to research tools employed to address them. In Section 4.3, the Action Research approach and rationale are set out, while the quantitative and qualitative methods used are described in Section 4.4. Section 4.5 presents the variant of action research used as the underlying research design, along with a customised diagram of its phases. The six studies that comprise the research are outlined in Section 4.6. Section 4.7 presents evaluation criteria obtained from the literature on ICT integration. These criteria articulate issues related to the research questions and are used to formulate the questions and evaluation statements for the research instruments. In Section 4.8 data collection and instrumentation are discussed. Section 4.9 explains the data analysis, while Section 4.10 mentions the triangulation of approaches. The issues of reliability and validation are briefly addressed in Section 4.11 and a conclusion is drawn to summarise the chapter in Section 4.12.
4.2 Research Question and Supporting Research Questions

The research questions were briefly presented in Section 1.6. The Main Research Question is:

How can effective e-learning and integration of ICT be supported in the science classroom in Lesotho secondary and high schools?

Table 4.1 presents the supporting research questions and indicates the research tools employed in answering them and the sections where the questions are addressed. As explained in Section 4.1, evaluation criteria to assess the situations, activities, attitudes, etc, were extracted from the literature of Chapters Two and Three and are presented in Section 4.7. The criteria were converted into questions and evaluation statements for the research tools generated, which are given in respective appendices. Chapters Two and Three thus impact on all the questions, and are not included in the last column of Table 4.1, since they are implicitly part of the answer to each subquestion.

Table 4.1: Supporting Research Questions

<table>
<thead>
<tr>
<th>Supporting Research Questions</th>
<th>Research Tools Employed</th>
<th>Sections contributing to the answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Questionnaire</td>
<td>Interviews</td>
</tr>
<tr>
<td>1. What are barriers/obstacles to the integration of ICT in Lesotho secondary and high schools?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. What familiarity, aptitude, skills and strategies do Lesotho secondary school science teachers and students have with the use of ICT?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3. What advantages/disadvantages do science teachers and students perceive when integrating e-learning with established classroom practice?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4. What preparations are required for the instruction of e-learning and how should infrastructural issues be addressed?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5. What guidelines do educators need when using ICT in the science classrooms?</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
4.3 Action Research Approach and Rationale

4.3.1 – Introduction

This study is based on a variant of Action Research (AR) as its underlying research design. As a pioneer of action research, Corey (1953: p.6) notes ‘We are convinced that the disposition to study ... the consequences of our own teaching, is more likely to change and improve our practices than is reading about what someone else has discovered of his teaching’. He believes the value of action research lies more in the change that occurs in localised everyday practice, rather than in generalization to a broader audience.

The AR concept originates from Kurt Lewin’s work on the dynamics of social change in action-based social psychology (Baskerville, 1999; Cohen, Manion and Morrison, 2000). The approach is based on the belief that complex real-world events cannot be investigated under laboratory conditions (Wood-Harper, 1985; du Poy and Gitlin, 1998). AR involves relatively small-scale interventions into the functioning of the real world and a close examination of their impact. Its participative, practitioner/researcher approach is relevant to educational research, where an evolving intervention or product is investigated over several cycles (de Villiers, 2005b; Herington and Weaven, 2008).

AR is appropriate when specific knowledge is required for a specific problem in a specific situation (Cohen, Manion and Morrison, 2005). This research design also supports the ethos of the practitioner/researcher, thus recognising that educational research is best when conducted by educators themselves, who, as experts in educational practice, are the most capable of understanding and improving their work. AR is participative, cyclic, reflective and qualitative (Baskerville, 1999; Herington and Weaven, 2008). The role of theory can be a key aspect. During early stages of the research, researchers draw on existing theory as a foundation on which to plan and take action (Baskerville and Pries-Heje, 1999). Following the evaluation of the outcome of each cycle and associated reflection, this theoretical framework may be reinforced, modified or withdrawn, to reflect the reality of action-taking.
However, not all researchers stress the role of theory as a primary aim in AR. For example, Hmelo-Silver and Barrows (2006) emphasises that its prime purpose is the examination of a real-world problem rather than proof of theory. As already mentioned, Corey (1953) also stresses the value of AR in everyday practice in a specific situation. This is the approach of the present study, as elaborated in Section 4.5.1, where the research design and approaches are presented in detail.

4.3.2 – Appropriateness of Action Research for this Study
Participation in action research projects influences thinking skills, a sense of efficacy, willingness to share and communicate and attitudes toward the process of change. Through action research, teachers and researchers gain confidence; learn about themselves, their students and their colleagues; and can determine ways to continually improve practice in a particular situation. AR is often seen as a tool for professional development, bringing a greater focus on the teacher than before (Noffke and Stevenson, 1995). According to Chee (2009), it is an approach to scholarly inquiry that can contribute to empowerment of teachers and students. Furthermore, action research methodology is used to bring about an improvement in problematic situations (Cohen, Manion and Morrison, 2005).

All of these viewpoints are relevant to the context and complexities of the Lesotho e-learning situation and confirm the adoption of AR as an appropriate research design for examining the longitudinal integration of ICT in the Lesotho science classroom.

Cohen, Manion and Morrison (2005) offer a model of the action research sequence:

1. Identify and formulate problem.
2. Discuss and negotiate with interested parties.
3. Review literature.
4. Modify or redefine initial problem, as necessary.
5. Select research procedures and methods.
7. Implement project and evaluate over required time period.
8. Interpret the data obtained.
De Villiers (2005b) similarly stresses the iterative and reflective nature of action research and presents an overview model of the process, depicted in Figure 4.1 as a series of cycles which close in as a solution is reached. Zuber-Skerritt’s (1996) sub-processes of plan, act, observe and reflect, characterise the phases of each cycle. In classic action research, evaluation studies are conducted in each cycle, followed by responsive developments and interventions, which lead to the next cycle of actions and evaluation. The researcher continuously holds a central participative role, as shown in Figure 4.1.

![Figure 4.1: De Villiers’ Action Research Model (2005b)](image)

This chapter focuses on the variant of action research used as the research design of this study, with reference to its phases; the research paradigm and methodology; the selection of sites and samples of participants; data collection and analysis methods used to answer the research questions; and the role of the researcher.

### 4.4 Qualitative and Quantitative Methods in Action Research

The methodology used for this study is a multi-technique investigation into ICT practices in the Lesotho secondary and high school science classroom. Quantitative and qualitative research methods (Marra, 2006; Creswell, 2009) are used to evaluate evolving ICT interventions and developments. The quantitative research is a structured investigation into quantitative phenomena, including a process of classifying and counting participants’ responses and tallying resources and activities in the nine schools selected as a representative purposive sample of schools. The qualitative research was conducted in natural settings, with the author observing,
conversing, and interviewing; gathering words and pictures for analysis and constructing a holistic representation of the situation.

Educational technology research in Lesotho secondary education faces challenges (Sections 1.2.1 and 1.4.1) due to the varied cultural backgrounds of schools; differing levels of ICT integration; geographic locations; survey participants; and differences between educational backgrounds of the research participants, including the teachers. This study employs a mixed-methods, combining qualitative and, to a lesser degree, quantitative approaches (Creswell, 2009), which help address the research questions and determine means of overcoming some of the challenges. The qualitative approach is interpretive (Carroll and Swatman, 2000; Denzin, 2001; de Villiers, 2005b) and takes place in a naturalistic world, appropriate for this study, which seeks to describe the topic holistically, in detail and contextually. The ethos of action research, such as for this study, is in line with de Villiers (2005b: p.15), namely ‘interpretivist, incorporating social enquiry based on the views and interpretations of the participants, all regarded as equals, making it an emancipatory process, while also incorporating the researcher as participant’. De Villiers further suggests that ‘though action research employs or integrates methods from both the experimental and naturalistic (interpretivist) traditions, it is consistent with naturalistic inquiry in that all research occurs within its natural context’. In the case of this study, the natural environment is the secondary and high school classroom.

De Villiers (2005b: p.13) finds the integration of qualitative and quantitative approaches ‘not mutually exclusive’ but rather effective and ‘complementary’, a finding supported by other researchers. This study uses both approaches to gather accounts of different realities, constructed by various groups and individuals in the learning environments where the study took place, such as principals, teachers and students. Figure 4.2 summarises the overall research approach of the study.
A qualitative methodology is suitable, because of its broad approach toward understanding and explaining the meaning of social phenomena in naturalistic settings (Merriam, 1998; Marshall and Rossman, 1999). For Erickson (1998: p.1155), qualitative information is particularly appropriate when researchers require ‘detailed information about implementation ... or to identify and understand change over time’. This is the case in the present research, which studies the implementation of ICT integration into science teaching and learning, and investigates situational change and progress over four years.

The qualitative data was collected using different types of tools (Section 5.9.3). Erickson (1998) mentions qualitative data collection methods such as: observed behaviours; field notes describing observation of lessons; face-to-face interviews with principals, teachers and students; detailed interpretations of situations; students and teachers’ interactions; as well as accounts of and quotations from stakeholders’ experiences, thoughts, beliefs, attitudes (in some cases), and recorded documentation. In this research, the qualitative data collection methods were: field
notes of observations of ICT-based lessons, face-to-face interviews with principals, teachers and students, and certain qualitative questions in questionnaire surveys.

Qualitative research shares the theoretical postulation of the interpretative paradigm, namely that social reality is created and maintained through the subjective experience of people involved in communication (Morgan, 1980). This study strives to describe and interpret the meanings of phenomena (Section 6.4) that occur in social-educational contexts.

Quantitative research entails counting and measuring events and making statistical analyses of numerical data (Smith, 1988). In this research, quantitative Likert-type scale data was obtained from a major questionnaire survey conducted among teachers as part of the Main Study. This data was analysed by means of frequency counts and small-scale statistical analysis. A concern of the quantitative paradigm is that measurements should be reliable, valid and can be generalised (Cassell and Symon, 1994). In the present study the data was validated by triangulating data collection methods and data sources.

4.5 Research Design of this Study

This section describes the variant of action research employed in this study and its distinct phases. For each phase, the selection of a sample of schools and participants for that phase is presented in detail in Section 4.6.

4.5.1 – Variant of Action Research

Based on the interpretive nature of the study, it was appropriate to use action research (AR) and case studies, as these are mainly qualitative in nature. For Zuber-Skerritt (1996) and de Villiers (2005b), the cyclical nature of action research supports the review of each action or interaction in this study. This, in turn, informs the planning of the next cycle. AR is frequently conducted by a practitioner in the role of researcher which is acceptable, provided the researcher’s own perceptions and assumptions are clearly identified.
The variant of action research used in this study is relevant to complex real-world problems; where there are many variables and where understanding is sought of the actual phenomena and actions for improvement rather than proof of theory as proposed by Baskerville and Pries-Heje (1999). For Corey (1953) and Hmelo-Silver (2006), action research emphasises examination by the researcher of a particular problem existing in practice. This was the case in the present study.

The AR phases of the present study relate to interventions and research conducted over a period of just over four years, comprising five interventions and six research studies. For each study, site selection involved choosing a representative set of schools, some of which were investigated in more than one study. At each school, a sample of volunteers served as a set of appropriate human participants. The studies and their participants are briefly described in Subsections 4.6.1 to 4.6.6.

The six studies compositely form a variant of Action Research, portrayed in Figure 4.3. The diagram shows the studies and interventions and indicates how the research differs from the classic action research approach. The main difference between the variant of AR in the present study (Fig 4.3) and more conventional classic AR (Fig 4.1) is that some of the six studies in the present research are not similar, nor even closely related. In the classic approach, the outcome of each study leads to reflection and associated changes to the interventions, which result directly from the findings of the previous study. In the present research, however, most of the interventions are external and would have occurred regardless of the findings of the researcher.

Action research is sometimes conducted cycle after cycle in the same sample or community, whereas in other cases the exact composition of the sample changes from study to study. This research is of the latter sort. Not only did the learners and teacher vary over the studies, but the schools in the studies also changed, in that some schools were used in several studies and others in only two or three.

However, this research complies with the AR model in terms of the participative and central role of the researcher. It also complies in that certain studies were closely related. For example, the Pilot Study influenced the methods and instruments of the Main Study, although the findings of the pilot did not lead to any new interventions.
Figure 4.3: Variant of Action Research

- The blue circles in Figure 4.3 represent the six studies in six phases respectively. The size of a circle indicates the scale of the study.
- The blocks with red print represent the five interventions.
This study is termed a variant of action research in that most of the interventions were not directly controlled by the author. The first occurred in the early years of the 21st Century when the Lesotho Ministry of Education started installing computers in schools (Intervention 1). The main interventions were the three projects, namely SchoolNet Project (Intervention 2), Microsoft STIC Project (Intervention 4a) and Intel NEPAD E-School Project (Intervention 4b), outlined in Sections 1.3.1, 1.3.2 and 1.3.3 respectively. Although closely informed on the three projects and, in some cases, involved as a facilitator, the author did not initiate or establish these interventions. The only intervention he initiated was the Orientation Intervention (Intervention 3), to provide additional supportive training to teachers who were unfamiliar with the newly-installed ICT equipment in their schools.

The interventions and studies are also set in Table 4.2 below.
### Table 4.2: E-Learning Implementation and Integration in Science Classrooms

<table>
<thead>
<tr>
<th>Year</th>
<th>Event / Intervention</th>
<th>Research Study</th>
<th>Aims</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990s</td>
<td>Distribution of computers in selected schools</td>
<td></td>
<td>Attempt at integrating ICT in education</td>
<td>5.4</td>
</tr>
<tr>
<td>2006–2007</td>
<td>Advent of SchoolNet Project</td>
<td><strong>Study 1:</strong> Baseline Study (2007)</td>
<td>To look at the current extent of e-learning integration in Lesotho</td>
<td>5.3, 5.4</td>
</tr>
<tr>
<td>2007</td>
<td>Orientation by Researcher</td>
<td><strong>Study 2:</strong> Post-orientation Study</td>
<td>To help teachers in learning and using ICT in classrooms</td>
<td>5.5.1</td>
</tr>
<tr>
<td>2008</td>
<td>Microsoft and Intel NEPAD E-School initiatives</td>
<td><strong>Study 3:</strong> Comparative Study in South Africa and Lesotho</td>
<td>To examine computer use and e-learning in science classrooms in two different situations</td>
<td>5.6</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td><strong>Study 4:</strong> Pilot Study</td>
<td>To test methodologies and techniques for the Main Study</td>
<td>5.9</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td><strong>Study 5:</strong> Main Study</td>
<td>To investigate progress of e-learning, barriers to ICT integration, attitudes, etc. in the Lesotho high school science classroom after 5 years of ICT integration.</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Study 6:</strong> Showcase Study: representing successes in 2009 and 2010</td>
<td>To overview two successful, award-winning cases of ICT integration in Lesotho schools</td>
<td>6.5</td>
</tr>
</tbody>
</table>

#### 4.5.2 – The benefits of this research

Action research assists in practical problem solving and expands scientific knowledge. In this study, the knowledge as explained in Section 4.3 and insights gained from evaluation in the various studies (Section 4.6) and subsequent reflection, will be of direct benefit to the real-world situation in Lesotho. It should also be transferable to other education milieus in Africa.

The research conducted was collaborative and participative. It was planned by the author with participating principals, teachers and students of the participating schools, collecting data as feedback in iterative cyclical processes aimed at increased understanding of the situation. Each study had its own cycle, involving the
stakeholders in searching for appropriate technological solutions to benefit day-to-day activities. Synergistically, these solutions contribute to the integration of technology in teaching and learning of science in Lesotho in general, thus helping to overcome obstacles see Sections 2.3.1 and 2.6.1 to 2.6.4.

Within each study, the processes of planning, action taking, fact gathering, observation, evaluation, diagnosis, reflection and response, were used, not explicitly to inform the next phase as in classic AR, but in the context of independent studies. But in some cases, such as when teachers were surveyed and interviewed in the Pilot Study, needs were diagnosed that influenced the planning of the next stage, i.e. the Main Study that followed. Results were evaluated as data was gathered, and these results were used to generate additional questions for interviews and questionnaires in the Main Study (See Appendices 5, 6 and 7).

4.5.3 – Role of Author

Wiersma, (2000) argues that to understand behaviour, the researcher (observer) should understand the context in which participants are thinking and reacting. the author is a lecturer at the Lesotho College of Education and is experienced in working with teachers and students. He is also closely involved with the implementation of STIC and PiL as explained in Section 1.3.2 and 5.7.1 and is therefore a practitioner-researcher as described in Section 4.5.1. He understands the process of learning as it occurs, and is able to depict and interpret the phenomena that emerged as findings.

As depicted in Figure 4.1, the author, in this case, plays a central and participative role in action research. He served as a participant-observer in each of the six studies that comprise this research, he interacted with students as they undertook learning experiences, and worked collaboratively with teachers in interviews and questionnaire surveys. The author conducted research, but also served as a facilitator. For example, during the orientation sessions, the author worked with teachers on integrating technology into their subjects and advised them on ways of using technology as a tool for teaching science at secondary and high school levels.
4.6 The Six Studies

The variant of Action research is suitable as a design for this research study for the following reasons:

- It addresses a real-world problem
- Its longitudinal nature lends itself to an investigation over a period of time, of the progress of ICT integration in the Lesotho secondary and high school science classroom
- There is a series of studies, culminating in the Main Study.
- The researcher holds a key participative role in the studies and in one of the interventions.

This section introduces the six studies completed as part of the variant of action research design depicted in Figure 4.3 and Table 4.2. The descriptions also outline the preceding interventions; research methods used in each study; and the sample of schools and/or participants. In general, the schools selected for these studies were chosen because they were part of one or more of the three projects introduced in Section 1.3. Participating teachers were identified through a call-for-volunteers among science teachers in those schools, in line with the decision to focus this research in the domain of ICT within science teaching and learning. The studies are: Baseline Study, Post-orientation Study, Comparative Study, Pilot Study, Main Study and Showcase, respectively. In reading the sections that follow, the reader should view Figure 4.3 and Table 4.2, which summarise the research.

4.6.1 – Study I: The Baseline Study

During 2004 and 2005 the Lesotho Government commenced the provision of computers to schools, but with little training or orientation. This is termed Intervention 1. The Baseline Study was conducted at the end of 2006 and beginning of 2007 to set the context at the commencement of this research. Information was acquired regarding the then ICT situation in nine representative Lesotho schools. The study was undertaken shortly after an intervention in the form of the SchoolNet Project, namely Intervention 2, in certain Lesotho schools. Apart from the six schools in which SchoolNet was operating, three government schools were included in this initial overview, as shown in Table 4.3, which summarises the Baseline Study. The
research methods involved visits to the schools to ascertain the situation by observation and interviews. In addition, statistics and totals were gathered at the schools, and further data was obtained from SchoolNet and the Lesotho Ministry of Education (Isaacs, 2007). The findings of the study are presented in Section 5.4, with details of the nine schools and their geographical distribution in Table 5.3.

**Table 4.3: Baseline Study**

<table>
<thead>
<tr>
<th>2006-2007</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Schools</td>
<td>Voluntary</td>
<td>Four rural and five urban schools.</td>
</tr>
<tr>
<td>143 teachers and 5136 students</td>
<td>Voluntary</td>
<td>1,273 students from rural schools and 3,863 from urban schools.</td>
</tr>
<tr>
<td><strong>Data Collection Methods</strong></td>
<td>Observations and interviews</td>
<td>12 students interviewed in rural schools and 15 in urban schools. Two observations were made per school. 18 teachers interviewed.</td>
</tr>
</tbody>
</table>

**4.6.2 – Study 2: Post-orientation Study**

The contextual overview undertaken in the Baseline Study indicated serious deficiencies. Although computing hardware and software were in place, they were used ineffectively or hardly at all. As stated in Section 5.5.1, no training had been organized for the teachers or principals and the software donated had not been made available for teachers to study or try out hands-on. As a result there was under-utilization of these resources. The author personally conducted an intervention, Intervention 3 in the form of training and orientation sessions at six SchoolNet Project schools, to create further awareness among teachers and to start a Post-orientation Study to evaluate the impact of the sessions conducted. The other three schools included in the Baseline Study decided not to participate further because the Post-orientation Study coincided with their students’ examinations period.

Following this orientation intervention, the Post-orientation Study was conducted in early 2007 at the six schools where the training sessions had been held. Table 4.4 sets out the research methods and the status of schools involved in the study, and the selection of participating teachers and students. The study is described in detail in Section 5.5.2 where a further table, Table 5.8 lists the nature and distribution of the participating schools.
Table 4.4: Post-orientation Study

<table>
<thead>
<tr>
<th>2007</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>6 Schools</td>
<td>Voluntarily, after a request from author</td>
</tr>
<tr>
<td></td>
<td>103 teachers 3,791 students</td>
<td>Voluntarily, after author’s request</td>
</tr>
<tr>
<td>Data Collection Methods</td>
<td>Observations and Interviews</td>
<td>Two students were interviewed in rural schools and five in urban schools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Two observations made per school</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nine teachers and seven students took part in interviews</td>
</tr>
</tbody>
</table>

### 4.6.3 – Study 3: Comparative Study

This study took place in 2008 and involved a comparison of ICT integration and application in secondary school science classrooms in the Kingdom of Lesotho and the Republic of South Africa. The study involved 21 teachers from four secondary and high schools, two in each country. The author examined cases of computer use and e-learning in science classrooms in these two countries. Of the 21 teachers, fourteen were from Lesotho and seven from South Africa. Data collection involved observation sessions (See example in Appendix 8), questionnaires and interviews. South African schools with well established e-learning programmes were compared with the Lesotho situation to establish precedents.

Two schools in each country were selected after positive responses to the author’s request. All twenty one science teachers participated in the survey and five from each country were interviewed. Students also participated in interviews. The findings are portrayed in detail in Section 5.6, while Tables 4.5 and 5.11 depict the profile of the participating schools in the Comparative Study. Table 4.5 describes the nature and distribution of the participating schools in the Comparative Study.
## Table 4.5: Comparative Study of South African and Lesotho Schools

<table>
<thead>
<tr>
<th>Participants</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Schools</td>
<td>By invitation to schools of good practice in the two countries. Voluntarily, in response to the invitations.</td>
<td>2 Lesotho schools, 2 South African state schools</td>
</tr>
<tr>
<td>21 teachers: 14 from Lesotho and 7 from SA</td>
<td>Volunteering science teachers in the selected schools.</td>
<td>All schools are located semi-urban or in a city.</td>
</tr>
<tr>
<td>2,834 Students: 1,204 from Lesotho and 1,630 from SA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Data Collection Methods

| Observation, teachers and students’ interviews, and questionnaires | There were two observations in each school; five teachers interviewed in each country; and all teachers participated in the survey questionnaire. Three students were interviewed. |

After the Comparative Study and before the Pilot Study, Microsoft (Intervention 4a) and Intel NEPAD e-School (Intervention 4b) intervened with the two projects to help train the teachers and provide ICT integration solutions as indicated in Section 4.5.1 and demonstrated in Figure 4.3.

### 4.6.4 – Study 4: Pilot Study

For all evaluative research, two major decisions must be made. The first is the choice of research methods and the second relates to the determination of evaluation criteria. In this research, evaluation criteria were required for the Main Study to answer the research questions in Table 1.4. A comprehensive framework of categories and criteria was synthesized by the author, based on the range of literature studied in Chapters Two and Three. The framework is given in Table 4.9 in Section 4.7, and mapping of the criteria in the framework to evaluation statements is shown in Appendix 1.

Before the Main Study could be conducted, a Pilot Study needed to be undertaken to test the research methods and the criteria, and refine them for the Main Study. A further purpose of this Pilot Study was to obtain some preliminary data, as described in Section 5.9.

The research methods included visits to three schools, to observe the situation in classrooms and undertake interviews. Further data was obtained from a questionnaire survey administered to teachers. The details of this Pilot Study are presented in Section 5.9 and details of the three schools, their nature and distribution, are listed in
Table 5.15. Tables 4.6 and 5.11 illustrate the status of schools in the Pilot Study, where nine science teachers and three students were interviewed. Two principals were available for interviews. Teachers also participated in the survey and completed the questionnaire (Appendix 7). The schools selected for the Pilot Study were chosen because they were part of one, or more, of the three active educational partnerships operating in Lesotho.

### Table 4.6: Pilot Study

<table>
<thead>
<tr>
<th>Participants 2009</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Schools</td>
<td>Taken from three project schools.</td>
<td>One school per project</td>
</tr>
<tr>
<td>Two principals, nine teachers and three students interviewed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Teachers with significant ICT professional development training programmes from the three projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Teachers who were using ICT in their classroom teaching.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Science teachers who volunteered to participate.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A total of 3 teachers per school were selected:
- 3 from Microsoft
- 3 from a NEPAD e-school
- 3 from the SchoolNet project.

| Data Collection Methods | Observations, interviews and questionnaires | All 9 teachers and three students were interviewed, each interview lasting 20 to 30 minutes. Two principals were also interviewed. Two observations were conducted per school. A questionnaire was distributed to all nine teachers, (Appendix 7). |

#### 4.6.5 – Study 5: Main Study

The data collection and analysis approaches used in the Main Study were similar to those in the Pilot Study. The categories and criteria obtained from the literature (see Table 4.9) to form the basis of surveys among teachers and students were restructured and adjusted for the Main Study in the light of the researcher’s experiences and findings in the Pilot Study.

The Main Study was an extensive in-depth investigation of the state of ICT integration in the science classroom. The nine participating schools were co-educational secondary and high schools with mixed gender classes. Each school had at least a computer laboratory, an intranet, Internet, and CD-based interactive subject software. Two of the schools also had at least one classroom equipped with computers. Although at present, the main subject-based e-learning and ICT ventures occur in science classes, the ultimate intention is that ICT will be used in curricula across the board in these schools.
The author personally conducted interviews with eighteen science teachers. Following these, in November 2010, a questionnaire survey was distributed to all 21 science teachers from the nine schools and one or two observations were conducted in each school.

The Main Study is presented in detail in Section 6.2 where Table 6.3 presents the structure and allocation of the participating schools. Table 4.7 presents details of participants and data collection methods.

<table>
<thead>
<tr>
<th>2010</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participants</strong></td>
<td>9 Schools</td>
<td>Schools from the three projects.</td>
</tr>
<tr>
<td></td>
<td>Two principals</td>
<td>Teachers who had undertaken significant ICT professional development training programmes from the three projects</td>
</tr>
<tr>
<td></td>
<td>21 teachers</td>
<td>Teachers using ICT in classroom teaching.</td>
</tr>
<tr>
<td></td>
<td>17 students</td>
<td>Science teachers who volunteered to participate.</td>
</tr>
<tr>
<td><strong>Data Collection Method</strong></td>
<td>Questionnaires, Observations and Interviews</td>
<td>A total of 14 observations, with one or two per school. 17 students and two principals were interviewed two or three per school. 21 teachers answered the survey questions. Two teachers per school were interviewed. A total of eighteen interviewed.</td>
</tr>
</tbody>
</table>

4.6.6 – Study 6: Showcase Study

Two Lesotho teachers were top performers who won international awards in 2009 and 2010 respectively. Along with other Lesotho teachers, they took part in the local Innovative Teachers Forum (ITF) and won awards, moving up to the Pan-African Innovative Teachers Forum, and finally reaching the Global Forums in Brazil (2009) and Cape Town (2010) respectively. Their success stories have been selected to comprise the so-called ‘Showcase Study’ in Section 6.5.

Table 4.8 shows the nature of the data collected regarding these success stories.
Table 4.8: Showcase Study

<table>
<thead>
<tr>
<th>2009-2010</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>2 Schools Schools that participated in the Innovative Teachers Forums (ITF).</td>
<td>Both schools are situated in an urban area (Maseru)</td>
</tr>
<tr>
<td></td>
<td>2 teachers Winners of ITF award.</td>
<td></td>
</tr>
<tr>
<td>Data Collection Methods</td>
<td>Observations and Interviews Two students were interviewed and a total of two observations made per school. The observations indicated that students of these teachers were more motivated and interacted well with the software they were using; especially in science subjects. The two high-performing teachers were interviewed.</td>
<td></td>
</tr>
</tbody>
</table>
## Table 4.9 Evaluation Criteria for Teachers and Students

<table>
<thead>
<tr>
<th>A</th>
<th>Criterion</th>
<th>Motivation/References</th>
<th>Thesis Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><strong>PERCEIVED TECHNOLOGY IMPORTANCE IN SCHOOL EDUCATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>Attainable Goals</strong>&lt;br&gt;ICT should have an impact on the attainment of outcomes. ICT can introduce positive changes into education</td>
<td>Miller, Martineau and Clark, 2000; Becta, 2004.&lt;br&gt;Pierson, 2001; Maguire, 2005; Sankey and St Hill, 2005.</td>
<td>2.3.3.1</td>
</tr>
<tr>
<td>2</td>
<td><strong>Relevance</strong>&lt;br&gt;Assessments must have value for the student beyond the classroom to have real integration. Work produced must have an audience beyond the teacher.</td>
<td>Newmann and Wehlage, 1993.</td>
<td>2.3.3.2</td>
</tr>
<tr>
<td>3</td>
<td><strong>Skills and Attitudes</strong>&lt;br&gt;Teachers’ skills and strategies can facilitate the effectiveness of using technology in the curriculum Attitude of teachers can facilitate ICT integration</td>
<td>Bitner and Bitner, 2002.&lt;br&gt;Zhao and Cziko, 2001.</td>
<td>2.3.3.5</td>
</tr>
<tr>
<td>II</td>
<td><strong>Pedagogic Rationale</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>BARRIERS TO ICT INTEGRATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>Professional Development of Teachers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The new role of teachers should be that of instructor, facilitator, mentor and collaborator of learning. Teachers should undergo regular scheduled professional development.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mostert, 2000; Kalanda and De Villiers, 2008; Ertmer, 1999; Pelgrum, 2001; Lujara et al., 2009; Mumcu and Usluel, 2010.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cuban, 2001a; Hunter, 2001; Zhao, Pugh and Shelden, 2002; dams, 2005; Tondeur et al., 2008.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>Time Allocation for Teachers’ Use of ICT Resources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers should be allowed more time to prepare lessons that use ICT and/or e-learning systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Schifter, 2002; Moser, 2007; Pelgrum, 2001; Elliot, 2007; Kalanda and De Villiers, 2008.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Infrastructural Support and Technological Issues</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers need technical support, training in pedagogy and didactics, and administrative support.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>Learning Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students need basic computer literacy before they use ICT in subject-related activities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generated from experience of the author.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generated from experience of the author.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generated from experience of the author.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maguire, 2005; Sankey and St Hill, 2005; O’Mahony, 2003; Mumcu and Usluel, 2010.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generated from experience of the author.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generated from experience of the author.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Other External and Internal Factors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers can be technophobic and unwilling to take what they perceive as risky. Changes are required to develop a successful framework of ICT integration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bittner and Bittner, 2002; Kalanda and De Villiers, 2008; Erixon, 2010.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generated from experience of the author.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT IN THE SCIENCE CLASSROOM</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology affords a bridge between concrete and abstract thinking as it create multiple representations of ideas.</td>
<td>Osborne and Hennessy, 2003. Molefe et al. 2007; Bingimlas, 2009; Blignaut et al., 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology can strengthen procedural knowledge relevant to science activity</td>
<td>Osborne and Hennessy, 2003.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using technology in the Science classroom can hold students’ attention and support recall</td>
<td>Alessi and Trollip, 2001.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The use of various media formats supports understanding</td>
<td>Kara and Kahraman, 2008.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animations and simulations facilitate students’ acquisition of science processing skills.</td>
<td>Wellington, 2000; Alessi and Trollip, 2001; Osborne and Hennessy, 2003.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The evaluation criteria in Table 4.9 form the basis for the research instruments, namely the questionnaires, interview protocols and observations that were used to answer the main research question and the supporting research questions, as given in this section Table 4.10 to show how the criteria relate to the research questions.

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Research Questions</th>
<th>Research Tools Employed</th>
<th>Sections contributing to the answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion A: perceived ICT Importance in Science Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI: Social Rational</td>
<td>Main RQ, RQ 3, 4</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ALL: Pedagogical Rational</td>
<td>Main RQ, RQ 2, 3, 5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Criterion B: Barriers to ICT Integration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1: Professional Development of Teachers</td>
<td>Main RQ, RQ 1, 4, 5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B2: Time Allocation for teachers’ use of ICT</td>
<td>Main RQ, RQ 1, 4, 5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B3: Infrastructural support and technological Issues</td>
<td>Main RQ, RQ 1, 4, 5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B4: Learning Environment</td>
<td>Main RQ, RQ 1, 4, 5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Criterion C: ICT in the Science Classrooms</strong></td>
<td>Main RQ, RQ 2, 3, 5</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### 4.8 Data Collection and Instruments

Data collection in this research was triangulated to provide varying perspectives and to increase validity and reliability. The three types of data collection instruments used in the Pilot Study and the Main Study were:

1. Interviews with principals, teachers and students (see Appendices 5 and 6): Information and Consent Appendix 11);
2. Observation of e-learning in the science curriculum (Appendix 8); and
3. A Survey questionnaire; qualitative and quantitative questions (Appendix 7).

Although there were overlaps, the instruments differed in the wording of questions to suit the method and type of respondent. For example, students were asked about strategies they used while operating a computer in the classroom and teachers were
asked open-ended questions, to assess their opinion on ICT integration in their school.

The approaches focused on answering the research questions. The data collection instruments used in the studies, ranging from the Baseline Study in Subsection 4.6.1 to the Showcase Study in subsection 4.6.6, are mentioned briefly in these respective subsections, but are further elaborated below. In each case, the research method is explained, followed by an explanation of how it was applied in practice.

4.8.1 – Observation
Observation is a method of gathering information about how a programme or initiative operates in a naturalistic environment, generally as discreetly as possible. Observations are usually conducted by external researchers or evaluators, and are used to authenticate and enhance information gathered through other methods. Observation can lead to further understanding when interviews are the primary means of gathering information, because they supply knowledge of the contexts under which events took place (Hoepfl, 1997; Denzin, 2006; Silverman, 2005).

On average, Lesotho science students interact with e-learning systems and tools during one or two lessons per week. In the present study, observations were carried out in science classrooms, for example, during experimentation with a virtual laboratory, which was used to study chemical reactions or observe microscopic cells, and while Microsoft applications were used, such as PowerPoint for presentations in class to their peers.

Observations were also conducted of teachers teaching with technology, for example, Teacher 3 using PowerPoint to introduce a chemistry lesson. The author’s approach to observation was to take field notes incorporating:

- Log sheets to record students’ activities and their reactions to the resources during class sessions, as well as their responses to instructions from the teachers.
- Journaling to note incidents regarding the classroom environment and resources.
4.8.2 – Semi-structured Interviews

Interviews are used to gather detailed qualitative descriptions of how stakeholders perceive the problem under investigation. Interviews can be conducted one-on-one or in focus-groups (Campion, Campion and Hudson, 1994). Semi-structured interviews are conducted with a fairly open framework, allowing for focused, conversational, two-way communication. They can be used both to give and receive information. Not all questions are designed and phrased ahead of time. Certain core questions are asked, but others are created during the interview, allowing both the interviewer and interviewee the flexibility to explore details or discuss issues (Baskerville, 1999; Cohen, Manion and Morrison, 2005).

In this study, students and teachers were interviewed face-to-face after they had used e-learning tools and applications that relate to the science curriculum. In general, theory was taught in conventional class lessons, followed by laboratory sessions, where the teacher gave a brief introduction and, on occasions, students worked in groups of two or three at a computer. Observation took place during these practical lab sessions and interviews were held afterwards. The questions were designed to help teachers and students discuss the lesson directly, and to aid the author in answering the research questions of this study.

The basic interview protocols for teachers, students and principals for both the pilot and main studies are included in Appendices 5 and 6. They comprise a set of questions designed to elicit opinions or beliefs about the integration of e-learning. A second set of questions was designed to extract more on aspects such as the perceived importance of technology from social and pedagogic rationales; barriers to ICT integration; and the use of ICT in science (See Law, Pelgrum and Plomp, 2008).

4.8.3 – Questionnaire Survey

At the end of the study, participating teachers completed a questionnaire survey. This approach was used as a data-gathering instrument in both the pilot and the Main Study (See Appendix 7). A Likert-type scale was used, since it enables respondents to answer questions easily. Furthermore, the numeric ratings provide quantitative data, and statistical software can be used to interpret selected data. There were also some open-ended questions which provided qualitative data.
With a view to refining the questionnaire for the Main Study, the author tested it in the Pilot Study with a limited number of nine teachers. After answering the questions, these teachers made suggestions for amendments and improvements, to the instruments. Based on these suggestions, the author revised the survey and the interview questions, as well as some of the criteria and also modified the approach to the observation sessions. Irrelevant questions were excluded; and changes were made to ambiguous or complex terminology.

### 4.9 Data Analysis

In the ongoing responsive learning cycle, the author used formal and informal reflection methods, as well as quantitative and qualitative data analysis. This study took into account the directions given by the literature on data analysis methods. Data analysis is an ongoing part of data collection (Bogdan and Biklen, 1992). Table 4.11 presents the quantitative and qualitative data collection and analysis methods used in the Main Study.

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire</td>
<td>Certain quantitative data analysis done by using the Statistical Package for the Social Sciences (SPSS 13.0) for Windows.</td>
</tr>
</tbody>
</table>
| Interviews and Observations | - Inspection of data to identify the occurrences of themes that relate to research question.  
                                - Use of coding of interview data and observation field notes to develop emergent themes using Microsoft Word and Excel. |

For the qualitative analysis of semi-structured interviews and observation log sheets, the author applied thematic analysis via a simple grounded theory approach (de Villiers, 2005b; Creswell, 2009). He coded the textual data and noted the themes that emerged. Data coding (du Poy and Gitlin, 1998) involves reducing the data by dividing it into units of analysis and coding each unit. Qualitative methods use codes to categorize data rather than to quantify it. The main aim of the qualitative data
analysis in this study was to determine categories and themes and to extract pertinent quotes from participants’ interviews:

- Data was consolidated in word processing documents for comparison;
- Textual data was coded and answers were grouped into categories;
- The themes, descriptions and narrative from the text were related to research questions and interpreted in the light of the criteria (Table 4.9).

4.10 Triangulation of Results

Cohen, Manion and Morrison (2005: p.112) define triangulation of data as ‘the use of two or more methods of data collection in the study of some aspect of human behaviour’. Analysis of qualitative data is complex, but the triangulation of data and methods and the use of several schools as cases enhanced validity. In this study, the methods used were questionnaires, interviews and observations. The qualitative interview data was coded as well as the field notes from observation. The texts were read with the aim of identifying categories, themes and recurring processes. Pertinent extracts from the interviews are included in Chapter 6 as quotations.

Interpretation of results and outcomes can be complex. Findings can be related to many factors, for example, better student results and improved teaching approaches. It can be difficult to measure the effectiveness of the methods used to solve the problem. Using both qualitative and quantitative approaches in a mixed-methods approach (Creswell, 2009) can be a suitable way to reduce these problems. In this study, triangulation also enhanced the reliability of findings, as diverse instruments were used to increase the amount of data and the perspective on it.

4.11 Reliability and Validity

In the broadest sense, reliability and validity address issues about the quality of the data and appropriateness of the methods used in carrying out a research project. According to Cohen, Manion and Morrison (2005), validity involves demonstrating that the research instruments do indeed measure what they are supposed to measure. The definition of reliability varies for quantitative and qualitative research. In quantitative studies, reliability entails consistency, accuracy and replicability over time, instruments and groups of participants. In qualitative studies, reliability means
getting a good fit between the data recorded by the researcher and what actually occurs in the naturalistic setting being investigated (Cohen, Manion and Morrison, 2005).

The quality of the data and the appropriateness of the methods employed are particularly important in the social sciences because of different philosophical and methodological approaches to the study of human activity. In this research, the author used different ways of obtaining high quality of data in each study. He carefully selected the schools he investigated and aimed for accurate sources of data. In the pilot and the main studies, the author was able to enhance his research instruments through repeatability and thus increased their internal validity in the process. The author revised the survey and interview questionnaire to improve reliability, but, simultaneously, was careful not to affect the validity of the instruments used. Revising the instruments also helped to determine whether the author truly measured what was intended to measure (Golafashani, 2003) and thus contributed to validity. The iterations in Action Research also contribute to validity.

4.12 Summary and Conclusion

In this chapter a detailed account was given of the research design, methods and strategies. The research can be considered as mainly interpretivist, within an action research approach. The six studies that comprised the longitudinal action research process were outlined.

The chapter explained how data was collected and analysed to achieve the research objectives. The author also studied a considerable volume of literature on research methods as secondary data to investigate past research and develop suitable instruments and evaluation criteria.

The six research studies that constitute the phases of the research design, are explained in detail in Chapters Five and Six. The author describes how participants (both schools and human participants) were acquired. The procedures used for data collection and analysis, are described in detail and the results are presented.
The Pilot Study, described in Chapter Five, formed the basis of the far more extensive Main Study, of which the findings are given and discussed in Chapter Six.
Chapter Five ~ E-Learning in Science Classes in Lesotho: Studies 1, 2, 3 and 4

5.1 Introduction

Chapter Three highlighted e-learning in the science classroom in general, while this chapter focuses on the situation in the Lesotho science classroom in particular. Here the researcher outlines the evolution of Information and Communication Technology (ICT) and its integration into science classrooms in Lesotho in recent years. The impact of diverse ICT initiatives is also highlighted, including the SchoolNet project, the Microsoft School Technology Innovation Centre project, and the Nepad Intel E-School project, which were introduced in chapter 1, Sections 1.3.1, 1.3.2 and 1.3.3. This chapter presents the findings of the first four studies depicted in Figure 4.3. The four studies, respectively, were the Baseline Study, the Post-orientation Study, the Comparative Study and the Pilot Study.

Section 5.2 presents the current status of access to ICT in Lesotho. In Section 5.3, the educational context of ICT in Lesotho secondary and high schools is reviewed. Section 5.4 describes the SchoolNet Project and Baseline Study. The Orientation and Post-orientation Studies are presented in Section 5.5 and a Comparative Study of e-learning is overviewed in Section 5.6. Government initiatives, as well as strategic partnerships with Microsoft STIC and NEPAD E-School, are discussed in Section 5.7. Section 5.8 looks at the impact of three projects on ICT integration in Lesotho, while Section 5.9 presents the Pilot Study. The professional development of science teachers is overviewed in Section 5.10, with a conclusion of the chapter given in Section 5.11. Furthermore, the discussion in Chapter Five also mentions:

- Integration by science teachers of ICT-based resources and e-learning software into their lessons over a period of three years,
- Increasing professional development of Lesotho science teachers, as they overcome challenges and obstacles in a quest for the successful usage of ICT in teaching.
5.2 Access to ICT in Lesotho

Lesotho has joined other developing countries in the fight against poverty, with technology perceived as one of the tools suitable to enhance development. As part of this commitment the Government undertook the preparation of an ICT policy to support all sectors, including education. The policy document states:

*The dream of a prospering Lesotho, fully integrated in the global economy cannot be realised without a well designed strategy. In order for Lesotho to seize and obtain maximum benefits from the opportunities provided by ICTs, it needs a roadmap that clearly defines what is to be done, when and how it will be done and who is going to do it*

(Government of Lesotho, ICT Policy, 2004 p.10).

Following this, the Government of Lesotho introduced multiple initiatives to increase computing power in various strategic sectors, including education and training. A National Information and Communication Technology (ICT) policy has been developed to enable the country to achieve its development goals expressed in the Vision 2020 Policy Document and the Poverty Reduction Strategy Paper (Government of Lesotho, ICT Policy, 2004). This policy is a basis to guide appropriate investment to achieve Lesotho’s objective of a transition to an information economy. The desired economy is based on both the Internet and on information technology in general and is driven by knowledge and information (Muller, Cloete and Badet, 2001). A major development in both private and governmental organizations is the acquisition of technologies that run on desktop or laptop computers, for managerial and administrative purposes. Improvements in productivity and management skills are being reported.

The next section focuses on the educational impacts of the implementation of ICT policy.

5.3 Educational Context of ICT in Lesotho

While the use of information and communication technology (ICT) in Lesotho education commenced in the early 1990s, with the main focus on computer literacy skills and the teaching of computer sciences (Government of Lesotho, Vision 2020,
2001), the major integration of computing into teaching and learning attained momentum with the launch of the *SchoolNet Lesotho* initiative in April 1999 (Section 5.4 in this chapter and Section 1.3.1 in Chapter One). The aim was to provide meaningful use of ICT in schools to enrich the learning environment for every student in the country (Teo, 1997; Cheah and Koh, 2001). The subsequent advent of the *Microsoft STIC* and *Intel NEPAD E-School* projects, as reported in Sections 5.7.1 and 5.7.2 and also Chapter 1, Sections 1.3.2 and 1.3.3, further accelerated the advance of technology in selected Lesotho schools.

As stated previously (Section 1.5 and Section 4.4), this study investigates how effective e-learning and integration of ICT can be supported in the Lesotho secondary and high school science classroom.

This chapter overviews the progression to date, It first sets the context and investigates the nature and extent of use of computing technology in Lesotho schools in the early days of the first project, the SchoolNet intervention. This was followed by a series of interventions and subsequent studies to investigate and analyse the progression of e-learning implementation and the factors addressed by the associated research sub-questions (Table 1.4). These events and investigations were carried out as a form of action research, as shown in Figure 4.3 which sets out the sequence and nature of the interventions and studies. The *Baseline Study* shows the situation at the end of 2006 and indicates a disturbing lack of usage of the initial technologies. It was followed in 2007 by an *orientation intervention* by the author personally, in an attempt to improve the situation in certain schools. This culminated in a *Post-orientation Study* in 2008, comparing the Lesotho situation with e-learning in schools in South Africa, to view possible benchmarks.

The *next interventions* came in the form of two initiatives later in 2008, which greatly increased ICT capacity, both in terms of the number of schools included in the projects and the standard of technology. These were nationally-instituted projects, as the Government signed memoranda of understanding with *Microsoft* and *Intel NEPAD* (see Sections 1.3 and 5.7.1 and 5.7.2). As the situation began to stabilise, usage of the resources increased and teachers were supported by training. The time was then ripe for the *Main Empirical Study* in 2010, which was preceded by a *Pilot Study*, towards the
end of 2009, to test methodologies and techniques to be used in the Main Study. The pilot provided certain useful data and gave the author the opportunity to refine the research approach and data collection instruments for the Main Study. The Main Study is discussed in Chapter Six, along with two Showcase Studies, which are success stories of cases where ICT was appropriately integrated.

Table 5.1 maps the studies presented in this chapter against the sections where they are discussed.

<table>
<thead>
<tr>
<th>Year</th>
<th>Interventions/ Studies</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Advent of SchoolNet Project</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>Baseline Study</td>
<td>5.4</td>
</tr>
<tr>
<td>2007</td>
<td>Orientation Intervention</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Post-orientation Study</td>
<td>5.5</td>
</tr>
<tr>
<td>2008</td>
<td>Comparative Study in South Africa and Lesotho</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Government initiatives with Microsoft and Intel NEPAD E-School</td>
<td>5.7</td>
</tr>
<tr>
<td>2009</td>
<td>Pilot Study</td>
<td>5.9</td>
</tr>
</tbody>
</table>

5.4 SchoolNet Project and Baseline Study

5.4.1 – SchoolNet Project

Before commencing the main research for this thesis, an initial Baseline Study was conducted late in 2006 and early in 2007 as the first phase of the action research iterations. The purpose was to overview the extent of e-learning integration at that stage. The schools used in the study were the six SchoolNet project schools and three other schools that were willing to participate.

The SchoolNet project provided computer equipment and connectivity to certain selected schools across the country; but there was no wide-spread professional development programme. In some schools, computers were kept in locked laboratories with no easy access for subject teachers. Only selected teachers, experienced in computer use, were allowed to use the computer laboratory and they used it mainly for teaching basic computer literacy skills. There was hardly any use of computers in teaching the curriculum. The little use that occurred, took place in only two schools. Certain other teachers resisted ICT initiatives, because they felt excluded. The project, though raising interest in teachers, did not live up to
expectations nor encourage teachers to teach their own subjects using ICT. The use of e-learning applications as courseware or tools was low. The six chosen SchoolNet schools were provided with ten computers each, network cabling, some CD-based interactive subject-teaching/learning software, and other open source software. Application software supplied to schools by SchoolNet included the Interactive Oxford Encyclopaedia and the Reekos Mad Scientist Lab which provides interactive virtual science experiments, including capillary action, air pressure, chemical reaction and light refraction. The Internet connectivity was limited to two schools. No technical support staff were appointed to help teachers when difficulties arose during the use of computers for class activities.

5.4.2 – Study 1: Baseline Study

Table 5.2, a reproduction of Table 1.1 in Chapter One, portrays the baseline situation in early 2007. It is presented here to set the context and support the discussions. It shows that most of the computers were in laboratories. Across all the schools, only four were located in classrooms and available for use in normal class lessons.

<table>
<thead>
<tr>
<th>School</th>
<th>Location</th>
<th>Students</th>
<th>Teachers</th>
<th>Computers</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lab</td>
</tr>
<tr>
<td>Highlands 1</td>
<td>R1</td>
<td>438</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Highlands 2</td>
<td>U1</td>
<td>866</td>
<td>24</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>Highlands 3</td>
<td>U2</td>
<td>904</td>
<td>23</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Midlands 1</td>
<td>R2</td>
<td>450</td>
<td>14</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Midlands 2</td>
<td>R3</td>
<td>300</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Midlands 3</td>
<td>U3</td>
<td>698</td>
<td>19</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Lowland 1</td>
<td>U4</td>
<td>607</td>
<td>21</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Lowland 2</td>
<td>U5</td>
<td>788</td>
<td>23</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>Lowland 3</td>
<td>R4</td>
<td>85</td>
<td>9</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>5136</strong></td>
<td><strong>161</strong></td>
<td><strong>13</strong></td>
<td><strong>124</strong></td>
</tr>
</tbody>
</table>

Despite the ICT infrastructure provided and a good range of learning resources, many teachers had not acquired basic proficiency in ICT integration nor did they have the expertise to make innovative use of the new technologies.
Table 5.3, a reproduction of Table 1.2, indicates that in two of the nine schools, a small number of computers were available to be used by science students for their projects. Furthermore, e-learning in science – at that stage – was restricted to the use of interactive computer-based tutorials in four of the schools. Some of the software was used by computer-literate teachers for administration purposes, such as keeping records of marks in spreadsheets. A few schools achieved appropriate levels of ICT use for management and general administrative services, but the students experienced little or nothing in terms of ICT for learning.

Table 5.3: Use of Computers in January 2007

<table>
<thead>
<tr>
<th>School</th>
<th>Use of Computers by:</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Teachers</td>
<td>Science Teachers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preparation</td>
<td>Teaching, e-learning tutorials, etc</td>
<td>Students’ projects</td>
<td>Preparation</td>
<td>Teaching, e-learning tutorials, etc</td>
<td>Students’ projects</td>
</tr>
<tr>
<td>Highlands 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Highlands 2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Highlands 3</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Midlands 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Midlands 2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Midlands 3</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lowland 1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Lowland 2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Lowland 3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
<td><strong>6</strong></td>
<td><strong>4</strong></td>
<td><strong>11</strong></td>
<td><strong>5</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

Table 5.4, a reproduction of Table 4.3, portrays the participating schools and human participants in the Baseline Study.

Table 5.4: Baseline Study

<table>
<thead>
<tr>
<th>2006-2007</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population</strong></td>
<td>9 Schools</td>
<td>Voluntary</td>
</tr>
<tr>
<td>143 teachers and 5136 students</td>
<td>Voluntary</td>
<td>Four rural and five urban schools.</td>
</tr>
<tr>
<td><strong>Data Collection Methods</strong></td>
<td>Observations and interviews</td>
<td>1,273 students from rural schools and 3,863 from urban schools.</td>
</tr>
</tbody>
</table>

12 students interviewed in rural schools and 15 in urban schools. Two observations were made per school. 18 teachers were interviewed.
Over a period of four months (October 2006 to January 2007), the author visited all the schools for observations and obtained background information pertaining to infrastructural facilities and professional development programmes. Each SchoolNet school had desktop computers in laboratories networked to a server.

This contrasts with the three non-SchoolNet schools, where only one had adequate infrastructure, namely one computer, one projector and tutorial software installed. Across these three schools, only one teacher was using technology in preparation and teaching. She was also making use of interactive e-learning tutorials donated to the school.

The sampling frame for participants comprised secondary and high school teachers in the six SchoolNet schools and three other schools selected due to their willingness to participate. After obtaining the logistical information, the author conducted face-to-face, semi-structured interviews with eighteen teachers distributed across the nine schools. The interview protocol is presented in Appendix 4. The questions that were asked, related to the following issues:

1. Computer facilities and infrastructural facilities in the schools, and how these supported ICT-integrated activities.
2. Attendance of computer training courses and professional development.
3. ICT skills and confidence in conducting ICT-integrated activities in the classroom.
4. Forms and methodologies of e-learning used in teaching and learning.
5. The challenges faced in integrating ICT and e-learning into teaching and learning activities.
6. Support from school leadership and administration.

Four main themes emerged from the teachers’ responses during the interviews, namely:

1. Limited Computer Facilities for Teachers,
2. Insufficient Computer Laboratories and Poor Maintenance,
3. Poor ICT skills in general,
4. Lack of adequate Professional Development Programmes.
These themes are elaborated below:

**Limited Computer Facilities for Teachers**

Almost half the respondents (8 teachers) specified that, although computers were being used for administrative purposes and computer literacy training, only a limited number were allocated for the staff to use. The teachers elaborated that they found it difficult to prepare lessons, examination questions and reports. A teacher in the SchoolNet Project lamented,

‘Every time I want to use the computer lab, somebody is using it. I hardly get the chance to use these computers, even for preparation’

She further commented:

‘My school has 45 computers, but when a teacher wants to use the lab for actual teaching purpose, he/she is told that the lab is used only for teaching basic computer skills, I nearly have to beg to access to the lab and to get computers in proper working order’.

**Insufficient Computer Laboratories and Poor Maintenance**

Almost all the respondents indicated that the computer laboratories in their schools were inadequate. In one SchoolNet school (Midlands 3), there was a computer laboratory which had networking facilities and computers connected to a server. This means that at any time, only one class could carry out ICT-related activities. This computer lab was heavily booked and teachers were frustrated when they could not gain access. What was of even greater concern, was the fact that of the seventeen desktop computers in the lab only seven of them were in proper working condition. As one teacher in that school stated,

‘Every time I am in the computer lab, computers hang and it takes time to come back to normal’.

Regarding the possibility of increased ICT integration in the curriculum, two thirds of the teachers appeared to feel threatened and unsure, but the other third were keen to pursue integration. A comment that supported the perception of insecurity, was:

‘I’m not sure at this point of time. There are so many challenges… I will give it a try… who knows, I might make it’.
Poor ICT skills in general

Twelve teachers acknowledged that their ICT expertise was generally poor. Some of the responses related to their inadequate computer skills. One teacher explained:

‘I am familiar with Microsoft Word, Excel and PowerPoint, but when it comes to surfing the Internet and using the scanning machine, I am lost. I have to seek help from other teachers or administration staff’.

Lack of adequate Professional Development Programmes

The majority of teachers (14 of the 18 interviewed), especially senior teachers, pointed out that they had not attended any computer courses at all. The opportunities to attend computer courses were mainly taken up by younger staff. One teacher from a government school said:

‘Maybe the older teachers are afraid and fear that they will be ridiculed by fellow teachers for being incompetent’.

Another comment supported this perception.

‘My fingers are stiff and I don’t like to use computers.... Let the young people use computers. It is of no use to people of my age’.

A teacher from SchoolNet school said:

‘When a computer malfunctions, there may be just a small problem that can normally be fixed right away by a person with basic computer repair knowledge, but because of lack of such knowledge, the problem ends up taking a long time to be fixed’.

Eight of the respondents noted that lack of computer repair, even minor repairs, and lack of maintenance skills was hindering both teachers and the administration from carrying out their work. Many computers had become completely unusable.

A teacher from a SchoolNet school argued:

‘The reason for several teachers not taking their classes to the computer laboratories is that only 6 out of a total of 25 computers in the lab are usable. Imagine 6 computers being shared by more than 40 students. The class becomes noisy’.

In such situations, it was not possible to do effective computer-based teaching or learning.
The sample of students (27 students – 12 from rural and 15 from urban schools) in this study was a sample of convenience from the population of 5136 students in total. Students were from the three most senior classes. The interviews with students were not structured by an interview protocol; instead, they were short and simple informal discussions to ascertain students’ opinions about e-learning in the classrooms.

Students felt that they were not well taught. They were concerned because some of the teachers did not know how to use technology to conduct research and access up-to-date information. One of the students, Student 2, indicated that certain of his fellow-students were technologically more advanced than the teachers.

5.5 Orientation and the Post-orientation Study

5.5.1 – Orientation Sessions

The findings of the Baseline Study were disturbing for the following reasons:

- Schools had computers, but teachers were not properly qualified to use them for teaching,
- Learners had no access to the labs for independent work,
- Administrative staff had no interest in ICT integration in the curriculum and felt intimidated by tasks such as typing examinations on the computer.
- The teachers did not have time to prepare ICT-based lessons.

The Baseline Study was therefore followed by an intervention in the form of orientation sessions in February 2007, facilitated by the author to create awareness and provide further training in use of the resources provided. This orientation was only done in SchoolNet schools. In his capacity as a lecturer at the Lesotho College of Education, the only teacher training institution in the country, the author had open access to all the project schools and was well accepted. Subsequently the author embarked on a Post-orientation Study to evaluate these impacts of the sessions.

Use of the software donated by SchoolNet for teaching and learning, presented a major challenge as teachers were not involved in the initial stages of implementation. No training was organized and software was not made available for teachers to study and practice. In some schools, software was stored in safe-keeping by the principal. The effect was a sense of disempowerment and under-utilization of the resources
provided. Not only were teachers and students losing the potential benefits of e-learning, but the author was also at a disadvantage, in that the environments were not appropriate for meaningful research on the application of ICT and e-learning.

Hence the author took a decision to precede any research studies by orientation sessions, during which he voluntarily offered familiarization and basic training to teachers. Groundwork was laid and training in the fundamentals was organised, with the aim of supporting these schools on the path towards effective integration of e-learning. The sessions contributed to increased awareness among teachers of how e-learning applications can be used in the classroom and helped them take ownership of the technologies. It developed their understanding of how ICT can enhance teaching and learning. It also strengthened their computer literacy and technological expertise across a range of computer-assisted instruction (CAI) systems and the various applications provided by SchoolNet.

Some administration staff became involved in the training, because of their involvement in the preparation of examinations (typing and reporting), hence, they needed ICT skills. In the cases of standard government schools, teachers from the three schools that had taken part in the Baseline Study and teachers from other schools in the area were initially interested in the workshops and attended, believing that they would benefit from the training. However, when the Post-orientation Study commenced a few months after the orientation intervention, they were not willing to participate further, because it coincided with a period when they were marking tests and examinations.

Orientation sessions were held separately at the College of Education and at the six SchoolNet Project schools, where training was delivered in two parts over three days:

- A day for viewing examples of CAI and other applications; investigation of certain available Internet resources; and an overview of existing success scenarios of ICT integration in other countries.
- Two days of skills development, with hands-on training in ICT skills for teachers and other staff; and use of specific CAI software in class situations.
In total, six principals, fifteen administrative staff, and twenty two teachers were trained at six schools. The workshops had a duration of three days. Some pupils were involved in trial lessons where teachers used the new technology to present subject matter. Table 5.5 sets out the plan for the orientation sessions.

### Table 5.5: Orientation Sessions

<table>
<thead>
<tr>
<th>Aims</th>
<th>Target</th>
<th>Number</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop general awareness of how ICT applications can be used in the classroom</td>
<td>Principals, Admin staff, Teachers</td>
<td>6, 15, 22</td>
<td>Internet-based applications, CAI software</td>
</tr>
<tr>
<td>Develop understanding of how ICT and specific e-learning applications can enhance teaching and learning</td>
<td>Principal, Admin Staff, Teachers, Students</td>
<td>5, 15, 22, 20</td>
<td>Reekos Mad Scientist Lab, MS-Office, Open Office</td>
</tr>
<tr>
<td>Develop practical ICT skills across a range of CAI and Microsoft office applications provided by SchoolNet</td>
<td>Teachers</td>
<td>22</td>
<td>Reekos Mad Scientist Lab, MS-Office, Open Office</td>
</tr>
</tbody>
</table>

Table 5.6 provides the number of participants trained during orientation sessions:

### Table 5.6: Participants Trained during Orientation Sessions

<table>
<thead>
<tr>
<th>No.</th>
<th>School</th>
<th># Principals</th>
<th># Teachers</th>
<th>#Admin Staff</th>
<th>#Students</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highland 2</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Highland 3</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Midland 1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Midland 3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Lowland 2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>Lowland 3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>6</td>
<td>22</td>
<td>15</td>
<td>20</td>
<td>63</td>
</tr>
</tbody>
</table>

5.5.2 – Study 2: Post-orientation Study

Figure 4.3, which portrays the research design, depicts the orientation intervention and the Post-orientation Study. An interval of two months lapsed between the completion of orientation and the start of the Post-orientation Study to give the teachers an opportunity for independent re-orientation and application of their new skills and practices. Interviews (see interview protocol in Appendix 4) among the twenty two teachers, who had undergone orientation and training, indicated increased confidence in using technological tools.

Table 5.7 is the same as Table 4.4 which describes the participating schools and the human participants in the Post-orientation Study.
Table 5.7: Post-orientation Study

<table>
<thead>
<tr>
<th>Participants</th>
<th>2007</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Schools</td>
<td></td>
<td>Voluntarily, after a request from author</td>
<td>Two schools rural and four urban Note: the three other schools did not participate</td>
</tr>
<tr>
<td>103 teachers</td>
<td></td>
<td>Voluntarily, after author's request</td>
<td>535 students from rural schools and 3256 from urban schools.</td>
</tr>
<tr>
<td>3,791 students</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.8: Profile of the six Schools in the Post-orientation Study

<table>
<thead>
<tr>
<th>School</th>
<th>Location</th>
<th>Students</th>
<th>Teachers</th>
<th>Computers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U – Urban</td>
<td></td>
<td>Admin.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R – Rural</td>
<td></td>
<td>Education</td>
<td>Location</td>
</tr>
<tr>
<td>Highlands 2</td>
<td>U1</td>
<td>866</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>Highlands 3</td>
<td>U2</td>
<td>904</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Midlands 1</td>
<td>R2</td>
<td>450</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Midlands 3</td>
<td>U3</td>
<td>698</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Lowland 2</td>
<td>U5</td>
<td>788</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Lowland 3</td>
<td>R4</td>
<td>85</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3791</td>
<td>103</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5.8 lists the nature and distribution of the six schools that participated in the Post-orientation Study. As stated in Section 5.5.1, teachers from the other three school in the Baseline Study, were not willing to participate in the Post-orientation Study, which coincided with a period of marking tests and examinations.

The table indicates that, in total, 103 teachers participated in the Post-orientation Study; of which 22 had been trained during the orientation-and-training interventions. The number 103 indicates that the 81 other teachers had been trained by peer-teaching from the 22 teachers.

Table 5.9 gives the perceptions of the 22 trained teachers as to whether their confidence levels had increased in using the seven items addressed in the survey. The least increase in confidence occurred for Item 5 ‘Web-based Courses’, which is related to the fact that teachers did not have regular Internet connectivity. Item 4 ‘CD ROM-Based Courses’ showed the greatest increase, namely 90%.
Semi-structured interviews were conducted with teachers, focused on determining their confidence in using some forms and methodologies of e-learning in their schools. The interview protocol in Appendix 4 was used for both the Baseline Study and the Post-orientation Study. Teachers in the Post-orientation Study compared their confidence levels before and after the training. Initially they had had low confidence in using some forms and methodologies of e-learning. For example, Table 5.9 shows that only three teachers out of 22 (13%) were originally confident to use CAI tutorials, but after the orientation sessions, sixteen (75%) indicated that they were confident in using tutorials. Similarly, with regard to the use of video and audio for teaching, confidence levels increased from 27% to 70%, and so on.

The qualitative data suggests that teachers’ previous experience with computers and level of education influenced their confidence in teaching with ICT. These findings are in accord with Pamuk and Peker’s (2009) survey of Turkish pre-service science and mathematics teachers’ computer self-efficacies and computer attitude, which found that science and mathematics teachers who took technology related courses show significantly higher levels of self-efficacy and confidence. Two notable themes emerged from the interviews, namely the role of previous experience and the teachers’ current confidence. These are discussed in Subsections 5.5.2.1 and 5.5.2.2. Opinions of some of the students are mentioned in Section 5.5.2.3.

### 5.5.2.1 Previous Experience
Teachers’ experiences were related to their earlier experience of technology. When discussing their previous experiences, twelve of the 22 referred to their ICT

---

**Table 5.9: Teachers’ Confidence in using e-Learning after Orientation Workshops**

<table>
<thead>
<tr>
<th>Forms and Methodologies of E-learning used</th>
<th>Prior to Orientation Workshops Jan/Feb 2007</th>
<th>After Orientation Workshops April/May 2007</th>
<th>Percentage of Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI Tutorial</td>
<td>3 (13%)</td>
<td>16 (75%)</td>
<td>62%</td>
</tr>
<tr>
<td>Video &amp; Audio</td>
<td>6 (27%)</td>
<td>15 (70%)</td>
<td>43%</td>
</tr>
<tr>
<td>Simulations</td>
<td>7 (31%)</td>
<td>15 (68%)</td>
<td>37%</td>
</tr>
<tr>
<td>CD ROM-Based Courses</td>
<td>2 (8%)</td>
<td>21 (98%)</td>
<td>90%</td>
</tr>
<tr>
<td>Web-based Courses</td>
<td>3 (13%)</td>
<td>8 (37%)</td>
<td>24%</td>
</tr>
<tr>
<td>Drill &amp; Practice</td>
<td>4 (20%)</td>
<td>18 (80%)</td>
<td>60%</td>
</tr>
<tr>
<td>Electronic Encyclopaedia-Based</td>
<td>3 (13%)</td>
<td>16 (75%)</td>
<td>62%</td>
</tr>
</tbody>
</table>
experiences at college level. Seven of these twelve stated that they had experienced poor quality ICT training, or none, during their own higher education. A typical interview response (by Teacher 4) was:

I had very little experience before attending this training. My experience at college was limited and I would say fairly negative. I felt that I couldn’t participate in computers because I was not good in mathematics and science.

On the other hand, some highlighted positive experiences in their higher education. Teacher 9 stated:

I studied ICT at college. I had a lecturer who gave me lots of opportunities to work with software that I always enjoyed. He was always positive and encouraged all of us and gave us confidence to experiment.

5.5.2.2 Current confidence in using technology
The majority of the 22 teachers acknowledged their increased confidence in teaching with technology after orientation and training conducted by the author. In addition, principals were grateful that they had taken part in the sessions. Principal 1 expressed it this way:

As principals, we need to know what is taking place in classroom if our support is needed. We can now see the changes in ICT and e-learning practice in our schools.

During the Post-orientation Study, changes in ICT and e-learning practice were in evidence, attesting to the worth of the orientation and training. Table 5.10 summarises the forms and methodologies of e-learning used in schools after the sessions. The data relates to usage in the six schools across the board. Different levels of usage occurred in different schools. The data indicates improvements, with schools starting to apply additional technologies, in comparison to Table 5.3.
Table 5.10: E-Learning in the Six SchoolNet Schools in mid-2007
(After orientation sessions)

<table>
<thead>
<tr>
<th>Forms of E-Learning</th>
<th>Forms used</th>
<th>Number of schools applying that form of e-learning (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI Tutorials</td>
<td>X</td>
<td>3</td>
</tr>
<tr>
<td>Multi-media Production</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>Simulations</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>Educational Games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive Learning/Practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD ROM-based Courses</td>
<td>X</td>
<td>6</td>
</tr>
<tr>
<td>Web-based Courses</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Drill and Practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Video Conferencing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet-based Research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Encyclopaedia-based Research</td>
<td>X</td>
<td>2</td>
</tr>
</tbody>
</table>

In terms of the ratio of students per computer, during the Baseline Study, the average number of students per computer in secondary and high schools in Lesotho was estimated at 32 in urban areas and 637 in remote rural areas, as in Section 1.4.1, Table 1.1. This ratio is in line with the Ministry of Education and Training’s (MoET’s) average estimate in 2005 of one computer for every 30 students in urban and more than 500 in rural schools. However, the ratio varies widely from one project to another and from one school to another.

From the information in Tables 5.9 and 5.10, and overall observations of the author on return visits to the schools for the Post-orientation Study, it can be concluded that the orientation sessions contributed to raising confidence levels of the participant teachers and in turn, their colleagues, thus increasing the extent of ICT integration and use of e-learning systems. By the end of 2007, teachers in Lesotho informed the author informally that they were applying, to an even greater extent, what they had learned in the orientation and training workshops. Their motivation had increased and their confidence levels were high.

5.5.2.3 **Students’ opinions on e-learning in the classroom**
The seven students, two from rural schools and five from urban schools, mentioned in the table of participants (Table 5.7 (same table as 4.4)) were a sample of convenience from Form C, D and E classes. Unlike the structured interviews with teachers, the discussions with students were not structured interviews, nor were they
based on an interview protocol. They were brief, informal conversations to ascertain students’ impressions of e-learning in the classroom at the time of the Post-orientation Study. In the discussions, students who attended schools where they were allowed to do hands-on activities on the computer, were generally positive about using ICT in classrooms for their own learning. According to them, teachers should be increasingly using ICT tools in classroom teaching.

Unfortunately, as indicated in Table 5.10, only one school was using multimedia systems and only one was using simulation programmes. Students suggested that teachers should have training in a wider range of ICT tools so as to make better use of technology in teaching. For example, e-learning tools such as simulations, would allow teachers to demonstrate experiments that would not otherwise be possible, and that have great educational potential to enhance learning. In general, the students in the Post-orientation Study agreed that use of ICTs makes them more effective in their learning, more organized in their work, and better able to meet their changing needs of society.

As indicated in Section 1.7, the author recognizes the importance of students’ opinions on e-learning integration in the science classroom, but that was not the purpose of the present research. However, he recommends in Section 7.7 that a student-based survey should be undertaken in a separate study.

5.6 Study 3: Comparative Study of E-Learning in Lesotho and South Africa

The next stage in the action research process was a study in January 2008 to compare cases of computer use and e-learning in science classrooms in Lesotho and South Africa (Kalanda and de Villiers, 2008). In Figure 4.3 ‘Variant of Action Research’, the Comparative Study is shown as the third study. Two schools in each country were selected as case studies, i.e. the study was based on a purposive sample (Cohen Manion and Morrison, 2005). The Comparative Study investigated the situations in four secondary/high schools: in Lesotho, two SchoolNet schools, Schools A and B, were selected, both of which had been schools in the Orientation intervention, and in South Africa (SA), two state schools, Schools C and D.
Table 5.11, which indicates the nature of participation in the Comparative Study, is the same as Table 4.5.

<table>
<thead>
<tr>
<th>Participants</th>
<th>2008</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>4 Schools</td>
<td>By invitation to schools of good practice in the two countries. Voluntarily, in response to the invitations.</td>
<td>2 Lesotho schools, 2 South African state schools</td>
</tr>
<tr>
<td>21 teachers: 14 from Lesotho and 7 from SA</td>
<td>2 Lesotho schools, 2 South African state schools</td>
<td>Volunteering science teachers in the selected schools.</td>
<td>All schools are located semi-urban or in a city.</td>
</tr>
<tr>
<td>1,204 from Lesotho and 1,630 from SA</td>
<td>2,834 Students: 1,204 from Lesotho and 1,630 from SA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Data Collection Methods | Observation, teachers and students’ interviews, and questionnaires | There were two observations in each school; five teachers interviewed in each country; and all teachers participated in the survey questionnaire. Three students were informally interviewed in each country. |

Data in this study was obtained mainly from the short questionnaires completed by 21 teachers and interviews among 10 teachers, five each from Lesotho and South Africa. The questionnaire and interview instruments are in Appendices 3 and 4. Informal discussions were also held with six students, three in each country. Finally, observations were undertaken during live classroom sessions.

Table 5.12 depicts the profiles of the four schools in the Comparative Study, namely Schools A, B, C, and D.

<table>
<thead>
<tr>
<th>Table 5.12: Profiles of Schools in Comparative Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>School A</td>
</tr>
<tr>
<td>School B</td>
</tr>
<tr>
<td>School C</td>
</tr>
<tr>
<td>School D</td>
</tr>
</tbody>
</table>
The four participating schools were selected as examples of good practice in each of the countries relative to its extent of application of e-learning. In total, twenty-one science teachers from the four secondary and high schools participated, fourteen from Lesotho and seven from SA, as shown in Table 5.12. E-learning in SA schools with established e-learning programmes was compared with the Lesotho situation to establish precedents and possible benchmarks. Some of the material in this section is used near-verbatim from a publication on this study by the author of this thesis and a co-author, namely Kalanda and de Villiers (2008).

**5.6.1 - Results of the comparison**

This section highlights some of the findings of the classroom observations in Lesotho and in South Africa. Table 5.13 is a comparative picture of the forms of e-learning used in the four participating schools. Schools A and B in Lesotho used a combination of CD-ROM-based courses and electronic encyclopaedia-based research, to teach chemistry, biology and physics.

**5.6.1.1 From Lesotho schools**

One Lesotho teacher had the approach of initially orientating students in the subject matter in a classroom setting, and then requiring them to use the **Cyber School Technology** simulation software installed in the laboratory to prepare their own presentations for the following week. Students also had access to other pre-installed electronic encyclopaedias for these assignments. The teaching of the curriculum was supplemented with electronic resources, and covered topics such as:

- The combustion of fuel, exothermic reactions and Faraday’s second law of electrolysis in chemistry;
- Velocity and sound, electromagnetism and fusion in physics; and
- Unicellular organisms, the human circulatory system and respiratory system in biology.

**5.6.1.2 From South Africa**

In the Kalanda and de Villiers study, it was found that science teachers in School C in South Africa used simulated experiments from **Crocodile Clips**, with its **Absorb** courseware, that combines ‘Crocodile’ simulations with a spoken narrative,
interactive animations and targeted exercises, to teach biology. Teachers referred students to a Web-based encyclopaedia, as preparation for their projects.

Another major form of e-learning in one of the South-African schools studied was the interactive electronic *Forum* running on the school’s intranet. This entailed asynchronous communication, whereby a science teacher posted a theme or issue for discussion over a specified period of time. All students taking the course were expected to participate in the discussion at least twice in a two-week period. Their views were ranked by the teacher and they were given marks (grades) for their participation in this constructive collaborative development of themes. Such forums were organised twice or three times per semester.

Teacher 3 in School C in South Africa supported his biology students by providing them with access to a virtual library. Apart from these electronic materials that could be accessed from anywhere, at any time, the teacher had an additional system whereby he personally sourced further relevant reference materials, in the form of notes or articles, and posted them in a special section of the virtual library. Unlike the situation in conventional libraries, students could access these materials *via* the Web at home, at school or elsewhere, and at any time of the day or night (Kalanda and de Villiers, 2008).

**5.6.1.3 Comparative data**

Table 5.13 indicates that usage of ICT and e-learning in the South African schools far exceeded that in Lesotho. Tallying the item-use $X’s$ in the South African schools gives a total of 20, compared with a total of only 10 in the Lesotho situation.
Table 5.13: Forms of E-Learning used in Participating Schools

<table>
<thead>
<tr>
<th>Forms of E-Learning</th>
<th>Lesotho</th>
<th>South Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School A</td>
<td>School B</td>
</tr>
<tr>
<td>CAI Tutorials</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Video and audio</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Simulations</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Educational Games</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Interactive Learning/Practice</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CD ROM-Based Courses</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Web-based Courses</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Drill and Practice</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Video Conferencing</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Internet-based Research</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Electronic Encyclopaedia-based Research</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Total forms of E-learning used</strong></td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Teachers in the schools in the Comparative Study were asked to rate their personal confidence in using ICT and their perceived ICT skill level, using a Likert scale (1 = low, 5 = high), and were also required to rate the confidence and skill levels of their students. Figures 5.1a and 5.1b, show that the overall perceived confidence and skill levels of teachers and students in both Lesotho and South Africa were fairly high.

Figure 5.1a: Average Perceived Confidence and Skill Levels in Lesotho

Figure 5.1b: Average Perceived Confidence and Skill Levels in RSA
The perceived confidence level mean of 3.7 and skill level of 3.4 for teachers (Figure 5.1a) – as rated by the Lesotho teachers themselves – and a confidence mean of 4.1 and skill mean of 4.2 for their students – also as rated by the teachers – on a scale where 5 is highest, are statistically strong levels of confidence and skill. Two teachers (14%) for schools A and B rate themselves as low in confidence and skill, confirming that confidence and skill are linked. However, they rated the students’ skills at 4.2 verses 3.4 for their own personal skills. Two of the fourteen Lesotho teachers acknowledged their inadequacies and expressed a strong aspiration to develop and improve their ICT knowledge.

The standard deviations of 0.9 for confidence levels and 0.6 for skills show how close the different teachers were in their responses, but it is of particular interest that the Lesotho teachers rated the confidence and skills of their students as higher than their own. Possibly these teachers experienced greater computer phobia than their students.

In South Africa, by contrast (Figure 5.1b), the teachers were well trained and scored higher perceived levels than the students’ levels. Furthermore, the confidence and skill levels of the South African teachers were higher than those of Lesotho. A confidence mean of 5 and a skill mean of 4.3 for teachers, and a confidence mean of 4.0 and skill mean of 4.0 for students are also statistically higher. Teachers rated their students’ confidence and skills lower than their own, unlike the case in Lesotho. The South African teachers pointed out a dichotomy, in that they deal with students who have different inherent levels of expertise – some have had extensive prior exposure to computing at home, and others none at all (Kalanda and de Villiers, 2008).

Most of the points raised in this section emerged from responses to the questionnaires, although some issues such as collaboration among teachers in preparing for ICT mediated lessons were investigated in interviews with both teachers and students.
5.7 Government Initiatives and Strategic Partnerships

The disappointing results of the first investigation into computer facilities in Lesotho schools namely, the Baseline Study, are given in Section 5.4. However, due to three partnership ventures introduced in Chapter 1 and described in more detail in this Chapter, the situation changed notably for the better. The initial project, SchoolNet, was discussed in Section 5.4, while Microsoft STIC is described in Section 5.7.1, and NEPAD E-School in Section 5.7.2. The latter two were more comprehensive interventions that supported the participating schools more effectively.

5.7.1 – Microsoft ‘School Technology Innovation Centre’ (STIC) Project

The School Technology Innovation Centre (STIC) project was implemented in 2008 by the Lesotho Ministry of Education and Training (MoET) and Microsoft. The STIC Project was established to explore the use of certain computer-assisted instruction (CAI) applications in science, through a partnership named Partners in Learning (PiL). The primary modus-operandi was an in-service professional development programme to equip teachers. STIC provided initial ICT skills training and ongoing computer experience, using scenarios related to teachers’ professional duties. The programme aimed to equip teachers with the necessary skills to help students develop independent learning habits and to promote confidence in ICT experience and knowledge on the part of both teachers and students.

The teachers were initially exposed to a series of drill-and-practice and simulation courseware that gave instruction and practice on various science topics in the secondary and high school curricula. These drill and simulation applications provide instant feedback to students and offer guidelines to users trying to solve problems. Although this exposure was not integral to the training curriculum, to some school teachers it was the first attempt to use ICT in a meaningful way in their teaching.

With the implementation of PiL, many schools, both in urban and rural areas, were equipped with the necessary ICT infrastructure and basic training to facilitate the use of ICT applications and integration into subject teaching in the science class. During PiL Training, science teachers also started to use application software, such as Microsoft Word, Excel, PowerPoint and Access to prepare their lessons, and
teaching aids, such as activity sheets, in a systematic way. After attending training, some teachers took their new knowledge even further and developed original electronic teaching-and-learning materials, using tools such as LearnThings, Smart Gallery and other software to design their own customised teaching materials. For example, Figure 5.2 depicts questions in a biology quiz prepared by one of the teachers using Microsoft PowerPoint with the Microsoft Mouse Mischief module. This allows students to interact in an electronic way; as they indicate their answers using the mouse for selection between alternatives. Subsequently, science teachers also began to incorporate Web-based and CD-based encyclopaedia information into their lessons to make them attractive and interesting. In turn, students were also encouraged to access web-sites in independent searches for further information and reflections on learning science subjects. This type of intervention occurred on a low level due to the students having very limited opportunities to access the Internet, or none at all.

![Figure 5.2: Lesson Preparation with PowerPoint](image)

PiL is a global initiative aiming to dynamically increase access to technology and enhance its use in teaching and learning. For Microsoft, the goals of this project are to:

- Help schools increase access to technology;
- Promote innovative approaches to pedagogy;
- Provide professional development for teachers; and
• Offer educators tools to visualize, implement and manage change in schools.

With the preliminary success of the PiL programme, Microsoft invested more resources in the development of further multimedia drill-and-practice, tutorial and simulation courseware for teaching science and for teachers’ professional development. Due to PiL and the NEPAD E-School Projects, a greater variety of software was placed in Lesotho schools. This is addressed further in Table 5.17 in Section 5.9.4.5, where findings of the Pilot Study are discussed.

Training of Educators
Together with governments and other partners around the world, Microsoft focuses on three key areas, all of which hold the potential to empower students and teachers and to transform education at all levels; namely:

• Human capital development in ICT;
• Innovation in ICT; and
• Advanced technical research and development.

Figure 5.3 shows Partners in Learning (PiL) software used in training educators to integrate technology in education. The electronic course includes modules for teachers, principals and leaders in education, including school inspectors from the Lesotho Ministry of Education.
The STIC venture incorporates the local, pan-African and World Innovative Educators’ Forums (IEF’s), which are organized to acknowledge the best innovative teachers and assist educators in developing teaching methods and school curricula which empower students to become agents of change. This partnership develops courseware, and offers international awards to educators for their use of technology. The programme now reaches out to teachers worldwide. (See Section 6.5 for discussion on two teachers who received such awards.)

Over and above Microsoft’s independent international initiatives, it enters into partnerships with state education bodies, where appropriate. As part of ICT implementation in Lesotho, the Ministry of Education and Training and Microsoft have jointly invested in purchasing engaging science courseware and tools that are now distributed to schools to support ICT in teaching and learning science.
The accessibility of these e-learning applications, the ICT infrastructure in place in schools, and the training provided to school teachers, contributed to teachers’ confidence levels and encouraged more extensive use of ICT in science classes by teachers.

**Application by Educators**

Equipped with such training, teachers started with enthusiasm to put their newly acquired skills into practice. For example, several science teachers began to make regular use of Microsoft *Encarta Encyclopaedia*, a page of which is shown in Figure 5.4. This has helped students to understand concepts that were difficult to demonstrate with traditional methods.

![Microsoft Encarta Encyclopaedia](image)

**Figure 5.4: Microsoft Encarta Encyclopaedia**

The recent availability and access to the Internet in classrooms in some schools, offers certain science teachers the opportunity to use Web-based resources, such as the *Encarta* (shown above) and *Britannica Encyclopaedias*, and *Flash animations* to illustrate concepts. These have helped students visualize abstract scientific concepts and encouraged Lesotho teachers to use technology in a constructivist way (Section 3.2.3) to support students in discovering information.
The teachers also discovered the value of simulation software. Figure 5.5 illustrates a chemistry simulation tool that is used by Lesotho science teachers in planning and presenting their lessons. The tools, which are incorporated in *Smart Board*, offer the flexibility to manipulate chemicals in virtual labs, as if in natural settings, but with no dangers of explosion or harm, no costs incurred in purchasing and storing chemicals, and no time spent setting up complex experiments to demonstrate concepts.

![Figure 5.5: Tools for a Chemistry Lesson](image)

5.7.2 – NEPAD E-School Project

The *NEPAD E-School* initiative, launched in Durban, South Africa in June 2003 was adopted as a continental undertaking, to support African youths in primary, secondary and high schools. The ultimate goal is to equip them with skills to improve and enrich their learning and to participate in the global information society. NEPAD works in partnership with governments throughout Africa. In each participatory country, it selected six project schools.

Just as STIC has a training course (i.e *PiL*, mentioned in the previous subsection), similarly, NEPAD E-School has a training course called *Intel Teach*. Within each of the selected schools, NEPAD provides training to a limited number of teachers.
According to the terms of the MoU between NEPAD and the Lesotho Government, hardware and software are provided by both parties. Schools under the NEPAD project in Lesotho have benefited from the training, as have others in countries selected for the first phase, with equipment for six demo schools in each. Although the NEPAD E-school project was launched in 2003, it only had an impact on science teaching in Lesotho in 2008 when the first intervention in training trainers and principals took place at the Lesotho Microsoft STIC.

NEPAD and Microsoft work in partnership on certain ventures. Although the Lesotho SchoolNet Project did not achieve the anticipated results, SchoolNet South Africa currently collaborates with both Microsoft and NEPAD E-school in facilitating training.

The training programme in the NEPAD E-School project includes training in spreadsheets to strengthen mental functions and cognitive processing (see Cognitivism in Section 3.2.2). The original purpose of spreadsheet was to support business and accounting operations. However, science teachers, as well as students, are advised to use the graphing functionality of spreadsheets for the generation of charts, bar graphs and pie charts to represent and interpret quantitative data. Teachers also use spreadsheets in designing templates to support students in entering numeric data for statistical analysis and decision making. These activities are examples of using software applications and the manipulation of parameters as cognitive computing tools.

5.8 Impact of the Three Projects on Science Education

Before the implementation of the SchoolNet, School Technology Innovation Centre and NEPAD E-School projects, Lesotho science teachers, by and large, used teacher-centred instructional approaches with textbooks as the main resource. A traditional science lesson in a secondary or high school was undertaken as follows: A teacher introduces the lesson by presenting the concepts or procedures on the blackboard. This is followed by presentation of problem examples to illustrate concepts to the students. Time is then allocated for the students to do exercises on a related problem.
More exercises are given as homework to strengthen and consolidate the new learning. In some cases laboratories are used for experiments.

After the implementation of the three formal projects, more science teachers became comfortable with the use of ICT in their lesson preparation and delivery. They are relying less on traditional ways of teaching via teacher-centred instruction models, and concentrate more on using electronic resources to integrate ICT into science teaching and to design their own teaching aids. Some of the more enthusiastic and innovative teachers who trained under the Intel Teach Train the Trainers programme, use tools such as Microsoft Excel and create their own interactive science resources, as in the example shown in Figure 5.2.

To put this into perspective, the teachers who designed student-centred lessons for teaching with ICT are few in number. The NEPAD E-School Project was implemented in only six schools across the whole country. The SchoolNet project was also implemented in only six schools. However, some of the teachers participating in the NEPAD E-School project have also been trained, up until 2010, under the PiL programme at the STIC premises. In total, more than 200 teachers from approximately 60 schools, had undergone the PiL training offered by STIC. For those who learned from the two programmes independently, it became easier to apply techniques. In 2010 there was a move towards extending Intel Teach’s Train the Trainer programme by NEPAD E-School’s Intel to more teachers. Since only forty teachers had been trained under this programme; it is not possible to assess any holistic impact on teaching and learning in Lesotho.

5.9 Study 4: The Pilot Study
This section describes the Pilot Study, the fourth study in this research design, which is a variant of action research. A pilot was designed and implemented as a preliminary trial of the research planned for the Main Study. This process is essential to the development of a major study, the idea of the Pilot Study being mainly to try out the research methods and instruments, and not to gather data as such. If problems were identified in the questionnaire or observation schedule, the instruments could be adapted before the Main Study begins. A further aim was to establish the nature of
the naturalistic environment in which the main research would be conducted. Moreover, a Pilot Study greatly reduces the number of treatment errors; because unanticipated problems revealed may be overcome in the subsequent Main Study (Olivier, 1999).

In this Pilot Study the entire research agenda was carried out, but with a smaller number of participating schools and just a few participants. The usual purpose of a trial or pilot is to improve data collection mechanisms and check the appropriateness of the methodologies, techniques and instruments. In this research, the data collection from principals, teachers and students in the Pilot Study and their feedback on the instruments led to changes and improvements to the research instruments. The author was therefore able to refine the survey and the interview questions by removing or adapting inappropriate questions and complex terminology. A similar approach was adopted after the observation sessions.

In addition to achieving all the usual objectives of a pilot, this Pilot Study did, however, provide certain additional data that can contribute to the overall research findings. Selected data is mentioned in Sections 5.9.4.3 and 5.9.4.5.

5.9.1 – The Context of the Pilot Study
The Pilot Study focused on science teachers who had undertaken significant ICT professional development training programmes through the three projects and who had used ICT in their classroom teaching for more than six months. All the teachers had participated in, among others, courses on the use and application of MS-Word, Excel, PowerPoint and Internet. They had also attended training on the use of multimedia in project-based learning, either PiL organized by STIC or NEPAD E-School’s Intel Teach course. The schools selected for the pilot, were three schools representing the three projects respectively (one in each project) and representing both rural and urban areas of Lesotho.

5.9.2 – Pilot Study Participants
Table 5.14 is the same as Table 4.6 which describes the participating schools and the human participants in the Pilot Study.
Table 5.14: Participating schools in the Pilot Study

<table>
<thead>
<tr>
<th>Participants 2009</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Schools</td>
<td>Taken from three project schools. One school per project</td>
</tr>
<tr>
<td>Two principals, nine teachers and three students interviewed</td>
<td>A total of 9 teachers were selected: 3 from Microsoft STIC, 3 from a NEPAD E-school, and 3 from the SchoolNet project.</td>
</tr>
</tbody>
</table>

Data Collection Methods
- Observations, interviews and questionnaires

All 9 teachers and three students were interviewed, each interview lasting 20 to 30 minutes. Two principals were also interviewed. Two observations were conducted per school. A questionnaire was distributed to all teachers.

The main participants were nine secondary and high school science teachers who met the selection criteria for the study. Firstly, they had previously been trained in basic ICT literacy and integration and, secondly, they demonstrated a willingness to participate in the study. With students, three were selected for informal interviews, whereas others were observed in their classes. As stated previously, they had access to several different software applications, but the main packages used by the students were: MS-PowerPoint for presentations, Encarta for multimedia search, and a software tool for organizing and structuring their thoughts on what they had learned about a topic. Two principals were also interviewed.

Table 5.15 gives further details of the participating schools, with the school location and the number of computers used in classrooms. The numbers of computers exclude computers in laboratories.

Table 5.15: Profile of Schools in the Pilot Study

<table>
<thead>
<tr>
<th>Project</th>
<th>Location</th>
<th>Principals</th>
<th>Teachers</th>
<th>Students</th>
<th>Computers in Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>SchoolNet</td>
<td>Urban1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>E-School</td>
<td>Urban2</td>
<td>-</td>
<td>3</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>STIC</td>
<td>Rural1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>53</td>
</tr>
</tbody>
</table>

5.9.3 – Physical infrastructure

The physical infrastructure of schools in the Pilot Study as shown in Table 5.15 was a great improvement on the 2007 situation described in Section 1.4.1. All three of
these schools were among those whose science teachers had attended the orientation sessions and the subsequent workshops. The nine teachers who served as participants had all undergone significant ICT professional development and were continually using ICT in their classroom teaching. Participation was voluntary, but all nine were most willing to be involved.

5.9.4 – Instruments

Three main data collection instruments were used in this study: observation of class situations; interviews with teachers, students and principals; and a questionnaire survey among teachers.

The interviews were conducted to determine how ICT was being applied in the classroom. A total of three students, nine teachers, and two principals were interviewed across the three schools. The observations and interviews triangulated data collected in the questionnaire survey among teachers, thereby increasing the internal validity of the study (Eder and Fingerson, 2002). It also gave the author a perception of what students experienced as they encountered computers in their classrooms. The interviews with teachers provided a holistic overview of the students’ ways of learning through the use of technology. Personal accounts from students and teachers reinforced some aspects that the author had previously noted in his observations. The interviews also allowed teachers and students to contribute to ownership of the research by giving their input and reflections on use of computers in the science class.

Tables 4.9 and Appendices 1 and 2 list the evaluation criteria which helped in the design of the questionnaires, the interview questions and the observation criteria.

5.9.4.1 Interviews

The strategies (Parkinson, 2001) used during interviews with students were:

(a) Establishing a climate of trust before the interviews;
(b) Interviewing in a familiar and convenient environment;
(c) Interviewing while participants are completing a task.
The author used interview protocols for matters to address during the interviews with students and teachers. The interview protocols were early versions of those used in the Main Study, which are shown in Appendices 5 and 6. This helped him focus on the topic and maintain consistency in the basic structure from one interview to another. At the same time, he explored unexpected aspects, asking other questions related to experiences in learning and teaching with technology. Based on the approach recommended by Cresswell (2009), the author took notes throughout the interviews, including name and title of subject, key questions, and associated answers. Empty spaces in the template allowed for open-ended comments. Responses to a question often guided the next question(s); consequently, the author initially required answers to a standard set of questions to generate further questions, in line with Parkinson (2001).

Teachers’ interviews took place after the observations to gather their perceptions about ICT integration in their classrooms, the barriers to integration and the proper use of ICT tools in science classes. In addition, principals were interviewed to give their evaluation of ICT in education and to suggest possible ways of improvement.

5.9.4.2 Observation

To establish exactly how students used computers in classroom, individually and in collaboration, the author conducted observations in the naturalistic field situation. In fact, observation was the main method used in the Pilot Study to collect data. The occurrence and length of observation sessions varied according to the way in which computers were used for the lesson and the tasks given to students. According to Merriam (1988, p.92), ‘The time spent with all schools, the number of visits, and the number of observations made per visit cannot be determined before time’. As the author observed students, he took field notes. Immediately after a session, he summarized, and wrote these observations as a narrative (Wiersma, 2000).

The reason for using observation as the prime method of data collection was the uniqueness and the essence of this unconventional research. Such studies may not be unusual elsewhere, but in Lesotho computers are not commonly used in education, especially not by the students themselves.
Although the main purpose of a Pilot Study is not to collect data (see Section 5.9), certain notable points of the observations and interviews are presented. The author documented how, and for what purposes, teachers and students were using computers within the teaching and learning processes.

5.9.4.3 Qualitative finding from the observations and interviews

Before observing the students’ presentations, the author spent time in the classroom, determining how teacher and students collaborated and made plans to use computing and technological devices in subject learning. The author’s early engagement in the setting provided the opportunity to get to know the students and create an environment of mutual trust. This contextualisation and contact provided ‘... informational orientation that will be invaluable in increasing both the effectiveness and the efficiency of the formal work’ (Lincoln and Guba, 1985: p.251).

In his field notes, the author recorded the location, participants, date and time, as well as the activities of the students, and a depiction of the setting. In total, 15 observation sessions were conducted across the three schools. In some cases one, and in other cases two, sessions were conducted in a day. Analysis of the field notes defined patterns that helped in preparing questions and a list of behaviours for a more intense study during later stage of the observations (Emerson, Fretz and Shaw, 2001). In this case the ‘later stages’ mean the Main Study.

Findings of Observation

In each school, the author organised with the participating science teachers that he would observe certain lessons and, in some cases, the follow-up lesson when pupils presented their homework resulting from the lesson. Of particular importance and an indication of progress, was the fact that lessons used computers tools within subject teaching. He attended physics, chemistry and biology classes. When he observed PowerPoint presentations by teachers, he noted that they were confident and well prepared.

He noted cases of malfunctioning equipment, as well as how the situations were handled. For example, a teacher had prepared a lesson on his laptop, but when he plugged it into the projector, no connection occurred. A student came to the rescue.
He took out his flash disc, copied the file and loaded it into the desktop in the classroom. The class was delighted when their fellow-student solved the problem.

The author also saw that students had learned to engage extensively and confidently in discussions about their solutions and shared ideas. They explored the use of different solutions to the problem. In their collaborative projects, and some workable ideas were developed.

He also saw groups of pupils presenting their projects using both PowerPoint and Movie Maker, the latter involving videos they had made with the school’s digital camera. A Form C (Grade 10) group at a school that had Internet connectivity downloaded a presentation system from the Internet and used it to give a physics lesson to the class. The same group also used Encarta to acquire information.

In another school, a group of Form D (Grade 11) students presented a simulation of the circulatory system. They had brainstormed the topic, then prepared and designed a presentation using Microsoft Movie Maker. They shared their knowledge with peers in the group, and collaboratively finalised the presentation. Finally, they presented a lesson to the entire class.

In a further example, Form C students connected cameras to their computers and took pictures of indigenous plants growing outside the school to prepare and present findings for a lesson on the environment. The pictures were inserted into a Microsoft Word document indicating where the plants could be found, and providing additional information about such plants and how to protect them. Under the supervision of the teacher, each group made a five-minute presentation to the class, allowing three questions from the class to each group and a final comment by the teacher. Students were assessed on their performances, including display of presentation; research undertaken; analysis of data; and basic computer skills.

In general, PowerPoint was used the most when students analysed their results and prepared presentation to make in class.
Compared to traditional, classes, the classes where ICT was used were more interactive and students were motivated. Students listened intently as teachers presented well planned and researched lessons, and in the discussion on the collaborative projects, students debated and discussed different ways of solving problems. When their fellow students presented projects they listened intently. In general, both teachers and students were highly motivated and engaged as they used e-learning tools for teaching and learning.

The teachers reacted to students’ presentations with positive approaches. Some teachers intervened in a discerning way to improve students’ incorrect use of software or to suggest other approaches or alternative software to be used.

These observation sessions provided the author with information that enabled the expression, through a narrative description, of how teachers and students were using computers to teach and learn in a collaborative way. In particular, he saw how technology had helped them to learn and perform in effective new ways.

**Findings of Interviews**

It was mentioned in Section 5.9.4 that interviews reinforced certain aspects that the author had previously noted in his observations. For example, in the observations, the author had suspected that some students were using the Internet for non-subject related purposes. Teachers confirmed this in the interviews.

Discussing this issue, Teacher 3 commented:

‘**Initially, I would leave students themselves in the computer lab, thinking that they would work independently on assignments and other tasks given to them ... I came to realise that some of the time they would either play games or open obscene materials on the web**’.

Teachers also showed awareness of the importance of using tutorials and simulations. Teacher 2 explained that after seeing simulations in class, students tended to use the information in their projects, which the researcher had confirmed in the observations during students’ presentations. They extensively made use of downloaded simulations from YouTube.
Teacher 5 expressed her satisfaction:

‘I am quite happy that now my students can contribute to their learning. Even the reserved students, and slow learners are motivated to use simulations’

In their interviews, two principals provided information on the state of ICT and professional development among all teachers, not just in the area of science. They proposed that each school develop its own ICT policy and professional development programme to cater for its own particular ICT needs.

Teacher 3 joined the principal on this issue and said:

‘Most of the schools that perform well in our district have ICT facilities, and a reliable professional development programme, adapted to the realities of the school ... having a school policy that relate to the national framework’.

The students interviewed also showed a positive attitude toward e-learning. Student 1 indicated that for him e-learning was the best way. He believed that for any teacher who wants to help students develop 21st century skills they should support their teaching with technology. He added:

‘Since some of our teachers started using computers in class, ... we feel encouraged to use it also in our projects, especially when presenting. ... I like using Microsoft PowerPoint’.

5.9.4.4 Questionnaire Survey

The development of the questionnaire was informed by a list of evaluation criteria developed by the author (Table 4.9, Appendix 1 and 2), and the nature of the questions elicited both qualitative and quantitative data. The questionnaire was an earlier version of the one used in the Main Study, which is shown in Appendix 7.

To investigate the use of technology and finalise the design of a questionnaire on science teaching and learning and on the barriers to ICT integration, the author used the Pilot Study to obtain initial perceptions of the teachers and understand the difficulties they experienced while integrating e-learning into their practical teaching. In total, all the nine participating science teachers completed the questionnaire. Responses to the questions gave valuable insights from the teachers’ professional
viewpoints into problems in science education in Lesotho, as well as their views on the future development of e-learning.

The author believes that responses from science teachers provide the most dependable and precise information about the current status of ICT integration in Lesotho and set the scene for further research, because science teachers were the first to start integrating technology into their subject teaching.

5.9.4.5 Findings from the questionnaire survey

As stated, the main purpose of a pilot is to refine the research instruments and not to obtain data. However, in this case, the pilot was also used to provide intermediate data between the Post-orientation Study of 2008 and the Main Study at the end of 2010. Some of the data, from a few selected questions in the survey, is discussed in this section.

The 2009 Pilot Study was conducted in three schools, instead of nine, as in the 2007 Baseline Study. However, the three participating schools had all been included in the Baseline, and therefore the findings can be viewed as a reliable indication of improvement, enabling comparisons to be made.

Table 5.16 shows how the use of computers for education in classrooms and laboratories increased from 2007 to 2009. The 2007 figures (based on Table 5.3), show 124 computers among 5136 students, making a ratio of 1:41. The 2009 figures show 86 computers among 1609 students, giving a ratio of 1:19, which is much better than the 2007 situation.
Table 5.16: Profile of Schools 2007/2009

<table>
<thead>
<tr>
<th></th>
<th>2007 (Baseline Study)</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools Surveyed</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Students</td>
<td>5136</td>
<td>1609</td>
</tr>
<tr>
<td>Teachers</td>
<td>161</td>
<td>67</td>
</tr>
<tr>
<td>Computers for educational purposes</td>
<td>124</td>
<td>86</td>
</tr>
<tr>
<td>Student/Computer ratio</td>
<td>1:41</td>
<td>1:19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th># of computers</th>
<th>Percentage</th>
<th># of computers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use in Laboratory</td>
<td>120</td>
<td>97%</td>
<td>46</td>
<td>53%</td>
</tr>
<tr>
<td>Use in Classroom</td>
<td>4</td>
<td>3%</td>
<td>40</td>
<td>47%</td>
</tr>
</tbody>
</table>

The 2009 data shows that the use of computers in actual classrooms increased greatly – from 3% to 47%. Teachers were integrating technology into the subject matter and not merely teaching basic computer skills, as often occurred during classes in computer laboratories. The increased use of computers for teaching may be mainly attributed to the STIC and E-School Projects.

Data from the questionnaire provided updated information on the nature of use of ICT in the schools surveyed. Table 5.17 shows that, by the end of the 2009 academic year, a greater variety of e-learning tools was available for teaching and learning than in the Baseline Study of 2006/7. However, not all of the forms and methodologies of e-learning were present in all three schools. The number of schools in which each form was present, is indicated in the rightmost column of Table 5.17.

Table 5.17: Forms of E-learning (2007 and 2009)

<table>
<thead>
<tr>
<th>Forms of E-learning used in Lesotho</th>
<th>2006/7</th>
<th>2009</th>
<th>Number of schools (n=3) where the software was present in 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI Tutorials</td>
<td>X</td>
<td>X</td>
<td>3</td>
</tr>
<tr>
<td>Video and Audio</td>
<td>X</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Simulations</td>
<td>X</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Educational Games</td>
<td>X</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Interactive Learning/Practice</td>
<td></td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>CD ROM-based Courses</td>
<td>X</td>
<td>X</td>
<td>3</td>
</tr>
<tr>
<td>Web-based Courses</td>
<td></td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>Drill and Practice</td>
<td>X</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Video Conferencing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet-based Research</td>
<td></td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>Electronic Encyclopaedia-based Research</td>
<td></td>
<td>X</td>
<td>3</td>
</tr>
</tbody>
</table>
The number of teachers who use computers for preparation, and who facilitate use of e-learning on the part of their students in the form of tutorials and use of computers for their projects, had also increased. Use across all subjects, for preparation, as indicated in Table 5.18, increased from 16% to 56%; application of e-learning tutorials increased from 4% to 48%; and use in the context of students’ projects increased from 2% to 59%.

For science education, in particular, use for preparation increased from a reasonable level of 45% in 2007 to a high 86%; use of e-learning tutorials increased from 45% to 71%; but use by students’ for projects only increased from 27% to 29%. This is a minimal increase, and further research will be required to determine why science teachers are reluctant to accelerate computer use for student projects. Science teachers started from a higher base in 2007 than other teachers, but their usage levels in 2009 are at high levels in aspects other than projects; which is a matter requiring attention.

Table 5.18: Use of Computers by Teachers – 2009

<table>
<thead>
<tr>
<th></th>
<th>ALL Teachers</th>
<th>Science Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preparation.</td>
<td>Tutorials etc</td>
</tr>
<tr>
<td>Total Teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>143</td>
<td>23</td>
</tr>
<tr>
<td>9 schools</td>
<td>100%</td>
<td>16%</td>
</tr>
<tr>
<td>2009</td>
<td>39</td>
<td>22</td>
</tr>
<tr>
<td>3 schools</td>
<td>100%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Certain questions related to professional development and training. The professional development of teachers in the three schools had moved from a traditional approach to one where, over and above the standard training offered under the projects, the schools could request customised training and workshops based on the needs of their curricula. The interviews, as well as the questionnaires, indicated that the various
ICT-based training sessions and workshops for teachers in all subject areas, as well in science, were achieving success.

5.9.5 – Refinement to the Main Study
Finally, and most important for a pilot, the reaction of participants identified redundant or ambiguous questions. For the Main Study, such questions were omitted or improved in the interviews and questionnaires. As stated earlier, the interview protocols and the questionnaire used in the Main Study are refined versions of those used in the pilot. Hence the actual instruments used in the Pilot Study described in this section, are not given in appendices, but the reader is referred to Appendices 5, 6 and 7 containing the final versions that were employed in the Main Study.

5.10 Professional Development of Science Teachers
This section relates to training in Lesotho in general and not to any particular one of the studies discussed in this chapter.

The training of science teachers in the effective integration of ICT into science teaching and learning is an important component. The emphasis in training science teachers in Lesotho is particularly on the pedagogic use of ICT in teaching and learning rather than on the possession of ICT skills, which most science teachers possessed prior to the advent of the projects.

The launch of the School Technology Innovation Centre (STIC) based at the Lesotho College of Education (LCE) was another milestone in education in Lesotho, particularly for professional development of teachers. Full-time trainee teachers and in-service teachers receive training at the centre. LCE is the only teacher training institute in Lesotho, and responsible for ensuring that graduates have essential basic ICT skills and knowledge for the successful integration of ICT into the teaching and learning of science.

In addition to conducting training workshops, the STIC organizes annual sessions of the Innovative Educators’ Forum (IEF) to recognize best practices in schools and encourage the innovative use of ICT in teaching. This is also organized in other
countries globally under the joint sponsorship of local governments and Microsoft. Following the regional Lesotho competition in 2009 and 2010, teachers from the groups trained in Lesotho won awards at the Pan-African IEF and the World IEF. These achievements are addressed in Section 6.5 under two case studies.

5.11 Conclusion

This chapter gave an overview of various aspects of ICT integration in Lesotho and developments over the last decade, discussing the interventions and the studies shown in figure 5.1. Different aspects of integration were addressed, including access to ICT in Lesotho in Section 5.2, and the educational context of e-learning in Lesotho in Section 5.3. In Section 5.4 an overview of the SchoolNet project and the situation before 2007 was given. A discussion of the orientation and Post-orientation Study was provided in Section 5.5, followed by the Comparative Study of the two cases, Lesotho and South Africa in Section 5.6. Various government initiatives to improve science education in secondary schools were discussed in Section 5.7. Section 5.8 addressed the impact of the three projects on ICT integration. The Pilot Study to test methodologies and instruments was discussed in Section 5.9. The chapter also presents comparison table between years of activities. The professional development of science teachers was addressed in Section 5.10, specifically the training of science teachers in the effective integration of ICT into science teaching and learning.

Chapter Six focuses on the findings of the Main Study and describes two highly successful cases in the Showcase Study.
Chapter Six ~ Data Collection and Analysis
Study 5: Main Study and Study 6: Showcase Study

6.1 Introduction

Chapter Five deals with analysis and interpretation of qualitative and quantitative data collected from the first four studies (Figure 4.3 and Table 6.1). The focus of this chapter, Chapter Six, is to present the qualitative and quantitative findings of the Main Study by describing the survey, interview and observation data collection and analysis. The research instruments used in this study are described in detail in Section 4.8 in the research design chapter.

The Main Study, which is introduced in Section 6.2, is an extensive study to re-evaluate and address the main research question and sub-questions of this research, which are re-stated in this section. Responses to the quantitative research questions are tallied and recorded in Sections 6.3.1 to 6.3.3, while the qualitative data is discussed in Section 6.4. Two Showcase Studies of schools where ICT is successfully integrated and teachers won awards are presented in Section 6.5. Section 6.6 concludes the chapter.

Table 6.1 is a tabular representation of Figure 4.3, which maps all the interventions and studies to that section of the research study in which each is discussed. The studies discussed in this chapter (last column) are shaded to show their context and roles as the culmination of this research.
Table 6.1: E-learning Implementation/Integration in Science Classrooms

<table>
<thead>
<tr>
<th>Year</th>
<th>Event / Intervention</th>
<th>Research Study</th>
<th>Aims</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2005</td>
<td>Distribution of computers in selected schools</td>
<td></td>
<td>Initial attempt at integrating ICT in education</td>
<td>1.3</td>
</tr>
<tr>
<td>2006</td>
<td>Advent of SchoolNet Project</td>
<td>Study 1: Baseline Study</td>
<td>Overview of early stage of ICT/e-learning integration in schools</td>
<td>5.4</td>
</tr>
<tr>
<td>2007</td>
<td>Orientation by Researcher</td>
<td>Study 2: Post-orientation Study</td>
<td>To allow teachers to use ICT in classrooms more effectively</td>
<td>5.5</td>
</tr>
<tr>
<td>2008</td>
<td>Microsoft and Intel NEPAD E-School initiatives</td>
<td>Study 3: Comparative Study in South Africa and Lesotho</td>
<td>To examine computer use and e-learning in science classrooms in two different settings</td>
<td>5.6</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td>Study 4: Pilot Study</td>
<td>To test methodologies and techniques for the main study</td>
<td>5.9</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>Study 5: Main Study</td>
<td>To investigate ICT integration in science classrooms in Lesotho.</td>
<td>6.2, 6.3 and 6.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Study 6: Show case Studies</td>
<td>To report on success stories of innovations by two award-winning teachers.</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Information presented in this chapter was obtained from a sample of participants in the three projects described in Section 1.3. The Main Study is aimed at addressing the main research question:

**How can effective e-learning and integration of ICT be supported in the science classroom in Lesotho secondary and high schools?**

Stakeholders were asked questions related to the supporting research questions; given in Section 1.6.
1. What are barriers/obstacles to the integration of ICT in Lesotho secondary and high schools?
2. What familiarity, aptitude, skills and strategies do Lesotho secondary and high school science teachers and students have with the use of ICT?
3. What advantages/disadvantages do science teachers and students perceive when integrating e-learning with established classroom practice?
4. What preparations are required for the introduction of e-learning and how should infrastructural issues be addressed?
5. What guidelines do educators need when using ICT in the science classroom?

6.2 Study 5: Main Study

The ultimate intention is that findings of this study can be used in supporting the use of ICT across the curriculum in Lesotho schools. Stakeholders in the Lesotho education system believe that incorporating technological tools into teaching and learning practice might bring the necessary improvements in instructional and pedagogical developments that will, in turn, elevate education standards, contributing to changes in teaching/learning methods and environments (Government of Lesotho, Vision 2020, 2001; Government of Lesotho, ICT Policy, 2005). Furthermore, it is expected that technology will continue to change and enhance learning environments and strategies.

As explained in Section 5.9, a Pilot Study was undertaken to test and refine the research methods, criteria and instruments to be used in the Main Study. After trying out the methodologies and instruments in the pilot, the Main Study, involving extensive in-depth investigation of ICT integration in the science classroom, was undertaken in nine co-educational secondary and high schools with mixed gender classes. Following the pilot, some criteria and questions were removed and other questions were rephrased to make them clearer.

The Main Study involved nine schools and forty participants – including principals, teachers and students. Table 6.2 lists the nature and distribution of the participating schools. Three of the schools were the schools used in the Pilot Study. The 17 (10 +7) teachers in Schools 4 to 9 had received Microsoft and E-School training.
Table 6.2: Participating Schools (Main Study)

<table>
<thead>
<tr>
<th>Project</th>
<th>District</th>
<th>Location</th>
<th>Numbers</th>
<th>Schools</th>
<th>Teachers</th>
<th>Students</th>
<th>Computers used by teachers</th>
<th>Internet Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 SchoolNet</td>
<td>HL</td>
<td>R</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>2 SchoolNet</td>
<td>ML</td>
<td>R</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>3 SchoolNet</td>
<td>LL</td>
<td>U</td>
<td>1</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>4 STIC</td>
<td>LL</td>
<td>U</td>
<td>1</td>
<td>4</td>
<td></td>
<td>3</td>
<td>45</td>
<td>Yes</td>
</tr>
<tr>
<td>5 STIC</td>
<td>LL</td>
<td>U</td>
<td>1</td>
<td>3</td>
<td></td>
<td>2</td>
<td>26</td>
<td>No</td>
</tr>
<tr>
<td>6 STIC</td>
<td>LL</td>
<td>U</td>
<td>1</td>
<td>3</td>
<td></td>
<td>3</td>
<td>49</td>
<td>Yes</td>
</tr>
<tr>
<td>7 E-School</td>
<td>ML</td>
<td>R</td>
<td>1</td>
<td>2</td>
<td></td>
<td>1</td>
<td>15</td>
<td>No</td>
</tr>
<tr>
<td>8 E-School</td>
<td>HL</td>
<td>R</td>
<td>1</td>
<td>3</td>
<td></td>
<td>1</td>
<td>21</td>
<td>No</td>
</tr>
<tr>
<td>9 E-School</td>
<td>LL</td>
<td>U</td>
<td>1</td>
<td>2</td>
<td></td>
<td>2</td>
<td>43</td>
<td>Yes</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>9</td>
<td>21</td>
<td></td>
<td>17</td>
<td>204</td>
<td></td>
</tr>
</tbody>
</table>

Key: HL - Highland; ML - Midland; LL – Lowland; U - Urban; R – Rural

Table 4.7 is repeated here as Table 6.3 to show details of the participants and data collection.

Table 6.3: Human Participants (Main Study)

<table>
<thead>
<tr>
<th>2010</th>
<th>Selection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Schools</td>
<td>Schools from the three projects.</td>
<td>Three schools per project.</td>
</tr>
<tr>
<td>Participants (n = 40)</td>
<td>Two principals, 21 teachers, 17 students</td>
<td>Teachers who had undertaken significant ICT professional development training programmes from the three projects. Teachers using ICT in classroom teaching. Science teachers who volunteered to participate.</td>
</tr>
<tr>
<td>Data Collection Method</td>
<td>Questionnaires, Observations and Interviews</td>
<td>A total of 14 observations, with one or two per school. 17 students and 2 principals interviewed - two or three per school. 21 teachers answered the survey questions. Two teachers per school were interviewed. A total of 18 teachers interviewed.</td>
</tr>
</tbody>
</table>

The questions asked in the questionnaire survey were formulated using criteria extracted from the literature studies in Chapters Two and Three, and consolidated in Sections 4.7 and 4.8 in the Research Design chapter. The criteria formed the basis of questions and evaluation statements for the questionnaire and interviews. A questionnaire survey was conducted among the 21 teachers from the selected schools. Responses were on a 5-point Likert scale indicating Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree respectively. Further questions are answered as True or False, and others are open-ended questions that provide
qualitative data. Participants were also asked to describe the ICT professional development programmes they had attended and whether they received an adequate supply of hardware and software from their school administration. The questionnaire is in Appendix 7.

In addition, principals, teachers and students were interviewed and asked to supply further information on ICT integration in science classrooms, and whether e-learning supports the instructional process and interaction between teachers and students and students among themselves.

The findings of these qualitative interviews and observations, were read, coded and categorised into themes, as discussed in Section 6.4. The interview templates are in Appendices 5 and 6.

6.3 Survey Results

As stated, the author conducted a survey among secondary and high school teachers from nine schools across the three projects, namely SchoolNet, STIC and E-School, to identify the extent of progress in ICT integration in Lesotho secondary and high school science classes. Twenty one questionnaires were distributed to teachers and there was a 100% response rate. Four respondents were from the SchoolNet Project, ten from STIC, and seven from E-School, as shown in Table 6.2. SchoolNet had only four because there were less science teachers in this project.

Table 6.4 presents the criteria, A1, A2, B1, B2, B3, B4 and C, on which the questionnaire was based and the number of questions/evaluation statements related to each criterion. The third column lists the relevant question numbers associated with each criterion.

Questions 1 to 4 in the questionnaire are concerned with the personal details of participant.
The sections and questions that follow each criterion in the text are related to the criterion. The questions are associated with the most appropriate criteria and are not discussed in the order in which they appeared in the questionnaire.

### Table 6.4: Criteria and Associated Questions

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Number of Questions</th>
<th>Questions</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Perceived Importance of Technology in School Education (Social Rationale)</td>
<td>11</td>
<td>Q. 5, 6, 7, 8, 10, 11, 12, 14, 15, 17</td>
<td>6.3.1.1</td>
</tr>
<tr>
<td>A2. Perceived Importance of Technology in School Education (Pedagogical Rationale)</td>
<td>7</td>
<td>Q. 9, 13, 20, 26, 27</td>
<td>6.3.1.2</td>
</tr>
<tr>
<td>B1. Barriers to ICT Integration (Professional Development of Teachers)</td>
<td>3</td>
<td>Q. 16, 17, 18, 17, 22, 23, 25</td>
<td>6.3.2.1</td>
</tr>
<tr>
<td>B2. Barriers to ICT Integration (Time Allocation for Teachers' Use of ICT Resources)</td>
<td>4</td>
<td>Q.24a, 24b, 33, 36</td>
<td>6.3.2.2</td>
</tr>
<tr>
<td>B3. Barriers to ICT Integration (Infrastructural Support and Technological Issues)</td>
<td>3</td>
<td>Q. 19, 28, 29, 36</td>
<td>6.3.2.3</td>
</tr>
<tr>
<td>B4. Barriers to ICT Integration (Impacts of motivation and Inappropriate Learning Environment)</td>
<td>4</td>
<td>Q. 30, 31, 32, 36</td>
<td>6.3.2.4</td>
</tr>
<tr>
<td>C. ICT In the Science Classroom</td>
<td>7</td>
<td>Q.12, 15, 21, 25, 34, 35, 36</td>
<td>6.3.3</td>
</tr>
</tbody>
</table>

The complete questionnaire is given in Appendix 7

### 6.3.1 - Criterion A ~ Perceived Technology Importance in Education

#### 6.3.1.1 Criterion A1: Human and Social Rationale

This section discusses the perceptions of teachers on the social and subjective aspects of technology use in schools by both teachers and students. They are discussed according to Questions 5, 6, 7, 8, 10, 11, 12, 14, 15, 17 in the survey and results are presented quantitatively.

#### 6.3.1.1.1 Human impact of teaching with technology (social rationale)

Classifying the results per batch, Table 6.5 gives the results for Questions 5 and 11.
Table 6.5: Questions 5 and 11

<table>
<thead>
<tr>
<th>Question</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5</td>
<td>ICT enhances students’ performance and progress</td>
<td>Yes</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Q11</td>
<td>I am content with a traditional way of teaching</td>
<td>Strongly Agree</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agree</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

In answering **Question 5**, the majority of teachers (19 out of 21, 90%) from the participating schools considered that ICT enhances students’ performance and progress. This is shown in Table 6.5 and Figure 6.1.

![ICT enhances learning](image)

**Figure 6.1: ICT Enhances Learning**

This result largely corresponds with the response to **Question 11**: where only three teachers (3 out of 21, 14%) (See Figure 6.2) preferred to continue with traditional teaching. By implication the other eighteen teachers, 86%, considered that teaching supplemented with technology use is better than traditional teaching.
Question 6 was an open-ended question (a follow up to Question 5) to explain why teachers believe ICT enhances learning. The answers represented multiple points of views, mainly positive. Table 6.6 categorises the teachers’ responses:

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Categories</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q6</td>
<td>Improvement in Matriculation</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>ICT helps students with interpretation, evaluation, analysis and synthesis of</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>information from different sources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ICT helps to solve problems and generate new knowledge</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ICT assists learners to become more independent</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 6.6 indicates that the majority of respondents (13 out of 21, 62%) had observed improvements in Matric results (Matriculation examination abbreviated to ‘Matric’ referring to the final year of high school). Ten teachers (48%) had found that using ICT helps students with aspects such as interpretation, evaluation, analysis and synthesis of information from different sources. Three teachers (14%) suggested that technology can help to solve problems and generate new knowledge, and eleven teachers (52%) believed ICT assists learners to be more independent, as they became effective information seekers and critical thinkers.
As secondary data to verify the teachers, stance and improved matric results, Table 6.7 presents the matriculation results of the nine schools involved in the study during the four years from 2007 to 2010.

**Table 6.7: Matriculation Examination Results**

<table>
<thead>
<tr>
<th>Schools</th>
<th>Total students passed</th>
<th>Percentage pass</th>
<th>Total students passed</th>
<th>Percentage pass</th>
<th>Total students passed</th>
<th>Percentage pass</th>
<th>Total students passed</th>
<th>Percentage pass</th>
<th>Average percentage pass over 4 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>SchoolNet 1</td>
<td>81</td>
<td>80</td>
<td>66</td>
<td>77</td>
<td>54</td>
<td>78</td>
<td>67</td>
<td>69</td>
<td>76</td>
</tr>
<tr>
<td>SchoolNet 2</td>
<td>109</td>
<td>80</td>
<td>95</td>
<td>76</td>
<td>99</td>
<td>63</td>
<td>89</td>
<td>65</td>
<td>71</td>
</tr>
<tr>
<td>SchoolNet 3</td>
<td>67</td>
<td>90</td>
<td>73</td>
<td>71</td>
<td>90</td>
<td>69</td>
<td>90</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>E-School 1</td>
<td>72</td>
<td>96</td>
<td>77</td>
<td>86</td>
<td>73</td>
<td>96</td>
<td>80</td>
<td>100</td>
<td>72</td>
</tr>
<tr>
<td>E-School 2</td>
<td>21</td>
<td>81</td>
<td>37</td>
<td>78</td>
<td>33</td>
<td>91</td>
<td>39</td>
<td>82</td>
<td>83</td>
</tr>
<tr>
<td>E-School 3</td>
<td>82</td>
<td>82</td>
<td>88</td>
<td>72</td>
<td>82</td>
<td>79</td>
<td>80</td>
<td>95</td>
<td>82</td>
</tr>
<tr>
<td>STIC 1</td>
<td>94</td>
<td>77</td>
<td>99</td>
<td>79</td>
<td>97</td>
<td>98</td>
<td>97</td>
<td>100</td>
<td>88</td>
</tr>
<tr>
<td>STIC 2</td>
<td>46</td>
<td>87</td>
<td>51</td>
<td>84</td>
<td>55</td>
<td>96</td>
<td>53</td>
<td>100</td>
<td>91</td>
</tr>
<tr>
<td>STIC 3</td>
<td>82</td>
<td>80</td>
<td>83</td>
<td>73</td>
<td>78</td>
<td>92</td>
<td>82</td>
<td>96</td>
<td>85</td>
</tr>
</tbody>
</table>

This table represents the overall pass statistics in all subjects, not only science. The ‘average percentage pass’ (last column) relates to the average percentage of students who passed matric across all the matriculants in each school over the four-year period. In seven of the nine schools (SchoolNet 3; E-School 1, 2, and 3; and STIC 1, 2 and 3), matric results either stayed relatively constant or improved considerably from 2007 to 2010. See figures highlighted in red in Table 6.7. In only two, SchoolNet 1 and SchoolNet 2, did the percentage pass drop. See figures highlighted in blue in Table 6.7.

In general, performance in SchoolNet schools is disappointing. In the other schools, the improvement in percentage pass is notable. This data triangulates the teachers’ beliefs that matric results improved during the period of increased use of ICT. It cannot be proved that this is directly related to technology use. It could be the result of various factors, including changes in the curricula. However, it is important to note that the percentage pass did not decline during the period when technology was increasingly integrated.

Table 6.8 presents the teachers’ responses to **Questions 10, 7, 8 and 17**, all of which are related to attitudes and students’ achievement.
Table 6.8: Questions 10, 7, 8 and 17

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q10</td>
<td>The way I personally view and use technology has an effect on the students’ attitude to ICT integration in my teaching and their learning</td>
<td>Strongly Agree</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agree</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Q7</td>
<td>Improvement in students’ attitude when technology is used, as an indication of positive change</td>
<td>True</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>False</td>
<td>2</td>
<td>0</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Q8</td>
<td>I enjoy using technology to help students have an authentic view of real-world phenomena</td>
<td>True</td>
<td>-</td>
<td>9</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>False</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Q17</td>
<td>In what ways do you and your students achieve better results when technology is used?</td>
<td>Exams and Tests</td>
<td>3</td>
<td>10</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

*Question 10* investigates the views of teachers on the relationship between their students’ attitudes towards ICT and their own use of technology. Seventeen teachers (81%) strongly agreed or agreed that students’ attitudes are influenced by their teachers’ views and use of technology. Where teachers are positive about e-learning, students tend to demonstrate positive attitudes and skills.

From the answers to Question 10, it appears that teachers from STIC and e-school projects are marginally more positive about views on technology than teachers in SchoolNet, especially those from rural areas. This could be due to the fact that, although these schools benefited from computer donations, teachers were not well trained to use them for teaching their subject matter. It must also be noted that there were only four respondents for SchoolNet schools, in contrast with ten from STIC and seven from E-school. With this difference in numbers it is not possible to make meaningful comparisons involving SchoolNet.

*On Question 7* regarding improvement of students’ attitude, six teachers (29%) did not agree or were unsure that attitudes had improved with the use of technology. STIC Teachers were positive about students’ attitudes. These teachers have been involved hands-on in helping their students in technology-based activities both in
teaching and in e-learning activities by the students. E-school teachers showed the most positive perceptions, with six out of the seven teachers seeing improvement. Figure 6.3 graphically depicts the responses from participant teachers.

![Improvement in learners' attitude](image)

**Figure 6.3: Improvement in learners’ attitude**

With responses to Question 7 mainly indicating improvement in students’ attitude when technology is used, it is of interest to see responses to **Question 8** which relates to whether they (the teachers) personally enjoy using technology in helping students to grasp real-world phenomena. Fifteen teachers out of the seventeen from STIC and NEPAD E-School projects (72%) enjoyed using ICT to demonstrate real-world phenomena, while the rest were either not sure (14%) or not enjoying it (14%). Figure 6.4 presents this graphically.

![Technology helps learners have an authentic view of real-world phenomena](image)

**Figure 6.4: Technology and Students’ View of World**

**Question 17** was an open-ended question, to enquire whether students and teachers achieve better results when technology is used.
In answering this, teachers focused mainly on examination results. Across the three projects, they indicated that since they started using ICT tools, their students had been performing better in Matric examinations (see Table 6.7). Some also mentioned improved performance in class tests. Of the STIC science teachers, all ten (100%) reported satisfaction in student results at Matric level. One teacher from the SchoolNet project was not sure whether the success depended on his use of technology. As pointed out earlier, SchoolNet teachers had been exposed to very few professional development programmes. This question is also addressed in other parts of this study, for example Section 6.3.2.1. and Section 6.4.1; it is answered across criteria. There is quantitative analysis of it in Section 6.3.2.1, where teachers mentioned other achievements.

Table 6.9 presents the results of Questions 12 and 14, focussing specifically on the use of e-learning applications.

<table>
<thead>
<tr>
<th>QNo.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q12</td>
<td>I believe e-learning can help me to become more innovative in class</td>
<td>Yes</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not sure</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Q14</td>
<td>I believe e-learning can support the instructional process</td>
<td>Yes</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

As Question 12 addressed innovation in teaching, fourteen of the twenty one teachers (67%) confirmed that e-learning has the potential to help them work creatively, and in novel ways. Two were not sure, while three disagreed. Figure 6.5 graphically presents these stances of teachers when using e-learning tools in class.
Having participated in workshops about innovation, teachers in the STIC project had a greater understanding of innovation. In the SchoolNet project teachers, however, even after the researcher explained what innovation involved, two out of four (50%) were not sure, possibly because they still did not fully comprehend the term or possibly because of their general difficulties with ICT and e-learning.

In response to Question 14, also shown in Table 6.9, sixteen teachers (76%) agreed that using e-learning applications supports them in their instructional responsibilities. To follow up on this, the open-ended Question 15 inquired ‘If Yes, How’. Responses from the sixteen teachers who agreed varied. See Table 6.10. Several mentioned the good collaborative interaction between students and the active participation of students in lessons that incorporated e-learning such as simulations and educational games. In many cases, students experienced simulations, games and tutorials only when teachers demonstrated them. Opportunities for personal hands-on exploration by students were very limited.

<table>
<thead>
<tr>
<th>Question</th>
<th>Question</th>
<th>Answer Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q15</td>
<td>If yes How (reference to Q14)</td>
<td>Collaborative interaction between students</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SchoolNet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Active participation of students in lessons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students’ participation in E-learning activities such as simulations and educational games</td>
</tr>
</tbody>
</table>
6.3.1.1.2 Summary

The findings indicate that teachers from all the projects perceive the value of technology for themselves and their students. The human and social reasons for ICT integration in schools are in agreement with findings from other research, both in the region (Howie and Blignaut, 2009) and elsewhere (Kozma, 2005; Yücel et al. 2010). As also indicated in the literature, students collaborated better with each other in the context of ICT-based lessons.

6.3.1.2 Criterion A2: Pedagogic Rationale

Apart from technology factors based on human and social rationale, the teachers answered questions on their perceptions of pedagogic aspects of integrating ICT and e-learning in teaching and learning. The questions related to pedagogy were Questions 9, 13, 20, 26 and 27.

6.3.1.2.1 Perceived technology importance in education (pedagogic rationale)

Table 6.11 presents Questions 9, 13, and 26 and data collected in answer to these.

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9</td>
<td>Students enjoy learning activities that take place in computer labs</td>
<td>True</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not sure</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>False</td>
<td>-</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Q13</td>
<td>My students are more motivated and engaged in a subject when feedback is</td>
<td>True</td>
<td>4</td>
<td>10</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>provided immediately via technology</td>
<td>Not sure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>False</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Q26</td>
<td>Consider the pedagogic and didactic approaches in your Science classes</td>
<td>Direct interaction</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>in the days of conventional teaching and now with the regular use of</td>
<td>Feedback</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>technology. How has learning changed with the use of technology? Mention</td>
<td>Simulations to present real-world phenomenon</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>three ways or more.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In answer to Question 9 on activities in computer labs, three teachers out of four from the SchoolNet project (75%) indicated their students enjoy activities that take place in the laboratory. This might be due to the fact that SchoolNet installed the computers in labs in these schools and not in classrooms. Teachers have therefore not been exposed to the experience of technology in their own classrooms.
Seven of the ten STIC project teachers (70%) responded negatively to this question about computers in labs and, overall, fourteen teachers (67%) from across the three projects did not agree with the statement. However, this is not a negative finding. The reason why students do not enjoy lab-based activities, is that they prefer to use computers in their classrooms, since STIC provides some twenty computers in one selected classroom. This venue is shared by different classes and several teachers. In STIC schools there is also a computer laboratory, which is used mainly for computer literacy, although a few teachers give students group assignments to do in the lab after official school hours.

Similarly, six out of seven (85%) in the E-School project indicated that their students do not enjoy activities in the lab, since they have access to computers in classrooms. E-Schools equip one or two classrooms per school with computers, usually one class with twenty computers and another with three or four. Only the matric classes have access to the classroom with twenty computers.

See also Figure 6.6, which shows that while 75% of SchoolNet students use computer labs, lower percentages use labs in STIC and E-School projects, because of access in classrooms. All the students have access to computer classes for science lessons, but in most cases, this involves shared use and taking turns with just a few computers.

![Figure 6.6: Students Enjoyment of Lab Activities](image)

**Question 13** related to the value of immediate feedback, which received positive responses from all the teachers. In answering this, teachers were referring to two forms of system-generated feedback: when using interactive e-learning tools such as
simulations and tutorials, as well as results from students’ Internet searches (where Internet connectivity was possible). Four of the five urban schools in the study have Internet connectivity.

*Question 26* was open-ended, asking for three ways in which learning has changed with the use of technology. Although they used varying terms in their answers, all 21 teachers from all projects (100%) agreed that students appreciate the interaction provided by technology. As given in Table 6.11, teachers’ answers could be categorised under three ways in which learning has changed:

- Direct interaction,
- Rapid feedback, and
- Use of simulations to present real-world phenomena.

Some teachers mentioned more than two ways which explains the number of teachers in each category. For example, six teachers from E-school chose direct interaction with software and among them, five also mentioned feedback. One of these was among the two who mentioned simulations to present scientific phenomenon. The answers indicate awareness of the value of e-learning applications such as tutorials, simulations, but does not necessarily mean that all the teachers use them.

Table 6.12 relates to *Question 20* on the development of higher-order thinking skills, such as analysis, synthesis and evaluation. (See mention of Bloom’s Taxonomy in Section 2.1.)

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q20</td>
<td>Technology is just a tool to help students do things and cannot help them develop higher-order thinking skills</td>
<td>True</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not sure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>False</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>19</td>
</tr>
</tbody>
</table>

In answering *Question 20*, only two teachers, from the SchoolNet project, did not believe higher-order thinking skills could be developed by students through ICT use. Responding to a negatively stated question, such as Question 20, calls for careful
thought to the answer, but among STIC and E-School teachers, there was a strong conviction that e-learning can improve students’ development of cognitive skills.

**Question 27** was an open-ended question that asks ‘*How do you overcome pedagogic and didactic problems in the context of learning with technology? Please mention specific problems you experience and how you overcome them (Criterion A2).*

In response to **Question 27**, teachers from the STIC Project indicated that after their training at STIC they faced the challenge of downloading *Webquest* lessons posted on the Internet by other teachers, including international educators. These were not always directly suited to their situation. But their subsequent exposure to computers and training in workshops during the following two years enabled them to adapt the downloaded material and align it with their curricula. In this regard, see Figure 6.10 in a subsequent section, which shows a PowerPoint slide. This was part of a presentation downloaded from the Internet by a Lesotho teacher and modified for the local curriculum.

Three other teachers (two from E-school and one from STIC) mentioned the difficulty of creating learning environments where students study independently. However, they addressed this problem by organising forums, web-pages, e-mail and blogs, which are not part of traditional educational practice. This could only be done to a limited extent, with a few students, because use of the Internet in the classroom is restricted.

Other teachers indicated that they asked colleagues to help them when they faced such challenges as adapting downloaded tools ‘*Such practices introduce novelties*’ said one teacher from the E-school project. Unfortunately not all of these innovations were sustained in the longer term.

**6.3.1.2.2 Summary**

In general, teachers from rural areas in the three projects considered themselves and their students as lacking skills and familiarity with ICT. Their knowledge was too limited to make optimal use of ICT or integrate it fully into teaching. However, teachers from urban areas remain positive about their, and their students’, newly
acquired skills. They believe that such skills are needed to help teachers solve the various pedagogic and didactic problems they encounter in day-to-day teaching. Only two teachers, representing 10% of the total sample (Table 6.12), believed that technology was merely a tool to help students do things and that it could not contribute to the development of higher-order thinking skills. The other 90% perceive e-learning as a valuable pedagogical tool for use within education.

Despite teachers’ positive perception of the usefulness of ICT and e-learning, they also list barriers hindering technology uptake, as discussed in the next section.

6.3.2 – Criterion B ~ Barriers to ICT Integration

This section addresses the matter of barriers to ICT integration. Barriers and obstacles are considered in Sections 2.6.1 to 2.6.4 in the literature study in Chapter two. Now they are addressed empirically among the teachers who participated in the questionnaire survey. The questions related to barriers were Questions 16, 17, 18, 22, and 23, 25.

Teachers were asked to indicate their reasons for not using a great variety of ICTs in classrooms. This section addresses and quantitatively presents survey results on this issue. All 21 teachers responded and the obstacles they encountered are categorised in order of importance in Table 6.13 and Figure 6.7.

The most important question for this criterion was Question 18: ‘What is the main reason why certain teachers in your school are not using technology?’ Some teachers gave more than one reason.

<table>
<thead>
<tr>
<th>Barrier/Obstacle</th>
<th>No. of teachers</th>
<th>Percentage</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of, or limited, professional development programmes</td>
<td>19</td>
<td>90%</td>
<td>6.3.2.1</td>
</tr>
<tr>
<td>Insufficient class time allocated to ICT activities</td>
<td>15</td>
<td>71%</td>
<td>6.3.2.2</td>
</tr>
<tr>
<td>Infrastructural/technical problems</td>
<td>14</td>
<td>67%</td>
<td>6.3.2.3</td>
</tr>
<tr>
<td>Demotivation among students</td>
<td>10</td>
<td>48%</td>
<td>6.3.2.4</td>
</tr>
</tbody>
</table>
Inadequate professional development was mentioned by nineteen teachers (the largest group) to be the main obstacle (90%). Fifteen teachers, (71%) indicated that the time allocated for preparation and presentation of ICT-based lessons was insufficient. Other teachers mentioned lack of, or limited, infrastructural support and low motivation as obstacles to ICT integration, with 67% and 48% respectively. Figure 6.7 presents these results for Question 18 graphically.

![Figure 6.7: Main Obstacles hindering ICT use in Education](image)

6.3.2.1  **Criterion B1: Lack of, or limited, professional development**

This subsection presents the finding from this criterion (Criterion B1) and discusses findings of the questions related to the first barriers hindering ICT integration (Lack of, or limited, professional development programme).

It also discusses related issues such as:

- Teachers’ Role Change;
- Professional Development of Teachers;
- Results achieved by Students when using ICT;
- Software facilities and e-learning systems available, used by teachers and students

The participating teachers were asked the questions shown in Table 6.14, to reflect on the forms of professional development and associated changes.
Table 6.14: Teacher as Mentor and Facilitator

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q22</td>
<td>Do you see your role today as being a mentor and facilitator of learning, rather than just being an instructor?</td>
<td>Yes</td>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not sure</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2</td>
<td></td>
<td>6</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Not Sure</td>
<td>2</td>
<td></td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q23: What type of ICT professional development programmes have been offered to teachers in your school?

<table>
<thead>
<tr>
<th>Question</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Training</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshop at school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Seminar/Workshop</td>
<td>-</td>
<td>8</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never Attended</td>
<td>3</td>
<td>-</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q17: In what ways do you and your students achieve better results when technology is used?

<table>
<thead>
<tr>
<th>Question</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training/Workshops</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students’ tasks that involve research</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online interaction with external subject-based discussion forums / social networks</td>
<td>2</td>
<td>9</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blogging</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3.2.1.1 Teachers’ Role Change

In answer to Question 22 on the change of role, twelve teachers, representing 57% of the participants, indicated their role is, in effect, changing from that of instructor to being a mentor and facilitator of learning. Nine teachers across the three projects (43%) were not convinced that their role has, or should, change with the integration of technology into teaching and learning. In the second section of Table 6.14, the responses to Question 22 are subdivided according to rural or urban areas. In all three projects, the majority of urban school teachers were positive regarding the change of role. Of the seven teachers (33%) who were not sure whether technology is a factor in this change of roles, five were from rural schools. Only two teachers were from
the STIC urban area. The two teachers who disagreed were both from rural areas of
the STIC and E-school project.

6.3.2.1.2 Professional Development of Teachers

The results from Table 6.14 show that most of the teachers had experienced the
benefits of one of the three projects and had undergone at least some training or
orientation. But it was clear to the author that many were still unable to fully
optimise the experience due to inadequacy of that training and orientation.

From the data in response to Question 23 it appears that teachers in rural areas are
not exposed to any form of professional development. When teachers were asked
about the type of ICT professional development programmes offered in their school,
five (24%) indicated they had never attended any internal training, workshops or
seminars of any sort. Among them were three SchoolNet participants (out of the four
from SchoolNet) and two from E-School. All five were employed in rural schools.
This might explain why SchoolNet teachers had negative perceptions of ICT in
improving students’ attitudes, helping students towards authentic views of real world
phenomena (Table 6.8) and supporting the instructional process (Table 6.9).

As recommended by Ya’acob, Nor and Azman (2005), in the use of educational
technology, training should be conducted on a continuous basis, rather than via one-
off courses. In this way ICT skills and knowledge could be continually improved
over time.

6.3.2.1.3 Results achieved by Students when using ICT

Question 17 investigated whether, and how, better results were achieved. Teachers
were allowed to give more than one way. All four of the SchoolNet respondents
suggested that training, workshops or conferences had helped them acquire personal
skills, develop teaching strategies, and gain familiarity with e-learning. Teachers
from STIC and E-School agreed with this, but required further that students should
be encouraged to work hands-on and independently, and should be encouraged to
undertake personal research. For this, additional computers would be required. They
also advocated that teachers should be part of social networking communities (13
teachers, 62%) and blogging (9 teachers, 43%). The result also suggests that school leaders should initiate partnerships with local ICT corporations for ICT training programmes suitable for teachers’ needs.

6.3.2.1.4 Software facilities and e-learning systems available

**Question 25** enquired: What learning resources (hardware and software):
- are available,
- used by teachers for administration and preparation, and
- used by students in your school (Criterion No. C2).

The first part of **Question 25** focussed on what software facilities and e-learning systems were currently available in the schools. The purpose of this question was to ascertain the context before discussing the type of media teachers are using. The responses are given in Table 6.15. Here too, teachers could select more than one tool on the list.

<table>
<thead>
<tr>
<th>Software Facilities/e-Learning Systems Available</th>
<th>No. Of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SchoolNet</td>
</tr>
<tr>
<td><strong>Computing Tools</strong></td>
<td></td>
</tr>
<tr>
<td>Word Processing</td>
<td>2</td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>2</td>
</tr>
<tr>
<td>Power Point Presentation</td>
<td>1</td>
</tr>
<tr>
<td>Database</td>
<td>0</td>
</tr>
<tr>
<td><strong>E-learning Software</strong></td>
<td></td>
</tr>
<tr>
<td>Tutorials</td>
<td>1</td>
</tr>
<tr>
<td>Drills</td>
<td>1</td>
</tr>
<tr>
<td>Simulations</td>
<td>0</td>
</tr>
<tr>
<td>Educational Games</td>
<td>1</td>
</tr>
<tr>
<td>Internet / E-mail</td>
<td>1</td>
</tr>
<tr>
<td><strong>Video Conferencing</strong></td>
<td></td>
</tr>
<tr>
<td>Smart board</td>
<td>1</td>
</tr>
<tr>
<td>Digital Camera</td>
<td>0</td>
</tr>
<tr>
<td>Computers</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 6.15 shows that schools across the three projects have reasonable volumes of computer equipment and adequate software. They all have computers and almost half (48%) have Internet access (Author’s note: Although a school might have Internet connectivity, in very few cases do teachers have Internet connectivity in their classroom). Regarding commercial software tools, 17 teachers (80%) have word
processing, sixteen (76%) have a spreadsheet package, fourteen (67%) have PowerPoint for presentations, and three (14%) have database systems. For educational applications, educational games are the most commonly available (62%); 52% of the teachers have access to e-learning tutorials; 57% to drill-and-practice systems; and 48% to simulations.

None of the schools in the projects has video conferencing facilities, although they do have a limited number of digital cameras (six, representing 28%) and smart boards (six, also 28%).

Possessing ICT tools is one thing but using them is another. Subsection 6.3.2.1.5 following, relates to actual usage, indicating that even schools with state-of-art computers are still struggling to use them for teaching.

6.3.2.1.5 Software Facilities and E-learning Systems used by Teachers

Table 6.16 depicts the answer to the second part of Question 25 on the actual use of software facilities and e-learning systems use by teachers for administration and preparation. Here too, teachers were able to indicate all the tools they were using. The figures on actual use are considerably less than the figures on availability in Table 6.15.

<table>
<thead>
<tr>
<th>Computing Tools</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
<th>Perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Processing</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>17</td>
<td>80%</td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>15</td>
<td>71%</td>
</tr>
<tr>
<td>PPT Presentation</td>
<td>0</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>38%</td>
</tr>
<tr>
<td>Database</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E-learning Software</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorials</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>43%</td>
</tr>
<tr>
<td>Drills</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>43%</td>
</tr>
<tr>
<td>Simulations</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>43%</td>
</tr>
<tr>
<td>Educational Games</td>
<td>0</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>48%</td>
</tr>
<tr>
<td>Internet / E-mail</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>43%</td>
</tr>
</tbody>
</table>

| Video Conferencing    | 0         | 0    | 0        | 0     | 0%    |
| Smart board           | 0         | 3    | 2        | 5     | 24%   |
| Digital Camera        | 0         | 4    | 2        | 6     | 28%   |
| Computers in administration and preparation | 3 | 10 | 7 | 20 | 95% |
As noted from Table 6.16, although 95% of teachers use computers for administration and preparation, only one uses database software, and nine (43%) the Internet. Forty three percent (43%) use tutorials, drills and simulations to strengthen their preparation.

The findings show that many computers have word-processing (80%) and spreadsheet (71%) applications installed, but educational application, such as tutorials and drills, to a lesser extent. Furthermore, current access to tutorials, drills and simulations is mainly via the Internet. Teachers’ responses to Question 25 reveal that the figures on actual use (Table 6.16) are lower than figures on availability of resources (Table 6.15), which indicates that the technology is not being used to its full capacity.

Teachers use these tools to strengthen their preparation. They also run tutorials in the class situation to show all the students simultaneously and they demonstrate simulations to classes instead of doing experiments with real chemicals and apparatus in a laboratory. Although it would be ideal for the use of tutorials, drills, and simulations to be independent learning activities, these e-learning tools are used only to a limited extent for student activities, due to the lack of laboratory space, CDs and DVDs, that would make it possible for all the students in a class to use them simultaneously. Nor is there intranet connectivity with all the software installed. The labs are mainly used for teaching basic computer classes, and there are not enough slots in school timetables for students to work independently in the labs. However, it is important to note that facilities and infrastructure vary between schools; therefore the problems outlined here do not apply to all schools.

Where other tools are concerned, video conferencing is not available at all (0%), five teachers (24%) use smart boards and six (28%) digital cameras. Regarding these tools, these results show that the situation remains similar to the condition in 2007 - 2009 see Tab 5.17 in Section 5.9.4.5.
6.3.2.1.6 Software Facilities and E-learning Systems used by students

The next part of Question 25, is focussed on use by students of software, computers, tools and educational applications. Table 6.17 shows teachers’ responses regarding use by students.

Table 6.17: Which Computer Tools are used by Students?

<table>
<thead>
<tr>
<th>Computing Tools</th>
<th>No. Of Teachers</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
<th>Perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Processing</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td></td>
<td>38%</td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>8</td>
<td></td>
<td>38%</td>
</tr>
<tr>
<td>PPT Presentation</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td></td>
<td>43%</td>
</tr>
<tr>
<td>Database</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
<td>9.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E-learning Software</th>
<th>No. Of Teachers</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
<th>Perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorials</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td></td>
<td>28%</td>
</tr>
<tr>
<td>Drills</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td></td>
<td>28%</td>
</tr>
<tr>
<td>Simulations</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td></td>
<td>24%</td>
</tr>
<tr>
<td>Educational Games</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td></td>
<td>28%</td>
</tr>
<tr>
<td>Internet / E-mail</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td></td>
<td>19%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Video Conferencing</th>
<th>No. Of Teachers</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
<th>Perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart board</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>Digital Camera</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td></td>
<td>33%</td>
</tr>
<tr>
<td>Computers</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>11</td>
<td></td>
<td>52%</td>
</tr>
</tbody>
</table>

The use of computer tools by students across the three projects is very low. Some students might be acquainted with these tools from home, but the majority have come to know and use them at school. Software such as video conferencing and smart boards are infrequently used, if at all. This is due primarily to the lack of them in schools, however, it is notable that 33% of the students use their schools’ digital cameras, which is higher than the level of use (28%, Table 6.16) by teachers.

6.3.2.1.7 Comparison of Software Facilities and e-Learning Systems available and used by Teachers and Students

Table 6.18 consolidates the answers to the parts of Question 25 as a basis for discussion and comparison of the use of available e-learning tools by teachers and students.

From a comparison of results from Table 6.16 and 6.17 it is clear that teachers’ use of computers is generally higher than that of their students. For example, the use of word-processing by teacher is 80%, whereas that of students is 38%; Tutorial, drill and simulation usage by teachers is 43%, but 24-28% by students. However, there are some notable exceptions. PowerPoint software is used by 38% of the teachers.
and 43% of the students. Similarly, technologies such as databases and digital cameras are used slightly more by students than by teachers.

Table 6.18: Software and Tools Available and Used by Teachers and Students

<table>
<thead>
<tr>
<th>Software and Tools</th>
<th>Percentage</th>
<th>Available</th>
<th>Used by Teachers</th>
<th>Used by Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing Tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word Processing</td>
<td>80%</td>
<td>80%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>76%</td>
<td>71%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>PPT Presentation</td>
<td>67%</td>
<td>38%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Database</td>
<td>14%</td>
<td>5%</td>
<td>9.5%</td>
<td></td>
</tr>
<tr>
<td>E-learning Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tutorials</td>
<td>52%</td>
<td>43%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>Drills</td>
<td>57%</td>
<td>43%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>Simulations</td>
<td>48%</td>
<td>43%</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>Educational Games</td>
<td>62%</td>
<td>48%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>Internet / E-mail</td>
<td>48%</td>
<td>43%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>Video Conferencing</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Smart board</td>
<td>28%</td>
<td>24%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Digital Camera</td>
<td>28%</td>
<td>28%</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>Computers</td>
<td>100%</td>
<td>95%</td>
<td>52%</td>
<td></td>
</tr>
</tbody>
</table>

Use of PowerPoint mainly occurs when students present collaborative projects to the class. It is a cause of concern that e-learning drills, tutorial and simulations which are intended for educational interaction, exploration and manipulation, and hands-on practice are only used by a quarter of the students, although they are available in more than half of the schools. This is probably due to the limited time and venues available for students to independently interact with e-learning applications.

These figures, which indicate greater use of e-learning tools by teachers than by students, are not in line with the findings of the Comparative Study of 2008 (Figure 5.1a in Section 5.6.1.3) where the confidence and skills of students were perceived as higher than those of teachers. This is a result of the fact that teachers in the STIC and E-school projects have undergone extensive training since 2009.

However, both teachers and students need training in a wider range of ICT applications and devices, to enable fuller use of technology in teaching and learning. Certain software, such as simulation programs, for example, are highly specialised. Teachers use them to show experiments to the class, which would not otherwise be possible. This means that although students do not get hands-on experience with simulations, they are exposed to them in demonstrations. E-learning applications thus
provide opportunities for teachers to improve their own skills and familiarity with technology as well as learners’ knowledge (Alessi and Trollip, 2001).

It also appears from **Question 16**, ‘What type of media used in interaction with students do you know?’, that teachers and students are aware of many e-learning tools and educational software used in teaching and learning, although they may not use them personally.

Teachers were also asked about media most needed for use in classroom or in laboratories, over and above what was already available ‘What learning resources (hardware and software) are needed in your school?’ (**Question 25**). Ratings are indicated in Table 6.19:

<table>
<thead>
<tr>
<th>Table 6.19: Learning Resources Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. Of Teachers</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>SchoolNet</strong></td>
</tr>
<tr>
<td>Word Processing</td>
</tr>
<tr>
<td>Spreadsheet</td>
</tr>
<tr>
<td>PPT Presentation</td>
</tr>
<tr>
<td>Database</td>
</tr>
<tr>
<td><strong>STIC</strong></td>
</tr>
<tr>
<td><strong>E-School</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>Perc.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Computing Tools</strong></td>
</tr>
<tr>
<td>Tutorial</td>
</tr>
<tr>
<td>Drills</td>
</tr>
<tr>
<td>Simulations</td>
</tr>
<tr>
<td>Educational Games</td>
</tr>
<tr>
<td>Internet / E-mail</td>
</tr>
<tr>
<td><strong>E-learning Software</strong></td>
</tr>
<tr>
<td><strong>Video Conferencing</strong></td>
</tr>
<tr>
<td><strong>Smart board</strong></td>
</tr>
<tr>
<td><strong>Digital Camera</strong></td>
</tr>
<tr>
<td><strong>Computers</strong></td>
</tr>
</tbody>
</table>

Findings reveal that more computers and Internet connectivity are the **tools most needed** for effective teaching and learning. All twenty one teachers (100%) indicated that they need connectivity and more computers. E-learning tools were also favoured, with twenty teachers (95%) requesting more science simulations, nineteen teachers (90%) educational games, and eighteen teachers (86%) requiring tutorials and drills. Teachers explained that these tools were the ones most needed at secondary and high school level, since they foster the acquisition of skills and strategies, and give exposure to 21st Century teaching and learning.
Teachers were asked this question because, although it is stated that computers and software are available in the classroom in most schools, some teachers do not have access. For example, in only three schools is the Internet available for teaching and learning, while in most schools it is only used for administration. Teachers who want to access the Web must do so in the office.

A further problem was that certain schools possess drills, tutorials and simulation software, for which the licences have expired or not been updated. This software can therefore no longer be used. In other cases, computers and operating systems have been upgraded and certain software packages are no longer compatible with the platforms, making them obsolete and useless. For example, Teacher 6 has a tutorial using a smart board, but the licence for use expired after six months. A further complexity is that other teachers use the classrooms with computers for non-computer-based subjects. This restricts teachers’ and students’ use of e-learning tools in science.

6.3.2.1.8 Summary

Results are consistent with the findings of research by Kalanda and de Villiers (2008) which reports a lack of, or limited, professional development as being among the main barriers to ICT use in schools in Lesotho. However, 90% of the respondents in this study consider that if proper professional development programmes were in place and adequate learning resources, in terms of both hardware and software, were used, it would contribute notably in helping teachers integrate e-learning into their teaching. This in turn, would enhance the learning outcome for students.

Finding from this study also show an inconsistency between the current software facilities used in administration and preparation and those used for teaching and learning. Comparison of Table 6.18 with Table 5.17 shows that the situation regarding use of ICT has improved from an almost total absence of Web-based, educational games tools to 62% availability and 48% usage in the Main Study at the end of 2010. However, the researcher also notes with concern the difficulties with software licences and upgrades, which prevent teachers from using all the available technologies.
Moreover, the additional time involved by incorporating ICT in teaching and learning remains a problem. Even if the best professional development programmes were in place, teachers felt, that without adequate time to prepare and present their ICT-based lessons, this would serve little purpose. The next discussion addresses the issue of time.

6.3.2.2 **Criterion B2: Time Allocation for Teachers’ Use of ICT Resources**

As depicted in Tables 6.13 and Figure 6.7, lack of time allocated to teachers’ use of ICT was reported by the respondents as the second key ICT integration obstacle (71%). The result is in agreement with the early finding by Prestons et al. (2000) which shows lack of time to explore ICT and prepare ICT resources for classroom is another barrier to the implementation of ICT. These researchers indicate that, at times, teachers are unable to fully utilise technology because they lack the time to plan usage of ICT and e-learning resources in their lessons, and to become familiar with the hardware and educational software packages.

Question 24 addresses time for preparation and length of school periods for science lessons. Table 6.20 presents quantitative analysis of the responses to Questions 24a and 24b and in Table 6.24 quantified data from Question 33 are provided. Question 36 is an open-ended question, which is discussed separately in this section.

| **Table 6.20: Questions 24a and 24b** |
|-------------------------------|--------------------|----------------|----------------|-------|---------|
| **Q24a** | Does the school afford you the time for preparation of computer-based lessons? If not, how many hours are you given to prepare each week? | **No. Of Teachers** | **SchoolNet** | **STIC** | **E-School** | **Total** | **Perc.** |
| | | | | | | | |
| Less than 5 hours | | 0 | 5 | 1 | 6 | 28% |
| Between 6 and 10 | | 1 | 1 | 2 | 4 | 20% |
| Between 11 and 20 | | 3 | 3 | 3 | 9 | 42% |
| More than 20 | | 0 | 1 | 1 | 2 | 10% |
| **Total** | | 4 | 10 | 7 | 21 | 100% |

| **Q24b** | The school periods in which computers are used are long enough to complete all the tasks. | **Answers** | **SchoolNet** | **STIC** | **E-School** |
| | | | | | |
| | | Strongly Agree | - | - | |
| | | Agree | - | - | |
| | | Not Sure | - | - | |
| | | Disagree | 4 | 7 | 6 |
| | | Strongly Disagree | - | 3 | 1 |
Findings from Question 24a indicate that most teachers have little time to prepare computer-based lessons. Six teachers (28%) have less than five hours per week and only two teachers (9.5%) have more than twenty hours to prepare for ICT-based lessons. Teachers in urban areas, in particular, have less time because of the distance of schools from their homes and the associated communities. They spend much time travelling. Those in rural areas indicate they have enough time to prepare, but insufficient time for lessons.

In answering Question 24b, teachers were requested to select only one answer. In terms of school periods in which technology is used, all teachers (100%) agreed that the time available was not enough to complete all the tasks that they need to prepare. Table 6.20 shows that seventeen teachers disagree, while four strongly disagree with the statement. This occurred across the three projects and across locations (rural and urban). School timetables do not have the capacity to grant teachers the time they require to use all the resources available.

Question 36: ‘Please add any comments that you wish to make concerning the use of ICT/e-learning in your school’, was an open-ended question that was answered across criteria. Eleven teachers (52%) spontaneously indicated that more preparation time would stimulate their interest in e-learning and their perception of its importance.

Results from regression analysis (Table 6.21a and b) indicate a strong relationship between the dependant variable (Teachers’ Perception) and independent variable (Teachers’ ICT Use). It allowed for the determination of the variance between the two variables. It also indicates that the statistically significant predictor accounted for close to half of the variance in attitude toward ICT integration ($R^2 = .418$). The coefficient is significant at 5 percent level of significance i.e. the $p$-value is 0.05. The coefficients of the model indicate that Teachers’ Use of ICT accounts for 43.8 percent variation in the Teachers’ Perception of ICT integration. Since the sign of this coefficient is positive, it can be concluded that the more time teachers spent using computers, the more their perception toward ICT integration in school improved.
Table 6.21a: Descriptive Statistics ANOVA(b)

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.159</td>
<td>1</td>
<td>4.159</td>
<td>4.021</td>
<td>.059(a)</td>
</tr>
<tr>
<td></td>
<td>19.651</td>
<td>19</td>
<td>1.034</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23.810</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Predictors: (Constant), Teachers’ ICT Use
b Dependent Variable: Teachers’ Perception

Table 6.21b: Descriptive Statistics Coefficients(a)

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>2.262</td>
<td>.849</td>
<td>2.665</td>
<td>.015</td>
</tr>
<tr>
<td>Teachers’ ICT Use</td>
<td>.437</td>
<td>.218</td>
<td>.418</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.005</td>
<td>.059</td>
</tr>
</tbody>
</table>

a Dependent Variable: Teachers’ Perception

Results for the Pearson Correlation Coefficient are reported in Table 6.22 (analysis which involved measuring the strength of a linear relationship between two variables)1. The results show that there is a positive correlation between teachers’ perception of ICT use in class and actual ICT use by teachers valued at 0.42. This indicates that as teacher’s perception of ICT use improves, it tends to impact positively on ICT integration in school reflected by actual usage.

A positive correlation (r = .041) is evidence of a general tendency that high values of independent variable (X) are associated with high values of the dependent variable (Y). This suggests that increased use of computers in education is linked to a more positive perception. This is in agreement with previous studies which found that pre-service teachers’ frequency of technology use are a key factor in predicting the attitude toward computers (Kalanda and Oliphant, 2009).

---

1 A correlation is a number between -1 and +1 that measures the degree of association between two variables called X (teachers’ perception of ICT use in class) and Y (actual ICT use). A positive value for the correlation implies a positive association (large values of X tend to be associated with large values of Y). In this case, X value was above average r = 0.41, and the associated Y value was also above average. Then the product \((X_i - \bar{X})(Y_i - \bar{Y})\) is the product of two positive numbers which is also positive.
Table 6.22: Pearson Correlation Coefficients Teachers’ Perception vs ICT Use Correlations

<table>
<thead>
<tr>
<th></th>
<th>Teachers Perception</th>
<th>Teachers Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers' Perception</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (1-tailed)</td>
<td>.030</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>21</td>
</tr>
<tr>
<td>Teachers' ICT Use</td>
<td>Pearson Correlation</td>
<td>.418(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (1-tailed)</td>
<td>.030</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>21</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (1-tailed).

Table 6.23 reports the correlation between the number of years of teaching experience and teachers’ perceptions of ICT integration. The results show that there is a high degree of correlation, $r = 0.62$ between perception and years of experience in teaching especially with less experienced teachers (less than ten years). This was ascertained using the answers to Questions 4, 5 and 11 discussed in Section 6.3.1, among teachers with less than ten years of teaching experience, and using the personal details given in answer to the survey Question 4. Clearly, teachers with less experience in teaching have a better Perception of ICT and are integrating it in their teaching more than experienced teachers (more than ten years) who, despite training and workshops are finding it difficult to integrate it in their teaching and continue with the traditional way of teaching. Experience in teaching has not helped teachers to improve their perception ICT integration.

Table 6.23: Pearson Correlation Coefficients Teachers’ Perception Vs ICT Use; Less than 10 years Experience

<table>
<thead>
<tr>
<th></th>
<th>Perception</th>
<th>ICTUseLes10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers’ Perception</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (1-tailed)</td>
<td>.037</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>9</td>
</tr>
<tr>
<td>ICT use less than 10 year</td>
<td>Pearson Correlation</td>
<td>.622(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (1-tailed)</td>
<td>.037</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>9</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (1-tailed).

Teachers were asked Question 33: regarding their confidence levels. The results are tabulated in Table 6.24.
Table 6.24: Confidence Levels

<table>
<thead>
<tr>
<th>Q33</th>
<th>No. Of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SchoolNet</td>
</tr>
<tr>
<td>Very confident</td>
<td>0</td>
</tr>
<tr>
<td>Confident</td>
<td>1</td>
</tr>
<tr>
<td>Not sure</td>
<td>0</td>
</tr>
<tr>
<td>For some subjects</td>
<td>2</td>
</tr>
<tr>
<td>Not confident</td>
<td>1</td>
</tr>
</tbody>
</table>

In response, ten (2+8) teachers (48%), from the three projects, were confident that they would make more use of technology if given more time for preparation and teaching. Another ten indicated they would only use e-learning tools in certain specific science modules, even if more time was given. Of these respondents, the majority (five teachers, representing 50% of those who were confident to use ICT with selected subjects) were from NEPAD E-School project schools. This could be due to the fact that the training programme for E-School is more focussed on science subjects with less practice on other subjects.

Findings from this criterion indicate that teachers are generally unable to fully utilise technology because they lack the time to plan for ICT resources for their lessons and to become familiar with both hardware and educational software. However, teachers remain positive and perceive technology as an important tool for the improvement of teaching and learning (Figure 6.1 and Section 6.3.1.1.1).

Time to use ICT is usually related to support in use of infrastructure use, which is discussed in the next section (Section 6.3.2.3).

6.3.2.3 Criterion B3: Infrastructural Support and Technological Issues

Findings in Table 6.13 point to a third barrier to technology integration, namely lack of, or limited, infrastructural support (67%). Just like the first (lack of professional development) and the second (lack of time allocation for teachers’ use of ICT resources), this can daunt teachers to the point of totally avoiding the use of ICT, for fear that the technical faults which occur might not be fixed, leading to unsuccessful lessons.
Table 6.25 shows two of the three questions asked to assess teachers’ views on support they and their students need in basic computer skills before using technology for teaching or/and learning (Questions 28, 29 and 36). Question 36 is an open-ended cross-criterion question asking for feedback on any aspects of ICT and e-learning in schools. Responses to it have already been discussed in Section 6.3.2.2 in the context of time allocation to ICT activities. It is not in Table 6.25, but responses to it are raised again in the present context of technological issues and infrastructural support. Table 6.25 provides the teachers’ responses to Questions 28 and 29.

<table>
<thead>
<tr>
<th>QNo.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Strongly Agree</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Q28</td>
<td>It is essential for teachers to have basic computer skills before using technology for subject-related activities</td>
<td>Agree</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Q29</td>
<td>My students need basic computer literacy skills before integration of ICT into the Science classroom</td>
<td>Strongly Agree</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agree</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

All twenty one teachers (100%) agreed that they need some form of basic ICT skills before embarking on ICT integration. Table 6.14 indicates that eleven (52%) prefer external seminars, workshops and conferences to in-house training.

Similarly to Question 28, in answering Question 29 teachers agree that their students also need basic training in computer literacy before technology is integrated into the learning of science. Nineteen teachers (90%) strongly agreed, while two agreed to the statement. Five teachers (23%) suggested specific training in their subjects and on the use of the Internet so they can search and communicate with other teachers around the world.

When answering Question 36, (which, as stated, is open-ended and answered across all criteria) seven respondents (33%) requested that action should be taken to ensure that teachers have sufficient access to hardware and software support. Among them,
three teachers (14%) suggested that certain teachers be nominated to undergo training in PC support and then be appointed as ICT support staff in their schools, to provide pedagogic support to other teachers in turn. Two teachers (9.5%) pointed out the frustration of teaching while trying to solve hardware and software problems during the lesson. Another two (9.5%) suggest the integration of a module on PC support for pre-service teachers at college level.

Also to **Question 19** which asked: ‘*In many cases, computers and software are available, but teachers do not know what to do with them. (Criterion No. B31) Give your opinion*,’ teachers admitted that they were frustrated when unexpected software errors or hardware malfunctions occurred. Teachers from all projects agreed that some basic knowledge of computers and related equipment is essential for teachers and students to improve their achievements, and to support their own acquired skills, but they should not be expected to serve as technicians.

Moreover, it is crucial to support teachers in making optimal use of ICT over all uses, academic as well as administrative, and across the use of ICT in all subjects. The application of e-learning in the domain of science is currently viewed as a priority, but this should change, and needs in other subject domains should be met as well.

Literature indicates that lack of motivation and an inappropriate leaning environment also hinder ICT uptake in Lesotho schools. This is discussed in the next section.

**6.3.2.4 Criterion B4: Impacts of Motivation and Occurrence of Distraction**

Finally, Table 6.13 in Section 6.3.2 shows lack of motivation (48%) among the key obstacles to ICT use in education. Approaching the issue from a similar perspective, this criterion’s four questions address teachers’ perceptions on the impact of students’ motivation and potential distractions caused by technology, on e-learning implementation, tabulated in Table 6.26.

This section discusses **Questions 30, 31, 32 and 36** asked in the survey.
Table 6.26: Questions 30, 31, 32

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q30</td>
<td>In my class, students like to discover new things by themselves when they are motivated.</td>
<td>Strongly Agree</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Q31</td>
<td>Technology can distract students from the learning content.</td>
<td>Strongly Agree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agree</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>-</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Q32</td>
<td>Students also use the technologies for activities not related to subject matter.</td>
<td>Strongly Agree</td>
<td>2</td>
<td>4</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agree</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Sure</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disagree</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

When asked **Question 30** on whether **Students like to Discover New Things by themselves**, fifteen teachers (71%), from across the projects agree that their students enjoy discovering information independently. Eleven teachers (52%) strongly agreed to this, whereas four teachers (19%) agreed. Five teachers (23%) were not sure. Four of the five teachers who were not sure came from rural areas (Table 6.27), which further indicates that use of technology by teachers and students in these areas is a major issue.

Figure 6.27 subdivides the data in answer to Question 30 (Table 6.26) into responses from rural and urban regions.

Table 6.27: Motivation (Question 30)

<table>
<thead>
<tr>
<th>Answer</th>
<th>SchoolNet</th>
<th>STIC</th>
<th>E-School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rural</td>
<td>Urban</td>
<td>Rural</td>
<td>Urban</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Agree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Not Sure</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Disagree</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
The situation depicted in Table 6.27 could possibly be due to lack of appropriate hardware and software in the rural schools, as well as the fact that, in general, there are no professional development programmes in place in these areas.

**Question 31** assesses the perception of teachers on whether technology can distract their students from the learning content. Though three teachers agreed with the statement and three were not sure, the remaining fifteen (71%) disagree. In terms of technology distracting students from learning, some of the teachers who disagreed suggested that when students are unsupervised and teachers unmotivated, the situation can get out of hand, with students also using computers for other purposes, such as entertainment and use of the Internet (where it is available).

Survey **Question 31**, which is related to **Question 32**, investigates whether students use the technologies for activities not related to subject matter. Fourteen teachers, representing 66% of the sample, support the idea that, given complete freedom, some students would use the technologies for activities not related to subject matter. Two teachers believed that computers should only be used when teachers are closely involved in supervision.

The open-ended **Question 36** brought some insightful information about motivation among students and the innovative environment. Teacher 4 considers,  

‘Each student is different and requires a different kind of motivation. What works for one student may not work for others in the classes’.

He then concludes:  

‘To find out what might work for each student would help increase their achievements’.

Another, Teacher 17, suggested that teachers should sometimes work hand-in-hand with students:  

‘Slow learners also would want to succeed in some ways so they can be motivated to succeed in greater ways’, and ‘to help them might require working with them on computers to prepare them for homework assignments’.
Three teachers (14%) suggested the practice of regularly and publicly praising students for achievement or presenting certificates of achievement. Teacher 11 from a rural STIC project school proposed that offering ‘individual and whole class rewards’ is a great motivation, especially when attempting to identify particular skills shown by particular students.

For the learning environment, five teachers (23%) from across the projects acknowledge that current classroom settings in their schools are not conducive for students. Some 80% of computers in SchoolNet project schools are in the laboratories. The seating arrangements in these labs do not allow the development of collaboration between students.

The data collected for this criterion indicates that teachers and students need motivation and an appropriate environment so students can achieve better results. It also indicates that, if not supervised, students can get involved in activities not related to the subject matter, especially when using the Internet. A few teachers felt that technology could distract students from the learning content, and that they would use it for personal activities.

6.3.3 – Criterion C ~ ICT in Science Classrooms
According to a study by Slaouti and Barton (2007), 90% of teachers agree that the use of ICTs makes them more effective in their teaching of science and enhances their students’ performance to meet changing needs. Similar findings emerged from this study in Figure 6.1, Section 6.3.1.1.1 and as discussed under previous criteria. The teachers in the Slaouti and Barton study also agreed that, with access to the Internet and related technologies, their science lesson plans were richer. They further reported that when ICT was properly integrated into the curriculum, it could motivate students, since it brings variety into lessons and stimulates the teachers’ own interest in teaching.

Questions related to this criterion were Questions 12, 15, 21, 25, 34, 35 and 36.
Following **Question 14** on whether e-learning can support the instructional process (considered in Section 6.3.1.1.1), **Question 15** is an open-ended question to ask ‘*How?’.* A teacher using simulation software commented

‘I have more time to interact with students, they ask questions and I explain with the simulation, I am able to download it from the Internet and my students understand better’.

**Question 36** is an open ended, cross-criterion question regarding teachers’ perceptions of ICT integration. It has been discussed in Sections 6.3.2.2, 6.3.2.3 and 6.3.2.4 and is relevant to this section as well. A further positive sign is that a majority of the teachers, nineteen out of twenty one from all projects (90%) indicated in response to Question 36, that they would like to use more educational software in their teaching. This corresponds to the results of **Question 25** in Section 6.3.2.1.7, and Table 6.19. The science teachers did indeed perceive the value of ICTs in enhancing teaching and learning, and were optimistic about the ongoing process of integrating e-learning into classroom instruction. Most of their responses, nevertheless, indicated a request for more hardware and software. Overall, science teachers perceived technology as a vital tool to achieve their professional tasks as classroom practitioners.

To discuss this criterion of ICT within classroom teaching and learning, science teachers were asked to rate statements regarding the use of e-learning applications. Table 6.28 presents the results of two questions (**Questions 34 and 35**). Two further questions were open-ended questions (**Questions 21 and 36**). Question 36 is discussed across criteria and Question 21 is discussed after Table 6.28.
An important finding is that most teachers (90%), including those in rural areas, believe that current e-learning applications can allow them to demonstrate a variety of scientific phenomena. Only two teachers were not sure. These two teachers were among the five who had never attended any form of professional development (Section 6.3.2.1). The other nineteen believe that e-learning enables them to demonstrate scientific phenomena to their students. Question 35 investigates whether the use of animations and simulations is essential in teaching science. All teachers except one agreed.

With chemistry experiments in mind, Teacher 9 noted: ‘In a traditional way of teaching, teachers and students would have to be in a laboratory to experience some phenomena’, but she pointed out that ‘with e-learning simulations I can help solve this problem. Students can use technology with little danger’. When asked to explain whether ICT and e-learning were effective in helping students to solve science problems (Question 21), the teachers provided some helpful insights on how technology could improve science education. They suggested that access should be provided to online materials. They also recommended the use of simulations, animation software, and engaging materials. Teacher 9, who commented on chemistry experiments, said:

‘Unlike other subjects, in science we need to demonstrate ... students retain more if they see... with ICT-based lessons we are able to have our students’ attention throughout the lesson’.
Another teacher, Teacher 6 added:

'It is amazing what those whom we label slow learners are able to do when technology is used. ... they participate in discussions, make comments and sometimes take the lead in presentations’.

Teachers further realised that if Internet access, local area networks and digital cameras are made available in schools, it would facilitate the use of simulations and educational games, books and courseware without schools needing to purchase CDs and books. They further expressed the need to collaborate electronically with peers to explore ways in which their teaching could be strengthened and to facilitate sharing of materials. Some also mentioned the advantages of posting important information, events and even school results.

The use of the Internet for research was also mentioned; teachers believed this could help them produce quality documents with diagrams and illustrations, and allow them to access lesson plans and learning activities on Internet sources such as Webquest and Windows Live as well as social networks.

6.4 Interviews and Observations

Two principals, eighteen teachers from nine schools and seventeen students were interviewed for the qualitative components of the study. Each participant was interviewed after an in-class observation (October 11th to November 26th, 2010). Each interview lasted some 30-45 minutes, and was literally transcribed. As an example, there is a transcription of an interview in Appendix 9

In addition, field notes were taken of fourteen observations, each observation covering a 45 minute lesson. See example in Appendix 10. These could only be conducted in the classrooms of teachers who felt comfortable to be observed, and with permission from principals. Immediately after each observation, the author held a discussion with the observed teacher to discuss his/her reflective thoughts on the lesson. The author also requested a copy of the lesson plans and samples of students’ work produced during the observed lesson.
The analysis of this qualitative data, as advocated by Onwuegbuzie and Teddlie (2003), began immediately after collecting the first set of data, and continued throughout the study and afterward when the data was consolidated. The constant comparative method (Glaser and Strauss, 1967) for data analysis was used as well as triangulation of data (Lincoln and Guba, 1985). For example, while analysing the qualitative data the author compared the facts in the text with the quantitative data from the questionnaire.

The coding stage, as outlined by Strauss (1987), followed after the empirical work with open coding and the identification of emerging themes as the researcher wrote memos. The themes identified in the literature (Sections 2.5 and 2.6) and discussed quantitatively in Section 6.3, emerged again in the observations and discussion, namely:

1) Perceived advantages of ICT in Classrooms (Section 6.4.1.1),
2) Barriers to ICT integration in school (Section 6.4.1.2),
3) Potential issues of ICT and e-learning in science classroom (Section 6.4.1.3),
4) Infrastructural preparedness (Section 6.5.2.1), and
5) Guidelines for science teachers and students 6.4.1.4.

The author further verified the link between interview data and observation notes to establish reliability and validity of the findings (Patton, 1990).

6.4.1 – Major Interview Findings
This section briefly presents some of the major findings obtained from participating principals, teachers and students on technology skills across the five categories of qualitative data collection (Research Questions, Section 1.6, Table 1.4 and Section 6.1). The transcripts of the observations and interviews, as well as responses to open-ended questions in the survey, also provided a broad picture of the views of the participants in this study.

The qualitative findings revealed that, in general, participants had experienced a consistent increase in their technological knowledge and skills during their preparation programmes. This was evidenced in particular with the STIC and
NEPAD E-School projects and to a lesser extent with SchoolNet programmes. Participants had improved their technological expertise and began to perceive that they possessed new skills as compared with their colleagues who had not yet undertaken the training.

6.4.1.1 Perceived Advantages of ICT in Classrooms

It emerged that almost all the teachers held a more positive view of teaching and learning with e-learning since their sessions during the orientation (Table 5.8 in Section 5.5.2). Answers given by principals, teachers and students follow.

The Principals

During the interviews, the two principals were asked:

What impact does professional development and training have on the teachers and students in your school? and Which forms of development and training have you implemented?

Both principals emphasised the importance of schools developing short-term and long-terms integration plans and a professional development programme to enhance teachers’ skills. However, one of them, Principal 1, commented:

‘We don’t have any idea whatsoever about how we are to start. In some schools the emphasis is on getting students using computers, in others it is the teacher … but all that we know is that both teachers and students, including ourselves (i.e principals) should use technology to improve learning and teaching’.

This indicated uncertainty on the part of this principal.

Principal 2 expressed her opinion on the question:

‘Do you believe teachers, students and yourself need basic training in the use of computers before integrating them into subject-related activities?’

as follows:

‘Since I attended the STIC workshop on ICT skills for education leaders, I have come to realise that everyone in my school, teachers, students and myself need basic computer skills and should be able to use it when teaching or learning any topic in any subject matter’.
She was more knowledgeable on the matter of ICT and stressed the value of integrating it into subject teaching.

To the question, 

‘From your experience, which subject would you like to see first being taught using technology and why?’, 

both the principals suggested starting with science subjects before extending ICT to other subject areas. This confirmed the worth of the researcher’s decision to conduct this study in the domain of science teaching and learning.

Overall, the author realised that the principals were highly aware of the value of ICT in contributing to improved teaching and more effective learning, but that they were unsure of how to actually manage the process. This identifies a need for principals to undergo practical training on the use of ICT in the curriculum, and to see demonstrations of e-learning.

**The Teachers**

Only a few of the teachers interviewed, were insecure about using ICT for supporting teaching and learning. This is also reflected by the survey results which indicate that only two of the eighteen teachers, 10% of the total surveyed (Figure 6.1), were unconvinced that technology enhanced learning and three (14%) preferred traditional ways of teaching. One of these saw a potential disadvantage in that students might focus more on using computers than on the learning content. Three teachers perceived the role of e-learning as replacing the teacher, not as a tool to reduce their workload, i.e. they viewed e-learning as a possible threat. In answering the question:

‘Many people believe that the use of E-learning supports collaborative learning. There is also a belief that learning with technology can help develop higher-order thinking? What are your opinions on these statements?’,

Teacher 5 commented:

‘Though I like it when a colleague uses technology in his/her class, I still personally believe integration is a difficult thing... I am still debating this’.

Another teacher, Teacher 1 answered:
‘The way my learners discuss ways to solve problems, makes me believe that ICT does help in developing high-order thinking. ... Sometimes, they are not just satisfied with one way of solving a real-world situation, they search for more’.

Teacher 17 also argued the same way, commenting:

‘if it wasn’t because of technology, I think my students and I would be struggling to do things the same way our own teachers did, rather than learning from other experienced teachers around the world ... there is just a lot on internet to make both us and our students more innovative’.

During interviews, it was noted that teachers who had attended the orientation sessions and subsequent training, discussed their perception of teaching and learning with technology and integration of ICT into subject teaching, with more realistic and optimistic views.

Teacher 11, one of the teachers who attended almost all workshops and has become familiar with different forms and methodologies of e-learning commented:

‘I am sure everyone will agree that teaching and learning with technology is the best way ever if one want to improve his work. Two years ago when I was introduced to this concept, I thought this will be just one more way of wasting my time, .... I can assure you, without technology I would hardly teach’.

This sentiment is also echoed by another teacher, Teacher 2 who said:

‘When my colleagues visit my class, they would always say, you are so innovative. When we try to imitate one practice, you jump on another .... we wish we would be like you. I am so pleased with such compliments’.

Qualitative data collected from the open-ended questions are consistent with these findings. When responding to an open-ended question:

‘Are ICTs and e-learning effective in helping students solving science problem?’,
respondents had remarkably positive perceptions on how the use of e-learning applications had contributed to better problem solving skills among students (Survey Question 21 in Section 6.3.3).

Teachers also believe the multiple media offered by ICT are an advantage, saying that learning is more effective when different media are used in science classrooms. Teacher 9 answered the question

‘Since you started using technology, are your students more active? Do they achieve better results than before?’

by relating that on the occasions when she used Microsoft movie maker to present her lesson on plant reproduction, illustrated with pictures from Encarta encyclopaedia, ‘students were more participative than usual and achieved good results on that work’.

**The Students**

In their interviews, students too, acknowledged the benefit of being equipped with ICT skills As a response to the question:

‘When you learn Science with technology, you use different ICT media, different modes, and you see things represented in different ways. Do you think these different ways of presentation make learning more effective?’,

Student 3 commented:

‘When teachers use technology in class, especially with science lessons I understand better than when it is taught to us using the books ... Many of us actively participate’.

Their interest and engagement is demonstrated in Figure 6.8, a photograph taken while the author observed students preparing for a group presentation.
They were asked:

‘Do you see yourself achieving better results as a consequence of learning with technology? Explain’.

Two students, Students 6 and 11, referred not only to their own results, but to results of the previous year with close to a 96% pass in their school in science and other subjects at matric level (Table 6.7, STIC 3). They optimistically believed that their cohort would bring this up to a record 100%.

Students confirmed there is more interaction with the teachers and between themselves during ICT-based lessons. Student 4 commented:

‘things are clearer, as if it was in real life situations’.

6.4.1.2 Barriers to ICT Integration in Schools

The interview participants identified various challenges that had influenced their decision on whether or not to use ICT and how to apply it in classroom teaching and learning. These obstacles presented were either school-related or personal.

The Principals

Principal were asked:

‘What impact does the professional development and training have on the teachers in your school?’.

Principal 1 reflected on his school’s professional development and said:
‘The amount of work teachers have as per the curriculum does not allow regular professional development programmes to take place. We would love to have one which is ongoing and takes into account our current situation’.

Principal 2 recommended that pre-service teachers should have ‘an e-learning module’ included in their course at college: suggesting that even with a minimal programme and limited hours of professional development, this would help them to integrate ICT in their teaching.

The Teachers

Teachers were asked during interviews

‘Please describe the ICT professional development programmes you have done in your school’,

In the context of barriers, nine participating teachers mentioned that attending the STIC and NEPAD e-school training was their first experience. They found that, although most of the schools in the country now have computers, teachers are still struggling to learn how to use them, because they had no background before the projects started. They had not been exposed to computers in their homes.

Some schools still had no professional development programmes; Teacher 14 commented:

‘The teachers themselves do not have any training programme which could help them prepare and use these tools while teaching. If they were trained, they would be more effective in trying other teaching approaches and strategies...’.

However, two teachers from SchoolNet felt they were being pressurised into integrating technology into teaching. They stated that it was imposed on them by school managements without input or buy-in from other teachers and colleagues in the schools.

These findings are consistent with the survey result (Table 6.13 in Section 6.3.2), which reflects that 90% of teachers believe that ‘professional development’ is the key barrier to ICT integration in Lesotho secondary and high schools.
The majority of participants considered the time given to prepare technology-based lessons as too short. They were asked:

‘Are the school periods in which you use the computer long enough for you to complete all the tasks?’

Fifteen teachers directly answered ‘No’. One of them, Teacher 2, commented:

‘because they [the teachers] have to cover syllabus content as emphasised by the school and so the time for using ICT is not emphasised’.

This finding is in agreement with the quantitative results of this research; where 100% of the surveyed teachers (Table 6.20) agreed that the time allocation for teachers’ use of ICTs and the preparation of lessons was very limited. Teacher 11 said:

‘It is unfortunate that my students do not have the opportunity to use the computer lab throughout during the lessons’.

She then explained:

‘I would have loved to use the lab, but the limitation is that I don’t have the time to prepare (e-learning activities) and I spend a lot of time following the syllabuses’.

In a personal context, some of the teachers have what can be termed a ‘culture of fear’, which limits their understanding of technology integration. They struggle with time management in implementing ICT-based lessons, as well as covering the required curriculum.

Though the time factor (71%) is viewed by teachers as one of major barriers (Table 6.13 and Figure 6.7) in preventing teachers from using e-learning activities extensively in classroom teaching and learning, 71% is small compared with 90% for the aspect of professional development. It may suggest that after training and hands-on involvement, teachers in the three projects are grasping the value of integration and have started making time to prepare and present their lessons using technology.

In a further interview question, the teachers were asked:
‘Do you receive an adequate supply of hardware and software from your school administration? If so what are you receiving?’

Two of the teachers, Teachers 4 and 7, who responded negatively, explained that although the schools were equipped with computers, when software or hardware problems arose, they had to wait several days for the issues to be fixed. This is a common problem with most schools; even those in urban areas. The aspect of infrastructure is discussed in Section 6.5.2.1 under the Showcase Study.

When asked to give their an opinion on ICT integration, Teacher 2 was concerned about ICT used by students, especially the Internet, and said:

‘I believe that this will distract students from concentrating on the real issues addressed by the content’.

He then added that students enjoyed focusing on the technology, but some of them were distracted and used it ‘to play games and use non-subject-related contents’.

The Students

Students were asked a similar interview question:

‘Can technology distract you from the learning content?’

and a related question:

‘Do you agree that non-subject-related content is what learners use ICT for? Explain’.

Most students disagreed that students would misuse their time if they were allowed to work on computers independently. Three of them, Students 2, 6 and 7 agreed that they might indeed use some non-subject related materials out of curiosity, if they had spare time during the absence of a teacher.

6.4.1.3 ICT Use in Science Classrooms

In the interviews, other questions related to ICT use in science classrooms were asked to the two principals, eighteen teachers and seventeen students.

The Principals

Principals consider that it is possible for science teachers to manage their own classroom in ways whereby students can benefit more from technology. In answering
a related open-ended survey question (Question 36) on opinions on ICT integration, Principal 2 commented:

‘The good result in my school is due to teachers’ discipline and management of their classroom’.

She further said:

‘We have included in our professional development programme a motivation speech to encourage science teachers to take the lead on ICT integration’.

The Teachers

Another interview question to teachers was:

‘Which Science activities can be well demonstrated by using technology in class? Are you using these appropriately?’.

Sixteen teachers felt that chemistry and biology are well suited to being presented via educational technology. A reason for this was that they have less text and more images. To the question,

‘Do you think that the technology you use in your Science classroom supports you in holding students’ attention and supports the students in recalling information? If so, how?’.

thirteen of the eighteen participating teachers responded positively. Teacher 18 commented:

‘Images help holding (attention) and recall’

and then added:

‘...whenever I use some pictures in my class, students tend to respond to questions. Using these... animations and simulations makes it even better.’

Teacher 1 was distinguished by his regular use of Internet exploration, communication and collaboration. He reported that he uses WebQuest and the social network, Facebook, to learn from other teachers globally as well as regionally. Figure 6.14 in Section 6.5.2.2 shows a biology lesson that he had accessed from WebQuest, at: http://www.zunal.com/Webquest.php?w=25856 and customised.

During an observed lesson, Teacher 1 used a lesson downloaded from the WebQuest. He had modified it to align it directly with the curriculum and presented a simulation on the human circulatory system (Figure 6.9); demonstrating that ICT can ‘enhance
teaching and learning in the classroom’. He said such experiences will ‘benefit students’ and ‘boost’ their confidence.

The Students

Students were asked the interview question:

‘Which science phenomena are you enjoying the most when e-learning is used?’.

They mentioned virtual chemical laboratories and biology simulations. One of them, Student 5, felt that physics theories are demonstrated better when technology is used. They were also asked:

‘What impact does animation and simulation software have in your learning of science?’.

Student 6 commented positively on interaction with simulations and said:

‘It makes it as in real life situation, I enjoy it ...’.

6.4.1.4 Guidelines for Science Teachers

Findings from the previous questions revealed a slow pace of ICT integration in all schools across the three projects or even a decline after a few years of attempting to integrate it in some schools. This raises the question of what additional strategies could be used to motivate and support school principals, teachers and students in the
application of e-learning and the integration of ICT into the teaching and learning of science.

This section provides guidelines to address the issues related to this component of ICT integration (Research Question 5). These guidelines are developed inductively from responses in the principals’ and teachers’ interviews. Five key themes emerged:

- Development of school’s ICT policy;
- Teachers’ professional development programme;
- Targets and performance indicators,
- Infrastructural guidelines, and
- Cost estimation and budgeting.

These guidelines are discussed below and detailed further in Section 7.3.5 in answering Research Question 5.

6.4.1.4.1 Developing the School ICT Policy

Teachers recommended the institution of an ICT committee that would oversee the school’s commitments to ICT integration. It should be representative of all relevant stakeholders (ICT persons, administrative staff, parents, teachers and technicians). These stakeholders should, according to Teacher 7, agree on the policy as well as all the procedures and process of integration.

6.4.1.4.2 Professional Development Programmes

Teachers are unanimous regarding the importance of their professional development. Among the driving factors that prevent ICT integration was teachers’ professional development (addressed in Section 6.3.2.1). Teachers in this study recognized the need for training, the impact that their training and development might have on students’ learning outcomes, and the rapid changes in pedagogic approaches. As Teacher 11 argued:

‘The result of any ICT integration project in the end depends on the teachers’ professional development’.

Teachers recommended that the school management should plan for learning platforms and programmes that will guide and support teachers. For example, certain workplaces, including some of the schools in this study, block Facebook. Three
teachers requested official permission to join educational communities-of-practice on social networking sites.

6.4.1.4.3 Setting Targets and Performance Indicators
Two teachers suggested that annual targets be set to classify the planned objectives into quantifiable sections that can be evaluated at the end of each year. They further proposed that the performance indicators be arranged by each school to set measurable attainments. Teacher 1 said:

‘These performance indicators should be set up to help in assessing which initiatives are more likely to contribute towards a successful integration’.

6.4.1.4.4 Infrastructural Guidelines
ICT infrastructural support was identified in Section 6.3.2 as among the barriers to ICT in schools (67%). Teachers suggest that the lack of facilities is an opposing factor working against ICT integration in schools. This lack might raise the ratio of students to computers.

6.4.1.4.5 Costing and Budgeting
ICT costing was not identified among the barriers to integration in the survey questionnaire. Only during the interviews did teachers mention it as a matter to consider before ICT uptake by schools. One teacher, Teacher 1, suggested:

‘Since most principals and administrators are not aware of how much the whole project might cost, it might be well to suggest a guideline that includes cost estimation’.

Teacher 2 argued that the cost of ICT in schools is mainly associated with the acquisition of computer equipment, and pointed out that the budget should also take other cost areas into account, such as software, maintenance, support, professional development expenses as well as connectivity. The cost is sometimes carried by the school alone but, on occasions, donors do commit support.

6.4.2 – Major Observation Findings
Section 5.9.4.3 of the Pilot Study describes lesson observations in detail. Three lessons were observed in the pilot and the author was subsequently invited to return
to see student presentations as a follow-up to one of the lessons observed. In that follow-up, the observations included watching and listening when students presented individual or joint projects in a period of time that was specifically extended for the purpose. Due to the thorough observations of students’ presentations during the Pilot Study, the author concentrated in the Main Study on observing teachers in the classroom.

Fourteen lessons were observed with nine teachers in the Main Study. In one of the fourteen, the author again attended a lesson that involved students’ presentations, namely, the presentations of chemistry projects by two matric students. The technologies used were PowerPoint, Movie Maker and the Smart Board.

In the observations of fourteen teachers, seven of the teachers used PowerPoint presentations to enhance their teaching. They informed the author that they regularly used PowerPoint and also enjoy using graphics, e-learning methodologies and movies as attention grabbers at the start of lessons. The other teachers gave traditional lessons, but one used the Smart Board to write in a conventional way, so that her handwriting appeared on the electronic white board. In a chemistry lesson, another teacher showed a movie from Encarta on the mixing of two acids. Afterwards the students had a discussion on what they had seen.

These observations confirm some of their answers in Section 6.4.1.3 from the interviews. Teachers found slides and graphics suitable to ‘retain students’ attention’ (Teacher 11). One science teacher in particular, Teacher 1, explained the rationale for using presentation software when asked:

‘Do you think that the technology you use in your Science classroom supports you in holding students’ attention and supports the students in recalling information? If so, how?’.

She explained:

‘I use PowerPoint, the technology part, because it allows me to interact well with my students... In the traditional way of teaching I spend more time writing on the board, leaving little time to interact with students’.

She further added:
‘using PowerPoint helped me teach faster and, more essentially, I can demonstrate using both text and graphics’.

An observation of a lesson by this teacher confirmed the respondent’s report on her use of PowerPoint in her classroom (Figure 6.10).

![THE CIRCULATORY SYSTEM](image)

**Figure 6.10: PowerPoint Presentation on Circulatory System**  
(used with permission from the teacher)

Another teacher, Teacher 4, reported that he was impressed by his students’ ability to use ICT and make PowerPoint presentations. Following their examples, he also started using it. Looking back on his effort in learning to use PowerPoint for teaching, he admitted that there is now a difference in his way of teaching; indicating that he spends less time talking and writing, because the material is already there.

Furthermore, most of the science teachers did not seem to involve their students in using e-learning systems for learning theoretical concepts and practicing exercises independently. Nevertheless, most of them perceive the benefits and have started using at least one form or methodology, such as tutorials, drills or educational games (Table 6.18). As has been mentioned previously, they tend to use these more by demonstrating them, than by setting aside time for the students to interact independently hands-on with the software.

Most of the teachers who participated in this study are now advocating the use of technology in classrooms. Teacher 13 said:
‘I can now see and I am even more convinced that all teachers should start to use ICT in classroom to be able to benefit students’.

6.5 Study 6: Showcase Study

6.5.1 – Introduction

Figure 4.3 presenting the variant of Action Research underlying this study, indicates that the AR cycle culminates in a showcase of success stories of ICT integration in Lesotho.

In 2009 and 2010, two different Lesotho teachers were award winners in the International Innovative Educators’ Forum and the Pan-African Forum respectively. They rose through the ranks, first winning at the Lesotho Finals, then at Pan-African Forum and one of them, ultimately, at the World Forum in the Educators’ Choice category. Figures 6.11 to 6.13 provide details of the two high-performing teachers, Teacher A and Teacher B respectively.

<table>
<thead>
<tr>
<th>Winner: Teacher A: Moliehi Sekese (name used with permission from the winner)</th>
<th>Category: Educators’ choice</th>
<th>Project Title: Indigenous Plants</th>
<th>Learners’ Ages: 13 to 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venue of the World Final: Brazil, November 6th 2009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.11 Award winner 1: Mrs Moliehi Sekese

The following link leads to a video about Mrs. Sekese winning the world competition http://coolcatteacher.blogspot.com/2010/10/moleihi-sekese-integrating-technology.html

<table>
<thead>
<tr>
<th>Winner: Teacher B: Lilian Ofori Asare (name used with permission from the winner)</th>
<th>Category: Educators’ choice</th>
<th>Project Title: Amazing Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners Age: 13 to 16</td>
<td>Venue of the Pan-African Final: Mombasa / Kenya 24 – 28th August 2010</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.12 Award winner 2: Mrs Lilian Ofori Asare

Figure 6.13 is a newspaper cutting showing award-winners on the 28th August 2010, in Mombasa, among whom is Mrs. Asare, who won under Educators’ choice category.
Table 6.29 sets out the nature and location of the award winners’ schools.

<table>
<thead>
<tr>
<th>Project</th>
<th>District</th>
<th>Location</th>
<th>Numbers visited and interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher A.</td>
<td>STIC</td>
<td>LL</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Teacher B.</td>
<td>E-School/STIC</td>
<td>LL</td>
<td>1 1 1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>2 2 2</td>
</tr>
</tbody>
</table>

**Key:** LL – Lowland; U – Urban; R – Rural

The two teachers in Table 6.29 are science teachers in two different schools who participated in training and workshops organised by STIC and NEPAD E-school projects and in the Microsoft Innovative Teacher Forum. They were both interviewed for the qualitative part of the study after observations in their classrooms in January, 2011. The interviews lasted between 30 and 45 minutes, and the information was compared with notes of 45-minute lessons taught by those teachers and observed in the Main Study. Two students, one in each school were also interviewed to obtain their opinions on the importance of ICT in education.

The next section is a brief presentation of qualitative findings from observations and interviews relating to those two science teachers and their students’ views on...
technology use in the classrooms. The findings contribute to answer some of the research questions in Section 6.1.

As these award winners had already been participants in the Main Study the author’s main focus during interviews was on the issues of interactive science activities during lessons and the tools to be used to enhance teaching and learning. These events gave added value to answering Research Questions 4 and 5:

- What preparations are required on the part of teachers and students for the introduction of e-learning and how should infrastructural issues be addressed?
- What guidelines do science teachers need when using ICT in Science?

6.5.2 – Major Findings

Infrastructural support was named as one of the obstacles to effective technology integration in schools. That is why it was important find out about preparedness from teachers who successfully integrated it in their teaching.

6.5.2.1 Infrastructural and Professional Preparedness and

The two participant teachers, who have attended other international gatherings and been exposed to the use of technology by other teachers worldwide, were more critical than other teachers regarding the ICT infrastructure in Lesotho. However they were positive about the future and Teacher A commented:

‘Although Lesotho appears to be behind many countries, my own experience shows that we have potential... I started with just one computer for my 68 students and now my school has more than fifteen computers; all used for teaching and the result is reflected in the results of our students...’ (Table 6.7: STIC 2)

The two teachers owe part of their success to the conducive environments of the schools where they are employed. A student (Student 2), who was asked to describe the impact of the strong ICT infrastructure in his school, commented:
‘There is a change in my school, I am now able to understand science lessons and even where I do not, I now know how to search on the Internet... it is amazing!’

Another student (Student 1) said:

‘I can’t just miss a science class’.

These findings are consistent with input to the survey by teachers which shows students’ positive attitudes, as indicated in Table 6.8 in Section 6.3.1.

Results in Table 6.13 indicate that 90% of teachers believe that professional development is the key barrier to ICT integration in Lesotho secondary and high schools. The two award-winning teachers have been well trained. They attended workshops at STIC as well as the NEPAD E-School Train the Trainers courses; Teacher A indicated that these training and workshops were ‘wake-up calls’ for ‘twenty first century teaching and learning’.

Both these teachers emphasised that more time should be allocated for their use of ICTs to prepare lessons, at least in the early stages. They further suggest that computers be available in classrooms, rather than in the laboratory, and extra time allocated to student use of them for learning. Teacher A who participated in Microsoft IEF (2010) and won an award, works in a school with about 50 computers. She teaches science to the matrics in her school, and uses 20 computers in her classroom, meaning that either every student can use a computer or pairs of students can use a computer. She said:

‘When using computers in my classroom, my students do not feel being in a strange environment ... the seating arrangement in the laboratory is not promoting collaboration’.

In the classroom, by contrast, she was able to arrange seating in groups, when required.

6.5.2.2 Guidelines for Science Teachers and Students

Apart from guidelines proposed in Section 6.4.1.4, namely the development of school ICT policies; teachers’ professional development programmes; targets,
performance indicators, and monitoring of such; infrastructural guidelines; and cost estimation, the award winning teachers proposed the following guidelines:

- Publicise the award winners of the Microsoft IEF as role-models for other teachers in the country, and
- Allocate more time, even after official school hours, for students to interact with e-learning tools independently, as well as to do Internet searches, where connectivity is available.

During observations, it was noted that these two teachers were more optimistic and used new software not only for presentations in class, but also in preparing their lessons. Teacher B who used Webquest to download lessons (Figure 6.14), commented:

‘Since I have discovered this site, I have made my lesson preparation enjoyable ... I always compare the lessons from more than one teacher and then prepare my own activities to give my students’.

This is an indication that, if given proper guidelines and a supportive environment, teachers can effectively integrate e-learning and added-value material into their teaching. Students will also benefit greatly if they can personally be more involved in various activities and thus be equipped with ICT skills for better learning in general.
The researchers’ observation of a lesson taught by Teacher B confirmed the effectiveness of *WebQuest* in this teacher’s lesson preparation. Teacher B also reported using other forms of software software, such as:

- **Moviemaker** (helping students to use photos, movies and slides to be shared on DVD or the web);
- **Autocollage** (to help students create fun, works of art projects etc...);
- **Learning Content Development system** (LCDS), a free tool to create interactive online courses that can be published with customised content, animations etc...; and
- **Chemistry Add-In** for Word (making it easy for students to insert and modify chemistry information such as labels, formulas etc...).

### 6.6 Summary of Findings and Conclusion

Chapter Six provided a detailed analysis of research data, collected during the Main Study and Showcase Study, to determine findings. The findings established that, although many teachers are still struggling to integrate e-learning in their day-to-day interaction with students, those who underwent proper professional development programmes, with one or more of the three projects, are better equipped to integrate it effectively. The studies found that, apart from adequate professional development to implement what they have learned, teachers need time and infrastructural support.

Students enjoy the use of ICTs; more especially when simulations are used in science classes. In the Pilot Study, the author had observed several presentations made by students on their collaborative projects. This was discussed in Section 5.9.4.3. These observations demonstrated how the use of e-learning and computing tools was helpful for collaboration between students. The development of new skills, such as data collection, analysis and presentation by students, was clearly evident.

Chapter Six provided details of the qualitative and quantitative analysis of data from the nine schools selected to participate in the Main Study, with a view to implementing ICT to enhance teaching and learning of science at secondary and high school level in Lesotho schools. The design of data gathering and analysis tools was
explained. The details of qualitative and quantitative data collection processes were provided. In addition, the chapter supplied general findings from the analysis and examined the data as it related to the questions and evaluation statements outlined in the criteria. Descriptions of activities and results from interviews, survey questionnaires and observation were also presented.

The chapter also presents the criteria and evaluation statements and discussion relating to perceived ICT importance in education, integration barriers and ICT tools use in science education.

The studies reported in this chapter are the two final phases in the variant of action research used as research design for this thesis. The findings assist in practical ways of solving problem. They also contribute to knowledge of pedagogical expertise on the part of teachers and progress on the part of learners.

New knowledge and insights from this study should be of benefit, both to the educational sector in Lesotho and to other educators in Africa.
Chapter Seven ~ Conclusion

7.1 Introduction

The purpose of this study was to overview the progress and extent of e-learning integration and use in the Lesotho secondary and high schools science classrooms. This research aimed to identify factors that can contribute to the enhancement of teaching and learning in the Lesotho educational system by integrating ICT and e-learning into the curriculum. To this end, science teachers’ perceptions of ICT integration and their familiarity with ICT were determined. Furthermore, it set out to establish what barriers and hindrances were perceived by educators. Studies were undertaken to quantify the available computing infrastructure and technical support in selected project schools, and to establish how e-learning activities have been used in the science classroom since 2007 by science teachers. Participants in the study were educators and students in the selected schools.

The research involved a four-year longitudinal approach, which was variant of action research (VAR). It involved six varying studies, one of which was a very extensive empirical study. As a foundation for this Main Study, serious consideration was paid to secondary data from relevant literature and to findings from the earlier studies in the AR process. This research employed a mixed-methods approach to answering the main research question and its sub-questions. Qualitative and quantitative data was collected, analysed and discussed. In the variant of action research (VAR) used, the studies were very different. The studies were not conducted among the same participants, nor did they use the same data collection instruments, although there were overlaps and interrelationships. Moreover, these were not successive studies of the same phenomena. Each study did not necessarily have a direct input into the next study, in the form of reflection and resulting action, as is the case in classic AR, although they did influence subsequent events and research.

Most of studies, therefore, did not follow the classic AR model, in which each study has an explicit impact on subsequent work. For example, the outcome of Study 1 did not affect Study 2, nor did Study 2 have an impact on Study 3. However, there were certain links and similarities:
There was a close relationship between the Pilot Study and the Main Study, in that the pilot was used to test the instruments and methodologies. This had an effect on the actions and research that followed, as it contributed to refining them for the Main Study.

There were also links and similarities in the data collected after Intervention 4a (Table 5.13) and Study 5 (Main Study). Table 5.13 shows the increased variety of e-learning software available in 2009 after the advent of Microsoft STIC and Pil, while Tables 6.15 to 6.18 in Main Study not only present the forms and methodologies of e-learning in use in 2010, but also elaborate on the ways they were used and by whom.

There is a connection between Study 2 (Post-orientation Study) and Study 5 (Main Study). In both cases, there was a notable increase in the teachers’ level of confidence in using technology (see Sections 5.5.2.2 and 6.3.2.2).

This chapter consolidates and summarises findings of the research. Insights from literature are presented in Section 7.2. In Section 7.3 the research questions posed in Section 1.6, Table 1.4, and Section 4.2 of the research design, are revisited and answered by referring to the results and findings of the six studies discussed in Chapters Five and Six. Section 7.3 also presents guidelines for the integration of ICT and e-learning in the Lesotho science classroom. In Section 7.4 ICT progress in Lesotho during recent years, is addressed, while Section 7.5 considers how certain research-related factors raised in previous chapters were implemented. Section 7.6 presents recommendations and Section 7.7 proposes directions suggestions for future research. The study is concluded with a summary and conclusion in Section 7.8.

Answers to the survey questions are not individually reported again in this chapter. Rather, findings are structured according to their criteria and topics, as related to the research questions. This chapter elaborates further on the findings in Subsections 7.3 and 7.4 respectively. Some of the findings are consistent with research conducted in Singapore (Chan, Tan and Khoo, 2007; Teo, Chai, Hung and Lee 2008).

### 7.2 Summary of Findings from Literature

The literature reviews in Chapters 2 and 3 form an important part of the research, because they provides secondary data. In general, the literature indicates a positive
impact of technology and e-learning in schools, despite various obstacles related to teaching or to institutional issues. The main focus was on the concepts that emerged as findings, some of which were used as a basis to establish criteria for data collection and analysis in the Pilot Study and the Main Study (see Section 4.7).

Some of the most relevant findings from the review are summarised below. From the literature it was established that:

1. ICT can contribute to enhancing quality of teaching and learning (Lujara et al. 2007; Howie and Blignaut, 2009; Lee et al. 2009).

2. Teachers are faced by challenges in the implementation of technology-based pedagogy (Tondeur et al. 2008; Hadjithoma and Karagiorgi, 2009; Lateh and Muniandy, 2010).

3. A variety of forms and methodologies of e-learning can be used to guide and support students in subject-related learning experiences (Alessi and Trollip, 2001; De Villiers, 2005a).

4. Some forms of e-learning are highly relevant in the science classroom. In particular, simulations are interactive software systems that provide wide opportunities to imitate situations that would be infeasible or dangerous or costly to do in real life (Alessi and Trollip, 2001). The use of hypermedia-based learning systems in science education has brought about a substantial contribution to the enhancement of teaching and learning by hyperlinking a wealth of valuable information and resources (Siorenta and Jimoyiannis, 2008). Electronic tutorials also play a useful role in providing teaching segments and opportunities for practice (Alessi and Trollip, 2001), while electronic encyclopaedias such as Encarta impart broad and detailed knowledge.

5. Lack of infrastructural support, such as: hardware and appropriate software; insufficient technical training; and lack of suitably qualified technical personnel, is named as a serious handicap in some studies (Almohaissin, 2006; Bingimlas, 2009; Howie and Blignaut, 2009).

6. ICT in education is relatively new to Lesotho teachers and students, and especially in rural schools. Use of educational technology in rural regions is not operating on the level of schools in urban areas and more affluent regions. In these areas, there are still some schools without access to basic ICT tools for use in teaching and learning (Kalanda and de Villiers, 2008). However, the
situation has improved considerably since the Comparative Study was undertaken in 2008, although there are still schools without Internet access.

7. Teachers must be encouraged to overcome their fear of change (Bitner and Bitner, 2002).

8. Resistance to ICT adoption is due to the contexts and unconducive environments in which ICT is implemented and not only to teachers’ fear of change (Bingimlas, 2009).

9. The rapid introduction of new technology, such as the Internet, in education without adequate preparation of teachers and students for the changed environment, has hampered the integration of e-learning in classrooms (Alessi and Trollip, 2001; Kalinga et al., 2007; Tondeur et al., 2008; Erixon, 2010).

10. The three main learning theories (behaviourism, cognitivism, constructivism) are relevant to many aspects of today’s changing society and technologies, and each is suitable as a foundation for particular e-learning technologies (Hung and Nichani, 2001; Alessi and Trollip, 200; de Villiers, 2005a).

### 7.3 Summary of Findings: the Research Questions re-visited

The research questions are listed in Table 1.4 in Chapter 1 and again in Table 4.1 in Chapter 4. The main research question is:

**How can effective e-Learning and integration of ICT be supported in the science classroom in Lesotho secondary and high schools?**

In general, this study identifies a variety of opportunities, challenges and obstacles that teachers and students face in the integration of e-learning into their teaching and learning (Section 6.3.1, and Section 6.3.2). The findings show that it is possible for teachers to make positive and innovative changes to classroom teaching if hindrances are addressed. Using data from Study 5, the Main Study, the following subsections elaborate and answer the five supporting research questions, before returning to the main question.
7.3.1 – Research Question 1

What are barriers/obstacles to the integration of ICT in Lesotho secondary and high schools?

Recent studies identify: lack of hardware and appropriate software; insufficient technical training; lack of suitably qualified technical personnel; and a need for ICT integration skills among educators as major barriers to effective integration of ICT in education (Almohaissin, 2006; Moser, 2007; Bingimlas, 2009; Erixon, 2010).

This research confirms the above and identifies further matters. The issues that emerged from the present research are:

- Insufficient professional development programmes in Lesotho (Section 6.3.2.1);
- Inadequate allocation of time for use of ICT resources in the classroom (Section 6.3.2.2);
- Unsatisfactory allocation of time for preparation in the context of the new way of teaching (Section 6.3.2.2);
- A lack of infrastructural and technological support (Section 6.3.2.3);
- Affective and subjective aspects, such as lack of motivation and an inappropriate learning environment instead of an innovative environment (Section 6.3.2.4);
- Need for regular updates of software, since existing software becomes obsolete due to incompatibility with new hardware or becomes unusable due to expiry of licenses. This impacts on the sustainability of e-learning.

Table 7.1 quantitatively summarises the extent to which these issues were raised in the Main Study as barriers and problems experienced by teachers.
Table 7.1: Barriers and Obstacles hindering ICT use

<table>
<thead>
<tr>
<th>Barriers/Obstacles</th>
<th>No. of teachers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of, or limited, professional development programmes</td>
<td>19</td>
<td>90%</td>
</tr>
<tr>
<td>Insufficient class time allocated to ICT activities</td>
<td>15</td>
<td>71%</td>
</tr>
<tr>
<td>Infrastructural/technical problems</td>
<td>14</td>
<td>67%</td>
</tr>
<tr>
<td>Demotivation among students</td>
<td>10</td>
<td>48%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Survey Question</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>interviewed</td>
<td></td>
</tr>
<tr>
<td>Lack of technical support</td>
<td>11</td>
</tr>
<tr>
<td>Lack of ICT policy in the school</td>
<td>10</td>
</tr>
<tr>
<td>Lack of infrastructural guidelines</td>
<td>9</td>
</tr>
<tr>
<td>Teachers’ fear of unknown</td>
<td>7</td>
</tr>
<tr>
<td>Lack of cost estimation</td>
<td>3</td>
</tr>
<tr>
<td>Lack of confidence</td>
<td>5</td>
</tr>
<tr>
<td>Lack of access to computers</td>
<td>3</td>
</tr>
<tr>
<td>Resistance to change</td>
<td>3</td>
</tr>
</tbody>
</table>

The data in Table 7.1 about teachers’ opinion on obstacles to ICT integration in their schools, comes from the questionnaire survey among the 21 teachers in the Main Study and the interviews with 18 teachers in the same study. Each teacher could give as many barriers as they wished.

Despite these obstacles, the findings also included positive aspects, with 95% of teachers using computers for administration and preparation (Table 6.16), and 45% using computers for e-learning activities within subject teaching. These percentages from the Main Study are higher than those of Study 1, the Baseline Study of 2007 (Table 1.2), which reported only 3.4% (5 teachers out of 143) using ICT for teaching with electronic e-learning tutorials. It is also an improvement on Study 3, the Comparative Study of 2008, which identified that many Lesotho teachers were not, at that stage, familiar with simulations and Web-based systems (Table 5.13).

**Discussion**

These identified issues should be addressed. They are important in schools where technology is already in place and also in any school where e-learning is planned, even before ICT integration processes are started.
Most teachers named more than one barrier and some indicated that the barriers were related. The majority of questionnaire respondents mentioned the lack of, or limited, professional development programmes and also indicated that insufficient class time was allocated to ICT activities. Some of the responses from the interviews corresponded with answers from the questionnaire survey, while other new aspects emerged spontaneously from the interviews. This shows the value of triangulating the sources used for data collection.

These responses to Research Question 1 have indicated the great extent to which barriers hinder teachers in using ICT. The identification of these barriers serves a purpose among the teachers, in that they can distinguish between the ones they can attempt to solve themselves and those that they should raise as grievances. Principals and school boards should consider ways and means of addressing these issues.

7.3.2 – Research Question 2

*What familiarity, aptitude, skills and strategies do Lesotho high school science teachers and students have with the use of ICT?*

Results in the Main Study showed that some teachers in the sample – across the three projects – were unfamiliar with certain ICT tools. Table 6.16 indicates that almost all the science teachers had computers in their schools, even if they were not used effectively for teaching purposes. These teachers have developed skills in the use of commercial software such as Word, Excel and PowerPoint, which they use in preparing ICT-based lessons and, to some extent, in teaching (Table 6.18). However, the findings also indicate that teachers need to acquire more skills and strategies in the use of other specialised software, for example, educational applications available on the Internet (at sites where there is connectivity). Teachers should use Web-based applications for personal enrichment and development before they can fully integrate e-learning in their schools (Table 6.19). This will:

- enable continuous development of the new skills required and application of the skills acquired,
• enable progressive access to a broader range of multimedia and other electronic learning resources, and
• facilitate teachers’ use and adaptation of teaching resources developed by others and independent creation of their own resources.

Discussion
The attendance of ICT-related courses, hours spent in such training, and the associated practice of skills, provide in-service teachers with the knowledge and skills essential to use various systems. Nevertheless, it is also important for educators to learn practical ways of integrating e-learning into their teaching practice in subject teaching. To develop these skills in pre-service teachers, training colleges should not only teach basic computer literacy courses, but should address key issues on the actual use of ICTs for teaching and learning.

As principals and teachers recognise the need for e-learning in their day-to-day work and the impact this new pedagogic approach can have on students’ learning outcomes, it may become necessary to develop School ICT policies. This would help to structure collaboration between stakeholders and stimulate an appropriate learning environment for students.

7.3.3 – Research Question 3

What advantages/disadvantages do science teachers and students perceive when integrating e-learning with established classroom practice?

A range of studies in the literature report that many educators acknowledge the usefulness of ICT in facilitating teaching and learning (Sankey and St Hill, 2005; Lim, 2007; Kara and Karhaman, 2008). Similarly, this study revealed the perceptions of participating teachers that the use of ICTs has definite advantages for teaching and learning. It can:

• support recall of prior learning and stimulate students’ interest in new learning (Section 6.4.1.3).
• make students more actively involved during lessons than in traditional class lessons (Section 6.4.1.3).
- enhance students’ performance (Section 6.3.1.1).
- provide a rich source of information when the Internet is accessible (6.3.2.1).
- increase teachers’ confidence levels (Section 5.5.2.2).
- contribute to the development of problem-solving skills among students (Section 6.3.3).

The data also showed teachers’ concerns about potential disadvantages of ICT in the class situation. It can:
- distract and discourage the teacher, particularly when equipment is faulty and technical malfunctions occur during an actual lesson (Section 6.3).
- distract students from the learning content (Section 6.3.2.4; RQ 31).
- lead students to start using technology for activities that are not subject-related (Section 6.3.2.4; RQ 31).

Students also agreed that there are benefits in being equipped with ICT skills. They believe it could help them towards achievements in life in general. Some acknowledged that they had sometimes accessed irrelevant information out of curiosity during science lessons (Section 6.4.1.2).

**Discussion**

More is required than the mere provision of resources to extend teachers’ expertise and the quality of learning. As stated in the answer to Research Question 2, more emphasis should be placed on the practical integration of ICT and e-learning into subject teaching in the classroom.

This study revealed that, despite mainly positive perceptions, teachers had some resistance to ICT adoption, due not only to doubting potential usefulness, but also to their lack of knowledge of how to use it optimally and to hindrances in the environment. Teaching and learning could be improved by a more conducive learning environment. In the Lesotho context, a conducive learning environment is one that is innovative, yet also task-oriented and similar to a conventional class situation, where students know what is expected of them and how to behave in order to succeed. The matters of motivation and an appropriate innovative environment are discussed in Sections 6.3.2.4 and 7.3.1.
7.3.4 – Research Question 4

What preparations are required for the introduction of e-Learning, and how should infrastructural issues be addressed?

There is a misconception that the mere access to technology motivates teacher and students to apply it in their teaching and learning. Literature shows that preparation is required before any infrastructural issue can be addressed. Various international and local studies, referred to in Chapters Two and Three, suggest that insufficient attention been paid to preparing teachers and students for the speedily-changing technological environment. They have also shown that the implementation and the infrastructure of ICT have not been appropriately managed (Howie and Blignaut, 2009; Lateh and Muniandy, 2010). On the other hand, measures have been put in place in certain countries (e.g. Southern Regional District, Manahawkin, New Jersey, USA) to support teachers by providing them with personal laptops and appointing skilled teachers within each school to serve as mentors (Hass, 2000). In another venture, the Education Ministry in Singapore adopted supportive strategies including the appointment of technical support staff in four Singapore schools to install and maintain hardware and software in schools, thus alleviating one of the serious barriers to ICT integration (Lim and Khine, 2006). A similar solution has been used in Portugal where technical assistance was provided to teachers by technical personnel (Gomes, 2005).

Teachers in this study believed that both they and their students need basic ICT training and computer literacy before the integration process starts (Section 6.3.2.3).

Teachers further believe that if they lack expertise in handling hardware and software issues, they might be under stress, and their insecurity and nervousness could make it difficult to concentrate on teaching. Such insecurity might also be evident to the class, which would embarrass the teacher and could also distract students from learning (Section 6.3).

If technical assistance was provided by the Ministry of Education or by local school leadership, teachers believe their environment would be improved to such an extent
that they could concentrate more effectively on their preparation and teaching and raise the standard of their students’ performances (Section 6.3.1.1.2).

Development of a school ICT Policy would assist by setting out structures and procedures (Section 6.4.1.4.1).

Discussion

In the 21st century, the provision of computers to schools is essential, but these can become redundant if teachers are not properly trained in their basic use. Similarly, if schools are provided with Internet connectivity, yet teachers are not trained in access to e-content, they might not use it optimally to the benefit of learners. Technical and infrastructural issues can be addressed in conjunction with professional development programmes. Basic technical expertise is indeed an asset; it increases self confidence, but teachers should not be expected to repair malfunctioning equipment.

The use of technology in learning has to be tailored towards:

- provision of access to high quality learning materials (whether Web-based or on portable media, e.g. multimedia CDs),
- a safe and well-functioning environment for teachers and learners, and
- avoidance of access to inappropriate material and prevention of improper or unauthorised use of systems.

These matters are addressed further under the proposed guidelines, which are presented in the following section.

7.3.5 – Research Question 5

*What guidelines do science teachers and students need when using ICT in the science classrooms?*

On the development of guidelines, five key themes emerged from Study 6, the Main Study that need to be addressed (Section 6.5.2.2), both from the literature and from the Main Study:

- Development of school ICT policy (Sections 2.3.3.1 and 6.4.1.4.1),
• Development of professional development programmes for teachers (Sections 2.6.1 and 6.3.2.1),
• Development of performance indicators for teachers (Section 6.4.1.4.3) and
• Setting up of an infrastructural plan and upfront analysis of costs (Sections 2.5.3 and 6.3.2.3). Lack of upfront attention to budgeting has led to situations where computers were purchased but funding was not available for maintenance and upgrades.

These themes are discussed in Sections 7.3.5.1 to 7.3.5.5.

Apart from guidelines that emerged from Study 5 and Study 6 (the Main Study and the Showcase Study respectively) five other guidelines were drawn from Studies 1 to 4 and are discussed in Sections 7.3.5.6 to 7.3.5.10. These are:
• Advice, training, and demonstration for teachers on how to incorporate ICT in teaching (Section 5.5 in Study 2, the Post-orientation Study).
• Collaboration among teachers in preparing ICT-mediated lessons (Section 5.6.1.3 under Study 3, the Comparative Study).
• Appointment of technical support staff (Section 5.4.1 in Study 1, the Baseline Study).
• Appointment and training of students for technical support as a ‘Students’ help desk’ (Section 5.6.1.3 in Study 3, the Comparative Study).
• ICT use for subject matter other than science (Section 5.9.4.3) and use more in classrooms rather than in computer laboratories (Section 5.9.4.5).

7.3.5.1 Development of ICT Policies

Findings from this research revealed a total absence of ICT policies in all schools during the duration of the investigation. Policies were not regarded as a necessary guide for the process of integration. Principals, teachers and students agreed that the development of a policy framework should be considered as the first step in the adoption of ICT in schools.
7.3.5.2 Developing Professional Development Programmes for Teachers

For effective professional development of teachers, it was suggested that training should be done on an ongoing basis. It was also suggested that the process should be evaluated according to factors such as:

- the number of teachers trained,
- the extent to which teachers use ICT tools, such as multimedia resources, in their teaching and in supporting learning, and
- the extent to which all teachers participate in professional development programmes.

Furthermore, informal training could be done by using skilled teachers within each school to serve as mentors to their peers.

7.3.5.3 Developing Targets and Performance Indicators

Strategic targets and associated performance indicators could be developed by the schools to make the vision a reality and provide a set of measurable achievements. This would also assist in assessing which projects and initiatives are more likely to contribute towards the overall success of the adopted plan. The performance indicators for the schools’ infrastructure could be tested in terms of the student-to-computer ratio, and the extent to which the school has Internet and/or intranet connectivity.

7.3.5.4 Setting up an Infrastructural Plan

Literature indicates that for proper integration to take place, schools should draw up an infrastructural plan (Section 2.3.1) for development and management of their ICT infrastructure. The planning should be based on the strategic objectives and needs of the school and should be consistent with the policies, as discussed in Section 7.3.5.1. Teachers pointed out that such planning for the development and management of ICT infrastructure would enable a better understanding of the school’s goals and needs, as well as the extent of the current ICT infrastructure, before undertaking to integrate technology into teaching or to increase the nature and extent of ICT integration.
Costing and Budgeting

Studies both in Africa and abroad have identified the cost of ICT in the schools as an important point to consider. This expense is primarily associated with the acquisition of ICT equipment, particularly hardware. To enhance teaching and learning and improve students’ skills, teachers suggested three categories to be taken into account when budgeting for ICT integration in schools: hardware, software and maintenance costs (Section 6.4.1.4.5). Hardware is usually provided by the Ministry of Education or by donors, but the schools are responsible for acquiring certain software, as well as all expenses related to maintenance and repair.

Advice, Training and Demonstration for teachers on how to incorporate ICT in Teaching

Most of the teachers were initially introduced to ICT integration without adequate advice, hands-on training in using e-learning software, or demonstration of a working model of integration. They were not sure what was expected of them (Section 5.5.1). Significant improvement might be evident if teachers:

- get advice from local leaders in educational technology or other specialists in the field of e-learning and ICT in education, and
- are exposed to reliable examples of successful implementation and best practice models.

Collaboration among teachers in preparing ICT-mediated lessons

Collaboration between educators was cited by certain teachers as one of the strategies for successful implementation of any ICT integration initiative. Teachers indicated in follow-up interviews that, under the current situation, where many teachers globally use lessons posted on sites such as FaceBook and Windows Live, access to such lessons (even under different curricula) might not be difficult. Teachers in Lesotho are currently working in isolation, which is not beneficial.

Appointment of technical support staff

There has long been general acknowledgment that effective use of ICT by teachers can be significantly improved by implementing changes in the manner the school deals with maintenance of available tools. Gomes (2005) advocates that ICT
integration be supported by technical personnel as has been done in some European countries. Although this strategy was recommended by Lesotho teachers early in this research (Baseline Study in Section 5.4.1.), it appears to be an issue globally (Lim and Khine, 2006). Teachers suggested provisional strategies in the absence of the official appointment of technicians as members of staff:

- Appointing new staff members to take care of the equipment and schedule regular maintenance programme; or alternatively
- Train current staff members to be able to troubleshoot computers when problems arise in educational hardware or software.

7.3.5.9 Appointment and training of students for a ‘Students’ Help Desk’

In one of the schools, Microsoft suggested that students with technological expertise and interest should be designated and trained to serve as a ‘Student Help Desk’. This particular school had no technical support, since it is located far from urban areas and from other Lesotho schools (interview with a teacher in STIC project). The proposal would also avoid the expense of hiring a new staff member for maintenance.

7.3.5.10 ICT use for other subject matter in classrooms

Literature has suggested that computers should be used across curricula, within subject-based teaching, and that they should be employed more in classrooms than in laboratories (Hohlfield et al. 2010). Teachers who participated in this study acknowledge that when students present their projects to the class, their fellow-students pay more attention and participate more actively (Section 5.9.4.3). They also believe that e-learning should be extended within their schools and actively practiced in subject-based teaching and learning beyond science.

7.3.6 – Main Research Question

*How can effective e-Learning and integration of ICT be supported in the science classrooms in Lesotho secondary and high schools?*

The answers to all the supporting research questions, as given in Sections 7.3.1 to 7.3.5, comprise the answer to this main research question. To give a final answer, some matters are briefly highlighted.
Research findings, both from literature and this study, indicate that effective integration is possible when all stakeholders are fully committed, suitable professional development is in place, and technical infrastructure is maintained (Sections 2.6.1, 5.10 and 6.3.2.1). Teachers must be equipped with appropriate skills and strategies (Section 3.5, Table 3.3 and Section 5.9.3) before and during the integration process.

The quantitative survey results showed that teachers across the three projects perceive and appreciate the social and pedagogic value of using e-learning technologies in the subject-matter, for themselves and their students (Section 6.3.1.1.1, Figure 6.1). This is in agreement with findings from other research, both regional and elsewhere (Section 2.5). The study also established that students collaborate better with each other and with teachers during ICT-based lessons (Table 6.26: Question 31).

The discussion of the two successful award winners in the Showcase Study demonstrated that appropriate professional development programmes can indeed address issues that hinder technology adoption in Lesotho schools. This is consistent with the findings of research studies noted in Section 6.5. The expertise and enthusiasm of the two high performers impacted positively on their students and should be explicitly communicated to other Lesotho teachers, as high performers are given opportunities to serve in mentoring roles.

Despite the progress indicated in this longitudinal VAR study, one must be cautious about describing ICT integration in the Lesotho secondary and high school science classroom as an unqualified success. This is not yet the situation. Extra efforts, beyond the initial investments, are needed. As an additional way of fostering sustainable integration, teachers suggested long-term access to e-content during all stages of the integration process, as part of their professional development programme. Appropriate training in the use of e-learning systems should also be part of the curriculum for pre-service teachers at teacher training college.
7.4 ICT Progress in Lesotho

Under the broad aims of this research, as stated in Section 1.2.2 and in Section 4.1 of Chapter 4, it was mentioned that one of the main purposes of this study was to investigate the progress of ICT integration and e-learning in the teaching and learning of science in Lesotho schools. This section considers this progress, but does not repeat content from Section 5.3, where the Research Questions are answered. Instead it investigates progress by providing some quantitative information and by referring to progress with regard to particular aspects mentioned in the literature studies. These aspects include active engagement and cognitive learning, collaborative learning, implementation of pedagogy and learning theories, higher-order thinking skills (HOTS), attitude and confidence of teachers, relevance of forms of e-learning, attitudes of teachers, and the learner-centred approach.

7.4.1 Progress in computing infrastructure

Table 7.2 tabulates the progress of e-learning starting from 2006/7, when this study commenced, up until 2010 when the Main Study was completed. The information is extracted from Tables 5.9, 5.13 and 6.14.

<table>
<thead>
<tr>
<th>Form of E-learning used in Lesotho</th>
<th>2006/7</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI Tutorials</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Video and Audio</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Simulations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Educational Games</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive Learning/Practice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD ROM-based Courses</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Web-based Courses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drill and Practice</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Video Conferencing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet-based Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Encyclopaedia-based Research</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 7.2 indicates that the use of e-learning tools increased in 2008 from their base level in 2006/7, as some schools started to use additional media such as educational games and interactive learning tools. With the advent of the Internet in designated Lesotho schools, 2009 and 2010 showed improvement in the areas of independent
research on the Internet, as well as the use of Web-based learning materials and courses. The abilities of the teachers to show leadership in these areas could be an indication that training and workshops had had a positive impact on education in Lesotho.

### 7.4.2 – Active engagement and cognitive learning

The literature indicated that ICT should be used to facilitate active learning (Sections 2.5.3.1 and 2.5.4.1) and engagement (Section 2.3.1) on the part of students. The Lesotho teachers have started to move toward an ICT-based teaching that favours more active learning, allowing students to try out interactive activities and become constructors of their own and others’ knowledge (Sections 4.8.1 and 5.6.1.1 and Table 6.18). Teachers are now attempting to create conditions by which students can take more charge of their own learning, moving beyond the traditional passive listening (Section 6.4.1.1 and Figure 6.8). A hindrance to full implementation of independent hands-on learning, is the lack of sufficient computers to allow simultaneous interactive activities by individuals or small groups.

### 7.4.3 – Collaborative learning

Collaborative learning was advocated in Sections 2.5.3.2, 2.5.4.2 and 2.6.4. This involves solving problems in a cooperative way. It was noted by the author in his observations that several of the projects he saw presented to the class by students were collaborative projects. Teamwork contributes to the development of motivation and critical thinking skills. Figure 6.8 in the Main Study, illustrates some collaborative work done by students independently of the teachers.

### 7.4.4 – Implementation of pedagogy and learning theories

E-learning tutorials, which tend to be mainly behaviourist in nature (Section 3.2.1), are effective for teaching well-structured concepts such as formulae for calculations, and the laws of physics and chemistry. Unfortunately there is little independent use of these by students in Lesotho schools. Instead, they are mainly demonstrated in class by the teachers. However, as mentioned, in some schools a few students are using presentation software, downloading from the Web and taking videos and photographs with the school’s digital cameras to create projects for presentation to the class (Section 5.9.4.3 and Section 6.4.1.1). An advantage of this personal
construction and communication of knowledge is that it implements creative thinking and constructivist learning (Section 3.2.3).

Responses to Question 27 in Section 6.3.1.2.1 about how teachers overcome pedagogic and didactic problems in the context of learning with technology, revealed that after their training at STIC and NEPAD e-school, they started downloading Webquest lessons posted on the Internet by other teachers, including international educators. This indicated that their exposure to computers and training in workshops enabled them to adapt the downloaded material and align it with their curricula.

7.4.5 – Use of higher-order thinking skills (HOTS)
The use of HOTS was raised in Sections 2.1, where the levels of Bloom’s taxonomy were mentioned. It was investigated in the Lesotho context in Table 6.12 in Section 6.3.1.2. The findings of the Main Study show that Bloom’s levels of analysis and synthesis are being achieved by students in their design and generation of projects and in communicating their knowledge to the class (Section 6.4.2). The Showcase Study demonstrates that the award-winning teachers had personally implemented Bloom’s levels of application and synthesis in the creative lessons they had designed (Section 6.5.2.1).

7.4.6 – Attitude and confidence of teachers
Analysis of Study 3 (Comparative Study) shows that in 2008, teachers rated the students’ confidence and ICT skills as higher than their own (Section 5.6.1.2: Figures 5.1a and 5.1b). The question was not asked in an identical form in Study 5 in 2010 (Main Study), but the data in Table 6.18 shows that teachers were using computing technology far more than the students, demonstrating a role reversal and indicating that their confidence, skills and competence had increased. This is probably due to the focused training and professional development they gained from the PiL and Intel Teach courses.

7.4.7 – Relevance
Literature advocates that the forms and approaches of e-learning used in education, must be relevant. They should be appropriate and add value to the learning experiences (Section 2.3.2.3). Similarly there should be authentic real-world
activities (Section 2.3.3.3). There are indications that this is indeed occurring in some best-practice Lesotho situations, where the tasks given to students relate to local contexts that are available and known to the students.

In the Pilot Study, the researcher observed a presentation of a biology lesson that a teacher had prepared on indigenous plants, with local application in mind (Section 5.9.4.3). This was followed by an activity in which the students were required to make photographic records and write textual reports of local plants and present their projects to the class.

7.4.8 – Attitudes of Teachers
Teachers should be motivated and empowered to change their teaching practices (Section 2.3.3.4). The attitudes and skills of teachers in Lesotho have been improving since the advent of the professional development programmes of STIC and NEPAD E-Schools (Section 6.3.1.1.1, Tables 6.5 and 6.6)

7.4.9 – Learner-centred approach
Recent literature advocates a learner-centred approach with teachers serving more as facilitators than as instructors (Section 2.3.3.5). According to the researcher’s observations, this is not happening in Lesotho in general. Much is still done in a traditional teacher-centred way. However, some teachers’ responses in interviews, indicated awareness of their potential changed role in the context of ICT integration (see Section 7.6.4).

7.5 Implementation of research issues raised in previous chapters

7.5.1 – Validity and Reliability
The need for validity and reliability was introduced in Section 4.11 in Chapter 4. Cohen, Manion and Morrison (2005) define validity as demonstrating that the research instruments do indeed measure what they are supposed to. They define reliability in quantitative studies as entailing consistency, accuracy and replicability over time, instruments and groups of participants. In qualitative studies, however,
they define *reliability* as getting a good fit between the data recorded by the researcher and what actually occurs in the naturalistic setting being investigated.

The author used a Pilot Study (Section 5.9) to check the appropriateness of the methodologies, techniques and instruments for their measuring task. The survey and interview questionnaire were then revised, thus contributing to the validity of data processing in the Main Study. The iterative studies used in the VAR approach, also contributed to validity. Reliability, i.e. aiming for a close fit between the data gathered and the actual occurrences in the Lesotho high school classroom, was ensured by using a set of different instruments to collect data, namely: questionnaires, interviews and observation. This was done as part of triangulation, which is discussed in the next subsection.

### 7.5.2 – Triangulation

Triangulation is defined in Section 1.8.2 and Section 4.10 as the combined use of different research methods on the same objects in the study of aspects of human behaviour (Cohen, Manion and Morrison, 2005). Triangulation results in a better understanding of a subject. *Data triangulation* involves using multiple sources of data, while *methodological triangulation* means using different research methods on the same objects of study. This research, in particular the Pilot and Main Studies, implemented both forms of triangulation. In methodological triangulation, questionnaires, interviews and observation were employed for data collection – see Section 5.9.4, second paragraph. Data triangulation was implemented by the use of nine different schools as cases. The schools varied in terms of their situation within Lesotho (highlands, midlands or lowlands) and according to whether they were located in urban or rural regions (see Table 1.1).

The various techniques of gathering data provided both quantitative and qualitative data in a mixed-methods approach (Creswell, 2009). Analysis of qualitative data is complex, but triangulation of data and methods enhances the reliability of the findings. Triangulation can play a *complementary* role, when one data collection method provides information that does not emerge from another. In other situations, the information obtained from different data collection methods played roles of *confirmation*. For example, confirmatory findings emerged with regard to distractions while using
technology. In the Pilot Study observations, the author noted that certain students were using the Internet for non-subject-related purposes (Section 5.9.4.3). Teachers in the same study (Pilot Study) and students in the Main Study confirmed this occurrence in the interviews (Section 6.4.1.2). It also emerged from the questionnaire survey in the Main Study (Section 6.3.2.4) that students were being distracted from the learning content and undertaking personal activities on the Internet that were not related to subject matter. This demonstrated the value of combining qualitative and quantitative methods. In another confirmatory example, the lack of time allocated to teachers’ use of ICT in the classroom was reported by the respondents in the Main Study as the second key ICT integration obstacle, with 71% of participants acknowledging it as a problem (Section 6.3.2.2). This was confirmed by qualitative information from the teachers’ interviews. One teacher elaborated, indicating that the main reason for lack of time is that many teachers focus primarily on following the syllabuses (Section 6.4.1.2). The present syllabuses do not yet prescribe e-learning activities. In an example of complementary findings, the issue of costing and budgeting related to ICT equipment emerged spontaneously from teachers’ interviews (Section 6.4.1.4.5). This matter had not been investigated in the quantitative questionnaires.

7.5.3 – Limitations

Section 1.7 has shown that this study was limited to teaching and learning of science at secondary and high school level.

Section 1.7 also explained that the research is based on a small, selected, representative sample of schools, all attached to either the SchoolNet Project, NEPAD E-School Project or schools in the Microsoft STIC Project. All participants – teachers and students – are from science departments in these schools. The studies are also limited in that, with a few exceptions, urban and rural schools are not separated in the analysis. These limitations work against broad generalization of the findings.

A further limitation is that no research was done on academic performance in science of students who had high exposure to e-learning. Due to the ‘no significant difference’ debate (Clark, 1994; Kozma, 1994), this is not necessarily a shortcoming. Was such an investigation to be done, it would call for an experiment with a
treatment group and control group, and would not be in the best interest of the participating students.

7.6 Recommendations

This section presents recommendations for ways of contributing to effective e-learning and integration of ICT in the high school situation. Some of them elaborate points advocated in the guidelines in Section 7.3.5 or mentioned elsewhere. The recommendations are not necessarily limited to science education.

7.6.1 – Technical assistance
Schools should appoint technical assistants as members of staff to help maintain and repair faulty equipment. This should not be the teachers’ responsibility. There are precedents for this, for example, Marcovitz et. al (2000) advocate it and it has been done in Singapore schools (Lim and Khine, 2006)

7.6.2 – Degradation as well as progress
In his series of studies, the author encountered cases where the use of certain ICT systems was decreasing while, at the same time, other aspects of ICT in education were moving forwards. He realised that some e-learning software he had seen being used in an earlier study, was no longer in use at the time of a subsequent study. This happened because of obsolescence, as well as incompatibility with upgrades and new hardware. Another cause was the expiry of license agreements. (See end of 6.3.1.5 and Section 6.3.2.1.7). These issues should be planned and managed to prevent the loss of good software systems.

7.6.3 – Increased hands-on use by students
Table 6.18 in Section 6.3.2.1.7 shows that there was little independent use by students of e-learning software such as tutorials and simulations. E-learning drills, tutorials and simulations, which are known for their value in interactivity, exploration and manipulation facilities, and hands-on practice, are used by a very limited number of the students. Instead, they are demonstrated by teachers as part of formal class teaching. Measures should be put in place to change this. It could
involve providing more copies of CS’s and making time available in labs for students so that they could learn independently and practice skills on CDs or the Web.

7.6.4 – Changed role of teachers: mentors and facilitators
The literature defines mentoring of teachers is a sustained relationship for supporting professional learners during the early stage of their career. It suggests that the role of experienced teachers changes to being a mentor and a collaborator in learning (Mostert, 2000). This can occur in two ways: firstly, gifted teachers can help less-senior teachers by mentoring them; secondly, teachers can serve more as facilitators than as instructors to their students.

Teachers in this study provided useful information when responding to Question 22 (Section 6.3.2.1.1) in the Main Study on the changed role of a teacher. Fifty seven percent of the participants (57%) indicated that their role is beginning to change from instructor to mentor and facilitator of learning. They were allowing students to work in groups and independently (Section 6.3.2.1.7), which is a new approach within Lesotho education.

7.6.5 – Application of findings
This research study provides information that can help teachers integrate e-learning into their subject teaching. The findings can also help school authorities in the implementation of professional development programmes. The results of this research should expedite the processes of challenging the obstacles that hinder full integration of ICT in education and can help to establish practices for the setting up and application of e-learning. This study can also help school leadership develop strategies that work best for their individual institutions in context, and can help teachers to become more directly involved in their own teaching.

The physical situation of this study might also help other countries in the region (Southern Africa) and Africa in general, since reports from the literature indicate similar circumstances and barriers across the region, for example, in countries such as Uganda (Lujara et al. 2007) and South Africa (Howie and Blignaut, 2009).
7.7 Future Research

Based on the results of this empirical research and the literature discussed in this chapter, further research can be conducted in several areas to aim for more effective integration of ICT into learning activities in schools.

Such studies can focus on:

- students’ perception of e-learning in subject-based teaching and learning, i.e. ICT in the curriculum.
- ICT integration in rural schools.
- the potential role of award-winning teachers in the Microsoft Innovative Educators’ Forum in promoting e-learning practice in schools.
- the possible appointment of experienced teachers as proponents and mentors in e-learning.
- Policies for ICT in Education.
- monitoring and evaluation procedures on the application of ICT in education.
- the impact of promoting collaborative activities facilitated by ICTs on students with little interest or background in computers.

7.8 Conclusion

The focus area of this research was the implementation of ICT to enhance teaching and learning, while the application area was e-learning in science education at secondary and high school level in selected Lesotho schools. Section 1.5 stated that the findings of this research have a dual benefit: they are directly applicable to the real-world situation in Lesotho and also have relevance to education on the African continent in general.

First, there is an immediate outcome relating to the current situation in Lesotho education. The study investigated e-learning in schools in the science curriculum, its advantages, disadvantages, and support needs, as well as barriers to ICT integration in Lesotho secondary and high schools. The results provide information that can help teachers integrate e-learning into their subject teaching. The conclusions, recommendations, and guidelines should help school authorities in the alleviation of identified barriers and in
the planning and management of professional development programmes. Such approaches and structures should contribute to a more conducive learning environment.

Lesotho schools are improving in terms of the use of ICT tools in schools, although there is a lag in rural regions. However, some rural schools are obtaining international funding in efforts to alleviate the situation. It should therefore be a priority for national education stakeholders to prepare a new generation of teachers who will use technology in innovative ways to enhance learning across the entire kingdom. Although the application area of this research is science education, the conclusions and recommendations are transferable to other disciplines and curricula.

Despite the above, the main findings of the six studies in this action research process, show that it is insufficient merely to equip schools with computers, networks and educational software. For teachers to maintain and increase their competence in the use of technology and the motivation to use ICT and e-learning, they should be supported in appropriate pedagogy on an ongoing process.

Second, the thesis contributes to the general literature and body of knowledge on ICT integration in schools in African countries. Research related to e-learning in secondary and high school education, which is conducted in Africa by an African, is presented from an African perspective and has value and relevance to other regions in the continent.

However, this study also makes a third major contribution to the body of knowledge on ICT integration with the science curriculum. This contribution is the synthesis of the framework of evaluation categories and criteria, structured under the categories:

1. Perceived importance of technology in school education – including social and pedagogic rationales for ICT integration;
2. Barriers and obstacles to ICT integration; and
3. Use of ICT tools and e-learning in the science classroom, in particular, the application of computing within the curriculum.
This evaluation framework serves as a generic template, which can be transferred to other studies. It can be customised and extended as required to fit it for varying contexts.
References


## Appendix 1: Criteria and Evaluation Statements

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Evaluation Statements (Used in Questionnaire for teachers in Main Study and as a basis for interview questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td><strong>PERCEIVED TECHNOLOGY IMPORTANCE IN SCHOOL EDUCATION</strong></td>
</tr>
<tr>
<td>1</td>
<td><strong>Social Rationale</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Attainable Goals</strong></td>
</tr>
<tr>
<td></td>
<td>ICT should have an impact on the attainment of outcomes.</td>
</tr>
<tr>
<td></td>
<td>ICT can introduce positive changes into education.</td>
</tr>
<tr>
<td></td>
<td>I believe ICT can have an impact on my students’ outcome.</td>
</tr>
<tr>
<td></td>
<td>Progress in student outcome since students started using computer is a positive indication.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Relevance</strong></td>
</tr>
<tr>
<td></td>
<td>Assessments must have value for the student beyond the classroom for real integration.</td>
</tr>
<tr>
<td></td>
<td>Work produced must have an audience beyond the teacher.</td>
</tr>
<tr>
<td></td>
<td>I enjoy using technology to help my students have a real view and application of all tasks in real.</td>
</tr>
<tr>
<td></td>
<td>Science activities in my teaching go beyond the classroom.</td>
</tr>
<tr>
<td></td>
<td>Students like learning that takes place outside the classroom.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Skills and Attitudes</strong></td>
</tr>
<tr>
<td></td>
<td>Teachers' skills and strategies can facilitate the effectiveness of using technology in the curriculum.</td>
</tr>
<tr>
<td></td>
<td>Attitude of teachers can facilitate ICT integration.</td>
</tr>
<tr>
<td></td>
<td>The way I view technology can facilitate ICT integration.</td>
</tr>
<tr>
<td><strong>II</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>Pedagogic Rationale</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Improved Productivity</strong></td>
</tr>
<tr>
<td></td>
<td>ICT can create technological innovations and a knowledge-sharing society.</td>
</tr>
<tr>
<td></td>
<td>ICT can make teaching and learning more effective</td>
</tr>
<tr>
<td></td>
<td>ICT can improve interactivity and feedback</td>
</tr>
<tr>
<td></td>
<td>E-learning can add value to the learning experience.</td>
</tr>
<tr>
<td></td>
<td>E-learning can support the instructional process</td>
</tr>
<tr>
<td></td>
<td>I still do not believe ICT can help me to be more innovative.</td>
</tr>
<tr>
<td></td>
<td>I prefer teaching that is carried out using technology.</td>
</tr>
<tr>
<td></td>
<td>My students are more interested in a subject when feedback is instantly provided, through technology.</td>
</tr>
<tr>
<td></td>
<td>In my view, e-learning can support the instructional process.</td>
</tr>
<tr>
<td></td>
<td>To interact more with my students, I use different ICT media.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Teamwork, Critical Thinking, Independent Learning, Concentration and Cognitive Processing</strong></td>
</tr>
<tr>
<td></td>
<td>ICT can enhance students’ achievements.</td>
</tr>
<tr>
<td></td>
<td>ICT can foster a sound pedagogic approach to improve learning</td>
</tr>
<tr>
<td></td>
<td>ICT encourages active learning and higher-order thinking</td>
</tr>
<tr>
<td></td>
<td>In my school students are more active and achieve better results when using technology.</td>
</tr>
<tr>
<td></td>
<td>Teachers using E-learning are more collaborative than those who do not.</td>
</tr>
<tr>
<td></td>
<td>Technology is just a tool and cannot help students develop higher-order thinking.</td>
</tr>
<tr>
<td></td>
<td>Students use ICT/E-learning to collaborate and solve science problems.</td>
</tr>
<tr>
<td>BARRIERS TO ICT INTEGRATION</td>
<td></td>
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<tr>
<td>----------------------------</td>
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</tr>
</tbody>
</table>

**1. Professional Development of Teachers**

- The new role of teachers should be that of instructor, facilitator, mentor and collaborator of learning. Teachers should undergo regular scheduled professional development.
- I don’t think my role today allow me to mentor and facilitate learning.
- I have done ICT professional development in my school.

**2. Time Allocation for Teachers’ Use of ICT Resources**

- Teachers should be allowed more time to prepare lessons that use ICT and/or e-learning systems.
- The school periods in which I use the computer are long enough for me to complete all the tasks.

**3. Infrastructural Support and Technological Issues**

- Teachers need technical support.
- Teachers need training in pedagogy and didactics.
- I receive good supply of hardware and software from my school administration.
- I can overcome pedagogic and didactical problems.

**4. Learning Environment**

- Students need basic computer literacy before they use ICT in subject-related activities. Students should receive computer literacy training in the school. ICT affords the opportunity to create a rich learning environment. Effective technological learning environments can encourage students to explore knowledge independently. Technology can distract students from the learning content. Students use technology for activities that are not subject-related.
- Teachers and students need to learn basic use of computer before using it for subject-related activities.
- My students already have basic computer literacy prior to integration.
- In my school the technological environment helps enriching teaching.
- Students like to discover new things by themselves.
- Technologies can distract students from the learning content.
- Non-subject-related content is what students use ICT for.

**5. Other External and Internal Factors**

- Teachers can be technophobic and unwilling to take what they perceive as risky. Changes are required to develop a successful framework of ICT integration.
- I don’t like trying things by myself.
- I am not confident to use ICT in my instructions.
<table>
<thead>
<tr>
<th>C</th>
<th>ICT IN SCIENCE CLASSROOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology affords a bridge between concrete and abstract thinking as it create multiple representations of ideas.</td>
<td>With e-learning I am able to demonstrate some science phenomena.</td>
</tr>
<tr>
<td>ICT can improve Science students' problem-solving skills.</td>
<td>Science activities are well demonstrated when technology is not used.</td>
</tr>
<tr>
<td>Technology can strengthen procedural knowledge relevant to science activity. Using technology in the Science classroom can hold students’ attention and support recall.</td>
<td>In my Science classroom technology allow me to hold students’ attention and support recall.</td>
</tr>
<tr>
<td>The use of various media formats supports understanding.</td>
<td>I always use animation and simulation software in my teaching of science.</td>
</tr>
<tr>
<td>Animations and simulations facilitate students’ acquisition of science processing skills.</td>
<td>I believe animations and simulations facilitate students’ acquisition of science processing skills.</td>
</tr>
</tbody>
</table>
## Appendix 2: Criteria for Teachers and Students

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Motivation/References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PERCEIVED TECHNOLOGY IMPORTANCE IN SCHOOL EDUCATION</strong></td>
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</tr>
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<td><strong>A</strong></td>
<td><strong>Social Rationale</strong></td>
</tr>
<tr>
<td>1. <strong>Attainable Goals</strong></td>
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<td></td>
<td>ICT can introduce positive changes into education</td>
</tr>
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<td>2. <strong>Relevance</strong></td>
<td>Assessments must have value for the student beyond the classroom to have real integration.</td>
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<tr>
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<tr>
<td><strong>II</strong></td>
<td><strong>Pedagogic Rationale</strong></td>
</tr>
<tr>
<td></td>
<td>ICT can make teaching and learning more effective</td>
</tr>
<tr>
<td></td>
<td>ICT can provide feedback</td>
</tr>
<tr>
<td></td>
<td>E-learning can add value to the learning experience.</td>
</tr>
<tr>
<td></td>
<td>E-learning can support the instructional process</td>
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<td>2. <strong>Teamwork, Critical Thinking, Independent Learning, Concentration and Cognitive Processing</strong></td>
<td>ICT can enhance students’ achievements.</td>
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<td></td>
<td>ICT encourages active learning and higher-order thinking</td>
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</tbody>
</table>
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<table>
<thead>
<tr>
<th>Criterion</th>
<th>Motivation/References</th>
<th>Thesis Section</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B</strong></td>
<td><strong>BARRIERS TO ICT INTEGRATION</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>Professional Development of Teachers</strong></td>
<td>2.6.1</td>
</tr>
<tr>
<td></td>
<td>The new role of teachers should be that of instructor, facilitator, mentor and collaborator of learning Teachers should undergo regular scheduled professional development</td>
<td>Mostert, 2000; Kalanda and De Villiers, 2008; Ertmer, 1999; Pelgrum, 2001; Lujara et al. 2009; Mumcu and Usluel, 2010 Cuban, 2001b; Hunter ,2001; Zhao, Pugh and Sheldon, 2002; dams, 2005; Tondeur et al., 2008</td>
</tr>
<tr>
<td>2</td>
<td><strong>Time Allocation for Teachers’ Use of ICT Resources</strong></td>
<td>2.6.2</td>
</tr>
<tr>
<td></td>
<td>Teachers should be allowed more time to prepare lessons that use ICT and/or e-learning systems.</td>
<td>Schifter, 2002; Moser, 2007; Pelgrum, 2001; Elliot, 2007; Kalanda and De Villiers, 2008</td>
</tr>
<tr>
<td>3</td>
<td><strong>Infrastructural Support and Technological Issues</strong></td>
<td>2.6.3</td>
</tr>
<tr>
<td>4</td>
<td><strong>Learning Environment</strong></td>
<td>2.6.4</td>
</tr>
<tr>
<td></td>
<td>Students need basic computer literacy before they use ICT in subject-related activities Students should receive computer literacy training in the school ICT affords the opportunity to create a rich learning environment. Effective technological learning environments can encourage students to explore knowledge independently. Technology can distract students from the learning content Students use technology for activities not subject-related</td>
<td>Generated from experience of the author Generated from experience of the author Maguire, 2005; Sankey and St Hill, 2005; O’Mahony, 2003; Mumcu and Usluel, 2010 Alessi and Trollip, 2001: 6. Generated from experience of the author Generated from experience of the author</td>
</tr>
<tr>
<td>5</td>
<td><strong>Other External and Internal Factors</strong></td>
<td>2.3.1</td>
</tr>
<tr>
<td></td>
<td>Teachers can be technophobic and unwilling to take what they perceive as risky. Changes are required to develop a successful framework of ICT integration</td>
<td>Bitner and Bitner, 2002; Kalanda and De Villiers, 2008; Erixon, 2010 Generated from experience of the author</td>
</tr>
<tr>
<td>C</td>
<td>Criteria: ICT IN SCIENCE CLASSROOM</td>
<td>3.4</td>
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<tr>
<td>Technology affords a bridge between concrete and abstract thinking as it create multiple representations of ideas</td>
<td>Osborne and Hennessy, 2003. Molefe et al. 2007; Bingimlas, 2009; Blignaut et al., 2010.</td>
<td></td>
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<td>Technology can strengthen procedural knowledge relevant to science activity</td>
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<tr>
<td>Using technology in the Science classroom can hold students' attention and support recall</td>
<td>Alessi and Trollip, 2001.</td>
<td></td>
</tr>
<tr>
<td>The use of various media formats supports understanding</td>
<td>Kara and Kahraman, 2008.</td>
<td></td>
</tr>
<tr>
<td>Animations and simulations facilitate students' acquisition of science processing skills.</td>
<td>Wellington, 2000; Alessi and Trollip, 2001; Osborne and Hennessy, 2003.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: Teachers’ Questionnaire (Studies 3)

ICT INTEGRATION IN LESOTHO SCHOOLS

Questionnaire for Science teachers in selected schools from the three Projects

This questionnaire contains questions and evaluation statements about effectiveness of the use of ICT in schools and the use of e-learning software.

Kindly tick [✓], in the square next to the appropriate answer or fill in the answer.

1. Gender  [ ] Male  [ ] Female
2. Subject  (e.g. Mathematics)
3. School  ..................................................................................
4. Level of Education (e.g. Diploma, Bed. Etc. …)
   ..................................................................................
5. Years of experience teaching …………. Years
6. What learning resources (Hardware and Software)  
   Are available in your school?
   ☐ Computing tools  
   ..................................................................................
   ☐ Educational Software  
   ..................................................................................
   ☐ Video Conferencing
   ☐ Digital Camera
   ☐ Smart board
   ☐ Computers

   Are used by teachers for administration and preparation?
   ☐ Computing tools  
   ..................................................................................
   ☐ Educational Software  
   ..................................................................................
   ☐ Video Conferencing
   ☐ Digital Camera
   ☐ Smart board
   ☐ Computers

7. I believe ICT enhances my students’ performance and progress  
   [ ] Strongly Agree  [ ] Agree  [ ] Not Sure  [ ] Disagree  [ ] Strongly Disagree

8. If Strongly Agree, Agree, Disagree or Strongly Disagree please explain
9. Technology is just a tool to help students do things and it cannot help them to develop higher-order thinking skills
   [ ] True [ ] Not Sure [ ] False

10. Are ICT and e-learning effective in helping students to solve Science problems? Please explain your answer and refer to specific technologies or e-learning software that serve, or that do not serve, this purpose.

11. I am content with a traditional way of teaching.
    [ ] True [ ] False

12. The way I personally view and use technology has an effect on the students’ attitudes to ICT integration in my teaching and their learning.
    [ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree

13. I believe e-learning can help me to become more innovative in class.
    [ ] True [ ] Not Sure [ ] False

14. My students are more confident than most of the teachers
    [ ] True [ ] Not Sure [ ] False

15. What is the main reason why most teachers in your school are not using technology? Give only one main reason

16. In many cases, computers and software are available but teachers do not know what to do with them.

   Give your opinion

17. What type of ICT Training programs have been offered to teachers in your school

18. Does the school afford you the time for preparation of computer-based lesson?
   If not how many hours are you given to prepare each week? (Criterion No.B2A)
   [ ] Yes [ ] Not Sure[ ] No
- Less than 5 Hours
- Between 6 and 10
- Between 11 and 20
- More than 20
Appendix 4: Teachers’ & Stud. Interviews Protocol (Studies 1, 2 & 3)

1. Are there adequate computer facilities in your school to support ICT integrated activities?
   a) If so, please mention the facilities.
   b) Indicate these computers are installed (Labs or Classrooms) and where you would prefer them to be.
2. If infrastructural facilities are improved would you conduct more ICT integrated activities?

3. Have you attended any computer training course?
   a) If so please give details.

4. Do you possess adequate ICT skills and are you confident to carry out ICT integrated activities in class?
   a) If confident, indicate which form and methodologies of e-learning you are using,
      □ CAI Tutorials
      □ Video and Audio
      □ Simulations
      □ CD ROM-based Courses
      □ Drill and Practice
      □ Electronic Encyclopedia-based Research
      You can select more than one form or methodology
   b) If the answer is negative, please mention the skills that you need

5. What challenges do you face in carrying out ICT integrated teaching and learning activities?

6. Does the school administration support your effort to utilize and integrate ICT tools in teaching and learning activities?
Appendix 5: Teachers’ & Student’s Interview Protocol (Main Study)

1. PEDAGOGIC RATIONALE FOR ICT INTEGRATION
For following up of questionnaire data:

a) In your view, does e-learning support the instructional process and interaction with your students? Explain. *(Criterion No. A1)*

b) Since you started using technology, are your students more active? Do they achieve better results than before? *(Criterion No. A1i2)*

c) Many people believe that the use of E-learning supports collaborative learning. There is also a belief that learning with technology can help develop higher-order thinking? What are your opinions on these statements? *(Criterion No. A1)*

2. BARRIERS TO ICT INTEGRATION
a) Please describe the ICT professional development programmes you have done in your school? *(Criterion No. B1)*

b) Are the school periods in which you use the computer long enough for you to complete all the tasks? Explain *(Criterion No. B1).*

c) Do you receive an adequate supply of hardware and software from your school administration? If so what are you receiving? *(Criterion No. B3)*

d) Do you think technologies can distract students from the learning content? *(Criteria No. B4)*

3. ICT IN SCIENCE CLASSROOM
a) Which Science activities can be well demonstrated by using technology in class? Are you using these appropriately? *(Criterion No. C1)*

b) Do you think that the technology you use in your Science classroom supports you in holding students’ attention and supports the students in recalling information? If so how? *(Criterion No. C2)*

c) Have you ever used animation and simulation software in your teaching of science? If so, which? *(Criterion No. C3)*

4. OTHER OPEN ENDED QUESTIONS
Give your opinion on ICT integration in your school
Students’ Interview Protocol

1. PEDAGOGIC RATIONALE FOR ICT INTEGRATION

   a) Do you see yourself achieving better results as a consequence of learning with technology? Explain. (Criterion No. AI1)

   b) When you learn Science with technology, you use different ICT media, different modes, and you see things represented in different ways. Do you think these different ways of presentation make learning more effective? (Criteria No. AI1, C1)

   c) Many believe that there is more interaction (teachers interacting personally with students) when different ICT media are used. What are your views? (Criteria No. AI1, C1)

2. BARRIERS TO ICT INTEGRATION

   a) Do you believe that the teachers need to learn more about basic use of computers before using ICT for subject-related activities? Explain (Criterion No.B31)

   b) Do you believe that you, yourself, need to learn more about basic use of computers before using ICT for subject-related activities? Explain (Criterion No.B31) (I separated the issues of teachers and students)

   c) Can technologies distract you from the learning content? (Criterion No. B42)

   d) Do you agree with those who think “Students mainly use ICT for non-subject-related content”? Explain. (Criterion No. B43).

3. ICT IN THE SCIENCE CLASSROOM

   a) Which Science phenomena are you enjoying the most when e-learning is used? (Criterion No. C2)

   b) What impact do you think animations and simulations have on your learning of science? (Criterion No. C3)

4. OTHER OPEN ENDED QUESTIONS

Give your opinion on ICT integration in your school.
Appendix 6: Principals’ Interview Protocol (Main Study)

1. GENERAL

d) How do you see the integration of ICT in the classroom changing the face of your school?

e) Do you believe teachers, students and yourself need basic training in the use of computers before integrating them into subject-related activities? (Criteria No. B31)

c) From your experience, which subject would you like to see first being taught using technology and why? (Criteria No. C1)

d) Which impact does professional development and training have on the teachers and students in your school? Which forms of development and training have you implemented? (Criteria No. B1)

2. OTHER OPEN ENDED QUESTIONS

Give your opinion on ICT integration in your school
Appendix 7: Teachers’ Questionnaire (Main Study)

Questionnaire for Science teachers in selected schools from the three Projects

This questionnaire contains questions and evaluation statements about effectiveness of the use of ICT in schools and the use of e-learning software.

Kindly tick [✓], in the square next to the appropriate answer or fill in the answer.

1. Gender [ ] Male [ ] Female
2. Subject (e.g. Mathematics)
3. School ………………………………………………………………… Project ……………………………………………………………………..
4. Years of experience teaching ………….. Years
5. I believe ICT enhances my students’ performance and progress (Criterion No. A1f)
   [ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree
6. If Strongly Agree, Agree, Disagree or Strongly Disagree please explain
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7. There is an improvement in students’ attitude since they started using computers, an indication of positive change. (Criterion No. A1f) [ ] True [ ] Not Sure [ ] False
8. I enjoy using technology to help my students have an authentic view of real-world phenomena (Criterion No. A1f) [ ] True [ ] Not Sure [ ] False
9. Students enjoy learning activities in computer labs. (Criterion No. AII2) [ ] True [ ] Not Sure [ ] False
10. The way I personally view and use technology has an effect on the students’ attitudes to ICT integration in my teaching and their learning. (Criterion No. A1f)
    [ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree
11. I am content with a traditional way of teaching. (Criterion No. A1f) [ ] True [ ] False
12. I believe e-learning can help me to become more innovative in class. (Criterion No. C1) [ ] True [ ] Not Sure [ ] False

13. My students are more motivated and engaged in a subject when feedback is provided immediately via technology. (Criterion No. AII1) [ ] True [ ] Not Sure [ ] False

14. Do you believe e-learning can support the instructional process? (Criterion No. AI1) [ ] Yes [ ] Not Sure [ ] No

15. If Yes, How?
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16. What type of media used in interaction with students do you know? (Criterion No. C2)
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17. In what ways do you and your students achieve better results when technology is used? (Criterion No. AI1, B1)
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18. What is the main reason why certain teachers in your school are not using technology? Give only one main reason
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19. In many cases, computers and software are available but teachers do not know what to do with them. (Criterion No. B31)
Give your opinion ..........................................................
20. Technology is just a tool to help students do things and it cannot help them to
develop higher-order thinking skills (Criterion No. AII2)

[ ] True [ ] Not Sure [ ] False

21. Are ICT and e-learning effective in helping students to solve Science problems?

Please explain your answer and refer to specific technologies or e-learning
software that serve, or that do not serve, this purpose. (Criterion No. C1)

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22. Do you see your role today as being a mentor and facilitator of learning, rather
than just being an instructor? Please explain your answer. (Criterion No. B1)

[ ] Yes [ ] Not Sure[ ] No
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23. What type of ICT professional development programs have been offered to
teachers in your school? (Criterion No. B1)

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24a. Does the school afford you the time for preparation of computer-based lessons?

If not how many hours are you given to prepare each week? (Criterion No. B2A)

[ ] Yes [ ] Not Sure[ ] No

• Less than 5 Hours [ ]
• Between 6 and 10 [ ]
• Between 11 and 20 [ ]
• More than 20 [ ]

24b. The school periods in which computers are used are long enough to complete all
the tasks (Criterion No. B2B)

[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree

25. What learning resources (Hardware and Software) (Criterion No. B1,C2)

Are available in your school?

☐ Computing tools  .................................................................
☐ Educational Software ...........................................................
☐ Video Conference
☐ Digital Camera
☐ Smart board
☐ Computers
Are used by teachers for administration and preparation?

- Computing tools
- Educational Software
- Video Conferencing
- Digital Camera
- Smart board
- Computers

Are used by Students?

- Computing tools
- Educational Software
- Video Conferencing
- Digital Camera
- Smart board
- Computers

Are needed by your school?

- Computing tools
- Educational Software
- Video Conferencing
- Digital Camera
- Smart board
- Computers

26. Consider the pedagogical and didactical approaches in your Science classes in the days of conventional teaching and now with the regular use of technology. How has learning changed with the use of technology? Mention three ways or more. (Criteria No. AII1, AII2)

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27. How do you overcome pedagogical and didactical problems in the context of learning with technology? Please mention specific problems you experienced and how you overcome them (Criterion No. AII1, AII2)

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28. It is essential for teachers to have basic computer skills before using technology for subject-related activities. *(Criterion No. B31)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

29. My students need basic computer literacy skills before integration of ICT into the Science classroom. *(From author’s experience)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

30. In my class, students like to discover new things by themselves. *(Criterion No. B41)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

31. Technology can distract students from the learning content. *(Criterion No. B42)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

If Strongly Agree or Agree, briefly explain.  
……………………………………………………………………………………………
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32. Students also use the technologies for activities not related to subject matter. *(Criterion No. B43)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

If Strongly Agree or Agree, briefly explain.  
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33. If given more time, how confident are you to use technology in your instruction?  
[ ] Very [ ] Confident [ ] Not Sure [ ] For some subjects [ ] Not Confident  

34. By using e-learning software, I am able to demonstrate various scientific phenomena. *(Criterion No. C2)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

35. It is essential to use animation and simulation software in teaching Science, since it facilitates students’ acquisition of scientific processing skills. *(Criterion No. C2)*  
[ ] Strongly Agree [ ] Agree [ ] Not Sure [ ] Disagree [ ] Strongly Disagree  

36. Please add any comments that you wish to make concerning the use of ICT/e-learning in your school.  
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276
Appendix 8: Observation Sessions (All Studies)

Observation is a method of data gathering in which a qualified person watches, or walks through, the actual processing associated with a system. It is a methodological techniques used to collect both qualitative and quantitative data. Non-verbal behaviour and concrete skills are particularly agreeable to observation. When the observer is there, the behaviour of subjects can be affected. Data collection can also be subjective according to the observers' expectations and intentions.

In this study the author observed:

- Non-behavioural Observation
  - Record analysis:
    - Analysis of historical or current records both public and private.
    - The types of e-learning software used in the different grades
  - Physical condition analysis
    - Observation of teachers’ own teaching and certain critical incidents during the practical sessions in the lab.
  - Process or activity analysis
    - Students manipulating computers for chemical reactions; students using software such as Google map to identify locations, etc.
    - Students’ reactions to the resources during class session as well as their interactions with e-learning systems.

- Behavioural Observation
  - E.g., study of a students’ content or the study of what, how, and how much information is conveyed in a learning situation.
  - E.g., study of the interaction between teachers and students.
  - Study of collaboration and teamwork between students

These observations are done at an average of a session of a few days at each school.
Appendix 9: Interview Transcript (Main Study)

Interviewer: Researcher

Interviewee: Teacher

Interview Setting: Interview conducted in the classroom at break time after the lesson. The interview was conducted at 10:30 AM on Wednesday.

(Start of Interview)

Interviewer: *In your view, does e-learning support the instructional process and interaction with your students? Explain.* (Criterion No. AI1)

Interviewee: I am convinced that e-learning support instructional process and it does allow me to interact well with my students. In science lessons, when I use simulations my students participate more.

Interviewer: *Since you started using technology, are your students more active? Do they achieve better results than before?* (Criterion No. AII2)

Interviewee: Yes, they are active as I indicated, the Matric results are proof that technology can change the way we do things for the better. I always encourage my colleagues to start integrating e-learning in their teaching.

Interviewer: *Many people believe that the use of E-learning supports collaborative learning. There is also a belief that learning with technology can help develop higher-order thinking. What are your opinions on these statements?* (Criterion No. AI1)

Interviewee: Collaboration yes, because even my lower performing students are now performing well. I always mix them with other higher-performing ones in different tasks. But as for the higher-order thinking I am not sure. Maybe it does, with much activities throughout the year.
Interviewer: Please describe the ICT professional development programmes you have done in your school (Criterion No. B1)

Interviewee: Some of us were privileged to attend workshops at STIC and once at NEPAD e-school. These are the only opportunities we had.

Interviewer: Are the school periods in which you use the computer long enough for you to complete all the tasks? Explain (Criterion No. B1)

Interviewee: They are not, we have other subjects to teach, and the classrooms where computers are, we share them with other teachers who do not even use them.

Interviewer: Do you receive an adequate supply of hardware and software from your school administration? If so what are you receiving? (Criterion No. B3)

Interviewee: Yes, the school board is very supportive, we get hardware from time to time. Even though it might be one or two computers. As for software, it is difficult to get new ones and even upgrade for what we already have. We do not have connectivity.

Interviewer: Do you think technologies can distract students from the learning content? (Criteria No. B42)

Interviewee: This can be the case only if they are not supervised.

Interviewer: Which Science activities can be well demonstrated by using technology in class? Are you using these appropriately? (Criterion No. C1)

Interviewee: I like demonstrating Chemistry and Biology activities.

Interviewer: Give your opinion on ICT integration in your school

Interviewee: I like the e-learning in my class, students like it and that is why I try my best to always having my students involved. I so wish everyone can do it in my school.

Interviewer: Thanks for your time.

Interviewee: You’re welcome.
Appendix 10: Student Class Activities (Daily Log Sheet) (All Studies)

Day 1
Date: 17th January 2011
Day of the week: Monday
Is there school today? ☑ Yes ☐ No

<table>
<thead>
<tr>
<th>Activity starting time</th>
<th>Duration (hour/minute)</th>
<th>Major activity</th>
<th>Tools selected</th>
<th>Location</th>
<th>Subject</th>
<th>Is this activity important?</th>
<th>Teacher’s performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 to 12:30</td>
<td>2 hours</td>
<td>1 Classroom activity (Brainstorming)</td>
<td>1 Web browser</td>
<td>1 In school lesson</td>
<td>Biology (Practical)</td>
<td>Yes</td>
<td>1 Very bad □</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 School works activity (<em>Students working together in Reproduction System, Biology</em>)</td>
<td>2 E-mail</td>
<td>2 Out of school lesson</td>
<td></td>
<td>2 Bad</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Browsing Internet</td>
<td>3 Word processor</td>
<td>3 Web bar</td>
<td></td>
<td>3 Average</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 Listening to others</td>
<td>5 Presentation software</td>
<td></td>
<td></td>
<td>4 Good</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 Audio/video software</td>
<td></td>
<td></td>
<td>5 Excellent</td>
<td>□</td>
</tr>
</tbody>
</table>

Comment: This Log sheet was used with all sessions.
Appendix 11: Information and Consent

Informed consent and information document for the project to investigate ICT integration in Lesotho’s Secondary schools

Mr. Kalanda Kasongo (31858244@mylife.unisa.ac.za; tel +266-58776319) of the Institute of Maths, science and Technology Education, UNISA, is undertaking research on ‘An Investigation of ICT integration in Lesotho’s Secondary schools’. This study is being conducted in schools under Schoolnet, Nepad e-schools and Microsoft Partners in Learning projects.

Thank you for being a participant in this study, which is conducted under the following conditions:

- Participants are not personally being tested, and their participation in this study will not impact in any way on their marks in school or in any professional performance evaluations.
- There will be no monetary payment to participants.
- Participants are free to withdraw from the research and there will be no disadvantage if they do so.
- In reporting results of this study, no names will be disclosed. Research findings will be presented in a PhD study and may be published in academic publications or conference proceedings, but anonymity and confidentiality will be preserved.

I (full name)

Contact details.

I declare that I am aware of all the information provided above, and have willingly served as a participant in this research on ICT integration in Lesotho’s Secondary schools. I am aware that findings of the study might be published in academic sources, but that my name will not be disclosed.

……………… at ………………… on ……………
Signature

……………… at ………………… on ……………
Teacher / Principal’s Signature

281
Appendix 12: Publication by the Author