Information Communication Technology in Secondary Science Education in Sri Lanka

by

Sarath Warnakulasuriya Patabedige

Bachelor of Science (Agriculture) (University of Peradeniya, Sri Lanka)
Postgraduate Diploma in Education (University of Peradeniya, Sri Lanka)
Master of Science Education (University of Peradeniya, Sri Lanka)

Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy, Deakin University

Deakin University

28th March 2012
I am the author of the thesis entitled Information Communication Technology in Secondary Science Education in Sri Lanka

submitted for the degree of Doctor of philosophy

This thesis may be made available for consultation, loan and limited copying in accordance with the Copyright Act 1968.

'I certify that I am the student named below and that the information provided in the form is correct'

Full Name  Sarath Warnakulasuriya Patabedige

Signed

Date  09-08-2012
DEAKIN UNIVERSITY
CANDIDATE DECLARATION

submitted for the degree of Doctor of Philosophy

is the result of my own work and that where reference is made to the work of
others, due acknowledgment is given.

I also certify that any material in the thesis which has been accepted for a degree
or diploma by any university or institution is identified in the text.

'I certify that I am the student named below and that the information provided in the form is correct'

Full Name. Sarath Warnakulasuriya Patabedige

Signed

Signature Redacted by Library

Date...27-03-2012

..........................................................
Dedication

To my loving wife, son and daughter
ABSTRACT

Sixty-eight pre-service teachers and eight NCOE (National College of Education) lecturers were selected from a cohort of science educators and pre-service teachers were introduced to the Technological, Pedagogical and Content Knowledge (TPACK) model with the objective of investigating the impact of the model as a tool to help pre-service teachers in the effective use of ICT in their teaching. As a part of this research an instrument was developed to measure changes in the technological skills, and the pedagogical and technological knowledge of the pre-service teachers over the period of the research. A small group of 15 pre-service teachers were followed closely as they applied the TPACK model in their teaching. Changes to the technological skills and pedagogical and technological knowledge of the 15 pre-service teachers were monitored.

This study aimed to enhance effective use of ICT in teaching science by pre-service teachers with the intention to promote deeper learning and supporting and enhancing secondary science teaching in Sri Lanka. Videos of the pre-service teachers, teaching with technologies, semi-structured interviews, questionnaires, and classroom observations were employed to collect data about the participants’ understandings of the TPACK model and the ramifications of its use on their practice. The minority of the participants were able to implement the three core TPACK elements in their science teaching, though with considerable variability. The research highlighted methodological difficulties in employing ill-defined constructs such as TPACK, and recommends the use of normalization metrics (TPACK score) and a subjective “TPACK index” to facilitate top-level comparisons (TK+PK+CK) of different instances of TPACK events, whilst recognizing the limitations of such metrics. Despite these limitations, the quantification of the TPACK model helped to identify the particular qualities of the teaching that was being measured. Secondary science pre-service teachers’ technological skills varied, and were impacted by their access to and
experience with technological resources. The technological skills of the volunteer focus group were good compared to that of the whole cohort, which was as expected because the volunteers are interested and familiar with the technologies. In this research study, pre-service teachers have shown limited knowledge and experience of pedagogy. Pre-service science teachers’ knowledge of technology is initially as based on their own personal experience. Most of the pre-service teachers used ICT in science lessons when they were in school. Pre-service teachers conducted science lessons using ICT with the TPACK model but their understanding in how to integrate the three knowledge domains was limited. This study has contributed to the understanding and implementation of the TPACK model through the development of a TPACK Scale, TPACK integration index, and the TPACK Rubric. These metrics provide descriptors of the thin and thick TPACK models that characterise variations within the model.
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Figures</td>
<td>7</td>
</tr>
<tr>
<td>List of Tables</td>
<td>8</td>
</tr>
<tr>
<td>Chapter One</td>
<td>12</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td>13</td>
</tr>
<tr>
<td>1.2 Education in Sri Lanka</td>
<td>16</td>
</tr>
<tr>
<td>1.3 The Pedagogy of Teaching with Technology</td>
<td>18</td>
</tr>
<tr>
<td>1.4 The Origin of the Research</td>
<td>21</td>
</tr>
<tr>
<td>1.5 The Nature and Scope of this Research</td>
<td>23</td>
</tr>
<tr>
<td>1.5.1 The TPACK Model</td>
<td>23</td>
</tr>
<tr>
<td>1.5.2 ICT in Secondary Science Education</td>
<td>24</td>
</tr>
<tr>
<td>1.5.3 Pre-service Teacher Training Program</td>
<td>24</td>
</tr>
<tr>
<td>1.6 Rationale of the Study</td>
<td>24</td>
</tr>
<tr>
<td>1.7 The Purpose and Objectives of this Research</td>
<td>25</td>
</tr>
<tr>
<td>1.8 Research Questions</td>
<td>26</td>
</tr>
<tr>
<td>1.9 Overview of the Research Methodology</td>
<td>26</td>
</tr>
<tr>
<td>1.10 Limitations of this research</td>
<td>27</td>
</tr>
<tr>
<td>1.11 The Structure of the Thesis</td>
<td>27</td>
</tr>
<tr>
<td>1.12 Chapter One Review</td>
<td>28</td>
</tr>
<tr>
<td>Chapter Two</td>
<td>30</td>
</tr>
<tr>
<td>2.1 Overview of Chapter Two</td>
<td>30</td>
</tr>
<tr>
<td>2.2 The Sri Lankan Education System</td>
<td>31</td>
</tr>
<tr>
<td>2.2.1 The School System</td>
<td>31</td>
</tr>
<tr>
<td>2.2.2 Categories of Schools</td>
<td>34</td>
</tr>
<tr>
<td>2.2.3 The Teachers in the Sri Lanka Education System</td>
<td>38</td>
</tr>
<tr>
<td>2.3 Teacher Training at National Colleges of Education in Sri Lanka (NCOE)</td>
<td>41</td>
</tr>
<tr>
<td>2.3.1 The pre-service teacher training program</td>
<td>42</td>
</tr>
<tr>
<td>2.3.2 The place of ICT in the teacher education program</td>
<td>43</td>
</tr>
<tr>
<td>2.4 Sri Lankan Government Educational Policy</td>
<td>44</td>
</tr>
<tr>
<td>2.4.1 Government policy of ICT in Education</td>
<td>47</td>
</tr>
<tr>
<td>2.4.2 Curriculum development</td>
<td>49</td>
</tr>
<tr>
<td>2.4.3 Human resource development</td>
<td>49</td>
</tr>
</tbody>
</table>
6.2 Lecturers at the NCOE

6.2.1 NCOE lecturers’ quantitative data analysis ........................................ 149
6.2.2 NCOEs’ Lecturers’ TPK Questionnaire Section B .............................. 151
6.2.3 NCOE Lecturers TPK Questionnaire Section C ................................. 153
6.2.4 NCOE 1 Lecturers Workshop to Pre-service Teachers ...................... 155
6.2.5 NCOE 2 Lecturers Workshop to Pre-service Teachers ...................... 156
6.2.6 NCOE 3 Lecturers Workshop to Pre-service Teachers ...................... 157
6.2.7 NCOE Lecturers Interview ............................................................... 157

6.3 The Pre-service Teachers Technological skills .................................... 158

6.3.1 Pre-service Teachers Previous Training and Experience in ICT .......... 158
6.3.2 Pre-service Teachers Use of Computers .......................................... 159
6.3.3 Pre-service Teachers’ Computer Keyboard Competencies ................ 160
6.3.4 Software applications of the pre-service teachers ............................ 161
6.3.5 Pre-service teachers’ use of computers when teaching ..................... 163
6.3.6 Summary of the pre-service teachers technological skills ................. 164

6.4 Pre-service Teachers Technological Knowledge .................................. 165

6.4.1 How the technology can be used as an educational tool (Q1 and Q2) .... 165
6.4.2 The Use of ICT in Teaching Science (Q3, Q5) .................................. 167
6.4.3 What skills are needed to be able to use ICT in your teaching (Q4) .... 169
6.4.4 Why should ICT be integrated into teaching science (Q5) ................. 170

6.5 Pre-service Teachers Pedagogical Knowledge .................................... 173

6.5.1 Learning Theories ........................................................................ 173
6.5.2 Planning a lesson ........................................................................... 175
6.5.3 Choice of Teaching Method .......................................................... 178
6.5.4 Ways of explaining scientific concepts ......................................... 181
6.5.5 Aids Used in Teaching ................................................................. 184

6.6 Chapter 6 Review ............................................................................. 187

Chapter Seven ......................................................................................... 188

7.1 Chapter Overview ............................................................................. 188
7.2 Observing and Videoing the Pre-Service Teachers ............................... 189

7.2.1 Common Technological and Pedagogical Aspects of the Lessons ....... 189

7.3 Pre-service Teachers’ Secondary Science Lessons NCOE 1 ................. 190

7.3.1 Pre-service Teacher Number 1 ...................................................... 191
7.3.2 Pre-service Teacher Number 2 lesson .......................................... 192
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.8.3 Calculating TPACK score</td>
<td>257</td>
</tr>
<tr>
<td>8.9 Pre-service teachers TPACK knowledge in 15 lessons</td>
<td>263</td>
</tr>
<tr>
<td>8.10 TPACK Rubric</td>
<td>264</td>
</tr>
<tr>
<td>8.11 Review of Chapter 8</td>
<td>269</td>
</tr>
<tr>
<td>Chapter Nine</td>
<td>270</td>
</tr>
<tr>
<td>9.1 Overview of the Chapter</td>
<td>270</td>
</tr>
<tr>
<td>9.2 Review of the Study</td>
<td>270</td>
</tr>
<tr>
<td>9.3 Issues with Observations</td>
<td>273</td>
</tr>
<tr>
<td>9.4 Limitations of the Study</td>
<td>273</td>
</tr>
<tr>
<td>9.5 Recommendations</td>
<td>274</td>
</tr>
<tr>
<td>9.5.1 Proposed Strategies to Improve Science Education in Sri Lanka</td>
<td>275</td>
</tr>
<tr>
<td>9.6 Contributions of this Study</td>
<td>279</td>
</tr>
<tr>
<td>9.6.1 TPACK Scale</td>
<td>279</td>
</tr>
<tr>
<td>9.6.2 TPACK Integration index</td>
<td>279</td>
</tr>
<tr>
<td>9.6.3 TPACK score</td>
<td>280</td>
</tr>
<tr>
<td>9.6.4 A TPACK Rubric</td>
<td>280</td>
</tr>
<tr>
<td>9.6.5 The TPACK Thin and Thick Models</td>
<td>280</td>
</tr>
<tr>
<td>9.7 Review of Chapter Nine</td>
<td>281</td>
</tr>
<tr>
<td>Reference</td>
<td>282</td>
</tr>
<tr>
<td>Appendix I</td>
<td>1</td>
</tr>
<tr>
<td>Appendix II</td>
<td>8</td>
</tr>
<tr>
<td>Appendix III</td>
<td>9</td>
</tr>
<tr>
<td>Appendix IV</td>
<td>11</td>
</tr>
<tr>
<td>Appendix V</td>
<td>15</td>
</tr>
<tr>
<td>Appendix VI</td>
<td>16</td>
</tr>
</tbody>
</table>
List of Figures

Figure 1.1 Three foci of the research study: science content; attributes of the technology; and the pedagogy of using the technology to teach science ................................................................. 14
Figure 1.2 UNESCO 2008 New Growth” Economic model. (Source: UNESCO, 2008) .......... 19
Figure 2.1 School System of Sri Lanka ............................................................................ 32
Figure 2.2 Nine Provinces of Sri Lanka ........................................................................ 34
Figure 2.3 Percentage of schools/pirivenas with computer laboratory by category of schools ... 52
Source: Ministry of Education, (2006b) .......................................................................... 52
Figure 2.4 Availability of E-mail Facilities. (Ministry of Education, 2006a) ................. 56
Figure 2.5 Availability of Internet Facility (Ministry of Education, 2006a) ..................... 57
Figure 3.1 The TPACK Framework and its Knowledge Components (Mishra & Koehler, 2006, p. 6), .................................................................................................................. 63
Figure 3.2 Components of TPACK for science teaching (Nicholson, 2001), .................... 86
Figure 3.3 A representation of how teachers knowledge beliefs and values may affect their pedagogical reasoning ................................................................. 87
Figure 4.1 Course Objectives for Grade 6-11 Science ...................................................... 94
Figure 4.2 School policies and programmes copied from the Grade 7 Science teacher manual... 96
Figure 5.1 Relationship between different terms relating to research in social sciences .......... 115
Figure 5.2 Elements used from Twining’s model .......................................................... 117
Figure 5.3 Stage one of the research ............................................................................ 134
Figure 5.4 Stage two of the research ............................................................................. 134
Figure 5.5 Stage three of the research ............................................................................ 135
Figure 5.6 Structure of this research ............................................................................ 138
Figure 8.1 TPACK thin and thick model ..................................................................... 266
Figure 9.1 UNESCO 2008 “New growth” Economic model ........................................ 275
List of Tables

Table 2.1 Number of government and Non government Schools in Sri Lanka ........................................ 35
Table 2.2 Number of various types of government and non government schools .................................. 35
Table 2.3 Classification of Sri Lankan Schools ..................................................................................... 37
Table 2.4 Type of Teachers in Sri Lanka ......................................................................................... 39
Table 2.5 Comparison of the Number of Teachers and Students at the Various Types of Schools in Sri Lanka .............................................................................................................. 40
Table 2.6 Student-Computer Ratios for Size of School ....................................................................... 52
Table 2.7 Student-Computer literate Teacher Ratio .............................................................................. 53
Table 2.8 Hardware availability in government schools .................................................................. 55
Table 4.1 A comparison of the characteristic of previous and present generations with regards digital skill ................................................................................................................................. 99
Table 4.2 Comparison of digital native learner and digital immigrant teacher .................................... 101
Table 4.3 The difference between the traditional learning environment and the new learning environment .......................................................... 102
Table 5.1 Perceptions of qualitative and quantitative (QQ) approach ............................................... 113
Table 5.2 Robson's case study classes .............................................................................................. 120
Table 5.3 Research diagram of the case study research .................................................................. 122
Table 5.4 List of data sources .......................................................................................................... 124
Table 5.5 General Description of the location of the three NCOEs .................................................. 130
Table 5.6 Approach, Reliability, and Validity ................................................................................... 139
Table 5.7 Proposed research plan according to TPACK model component ........................................ 143
Table 6.1 The percentage of pre-service teachers using hardware and accessing services (N=68) ...... 148
Table 6.2 The level of ICT training experienced by pre-service teachers at each NCOE (68) .......... 159
Table 6.3 The percentage of pre-service teachers use computers (N=68) ....................................... 160
Pre-service teachers' explanations of which type of teaching methods would be the best to promote learning (N=68) .................................................................................................................. 183
Table 6.24 ....................................................................................................................... 185
Why pre-service teachers explained choose these teaching aids (N=68) .................... 185
Table 6.25 ....................................................................................................................... 185
How pre-service teachers think the use of ICT can improve their teaching (N=68) ...... 185
Table 6.26 ....................................................................................................................... 186
Why pre-service teachers why they use ICT to improve their teaching (N=68) ......... 186
Table 7.1 ....................................................................................................................... 210
The percentage of computer use of pre-service teachers at NCOE and outside NCOE (N= 68)
Stage One, N=15 Stage Two and Three) ........................................................................ 210
Table 7.2 ....................................................................................................................... 210
Pre-service teachers' computer typing skills (n=15) ...................................................... 210
Table 7.3 ....................................................................................................................... 211
The percentage of pre-service teachers who agree that they can use software applications
proficiency at Stage One Two and Three (N=15) ......................................................... 211
Table 7.4 ....................................................................................................................... 212
Percentage of pre-service teachers' skills when they are in teaching and learning (N=15) ................................................................. 212
Table 7.5 ....................................................................................................................... 213
Percentage of pre-service teachers use learning theories to guide the way they teach students (N= 68, 15) ................................................................. 213
Table 7.6 ....................................................................................................................... 213
Pre-service teachers’ response when planning a secondary science lesson they might consider the
following approaches .................................................................................................. 213
Table 7.7 ....................................................................................................................... 214
How Pre-service teachers innovate science lesson all three stages (N=68, 15) ............ 214
Table 7.8 ....................................................................................................................... 215
Percentage of pre-service teachers answered why you chosen these .................................. 215
Table 7.9 ....................................................................................................................... 216
Percentage of pre-service teachers answered why you chosen these (N=68, 15) ......... 216
Table 7.10 ..................................................................................................................... 217
Pre-service teachers reflection of which type of teaching method would be the best to promote
(N=68, 15) ..................................................................................................................... 217
Table 7.11 ..................................................................................................................... 218
Pre-service teachers’ reflection of why, which type of teaching method would be the best to
promote (N=68, 15) ...................................................................................................... 218
Table 7.12 ..................................................................................................................... 219
Pre-service teachers have many ways of explaining scientific concepts ......................... 219
Table 7.13 ..................................................................................................................... 220
Pre-service teachers' answers which method(s) would be the best to promote among the students
(N=68, 15) ..................................................................................................................... 220
Table 7.14 ..................................................................................................................... 221
Pre-service teachers explanations of which type of teaching methods would be the best to
promote learning (N=68, N=15) .................................................................................... 221
Table 7.15 ..................................................................................................................... 222
Pre-service teachers circling the teaching aids you use when they are teaching ............ 222
Table 7.16 ..................................................................................................................... 223
Pre-service teachers explained why choose these teaching aids (N=68, 15) .................................................................................. 223
Table 7.17 .................................................................................. 224
Pre-service teachers explained how ICT could be used as an educational tool (N=68, 15) ........................................................................ 224
Table 7.18 .................................................................................. 225
Pre-service teachers explained how you think ICT can use to change the way to teach science (N=68, 15) .................................................................................. 225
Table 7.19 .................................................................................. 226
Pre-service teachers explained how ICT is currently used in teaching science in Sri Lanka (N=68, 15).................................................................................. 226
Table 7.20 .................................................................................. 227
Pre-service teachers needed ICT skills in their teaching of science (N=68) .................................................................................. 227
Table 7.21 .................................................................................. 228
Pre-service teachers’ ICT skills (N=68, 15) .................................................................................. 228
Table 7.22 .................................................................................. 228
Percentage of pre-service teachers' science lessons ICT applications (N=68, 15) .................................................................................. 228
Table 7.23 .................................................................................. 229
Pre-service teachers’ using ICT in science lessons .................................................................................. 229
Table 7.24 .................................................................................. 230
Pre-service teachers’ describing ways of ICT integrated into their teaching methods (N=68, 15) .................................................................................. 230
Table 7.25 .................................................................................. 230
Percentage of pre-service teachers’ idea about the use of ICT to promote learning (N=68, 15) .................................................................................. 230
Table 7.26 .................................................................................. 231
Pre-service teacher’s how to promote learning using ICT (N=68, 15) .................................................................................. 231
Table 7.27 .................................................................................. 232
Why Pre-service teachers’ promote using ICT for learning (N=68, 15) .................................................................................. 232
Table 7.28 .................................................................................. 233
Pre-service teachers think ICT can improve their teaching .................................................................................. 233
Table 7.29 .................................................................................. 233
How Pre-service teachers they think the use of ICT can improve their teaching (N=68, 15) .................................................................................. 233
Table 7.30 .................................................................................. 234
Why Pre-service teachers use ICT to improve their teaching (N=68, 15) .................................................................................. 234
Table 8.1 .................................................................................. 244
Technologies commonly used in Teaching .................................................................................. 244
Table 8.2 .................................................................................. 253
Rubric – Application of PK, CK, and TK .................................................................................. 253
Table 8.3 .................................................................................. 254
TPACK domains (PK, CK, and TK) scale .................................................................................. 254
Table 8.4 .................................................................................. 258
Pre-service teachers TPACK score in their 15 lessons .................................................................................. 258
Table 8.5 .................................................................................. 258
Pre-service teachers PK, CK, TK observations about their 15 lessons .................................................................................. 258
Table 9.1 .................................................................................. 276
UNESCO 2008 “New Growth” Economic three-stage model .................................................................................. 276
Table 9.2 .................................................................................. 277
Chapter One

Introduction to the Study

“By 2008, all regional Member States will be in a position to offer teachers an education on how and when to best use technologies for teaching and learning, through training which is integrated in all national pre-service teacher training institutions in the Asia-Pacific region. Learners will directly benefit from this new generation of well-educated teachers, who will be empowered to use technologies and to facilitate the learners’ active participation in learning, and in the knowledge societies and economies” (United Nations Educational Scientific Cultural Organisation, 2008, p. 6).
1.1 Introduction

This research study investigates the effectiveness of the instruction of pre-service science teachers in the use of Information Communication Technologies (ICT). The setting of the study is in Sri Lankan Colleges of Education where students undertake teacher training. This introductory chapter includes the following sections; introduction, the pedagogy of teaching with technology, the origin of the research, rationale of the study, the nature and scope of the research, the TPACK (Technological Pedagogical Content Knowledge) model, ICT in secondary science education, pre-service teacher training program, research questions and the structure of the thesis.

The theoretical framework for the study is based on a pedagogical approach that centres on the use of ICT for effective science education. There are three foci that interplay when considering the pedagogical use of technology when teaching science; firstly, the content of science - a subject that many students can find abstract and difficult to understand (Loughran, Berry, & Mulhall, 2006), secondly, the attributes of the technology, and lastly, the use of a pedagogical framework to inform the use of ICT in the science classroom (see Figure 1.1).

Science teachers play a vital role in helping students to learn and understand difficult and often abstract scientific concepts. They draw on their expert discipline knowledge and their pedagogical knowledge to deliver the science ideas coherently to their students. They create learning opportunities, so students can engage in science and come to understand the world around them. Science education plays an important role in students gaining knowledge, skills and positive attitudes to build their capacity for future careers, especially for careers based in science. With the advances in digital technologies the teacher’s role in the classroom is changing (Shelly et al., 2006), for example, there are many digital resources to help explain abstract
scientific ideas, and access to knowledge banks provide current and detailed information. The
technology has the potential to allow greater choice and autonomy for student learning, and more
varied ways to demonstrate and understand the scientific ideas. For these reasons there is clear
justification to capitalize on these digital resources for teaching and learning. However, the way
the technologies are incorporated into teaching becomes critical for its effectiveness. Therefore
teachers need to be skilled to use these technologies effectively in their teaching strategies. This
study explores the impact of using a pedagogical framework to improve the effective use of ICT
by science teachers.

![Diagram showing three foci: science content, pedagogical approach, and technological knowledge and skills]

*Figure 1.1 Three foci of the research study: science content; attributes of the technology; and the pedagogy of using the technology to teach science.*

The digital age is providing an information rich, knowledge based society characterized
by the sharing and building of knowledge to learn (Prensky, 2001). Globally, society and work
places are changing due to technological development. ICT addresses specifically the digital
technologies, which are used to achieve this aim. Children living in a digital world are ‘digital
kids’ and they are living in a digital media culture. In this digital world, they need technological
knowledge because the use of high technology today is ubiquitous (Prensky, 2001). For example,
people require ICT skills to participate in e-learning and e-business environments, including the use of e-banking. Some people use personal digital entertainment devices (PDEs), MP3 players, personal digital assistances (PDAs) and pocket PCs. These devices are being used as educational tools (Finger, Russell, Jamieson-Proctor, & Russel, 2007). The rapidly expanding use of digital devices and access to digital information has created an increasing need for teachers to become skilled at integrating technology into their teaching and are encouraged to use it as a driving force behind preparing students for the ‘real world’ (Finger et al., 2007). Forcier & Descy, (2002) explain that “this will have important implications for teachers and schools. Students will make use of a variety of technologies such as computers, multimedia, virtual reality and holographic imaging. Children’s access to new and emerging technologies, skills and use them as a freely to learn and explore…will be able to produce work, that is hardly imaginable to adults today” (pp. 15-16).

In this context teachers are encouraged to use digital technologies to enhance the learning process (Kalogiannakis, 2007). Examples of technologies being used in schools include data trackers, data-loggers, word processing, E-portfolios, online curriculum (Busenske, Bonney, Judt, & Newhouse, 2008). Learning with ICT’s require alternative learning approaches rather than a more traditional teaching approach in order to take advantage of the attributes of the technologies, for example, global, innovative and collaborative learning opportunities with technology-based societies (Trilling, 2006). ICT has the potential to allow students to take more ownership of their own learning, and as a result has the potential to impact the role of the teacher.
1.2 Education in Sri Lanka

Sri Lanka was suppressed by the 30 years of war with the Liberation Tigers of Tamil Elam (LTTE). LTTE is a separatist military organization that fought to create an independent state named Tamil Eelam in the North and East of Sri Lanka. As a result of 30 years of war, Sri Lanka lost more than 60,000 human lives and trillions of dollars’ worth of properties. The Sri Lankan government also spent trillions of dollars to fight against LTTE. In May 2009 Sri Lankan security forces defeated LTTE. Following the death of Velupilla Prabhakaran and other senior leaders, Sri Lanka became a peaceful country. At the end of the war, the government of Sri Lanka faced new challenges to develop the country specifically in the north and east. The Sri Lankan government is spending billions of dollars to develop infrastructure in these areas and investing money in professional development programs to improve the integration of ICT into the education sector.

In 1997, the government of Sri Lanka commissioned a National Education study into the problems in the education sector of the country. The findings and recommendations of the study were the basis of a range of educational reforms (Ministry of Education, 2005a). The main aims of these educational reforms were: to enhance life competencies; develop peace and social unity; and to introduce a critical thinking, creative and problem solving teaching and learning culture (Ministry of Education, 2005a). The educational reforms to the Sri Lankan education system included an increased recognition of the value of ICT education (Ministry of Education, 2005b). In 2000, policy on the use of ICT was introduced into the Sri Lankan education system (Ministry of Education, 2005b). This is supported and consistent with the policy expressed in the UNESCO (United Nations Educational Scientific Cultural Organisation) World Education Report, (1998):

*The young generation is entering a world that is changing in all spheres, scientific and technological, political, economical, social and cultural. The*
emergence of the “knowledge-based” society is changing the global economy

In the field of education, schools and teachers are under pressure to prepare students to
face these challenges. Providing ICT skills to students was seen as important for social and
economic development that would improve the quality of life of the Sri Lankan people (Ministry
improve learning, stating that “we need to acknowledge the critical role played by the teacher, in
creating conditions for ICT-supported learning”. Teachers are facing the challenges to acquire
new skills (UNESCO, 2006) and teacher training institutes face enormous pressure to adequately
train and prepare teachers with these new skills. The majority of ICT educators, teachers and pre-
service teachers in Sri Lanka, do not have a strong immersion in the ICT education. This is not
surprising considering that Sri Lanka is a developing country, with a scarcity of the facilities and
resources required to take education into the 21st century. In this context, teacher training
institutes are looking forward as they anticipate the digital revolution and the need to prepare
teachers for the future using ICT in secondary science education. These institutes also appreciate
the need to be innovative to understand the use of ICT in the classroom (Angeli, 2005).
UNESCO has identified general challenges faced by developing nations in the Asia-Pacific
counties in their attempt to integrate ICT into their education systems (UNESCO, 2007a). These
challenges include:

- Accessibility and affordability of technologies (high cost of accessories, Internet
  connection and etc.);
- Integration of ICT in the curriculum;
- Shortage of trained man power;
- Teachers’ fear of the technology and lack of motivation;
• Budget constraints – most investment being for hardware, are not for improving teachers’ skills and content production;

• Maintenance of ICT resources and lack of technical staff;

• Sustainability;

• Limited availability of educational software and courseware (UNESCO, 2007a).

Finger et. al. (2007) suggests further challenges facing educational systems wishing to integrate e-learning and mobile-learning to the ICT environment. All these challenges identified by the UNESCO study apply to the Sri Lankan education environment. At this time, Sri Lanka is emerging after 30 years of suppression and education is recognized as being critical to the development of the nation. Consequently, there is an enthusiasm to incorporate digital technologies in education to improve the education system. At present the Sri Lankan Government is facing financial difficulties but they acknowledge and understand the value of ICT integration to education system. Gradually the Sri Lankan government is providing necessary ICT equipment to schools.

1.3 The Pedagogy of Teaching with Technology

Shulman’s Pedagogical Content Knowledge (PCK) framework integrates pedagogical knowledge, curricula knowledge and subject matter content knowledge (Shulman, 1986). The knowledge of teaching and context is further divided into two categories – pedagogical knowledge and curricular knowledge (Nicholson, 2001). Content knowledge and pedagogical knowledge are difficult to differentiate between because both are bodies of understanding (Shulman, 1986). Traditionally, it has been assumed that teachers with expertise in a specific subject matter will be able to teach it, but this ignores the pedagogical expertise required to teach
well. PCK is described as the ability to select appropriate and optimum pedagogical experiences in different contexts for different audiences. “Content knowledge refers to the amount and organization of knowledge in the mind of the teacher” (Shulman, 1986, p. 6).

The UNESCO ICT Competency Framework for Teachers (2011) identified three sequential and overlapping approaches that connect education policy and economic development: Technology Literacy, Knowledge Deepening, and Knowledge Creation (see Figure 1.2). Figure 1.2 shows a developmental route in educational reforms, with the aim of enhancing opportunities to develop the economy and society of a country. Obtaining a technology rich labour force leads to a higher level of performance, which in turn maintains and improves knowledge promotion, economic growth and information insemination. Students, given the opportunity to attain a high standard of ICT knowledge from these educational reforms, are given the opportunity and ability to incorporate, maintain and improve a rapidly growing and sophisticated workforce that requires increasingly complex skills. By providing the opportunity and access to ICT early on, these students are empowered to improve economic growth and lead a higher standard of living.

![Flowchart showing Technology Literacy, Knowledge Deepening, and Knowledge Creation](image)

*Figure 1.2 UNESCO 2008 New Growth Economic model. (Source: UNESCO, 2008)*

Currently, Sri Lanka is at the phase 1 of the New Growth Economic model, called Technology Literacy and so should begin to use the aspects of technology, pedagogy, and
content. This phase is described as “enabling students to use ICT in order to learn more efficiently” (UNESCO, 2008, p. 3). This description matches the current status of Sri Lanka and correlates with the focus of this research. The other two phases of this model are not applicable to the Sri Lankan situation at present. Knowledge Deepening and Knowledge Creation stages require higher levels of access and understanding in regards to ICT. With appropriate government policy Sri Lanka can move forward to these later stages of UNESCO’s 2008 model within a short period of time.

UNESCO, (2007b) has highlighted issues relating to ICT integration into educational systems, which fit the context of the current Sri Lankan education system. These issues are described below:

- New, mixed models of learning are emerging;
- Distance education is now being delivered in two different ways, namely in a synchronous model and asynchronous model;
- ICT has become a driving force of educational reform and they are an integral part of national educational policies and plans;
- The introduction of ICT in schools has lead to a more positive attitude among learners;
- Online classrooms tend to be more successful if ICT is combined with appropriate pedagogy;
- Online learning enables learners to have more control over educational content and activities;
- The interactive features of learning resources enable learners to become more positively engage in the construction of content;
• Online learning provides built-in technical tools that can make learning easier.

• The education and training of educators are now included just-in-time for collaborative learning;

• ICT helps to break the professional isolation from which teachers may suffer.

• The uses of networked computers, promote group learning activities, becoming more and more popular.

• ICT is an alternation for the functions of libraries and intrinsically changing the role of librarians (UNESCO, 2007a).

This research study design has been influenced by the importance of training new teachers in the effective use of ICT to correspond to the rapid developments of technological resources that are becoming increasingly and widely available.

1.4 The Origin of the Research

My 15 years of teaching career in secondary science education started as an agriculture graduate teacher in a rural secondary school. Through my teaching experiences, I observed that most of my students found it very difficult to understand secondary science concepts due to the abstract and imaginative examples typically provided to explain these concepts. The issue of whether to provide students with teaching aids to develop their understanding was raised and debated with my colleagues. After my secondary teaching experience I became an Assistant Director in a rural zone educational office for five years. During this period I was a part of the inspection team of schools. Based on my observations of the pedagogical approaches undertaken by the inspected schools, a trend was evident. Most of the teachers within these schools used a lecture method to explain scientific concepts; they explained the content as a story and there were limited opportunities for response from the students. Only the high achieving students in
the class responded to the teacher. Whilst some teachers taught secondary science with a student-centred method, it was surprising to note that most of these students did not appear to understand the content of the lesson. This perceived lack of understanding is supported by the Sri Lankan Department of Examination, G. C. E. (O/L) data, which revealed that every year more than 50% of students fail the exam in secondary science.

At present, I am undertaking the role of a Project Officer, attached to the Institutional Development Department of the National Institute of Education in Sri Lanka which is responsible for the pre-service teacher programs in Sri Lanka. This role includes regular visits to these colleges of education. Pre-service teacher education occurs at the 17 Colleges of Education under the control of the Institutional Development Department of the National Institute of Sri Lanka. In 1980, the first College of Education was established. The same teaching methods and timetable practices are still in effect today as they were in 1980.

The pre-service teaching programme in Sri Lanka mainly focuses on content knowledge and pedagogical knowledge. In-service teachers mainly focus on content based, exam oriented teacher centred teaching methods. Teachers play a critical role in enhancing students’ critical and higher order thinking, and deeper levels of understanding, which will help to build capacity and improve the nation’s wealth as identified in the UNESCO, ICT competency framework for teachers’ document (2011).

My personal experience as a classroom teacher, observing the difficulties many students faced in understanding and learning science prompted this research study. To overcome this problem, one solution is to use technology to enhance teaching and learning. However, the majority of the in-service teachers do not have the skills of teaching science using ICT. This research seeks to address this issue for future teachers by investigating the benefit of instructing
pre-service teachers in a theoretical framework to improve their pedagogical approach to using technology in science education.

1.5 The Nature and Scope of this Research

This research investigates the education and training of pre-service science teachers to integrate ICT effectively into their science lessons. The three main factors influencing the research study are:

- The TPACK model,
- ICT in secondary science education, and
- The training of pre-service teachers in Sri Lanka.

1.5.1 The TPACK Model

This study will investigate the impact of using a theoretical instructional framework developed by Mishra & Koehler, (2006) called the TPACK model with pre-service science teachers. TPACK is an abbreviation for Technological, Pedagogical and Content Knowledge. The TPACK model is an expansion of the original PCK model proposed and developed by Shulman, (1986) but also includes the use of technological skills, tools and attributes; i.e. ICT (Nicholson, 2001). It is proposed that knowledge of the theoretical framework will enhance the pre-service teacher use of ICT when teaching secondary science education in Sri Lanka. In this study, the main objective is to assess the effects of training pre-service teachers in the use of the TPACK model in the planning and implementation of their science lessons. The long term goal is for the pre-service teachers to be better equipped to become secondary science teachers through improved use of ICT for learning.
1.5.2 ICT in Secondary Science Education

Computer-based instructions have shown considerable enhancement of students’ learning in secondary science education as well as positive developments in socialization skills (UNESCO, 2011). Science is a difficult subject for many students with many complex ideas and abstract concepts. ICT can be advantageous to students learning by providing instant feedback; visualization and animation of many scientific ideas and access to viewing experiments too dangerous, expensive or difficult to conduct in the classroom. For these reasons, it is important and worthwhile investigating the effective use of ICT in teaching science.

1.5.3 Pre-service Teacher Training Program

In Sri Lanka prior to 1980, teachers were recruited after completion of their secondary school GCE (O/L), GCE (A/L) examinations or University degrees. After a few years of teaching, they were enrolled for teacher training. In 1980, National Colleges of Education (NCOE) were established and pre-service teacher training programs were introduced for the first time. There are currently 17 NCOE established throughout the country. The three year pre-service teacher training program in Sri Lanka consists of a two-year residential training program and one-year practical training in selected schools. At the completion of this program, pre-service teachers are awarded a National Diploma in Teaching.

1.6 Rationale of the Study

While Sri Lanka is still a developing nation it is aspiring to grow and a significant part of this growth is focused at educating future citizens. Similar to many developing nations, Sri Lanka faces challenges a digital technological age presents, as well as the constraints of limited resources and educational facilities. As Sri Lanka emerges from political instability, it has high aspirations for students; educating students in the essential knowledge area of science with 21st
century technologies is part of this future. While the availability of technology in Sri Lanka may currently be at times unreliable and inconsistent, it is improving rapidly as new technologies including wireless connectivity and increased speed becomes more widely available. This provides concrete justification for exploring how best to prepare future teachers to integrate technologies into science education; with the aim to promote deeper learning and understanding that will be reflected in greater exam performance by students in the future.

This study aims to enhance effective use of ICT in teaching science by pre-service teachers. The pre-service teachers will be trained how to implement the technological, pedagogical and content knowledge model TPACK model of Mishra & Koehler, (2006) into their teaching process. The consequence of this intervention is to improve the secondary science pre-service teachers’ skills and ability to use ICT effectively. This study is significant because it investigates the impact of applying the TPACK model to teaching science. In this way it will be able to substantiate the claims that TPACK has the ability to improve teaching outcomes by providing greater awareness of the technological, content and pedagogical aspects of teaching styles in pre-service teachers.

1.7 The Purpose and Objectives of this Research

This current research is designed to achieve the following objectives;

- To investigate pre-service teachers’ pedagogical knowledge, technological knowledge, and content knowledge.

- To analyse the pedagogical approaches used in teaching science education in three National Colleges of Education in Sri Lanka.

- To examine the secondary science pre-service teachers’ application of the TPACK model in secondary science education.
To examine the effectiveness of the TPACK model as a tool to help pre-service teachers use ICT in their teaching.

1.8 Research Questions

The overarching research question for this study is “Can the TPACK model be applied to help Sri Lankan secondary science pre-service teachers to become effective in using ICT?”

There are five sub-questions:

1. What are the secondary science pre-service teacher’s technological skills, technological knowledge, and pedagogical knowledge in teaching and learning science?

2. What pedagogical practices are used in National Colleges of Education in Sri Lanka?

3. What changes, if any, happened to secondary science pre-service teachers’ technological skills, technological knowledge, and pedagogical knowledge after instruction in the TPACK model and after applying the TPACK model in teaching secondary science?

4. How do secondary science pre-service teachers apply elements of the TPACK model in secondary science teaching after instruction in the model?

5. What are the implications (if any) of using a TPACK instructional model for pre-service science teachers on their teaching of science?

1.9 Overview of the Research Methodology

This research methodology is of an interpretive nature. This research method and design was developed according to the Twining, (2007) research framework. The research design is based on a case study approach. The pre service teachers at three NCOE’s are a case that is investigated. The researcher acts as a participant observer, delivering instruction on the TPACK model to the pre-service teachers. The study includes both qualitative and quantitative data including pre and post questionnaires, observations, video of pre-service teachers teaching and
interview data. Research participants are secondary science pre-service teachers and NCOE lecturers. The quantitative data is analysed using descriptive statistics. The qualitative data is initially analysed by the researcher, through an interpretive analysis with attention to the TPACK framework, coding the data for themes that are relevant to the research questions. The organization of this analysis and the identification of themes are proposed, with evidence from the data obtained used to support any themes that emerge. These constructs were then presented to colleagues and supervisors for member checking.

1.10 Limitations of this research

This research methodology is limited by the number of secondary science pre-service teachers and NCOE lecturers (68 secondary science pre-service teachers and 8 NCOE lecturers) participating in the research. The same questionnaire is used within three stages of the research. Secondary science pre-service teachers are inexperienced teachers and as such face challenges with teaching, but they are familiar with technology and willing to try new approaches in their teaching practice.

1.11 The Structure of the Thesis

The organizational structure of my thesis is given below:

Chapter One: An introduction of the study. In this chapter an explanation of the outline of the study and the structure of the thesis, are discussed

Chapter Two: Provides a general description of the Sri Lankan school system and National College of Education in Sri Lanka. An overview of the present pre-service teachers’ learning programme in Sri Lanka is discussed as well as the importance of support service development in ICT education.
Chapter Three: Provides TPACK model and its involvement in this study, and the relationship between the TPACK model and this study.

Chapter Four: Discusses the pre-service teacher training program, secondary science education, and ICT relevance to this study.

Chapter Five: Describes the research methodology, research design, the data sources and the proposed analytical process, along with the limitations of the research process.

Chapter Six: Presents the analysis of the qualitative and quantitative data from Stage One.

Chapter Seven: Presents the analysis of the qualitative and quantitative data from Stage two and three.

Chapter Eight: Presents a discussion of the analysis of the data.

Chapter Nine: Discusses the conclusions, implications and recommendations of this research.

1.12 Chapter One Review

This first chapter describes the study, provides background information about the education system in Sri Lanka as well as a brief overview of the recent history of Sri Lanka that has influenced the education system. The important role that technology is expected to play in the future education of developing countries in particular is presented, alongside a description of the pedagogy of teaching with technology. The researcher has presented his personal experiences as significant motivation to conduct this research. This chapter describes the nature and scope of the research, focussing on the TPACK model, ICT and secondary science education and the training of pre-service teachers in Sri Lanka. The rationale provides clear justification for this research highlighting the role of technology in education for the future. The research objectives and purpose support the overarching research question, “Can the TPACK model be
applied to help Sri Lankan secondary science teachers to become effective in using ICT?” A description of the interpretive research methodology that uses a case study method to gather various data results to achieve this objective is also discussed.
2

Chapter Two

Origin of the Study

“If we teach today as we taught yesterday, then we rob our children tomorrow.”
John Dewey (Good Reads, 2012)

2.1 Overview of Chapter Two

This chapter presents a detailed description of the context and content area of the study. There are four parts to this chapter: The first part of this chapter describes the Sri Lankan educational system; providing details of the number and type of schools in Sri Lanka; the number of students in the various types of schools; and, some information about the qualifications of the teachers working in the schools. The second part describes the Teacher Training that is provided at National Colleges of Education in Sri Lanka (NCOE) which provide the pre-service teacher training programs. The third part describes the Sri Lankan Government
educational policy to incorporate ICT into all education programs. The final part describes the ICT facilities available in Sri Lankan schools and in the National Colleges of Education.

2.2 The Sri Lankan Education System

Sri Lanka is an independent socialist republic island situated in the Indian Ocean close to the southern tip of India. According to the Sri Lanka Central Bank report 2011, the country’s population is 20.635 million people (Central Bank, 2005). The ethnic composition is 73.9% Sinhalese, 12.7% Sri Lankan Tamil, 5.5% Indian Tamils, 7.1% Sri Lanka Moor, 0.2% Burgher, 0.3% Malay, and 0.3% other (Central Bank, 2011). Meanwhile the religion composition is 69.3% Buddhist, 15.5% Hindu, 7.6% Islam, 17.6% Roman Catholic and other Christian, and 0.1% others (Central Bank, 2011). Sinhalese and Tamil are the official languages of Sri Lanka but three-quarters of Sri Lankan people speak Sinhalese languages. The Sinhalese language is used to educate Sinhalese students and Tamil language is used to educate Tamil students. Some schools have bilingual languages, timetabled to incorporate four subjects taught in English with other subjects taught in either a Sinhalese or Tamil medium. These four subjects are Science, Maths, History and Health science. The English language is used as a ‘link’ language and is taught from grade one to grade thirteen in the schools. This research investigates science education, which in Sri Lanka, may be taught in the language of student ethnicity, Tamil or Sinhalese, and in some cases, English.

2.2.1 The School System

In Sri Lanka there were 3,893,722 pupils studying in 10,832 schools in 2010. (Ministry of Education, 2005a). Education is compulsory for children from grade 1 to grade 9. Sri Lanka gives free education from grade 1 to University level according to the educational reforms
introduced by Dr. C. W. W. Kanangara who is respectfully regarded as the father of free education in Sri Lanka (Lankanewspaper, 2009).

Figure 2.1 School System of Sri Lanka.


The Sri Lankan school system consists of four levels which are called cycles. As can be observed in Figure 2.1, the four cycles are: the primary cycle (grade one to grade 5); junior secondary cycle (grade 6 to grade 9); senior secondary cycle (grade 10 to grade 11); and the collegiate cycle (grade 12 and 13) (Ministry of Education, 2005a). This study is mainly confined
and focussed on the teaching styles and science education of the junior, secondary, and senior secondary cycle levels.

The country of Sri Lanka is divided into nine provinces. Sri Lanka has a central government body for the whole country located in the central province and each of the nine provinces has a provincial council (see Figure 2.2). The Provincial Councils were established in terms of the Indo-Sri Lanka peace accord in 1988. The central government rule National Schools and their responsibilities are to provide curriculum, teacher training, administer national exams, and provide facilities to all schools. The Provincial Council’s responsibilities include school supervision, teacher and supporting staff salaries, the recruitment of teachers and school management. Each province is responsible for their own schools. Within each province there are Educational Zones, run by a Zonal Director. There are 108 educational zones throughout the nine provinces (Ministry of Education, 2005a).
Figure 2.2 Nine Provinces of Sri Lanka.

(Provinces of Sri Lanka, Wikipedia, 2008)

2.2.2 Categories of Schools

The Sri Lankan education system has multiple types of school classifications, related to the source of funding and governors. There are National Schools, Provincial schools, Navodya schools, Isuru schools, Pirivenas and Private schools (Ministry of Education, 2006b).

The National Schools are governed and funded by the central government and the other government schools are governed and funded by each of the nine provincial councils (Ministry of Education, 2006b). Most of the National Schools have a large staff and are well equipped compared to some of the provincial schools. Some National Schools have a large student population of more than 5000 students, and there is a considerable demand for the admission to these schools. To overcome this problem the government established two Navodya schools and Isuru schools in each educational zone.

The Navodaya schools are governed and funded by provincial councils. Navodya means in Sinhalese language “racing up” schools. The government developed these schools to improve the opportunities for all Sri Lankan people to have a good education by providing schools with good quality facilities. The Navodya concept was initiated by the government to achieve their goal for providing a better education for the students.

Each province is divided into districts and each district of Sri Lanka has National Schools. These selected 150 schools are named as “Isuru schools” with good facilities provided by the government. The number of Isuru schools is anticipated to increase up to 325 at the end of 2012. Further, the government has already taken steps to have 1000 fully functioning country wide secondary schools. The government expects to establish a primary schools network to
promote the quality of education for all in 2013. To overcome teacher shortages in remote areas the government has launched a scheme referred to as “Teachers Village” to ensure safe boarding and lodging for teachers undertaking up positions in remote locations (Ministry of Education, 2011; Lankika, 2010).

The private schools funding and administration is varied. Some schools are affiliated with the Catholic Church whereas some international schools are owned by businesses. The Pirivena schools are under the authority of the Buddhist monks and are funded and provided with facilities by the government. The Pirivena schools are single sex schools for either girls or boys (Ministry of Education, 2010). See Table 2.1.

**Table 2.1**

*Number of government and Non government Schools in Sri Lanka.*

<table>
<thead>
<tr>
<th>Categories of Schools</th>
<th>2009</th>
<th>%</th>
<th>2010</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of schools in Sri Lanka</td>
<td>10,539</td>
<td></td>
<td>10,832</td>
<td></td>
</tr>
<tr>
<td>Government schools</td>
<td>9,744</td>
<td>92.45</td>
<td>10,015</td>
<td>92.45</td>
</tr>
<tr>
<td>Non-Government schools</td>
<td>795</td>
<td>7.55</td>
<td>817</td>
<td>7.55</td>
</tr>
</tbody>
</table>

Source: (Central Bank, 2010)

**Table 2.2**

*Number of various types of government and non government schools.*

<table>
<thead>
<tr>
<th>Categories of Schools</th>
<th>2009</th>
<th>%</th>
<th>2010</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provincial schools</td>
<td>9,410</td>
<td>89.29</td>
<td>9,675</td>
<td>89.32</td>
</tr>
</tbody>
</table>


Including Navodaya schools

<table>
<thead>
<tr>
<th>National schools</th>
<th>334</th>
<th>3.16</th>
<th>340</th>
<th>3.13</th>
</tr>
</thead>
</table>

Categories of Non-Government schools

<table>
<thead>
<tr>
<th>Private Schools</th>
<th>98</th>
<th>0.93</th>
<th>98</th>
<th>0.91</th>
</tr>
</thead>
</table>

| Pirivena Schools managed by Buddhist Monks | 697 | 6.62 | 719 | 6.64 |

Source: (Central Bank, 2010).

92% of schools in Sri Lanka are provincial that includes Navodaya Schools. In all of the government schools and some private Catholic mission schools students are taught according to the National Sri Lankan Curriculum. The National Sri Lankan Curriculum is taught in every classroom in all Sri Lanka government schools and all the same subjects offered. In International schools the most widely adhered to curriculum is the London, General Certificate of Examination (G.C.E (O/L)). There are primarily five different types of school systems available to students in Sri Lanka (see Table 2.2) Table 2.3 shows the five categories of schools available to the students in Sri Lanka. The schools called IAB, offer advanced level classes in Science, Commerce and the Arts streams from Grade 1-13. In Sri Lanka there are 712 IAB Schools, including National schools, Navodya schools and some private schools. The schools called IC also extend from Grade 1-13 however; they offer Advanced Level in Art and/or Commerce streams only. There are 2,013 IC Schools operating in the country. The schools called Type 1 have classes from Grade 1 to Grade 11. The students who are qualified at the G.C.E (O/L) examination are admitted to the closest 1AB or 1C school, which is usually situated within one or two kilometre radius of their home. Type 2 schools provide classes up to grade 8. At the successful completion of grade 8 the students in the type 2 schools are admitted to a 1AB or 1C
School in their locality. Type 3 schools have classes up to Grade 5. After passing grade 5 the students admitted to closest 1AB or 1C School. There are 4,084 type 1 and 2 schools in the country, and there are 2,866 type 3 schools (Ministry of Education, 2010). The students who are reading in grade 5 sit a scholarship examination. The students who obtain the highest marks are provided with the opportunity to be admitted to a popular National school and the students who come from low income families, and are within the cut off marks are given financial aid. Most of the Type 1, 2 and 3 schools are rural schools and the student population is less than 1000 students and lack the basic facilities often typically found in the National Schools located in urban and regional areas.

Table 2.3

*Classification of Sri Lankan Schools.*

<table>
<thead>
<tr>
<th>Type of School</th>
<th>Characteristics</th>
<th>Category of School</th>
<th>Number of Schools (N = 9714)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1AB Schools</td>
<td>Grade 1-13, G.C.E (A/L)Science, arts, commerce three sections available schools.</td>
<td>National schools and Provincial Navodaya schools, other Provincial schools, Private schools run by the Catholic church missions, and some Pirivena schools.</td>
<td>712</td>
</tr>
<tr>
<td>IC Schools</td>
<td>Grade 1-13 G.C.E.(A/L) Arts and/or commerce sections available schools.</td>
<td>Provincial schools, Private schools (International schools), Pirivena schools.</td>
<td>2013</td>
</tr>
<tr>
<td>Type 1 Schools</td>
<td>Grade 1 to grade 11 schools.</td>
<td>Provincial schools, Private schools (some International schools)</td>
<td></td>
</tr>
<tr>
<td>Type 2 Schools</td>
<td>Grade 1 to grade 8 schools.</td>
<td>Provincial schools</td>
<td>4084 for type 1 and 2 combined</td>
</tr>
<tr>
<td>Type 3 Schools</td>
<td>Up to grade 5 schools.</td>
<td>National schools and provincial schools</td>
<td>2866</td>
</tr>
</tbody>
</table>

Source: (Ministry of Education, 2010)

There is a relationship between the category of schools and the types of schools. The National Schools were originally established as centres of educational excellence and to continue to offer schooling to Grade 13 with a high level of academic performance, exemplary teaching and learning processes and a variety of subjects offered to students. The Navodaya schools were established to provide high quality education to Grade 13 for all people in Sri Lanka with at least two Navodaya schools in each education zone to ensure equity in representation. The distribution of types of schools and the categories of the schools can be seen in Table 2.3.

**2.2.3 The Teachers in the Sri Lanka Education System**

All the teachers working in the Sri Lanka government schools are attached to the Sri Lanka Teacher Service. The Sri Lanka Teacher Service grades are varied according to Teachers’ qualifications, as some teachers are graduates with postgraduate diplomas in education, and others are graduates without postgraduate diplomas in education (Ministry of Education, 2005a). Trained teachers hold a National Diploma of National Colleges of Education or two year teacher training certificate. Less than three percent of teachers are classified as untrained teachers. These teachers have been in service for more than 10 years with minimal qualifications and have not updated their teacher training qualifications. These “other” teachers work in government schools but they are paid by Non Governmental Organisations (NGOs) and other government authorities,
e.g. Samurdi Authority (Ministry of Education, 2005a); their qualifications are not listed by the Ministry of Education. The numbers of teachers in each of the five categories are presented in Table 2.4.

Although Sri Lanka is a developing country, the student / teacher ratio average is 18:1 (see Table 2.5). This ratio is comparable to that of developed countries such as the USA, which has a ratio of 10-19:1 (UNESCO Institute for Statistical Data Centre, 2008) but most of the selective National Schools teacher student ratio is 22:1. The student / teacher ratio across the various types of schools, and provinces in Sri Lanka does not vary greatly, with a range from 14:1 to 23:1 (Ministry of Education, 2006a).

\[\text{Table 2.4}\]

**Type of Teachers in Sri Lanka.**

<table>
<thead>
<tr>
<th>Type of Teachers</th>
<th>Qualification</th>
<th>Number of Teachers</th>
<th>Percentage of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate teachers</td>
<td>Bachelor Degree / Bachelor Degree with Postgraduate Diploma in Education</td>
<td>78,412</td>
<td>36.4</td>
</tr>
<tr>
<td>Trained Teachers</td>
<td>National Certificate Diploma of Education and two year teacher training certificate</td>
<td>127,153</td>
<td>58.9</td>
</tr>
<tr>
<td>Untrained teachers</td>
<td>No formal teaching qualifications</td>
<td>6,362</td>
<td>2.9</td>
</tr>
<tr>
<td>Other teachers</td>
<td></td>
<td>3,711</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>215,638</td>
<td>100</td>
</tr>
</tbody>
</table>
Source: (Ministry of Education, 2010).

Table 2.5 compares the number of teachers and students at the various types of schools in Sri Lanka. There is a high demand for admission to 1AB schools, which can average 3000 – 5000 in student admissions. Student to teacher ratios in these schools is reported to be 23:1 (Table 2.5). According to researcher observations there are more than 40 students in a class. Commonly, there are five to ten parallel classes in a 1AB schools. IC schools generally, have less demand for admission than 1AB schools. Type 1, 2 and 3 schools situated in rural areas with limited facilities, have less demand for admission. All these schools follow the same curriculum. Interestingly, the schools with less demand have lower student to teacher ratios. Typically, in developed countries, schools offering lower student to teacher ratios are in high demand.

**Table 2.5**

*Comparison of the Number of Teachers and Students at the Various Types of Schools in Sri Lanka.*

<table>
<thead>
<tr>
<th>Type of School</th>
<th>Schools</th>
<th>Students</th>
<th>Teachers</th>
<th>Student-Teacher ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1AB</td>
<td>712</td>
<td>1373835</td>
<td>58,518</td>
<td>23:1</td>
</tr>
<tr>
<td>1C</td>
<td>2013</td>
<td>1279102</td>
<td>69203</td>
<td>19.1</td>
</tr>
<tr>
<td>Type 1 &amp; 2</td>
<td>4084</td>
<td>917003</td>
<td>66,694</td>
<td>14.1</td>
</tr>
<tr>
<td>Type 3</td>
<td>2866</td>
<td>362782</td>
<td>21,223</td>
<td>17.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9675</strong></td>
<td><strong>3932722</strong></td>
<td><strong>215,638</strong></td>
<td><strong>18.1</strong></td>
</tr>
</tbody>
</table>

Source: (Ministry of Education, 2010).
2.3 Teacher Training at National Colleges of Education in Sri Lanka (NCOE)

In Sri Lanka the training of teachers is governed by the Ministry of Education and occurs through the National Colleges of Education (NCOE). There are 17 National Colleges of Education in Sri Lanka spread across the country. Nilwala NCOE, Ruhuna NCOE, Dharga Nagar NCOE, Ruwanpura NCOE, Pasdunrata NCOE, Uwa NCOE, Sri Pada NCOE, Sariputta NCOE, Siyana NCOE, Hapitigama NCOE, Mahawali NCOE, Addalachana NCOE, Pulatisipura NCOE, Vavuniya NCOE, and Jaffna NCOE. The secondary science education for the pre-service teacher trainees is available at Sri Pada NEOE, Nilwala NCOE, and Siyana NCOE only (Ministry of Education, 2005). The Ministry of Education’s vision for quality teachers and the role of educating new teachers in the future recognise the importance of equipping teachers with the necessary skills (New Vision for Education 2010). According to Ministry of Education, Vision of the “NCOE is producing professional competent teacher in order to achieve the objective of delivering quality education to every child” (2010, p. 1).

According to Ministry of Education, the mission of the National College of Education is to provide all teachers with skills and tools necessary to allow them to enter the school system as competent teachers (Ministry of Education, 2010). Hettiarachige corroborates this objective stating:

*The mission of the National College of Education is, to provide to the school system, teachers who are professionally competent and committed to fulfilling educational policy objectives and possessing the efficiency, enthusiasm and innovativeness necessary to face the future challenges including that the global society. (Hettiarachige, 2005, p. 29)*
2.3.1 The pre-service teacher training program

The Ministry of Education selects pre-service teachers for the 17 Colleges of Education based on the results of the General Certificate of Examination (Advanced Level). After three years of pre-service education, the pre-service teachers are awarded with a Diploma in National Certificate of Teaching by the National Institute of Education (Ministry of Education, 2005a). In 2005, 17 Colleges of Education offered 8,629 pre-service teachers in Sri Lanka teacher training program (Ministry of Education, 2005a). When they are enrolled into the NCOE, the pre-service teachers are typically between 19 and 22 years of age. The teacher training is a two year full time residential program plus one year teaching practice in NCOE’s selected schools (Ministry of Education, 2006a). In 1980, the first College of Education was established. Initially these colleges were well equipped and lecturers were selected among the teacher educators.

Pre-service teachers are selected into respective NCOE’s according to G.C.E. (A/L) results where they are required to undertake their pre-service training. They learn the basic principles of education, teaching and learning methodology, psychology, teaching practice and respective content subjects in the curriculum area they will teach in the future. In addition, all pre-service teachers undergo training in curriculum areas like music, dancing, art, and physical education. Secondary science pre-service teachers undergo training in general science and secondary science curriculum. The training for secondary science pre-service teachers consists of four components.

- Component A: consists of basic laboratory skills, such as practical and resource development.
- Component B: deals with the nature of science and learning of science.
- Component C: considers the implementation of the secondary science curriculum.

During the first two years of the three year course, pre-service secondary science teachers under take teaching practice at selected schools where they are supervised by teacher educators. Upon successful completion of these two years of training a pre-service teachers’ examination is conducted by the Department of Examination of Sri Lanka (National Institute of Education, 2007). In the third year of their program, the pre-service teachers undergo field training at a selected school where they are supervised by the principal of the school, two senior teachers, and a teacher educator from the NCOE. After the successful completion of the three-year program, pre-service teachers are awarded a National Diploma in Teaching and designated to a government school. Despite government efforts and initiatives to include ICT into the curriculum of NCOEs, the current curriculum available is not inclusive of ICT (National Institute of Education, 2007).

2.3.2 The place of ICT in the teacher education program

ICT has recently been introduced to the Sri Lankan school curriculum as a separate topic, however there is little or no teacher training for teachers on how to use the ICT effectively. Without training, the effective use of ICT in the teaching learning process is not guaranteed. At present, pre-service teachers are trained to use pedagogical knowledge and content knowledge in their syllabi but they are not trained to use ICT as a teaching tool (National Institute of Education, 2007). This is despite the need for pre-service teachers to develop the competency, confidence, and knowledge that are vital to support, plan, implement and assess productivity in the use of ICT for learning (Finger et al., 2007). The ICT facilities available at NCOE’s are limited, thereby making it difficult to achieve the desired level of training. Some school authorities do not allow pre-service teachers to use the school’s computers and related facilities
while some schools do not have Internet connections. Most of the teacher educators are not familiar with using ICT in teaching and learning processes and therefore, are not in a position to provide pre-service teachers with the expertise on how to use ICT in the teaching and learning process.

Pre-service teaching programs ideally need to include meaningful ICT learning experiences so the pre-service teachers can learn how to integrate ICT effectively in the classroom. Suggested skills and knowledge that pre-service teachers need to develop in order to use ICT more effectively include:

- Support and design student-centred, project based and group work.

- Promote skills of higher order thinking, collaboration and communication.

- Address higher order thinking.

- For collaboration and structure thinking.

- Conduct classroom assessment (Finger, Russell, Jamieson-Proctor, & Russel, 2007)

For pre-service science teachers the issue of not being trained in the use of ICT is more prominent, as the benefits associated with the use of this tool in science education has the potential to be the most extensive. For example, science education curriculums have many abstract concepts that can be represented with digital visual forms like videos, animations and images, as well as the digital collection of data, which can be recorded and graphed instantly (Shelly et al., 2006).

2.4 Sri Lankan Government Educational Policy

Major Educational Reforms in Sri Lanka were introduced in 1997, according to the recommendation of the National Educational Commission. The National Educational
Commission’s findings and recommendations were based on a wide public consultation on the existing problems and issues in the education sector. The recommendations cover general education, university education, technical education and vocational education (Ministry of Education, 2005a).

In the 1997 educational reforms, the Department of Education in Sri Lanka introduced nine national goals. These national goals are (Ministry of Education, 2005a, http://www.moe.gov.lk):

- The achievement of national cohesion, national integrity and national unity.
- The establishment of a pervasive pattern of social justice.
- The evolution of a sustainable pattern of living.
- The generation of work opportunities that are, at one and the same time, dignified, satisfying and self-fulfilling.

In the above framework, the institution provides a variety of possibilities for all to participate in human resources development, leading to cumulative structures for the growth of nation. The active participation in nation building activities should ensure the nurturing of a continuous sense of deep and abiding concern for one another. In a rapidly changing world, such as we live in today, it is imperative to cultivate, and evolve elements of adaptability to change – learn to adapt to changing situations. The cultivation of a capacity to cope with the complex and the unforeseen is an essential component in achieving a sense of security and stability. The development of those competencies is linked to securing an international community.
The main aim of these national goals is to improve living standards of Sri Lankan people, which is consistent with the aim of this research; to improve quality of life of Sri Lankan people by using ICT as an educational tool. The 1997 curriculum reforms focused on five competencies as core to the educational system (Ministry of Education, 2005a, http://www.moe.gov.lk), with a requirement to demonstrate competencies in:

- Communication.
- Literacy
- Numeracy
- Graphics
- Competencies relating to the environment.
- Social Environment
- Biological Environment
- Physical Environment
- Competencies relating to ethics and religion.
- Competencies in games and the use of leisure.
- Competencies relating to “Learn to Learn”.

Pre-service teachers are the future of education and require priority when reforming any educational system. The National Education Commission is highly influential on pre-service teacher training programs; however there has been little progress on recommendations made to improve these programs.
One of the recommendations of the National Education Commission was to introduce ICT to schools. In year 2000, the government of Sri Lanka introduced ICT into the school system, however there were only limited facilities available. It is relevant to point out that some of the NCOEs still do not have adequate facilities. At present, pre-service teacher training programs in NCOE are limited to train pre-service teachers to use content and pedagogical knowledge and not technological knowledge. In 2007, the NCOE at Ruwanpura was converted to training pre-service teachers to teach ICT. According to this researcher’s observation, the ICT training provided at Ruwanpura NCOE related to content and pedagogical knowledge - with no focus on technological knowledge and skill.

2.4.1 Government policy of ICT in Education

The government of Sri Lanka has recognised that future education includes developing ICT skills and therefore requires more funding than previously made available to implement ICT in schools. The expenditure is a direct result of the implementation of government policy to promote the use of ICT in schools in Sri Lanka. This money was not used for teacher training programs; instead the funds were solely used for setting up computer laboratories in schools. The Ministry of Education of Sri Lanka has laid out the foundations to face the future challenges of ICT education. At present, the government is providing opportunities for the use of ICT in learning and teaching at all levels of Sri Lankan schools, with aims to prepare “information literacy” for school leavers. ICT is viewed as a life-long educational tool, and these skills are important as preparation for an information literate society among the teachers and teacher educators (Ministry of Education, 2005b). The following are the goals of ICT in Sri Lanka:

- Envisage and foresee the future global challenges in IT education and lay the foundation for appropriate human resource development to meet such challenges;
- Create conditions enabling the effective use of IT as a tool in learning and teaching at all levels in the general education;
- Provide "information literacy" for all school leavers;
- Create conditions for effective involvement of school system in lifelong education of citizens; and
- Create an information literate population of teachers and teacher educators. (Ministry of Education, 2005b, p. 1)

In 1997, changes were made to the educational policy to promote the use of ICT in schools. These changes called for the introduction of ICT into Sri Lankan schools. From my observations, prior to 1997, the Sri Lankan education system was considered teacher-centred and employed traditional teaching methods. Student-centred educational reforms were introduced in 1997. In the year 2000, ICT was introduced to the school system with the main objective of establishing an information rich society with an e-culture (Ministry of Education, 2005b). The expectation was to meet perceived needs of younger generations of Sri Lankans to develop ICT skills to face the challenges of the 21st Century, while providing them with opportunities to access more ICT skilled-based jobs. ICT education is now taught as a separate subject.

The National Policy on ICT Education defines a vision of "a new generation of Sri Lanka empowered with ICT" facilitating the "planning implementation and sustenance of information technology education in school to enhance students learning and quality of learning" (Ministry of Education, 2006a, p. 1). The Mission of the Ministry of Education was to include and enhance ICT application in the teaching and learning processes. The Mission's statement was "to facilitate the planning, implementation and sustenance of Information Technology education in schools to enhance student's learning as well as quality of teaching" (Ministry of Education,
2006a, p. 1). In practice the implementation of the policy was far more problematic than expected. As a result it has not yet been possible for the education system in Sri Lanka to reach the objective of developing ICT to world standards.

In order to reach these goals the main objective is to ensure that technology reaches the classroom. To achieve this main objective, four major strategic themes are needed:

1. Curriculum development,
2. Human resource development,
3. Physical/infrastructure development, and
4. Support services development as outlined in the following sub-sections (Ministry of Education, 2005b).

2.4.2 Curriculum development

The intent to introduce, sustain and enhance ICT involvement into the general education in schools and to create opportunities for ICT based learning and teaching is embedded in the reformed curriculum. To achieve this objective, teachers need to be skilled in ICT and therefore introducing training and preparation in the use of ICT into pre-service and in-service teacher development and training programmes is essential. (Ministry of Education, 2005b).

2.4.3 Human resource development

Investing in the training and development of all teachers in government schools is necessary to make them competent in using ICT for teaching purposes. This requires education and training of officers in the education system to handle IT related activity with ease. It also extends to creating opportunities for out of school populations to utilize resources in school based ICT resource centres, thus creating an environment of community learning (Ministry of Education, 2005b).
2.4.4 Physical/Infrastructure development

The ICT reforms provide a way to allocate and distribute optimal resources in an equitable manner to meet learning needs of students and learning/teaching requirement of teachers. Through the setting up an Information Technology Educational Resource Centre (ITERC) at the national level, and at the provincial level and zones level for teacher training/development. In addition though the establishment of an ICT education laboratory at the National Institute of Education (NIE) to improve curriculum development. And the establishment of an ITERC at the Centre for Professional Development of Management of Education. One National College of Education (NCOE) is allocated to specialising in the development of ICT teachers under pre-service teacher training only. These initiatives are possible ways of providing innovative means of training through activities such as mobile training laboratories (Ministry of Education, 2005b).

2.4.5 Support services development

The developments of support services are important to ensure the progress of ICT education in the school system. As ICT undergoes rapid changes in terms of technology and usage, the support services though the Ministry of Education will ensure that such changes are incorporated in the learning process of students without having to wait for the curriculum changes. The government has made plans for a variety of support services such as ICT school clubs for students and a professional organisations for teachers involved in ICT education in schools; the use of web sites in e-learning and information management for schools; assisting teachers to own personal computers.
2.5 ICT Facilities in Sri Lanka Schools and Pre-service Teacher Training Program.

Today computers play an important role in education. In 2004, ICT curricula were introduced to Grade 1 to Grade 13. In 2006, ICT as a technical subject was introduced into G.C.E. (O/L) class. In 2004, ICT was introduced as a common subject for Grade 12 students in the G.C.E. (A/L) class. ICT was also introduced to Junior Secondary classes in which ICT was used as tool for mathematics, science and geography teachers from Grade 1 to Grade 13 (Ministry of Education, 2005b).

In Sri Lankan schools, the student to computer ratio is around 137 to 1, significantly higher than Australian schools, which has a current ratio of 3 to 1. Figure 2.3 illustrates that only 17% of the all Sri Lankan schools have computer facilities, despite some schools having over 90%. This clearly shows the unequal distribution of resources across the various types of schools.
Figure 2.3 Percentage of schools/pirivenas with computer laboratory by category of schools.

Source: Ministry of Education, (2006b)

Table 2.6

Student-Computer Ratios for Size of School

<table>
<thead>
<tr>
<th>Number of students at school</th>
<th>All Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 or less</td>
<td>300</td>
</tr>
<tr>
<td>100 to 300</td>
<td>930</td>
</tr>
<tr>
<td>300 to 930</td>
<td>132</td>
</tr>
<tr>
<td>930 to above</td>
<td>120</td>
</tr>
<tr>
<td>132 to 120</td>
<td>137</td>
</tr>
</tbody>
</table>

Table 2.7 demonstrates the high student to computer ratio indicating that most students do not have access or have extremely limited access to a computer in Sri Lankan schools. However, there is also evidence of uneven distribution of computers and ICT facilities (Table 2.7). The 1AB schools and 1C schools have computer laboratory, the 1AB schools’ student population varies from 1,500 – 5,000. For 1AB schools, computer labs generally contain between 10 – 20 computers. Some 1AB schools are National Schools, and 92.1% of National School have a computer laboratory. Yet the small number of computers is not adequate to conduct ICT classes for all the 1AB school students. The same problem affects students attending 1C schools. The 1C school population varies between 1,000 – 1,500 students on average. The 1C schools have computer labs, which generally contain the same number of computers as 1AB schools; between 10 – 15 computers on average. 1AB and 1C school students all face a lack of computer access. Some of the 1AB and 1C schools are categorised as Navodaya schools. 82.2% of Navodaya schools have computer laboratories. The other government schools (except for National schools and Navodaya schools) have only 10.5% computer laboratory facilities (Ministry of Education, 2007). The availability of ICT resources will impact on the ability to use ICT effectively when teaching science.

Table 2.7

*Student-Computer literate Teacher Ratio.*

<table>
<thead>
<tr>
<th>Number of students at school</th>
<th>100 or Less</th>
<th>100 to 300</th>
<th>300 to 930</th>
<th>Above 930</th>
<th>All schools</th>
</tr>
</thead>
</table>

| Student – Computer Literate | 40 to 1 | 59 to 1 | 59 to 1 | 57 to 1 | 57 to 1 |

Teacher Ratio

Table 2.8 demonstrates the student to computer literate teacher ratio. In schools with 100 or less students, this ratio was recorded at 40 students to one teacher. In schools with a 100 – 300, and 300-900, student body population, the ratio was 59 students to one teacher. Schools with student numbers recorded as 930 or higher, the ratio was measured at 57 students to one teacher. All schools averaged a ratio of 57 students to one teacher. These ratios indicate large numbers of teachers need ICT training.

To overcome the computer literacy issues facing teachers, the government of Sri Lanka provided ICT skill training for teachers, through recognised private institutes in a collaborated effort with the Asian Development Bank; however this process has proven to be too costly and slow due to administrative problems associated with the Ministry of Education. To counter this unforeseen issue the Sri Lankan government should develop loan schemes to enable teachers to own computers to encourage computer literacy and skills.

2.5.1 Availability of ICT resources

The government is spending millions of rupees on education. ICT books and other materials are very expensive. In ICT education, new books and other materials are published and available in the market at an increasing rate. New books and other published materials lead to the development of extensive knowledge and experience in ICT. These books and other materials have to be bought but because of lack of funds, the government is unable to buy them. The schools with 100 or less students have about 8.7% of books/magazines related to ICT. The 100 to 300 schools have 15.5% ICT related books/magazines. The 300 to 930 schools have 41% of books/magazine related to ICT. The 930 and above have 76.7% of book/magazine that is related to ICT (Ministry of Education, 2006a). Large numbers of schools are facing shortages of
peripherals, such as printers, scanners, multimedia projectors, overhead projector and laptop computers.

*Table 2.8*

*Hardware availability in government schools.*

<table>
<thead>
<tr>
<th>Peripherals</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 or above</td>
</tr>
<tr>
<td>Printers (%)</td>
<td>4.3</td>
</tr>
<tr>
<td>Scanners (%)</td>
<td>0.4</td>
</tr>
<tr>
<td>Multimedia</td>
<td>0.0</td>
</tr>
<tr>
<td>Projectors (%)</td>
<td></td>
</tr>
<tr>
<td>Overhead</td>
<td>0.3</td>
</tr>
<tr>
<td>Laptop</td>
<td>0.3</td>
</tr>
<tr>
<td>Computers (%)</td>
<td></td>
</tr>
</tbody>
</table>


2.5.2 Shortage of ICT resources

To run an ICT laboratory efficiently additional funds are urgently required for printing, CD writing, photocopying, Internet access and minor repairs. Most of the schools do not have sufficient money for these expenses. According to Table 2.9 schools with a large number of students have more hardware available than schools with lesser numbers of students. Most of the large schools receive money and equipment from alumni and donors.
2.5.3 Internet and E-mail access

Today, the Internet plays a major role in education. Due to the costs associated with running the Internet, not all schools have access to the Internet or the equipment required to make Internet access available. The government is responsible for the facilities provided to all schools and therefore should address this issue. A possible interim arrangement may be to negotiate with Internet Companies to provide Internet access at subsidised rates to all schools in Sri Lanka.

![Bar Chart]

*Figure 2.4 Availability of E-mail Facilities. (Ministry of Education, 2006a)*

Most of the IAB and IC schools have Internet facilities. Most principals are reluctant to use the Internet because of the high costs. Some teachers still like to use old methods to teach. Another further compounding issue is that a large number of teachers do not know how to use the Internet. Today, e-mail is used as a time effective medium to exchange information. E-mail is used for teaching and learning and also for administrative purposes. However, only 4.1% of the schools are using E-mail (Ministry of Education, 2006a). With reference to Figure 2.4 in
relation to all schools in Sri Lanka, only 6.4% of schools have Internet connection (Ministry of Education 2006a). Figure 2.4 and 2.5 shows the level of Internet and E-mail facilities that are available at all schools in Sri Lanka. According to Figure 2.4 private schools have the highest level of availability in relation to e-mail facilities. Availability of Internet facilities was the highest in both private and national schools.

![Bar chart showing availability of Internet facility by types of schools]

*Figure 2.5 Availability of Internet Facility (Ministry of Education, 2006a)*

2.5.4 Providing ICT Education for Teachers

The Ministry of Education in Sri Lanka has announced that 35% of teachers have adequate computer literacy (Ministry of Education, 2006a; Ministry of Education, 2006b). However, 65% of teachers are computer illiterate. The government of Sri Lanka has to provide training to all teachers who do not possess computer literacy. At the same time, it will be
beneficial if the government initiates loan schemes to enable teachers to own computers. If the Ministry of Education cannot provide these facilities to train teachers in ICT immediately, then the government can put in place an interim measure by collaborating with private ICT institutes to provide ICT education for teachers. Sri Lankan schools are also in short supply of other ICT materials, such as, ICT books, magazines software, scanners, multimedia projectors, overhead projector and laptops. ICT laboratories are costly to operate and maintain, and include expenses relating to printing.CD writing, photocopying, Internet access, as well as minor repairs. The government needs to substantially increase its budgetary allocations not only to operate and maintain few ICT laboratories available now but also to expand the availability to other schools.

2.6 Chapter Two Review

This chapter provides a general description of the Sri Lankan school education system that includes the school system, categories of schools and the teachers within this educational system. Discussions are also raised on the current state of pre-service teacher training programs at National Colleges of education in Sri Lanka, including the place and purpose of ICT in these programs, curriculum and human resource development, and the government policies surrounding ICT education. Lastly this chapter highlights the availability and limitations associated with the current state of ICT facilities available in Sri Lankan schools and pre-service teacher training programs, in particular Internet and E-mail access and providing ICT education for teachers.
Chapter Three

TPACK Model

“The learning by design approach is used to help teachers develop a flexible and situated understanding by technology”

(Koehler & Mishra, 2005, p.131)

3.0 Chapter Overview

Chapter three provides a description of the TPACK model, including a discussion on the interactions between its three main components; pedagogical knowledge, content knowledge and technical knowledge. This chapter also describes the effective use of ICT with the TPACK model.
3.1 Introduction

Human society began as simple hunter-gatherers to expand into agricultural and industrial evolutions. These progressions within our society have lead to, what has been described as, an information and technology rich age of the 21st Century; and are a major milestone within our social evolution. As a result of this new era of social evolution, a wide variety of advanced technology is now affordable, and more importantly, available within schools and have become an important part of modern learning environments. Teaching is a complex, complicated, interwoven and problematic profession with transmissive views of teaching that need skills, knowledge, and ability (Loughran et al., 2006). The consequences of bringing this new technology into classrooms relate to the pressures teachers and schools face in up-skilling teachers to effectively use ICT as an education tool (Hargreaves, Earl, Moore, & Manning, 2001).

As teachers progress through their teaching experiences they gain understanding and skill in integrating content and pedagogy, however gain little experience integrating technology with content and pedagogy. Effective use of technology as a teaching tool allows for the integration of content, pedagogical and technological knowledge that can grow and develop as teachers progress through their careers (Mishra & Koehler, 2006; Koehler & Mishra, 2009). In order to address this issue Mishra & Koehler, (2006) introduced the TPACK model – an integrated content, technological, and pedagogical knowledge model (Mishra & Koehler, 2006). The TPACK model may be a useful framework to help teachers as they to prepare students “to live learn, and work successfully in an increasingly complex and information-rich society” (ISTE, 2000, p. 5). “With policy directions designed to equip students with skills for living and working in the 21st century, there is a need for teachers to build the body of knowledge, skills and
behaviours’ to teach the interdisciplinary ICT” (Victorian Curriculum and Assessment Authority, 2005, p. 2).

Lesson planning is an integral component of teaching, is more likely to be activity based and content focused (John, 2006; Yinger, 1979). Learning behaviours are conceptualized and developed through a variety of learning experiences (Shulman, 1986; Stodoslisky, 1988).

3.2 TPACK Model

Technological Pedagogical Content Knowledge (TPCK) is an extension of pedagogical content knowledge (Shulman, 1986). Shulman’s original pedagogical content knowledge framework is named the Pedagogical Content Knowledge (PCK model), which integrates pedagogical knowledge, curricula knowledge, and subject matter content knowledge (Shulman, 1986). According to Nicholson (2001), the knowledge of teaching and context is divided into two categories; pedagogical knowledge and curricular knowledge, this idea is consistent with the PCK model. Content knowledge and Pedagogical knowledge have been difficult to differentiate because both of them are bodies of understanding (Shulman, 1986). Shulman, (1986) was the first to value the knowledge of how to teach particular content. He distinguished this knowledge from the knowledge of the subject matter and described it “…second kind of knowledge is content knowledge, pedagogical knowledge, which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching” (Shulman, 1986, p. 351).

Shulman’s, model concerning the professional knowledge of teachers consists of several components:

- Knowledge of subject matter.
- Pedagogical content knowledge.
- Knowledge of curriculum,
• General pedagogical knowledge,

• Knowledge of learners and their characteristics,

• Knowledge of educational contexts,

• Knowledge of educational aims, purpose, and values (Shulman, 1987, p. 351).

The TPACK model is an extension of (Shulman, 1987) model, with the addition of a new domain – technology (Mishra & Koehler, 2006a). The main components of the TPACK model consist of three primary types of knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK), which require equally important consideration and will be further discussed below.

According to ROSE, (2007) in order to achieved TK, teachers require the ability to choose the most effective technological tools to present specific content area to maximise learning outcomes. The TPACK model has the potential to provide opportunities for students and teachers to use technology as a vehicle to explore subject matter within a student-centred environment.

“TPACK is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content knowledge which make concepts difficult or easy to learn and how technology can help redress some of the problems that students face. Students’ prior knowledge and theories can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones”. (Mishra & Koehler, 2006, p. 1029)

The TPACK model framework and its knowledge components can be employed for training pre-service teachers’ as an introduction to technological knowledge integration into their teaching practices (Mishra & Koehler, 2006). The significance of this model is that it emphasizes
the need to develop teachers’ knowledge and skills concurrently in each of the three knowledge areas, rather than ‘adding on’ or subsequently ‘integrating’ ICT into the curriculum which is demonstrated in Figure 3.1.

![TPACK Framework and its Knowledge Components](image)

*Figure 3.1 The TPACK Framework and its Knowledge Components (Mishra & Koehler, 2006, p. 6).*

The main objective of this study is to analyse the effectiveness of the TPACK model on ICT integration into secondary science education in Sri Lanka. Secondary to this objective is to improve the teacher training program for secondary science teachers by equipping them with the knowledge, skills and tools necessary to integrate modern technology effectively within the classroom to maximize learning and teaching outcomes. The TPACK model “contextualizes and
extends Shulman’s original PCK model (Shulman, 1986) through its explicit focus on the use of pedagogical tools (i.e. ICT) and by adding additional constructs to the model” (Nicholson, 2001, p. 7).

This research draws its structure from the emerging construct of the TPACK model (Mishra & Koehler, 2006a). In the context of this thesis the focus is on the interaction of the three knowledge domains of the TPACK model, rather than primarily focusing on a single domain. Previously software application in teaching and learning process was not considered as a separate skill of technology. Figure 3.1 illustrates that integrating TK with CK and PK as a whole represents a pedagogical framework for teaching and learning. According to Mishra & Koehler, (2006) TPACK model there are seven main components of knowledge as outlined below:

- Content Knowledge;
- Pedagogical Knowledge;
- Technological Knowledge;
- Content Pedagogical Knowledge;
- Content Technological Knowledge;
- Pedagogical Technological Knowledge;
- Technological Pedagogical Content Knowledge.

The following section elaborates these seven components of knowledge.

3.2.1 Content Knowledge (CK)

“Content Knowledge (CK) is the knowledge about the actual subject matter that is to be learned or taught” (Mishra & Koehler, 2006). “It is also the “teachers’ knowledge about the
subject matter to be learned or taught” (Koehler & Mishra, 2009, p. 4). Content Knowledge includes concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof; and is a crucial component in any teaching practice. Teachers must have a sound understanding of the subject matter that they teach including knowledge of essential facts, theories, and knowledge to explain the subject matter (Mishra & Koehler, 2006). Deep understanding of CK enables teachers to provide students with high quality learning experiences and environments (Shulman, 1986). CK differs from subject to subject, for example, science teachers require specific knowledge and understanding on scientific facts, theories, methods, and evidence-based reasoning and practice (Koehler & Mishra, 2009). CK is developed throughout an individual’s schooling at the elementary, secondary, and college level of their education (Niess, Lee, & Kajder, 2008). Teachers who possess misconceptions and alternative conceptions relating to their CK inadvertently pass on these ideas to their students rather than accurate CK (Ball & McDiarmid, 1990; Mishra & Koehler, 2006). The main aim of the science pre-service teachers’ training program in Sri Lanka is to develop the depth and breadth of CK relating to science concepts included within the science education curriculum. Science pre-service teachers’ basic CK includes initial science skills and wider general knowledge (Niess, 2005). Teachers’ CK contains both subject area knowledge and an understanding of curriculum standards and requirements (Hofer & Swan, 2008).

3.2.2 Pedagogical Knowledge (PK)

“Pedagogical Knowledge (PK) is deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims” (Mishra & Koehler, 2006, p. 1026). According to (Niess et al., 2008) PK is the knowledge of teaching and learning. Similarly, Loughran et al., (2006) describe
pedagogy as being concerned "with understanding the relationship between teaching and learning in ways that foster children's development and growth" (Loughran et al., 2006, p.4). PK allows teachers to cater for the needs of individual students, and therefore must be developed and drawn on appropriately for each learning experience. PK includes learners' pedagogy and creating learners' environment, curriculum, and assessment (Niess et al., 2008).

A teacher's chosen pedagogy is usually dependent on a fusion of their personal philosophies with established philosophies of learning, such as:

- Authentic Pedagogy (Newmann, Marks, & Gamoran, 1996);
- Critical Pedagogy (Giroux, 2000; Lankshear, Peters, & Knobel, 1996; Lather, 1995);
- Productive Pedagogy (Queensland, 1999).

Some teachers tend to advocate an authoritarian, teacher-centred instructional approach, however these pedagogical approaches have been shown to be unfavourable by students (Swan & Hofer, 2006). The preferred approach is believed to be student-centered in nature.

PK involves students' learning, classroom management, lesson plan preparation and implementation, student assessment and teaching methods and techniques used within a classroom. Teachers with sound PK will be able to facilitate students in constructing and developing their own content knowledge and constructive learning habits, will enabling them to acquire meta-cognitive skills. PK provides teachers with the tools to understand students' cognitive, social and developmental progress and enhance learning in the classroom (Mishra & Koehler, 2006). Pedagogy can be used effectively depending on the level of students' attainment of knowledge, skills, attitudes and disposition within their social and material background (Valanides & Angeli, 2006). Taking this into consideration, teachers can use any pedagogical
models or strategies, however ultimately it is the students learning that determines the quality of a teacher's abilities (Vacirca, 2008).

"Systems and school implement programmes to develop teachers' pedagogy based on the notion that it is the quality of pedagogy that most directly and most powerfully affects the quality of learning outcomes that students demonstrate" (Gore, Griffiths, & Ladwig, 2004, p. 75).

Based on Shulman's model, there is a range of pedagogical reasoning skills which include:

- **Comprehension** – Grouping the content to be taught and taking into consideration about interaction with other subjects;
- **Transformation** – students can learn through transforming ideas of knowledge;
- **Preparation** – in relation to the aims and objectives of the curriculum;
- **Representation** – The way ideas and skills are presented to students understanding;
- **Adaptation** – preparation of materials to suite students' characteristics, i.e. age, gender, culture, etc…
- **Tailoring** – Appropriate curriculum and teaching plans to suite a particular group of students;
- **Instruction** – Presenting various teaching methods and class management activities;
- **Evaluation** – Evaluate the efficiency of the teaching during the assessment of students and use all the other types of evaluation (Shulman, 1987).
3.2.3 Pedagogical Content Knowledge (PCK)

The pedagogy knowledge is pertinent to the teaching approaches that are appropriate to the content and that fit best to communicating the concepts of the content (Mishra & Koehler, 2006). The pedagogical content knowledge is the teacher’s expertise in presenting the subject matter for teaching (Koehler & Mishra, 2009). Shulman explains the concept of pedagogical content knowledge: “the most regularly taught topics in one’s subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations... Including an understanding of what makes the learning of specific concepts easy or difficult: The concepts and preconceptions that students of different ages and backgrounds bring with them to the learning” (1986, p. 9).

A teacher’s knowledge extends across a number of different areas, and Grossman (1989) has described four areas of teachers’ knowledge. They are:

- subject matter knowledge;
- general pedagogical knowledge;
- knowledge of context;
- pedagogical content knowledge

Shulman, (1986) originally defines pedagogical content knowledge as “The particular form of content knowledge that embodies the aspects of content most germane to its teach ability” (p. 6), and Wilson, Shulman, & Richert, (1987, p. 118) describe it as an “understanding of what it means to teach a particular topic as well as knowledge of the principles and techniques required to do so”. While pedagogical content knowledge is specific to the content, it draws on a range of teachers knowledge areas. “PCK covers the core business of teaching, learning, curriculum,
assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment and pedagogy” (Mishra & Koehler, 2006, p.6). Content knowledge is defined as subject knowledge that a teacher should possess (Enfield, 2006).

“Pedagogy is defined as actions and strategies of teaching, organization of classroom experiences, providing diverse learners needs, evaluation and implementation of learner’s prior notations, and transformation of ideas into understandable pieces” (NSTA, 1998, p. 2).

This is the intersection of content and pedagogy in the learning on how to teach the process of inquiry (Enfield, 2006). PCK is different from the official ‘subject content matter knowledge’ because it is recognized facts of the field, rational association with facts, concepts, and principles, it’s substantive and syntactic structures, related consistence structures and paradigms (Nicholson, 2001). PCK is a vital constituent of the knowledge base on science teaching (NSTA, 1998) and the science education is likely to mainly impact on teachers’ classroom actions (Gess-Newsome, 1999, p. 4).

This knowledge includes teachers who are teaching approaches that fit the particular content and arrange and present the content to suit the learners’ needs (Mishra & Koehler, 2006). Mishra and Koehler (2006) pointed out within a constructivist approach the PCK begins with a consideration of the students’ prior knowledge as the starting point for all teaching and learning process. The PCK includes the representation of concepts, pedagogical methods and theories of epistemology (Mishra & Koehler, 2006). Teaching strategies are selected to address students’ misconceptions and learning difficulties (Mishra & Koehler, 2006).

- Pedagogical Content knowledge covers knowledge of the following:
  - Learning;
  - Curriculum;
• Assessment of reporting;

• Expression of ideas (Harris, Mishra, & Koehler, 2007, p. 7).

An understanding of students’ prior knowledge, alternative teaching strategies, common content-related misconceptions that are associated with different content-based ideas, and the flexibility of discovering alternative behaviour of looking at the similar idea or problem and more, are all lexis of pedagogical content knowledge and they are crucial for effective teaching (Harris et al., 2007, p. 7).

3.2.4. Technological Knowledge (TK)

“Technology knowledge (TK) is knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video”. (Mishra & Koehler, 2006, p. 1027)

Unlike CK and PK, TK is in a constant state of change (Mishra & Koehler, 2006). The definition of TK is close to that of Fluency of Information Technology (FITness) as proposed by Committee of Information Technology Literacy of the National Research Council (NRC, 1996).

“FITness goes beyond traditional notions of computer literacy to require that persons understand information technology broadly enough to apply it productively at work and in their everyday lives, to recognize when information technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology” (Mishra & Koehler, 2006; NRC, 1996, p. 6).

Teacher educators and teachers in the 21st century need a well-developed knowledge of technology and therefore TK involves the skills needed to handle a variety of technologies. This knowledge can be used as a productivity tool, as a communication tool, as a research tool, and as a problem-solving and decision-making tool (Niess et al., 2008). TK includes a solid basic understanding of technology operations and concepts. Teachers require the skills that allow them
to effectively install hardware and software and use programs, such as word processors, spreadsheets, internet browsers, and e-mail (Mishra & Koehler, 2006). This knowledge is not limited to using keyboards, sending e-mails, and accessing the Internet, but rather is inclusive of the social, ethical, and human issues relating to technology.

This study focuses on how digital technologies are used by teachers and students in the classroom. Technology is advancing and continually changing every day. As such, the need to keep in touch with constant technological development has become a full time job, for everybody (Harris, Mishra, & Koehler, 2004). More ‘user-friendly’ software is required to diminish current software barriers impacting teachers (Swan & Hofer, 2006).

There are five common approaches that govern past and current attempts of technological integration, and include:

- **Software-focused initiatives**-Software, which provides individualized instructions while tracking students’ learning needs and progress;

- **Demonstrations of sample resources, lessons and projects**- That recommend curriculum-based lessons, projects, and online resources that have been used successfully by teachers;

- **Technology-based educational reforms** are often grant-funded projects, such as Apple’s Classroom of Tomorrow;

- **Structured/standardized professional development workshops or courses.** Large scale professional development initiatives such as Marco Polo and PBS’;
- Technology-focused teacher education courses. These can serve as recertification courses taken on an unclassified student basis or as element of graduate or undergraduate programme of education (Harris et al., 2004).

### 3.2.5. Technological Content Knowledge (TCK)

“Technological content knowledge (TCK) is knowledge about the manner in which technology and content are reciprocally related” (Mishra & Koehler, 2006, p. 1027). “An understanding of the manner in which technology and content influence and constrain one another” (Harris et al., 2004, p. 8). Technological changes have offered new images for understanding the world (Mishra & Koehler, 2006). TCK is considered as the manner in which technology and content influence and constrain one another. “Teachers need to understand which specific technologies are best suited for addressing subject-matter learning in their domains and how the content dictates or perhaps even changes the technology” (Mishra & Koehler, 2006, p. 1027).

TCK involves representing subject matter with an application of technology (Mishra & Koehler, 2006). Teachers must know the subject matter. However, when they incorporate the technology in their teaching approaches, the subject matter may change depending on the application of the technology (Mishra & Koehler, 2006). In this study CK is focused on the field of science education. TCK in this study therefore refers to the teachers’ knowledge of how technologies can be used in teaching science content areas. Teachers must understand what type of technology is best suited for subject matter learning (Harris, et al., 2007). Every new technology affects human cognition, for example, from the writing process of the computer to talking on the telephone; from the normal camera to the digital computer (Harris, et al., 2007). As technology develops, new metaphors and languages appear in the world (Harris, et al., 2007).
'T and C taken together produce Technological Content Knowledge. This kind of knowledge involves an understanding of the manner in which technology and content are reciprocally related to each other. Technology often affords newer and more varied representations and greater flexibility in navigating across these representations. Teachers need to know not only just the subject matter they teach, but also the manner in which the subject matter is transformed by the application of technology' (Koehler, et al., 2007, p. 6).

Teachers must decide according to the content what the best technologies suitable for the content are and how the content dictates or shapes the technological application. Therefore, these teachers must understand the three key elements: technology, content, and pedagogy (Harris, et al., 2007).

3.2.6 Technological Pedagogical Knowledge (TPK)

"Technological pedagogical knowledge is an understanding of how teaching and learning changes when particular technologies are used" (Mishra & Koehler, 2006, p. 1028). Thus, TPK requires an advanced, inventive and open-minded approach to exploring technology for the sake of advancing student learning and understanding.

TPK involves understanding the selected range of tools that must fit particular tasks in each lesson (Mishra & Koehler, 2006). This ability accommodates for teachers’ PK and strategies, and provides direction as to how teachers should be applying those strategies with technology (Mishra & Koehler, 2006). TPK includes knowledge of technology particularly in maintaining class records, such as attendance, and the use of technology that facilitate students to gain knowledge, such as the Internet, and chat room (Mishra & Koehler, 2006).

'A consideration of overlap between T and P results in Technological Pedagogical Knowledge. This knowledge emphasizes the existence, components and capabilities of various technologies as they are used in teaching and learning settings. This might include an understanding of a range
of tools exist for a particular task (e.g., fostering collaboration) as well as knowing what pedagogical strategies to get the most out of a piece of technology' (Koehler, Mishra, & Yahya, 2007, p. 743).

3.2.7 Technological Pedagogical Content Knowledge (TPACK)

“TPACK represents a class of knowledge that is central to teachers’ work with technology” (Mishra & Koehler, 2006, p. 1028). “TPACK is the basis of effective teaching with technologies; requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build existing knowledge to develop new epistemologies or strengthen old ones” (Koehler & Mishra, 2009, p. 9).

Teachers planning to teach using technology need the interaction of TK, CK, and PK (Niess, et al., 2008). TPACK is truly a meaningful and deeply skilled teaching with technology and it is different from knowledge of all the three concepts individually. Teachers need to build up their fluency and cognitive flexibility not just in each of these key domains but also in the manner in which these domains are interconnected, so that they can affect solutions that are responsive to specific contexts (Mishra & Koehler, 2006).

“TPACK for teaching with technology means that as teacher think about particular subject matter concepts, they are concurrently considering how they might teach the important ideas embodied in the concepts in such a way that the technology places the concept in a form understandable by their students”(Niess, et al., 2008, p. 8). The centre of the TPCK model culminates in the integration of all the three sources of knowledge - technology, pedagogy, content and describes technology integration in teaching and learning (Mishra & Koehler, 2006). The TPCK model may help teachers to develop a deeper understanding of the complex relation
between technologies, pedagogy, and content to improve the quality of teaching, and using this understanding, they can develop suitable context-specific strategies and representations. Teachers need to have a dynamic equilibrium between technological knowledge, pedagogical knowledge, and content knowledge to do quality teaching (Mishra & Koehler, 2006). Thus each teacher training course needs a unique combination of PK, CK, and TK. There is no single technological solution for teacher training course (Koehler & Mishra, 2009). Properly prepared lessons should produce advantages of exclusive features of teaching content with technology which otherwise they could not deliver quality lessons (Garofalo, Drier, Haper, Timmerman, & Shockey, 2000).

TPCK is the body of knowledge teachers need to teach with and knowledge about the use of technologies in teaching and learning. Content, pedagogy, and technology knowledge in TPCK are highlighted in the form of interconnection and intersection (teaching and student learning) (Shavelson, Ruiz-Primo, Li, & Ayala, 2003; Mishra & Koehler, 2006; Zhao, 2003) offered a more detailed explanation about the thinking related to TPCK. They describe four specific types of thinking:

- **Declarative** (knowing that include definitions, terms, facts, and descriptions);
- **Procedural** (knowing how, which, refers to sequences of steps to complete a task or subtask);
- **Schematic** (knowing why, by drawing on both declarative and procedural knowledge, such as principles and mental models);
- **Strategic** (knowing when and where to use domain-specific knowledge and strategies, such as planning and problem solving together with monitoring progress towards a goal) (Shavelson et al., 2003).
TPCK exists when particular technologies are used to understand how teaching and learning process can be improved. This includes how pedagogy and technology are used in relation to the lesson. Teaching with TPACK requires building a deeper understanding of pedagogical knowledge, content knowledge, and technological knowledge (Harris, et al., 2007).

In this study, the TPACK model described above, illustrates the importance of the integration of the three knowledge’s required to become an effective teacher. To identify an effective teacher, the technological standards for teachers as stipulated by the International Society for Technology in Education (ISTE) will be employed. The following section will describe the relevant standards employed in this study.

In this study, the TPACK model was used by the pre-service teachers to teach secondary science. When the pre-service teachers teach secondary science subjects, the three domains (T, P and C) were either treated independently or in integrated manner. Therefore, this model can be used in the teaching of secondary science in Sri Lanka, the level of technology used in their teaching is considered not as advanced as those used in the USA. This is due to the fact that the development of technology used for teaching in Sri Lanka is comparatively lower than those in USA.

3.3 Researching TPACK Model

There are a few studies conducted on this new area, among them two recent surveys explore how participants reflect about various constituents of the TPACK model (Mishra & Koehler, 2006). Both of these survey questions were designed to measure the T, P, C, individually and in relation with the PC, TP, TC, and TPCK constituent of the model. In the first survey, one of the researchers prepared a ranking scale in which the participants agreed or disagreed about their activity and thinking process. The second survey used ‘Discourse
Analysis’. Faculty members developing online courses worked together with masters’ students. The conversation analysis throughout the semester was conducted by (Koehler et al., 2007). In this research quantitative discourse analysis were carried out on 15 weeks of field notes for two of the design teams. Each statement is coded according to the following categories: Other (O), Content (CK), Pedagogy (PK), and Technology (TK) (Koehler et al., 2007). During the early weeks of the semester, the researchers found participants tended to focus on their area of specialty. Specifically, the technological specialist (the Ed-tech masters’ students) talked technology, Faculty members who were content specialists talked about content and pedagogical experts spoke about pedagogy (Koehler, et al., 2007). Later in the semester, the researchers found Technology Pedagogy and Technology; bodies of knowledge were no longer seen in isolation. These bodies of knowledge act together and become more evenly distributed for all three bodies of knowledge (Koehler, et al., 2007). According to, Shin, Koehler, Mishra, Schmidt, Baran & Thompson (2009) the in-service teachers gained deeper and more complex understanding of technological pedagogical content knowledge. Figure 3.2 shows the components of TPACK for science teaching (Nicholson, 2001), and the extensive range and different natural elements in science teaching. The TPACK model is a conceptual research program based on models for science teaching and learning.
Figure 3.2 Components of TPACK for science teaching (Nicholson, 2001).
Figure 3.3 A representation of how teachers' knowledge beliefs and values may affect their pedagogical reasoning (Cox, et al., 2003).

Figure 3.3 demonstrates “teachers’ knowledge bases, values, beliefs and reasoning processes, as well as interaction between teachers, students and ICT” (Cox, et al., 2003, p.2). Students’ own knowledge, belief and capabilities are the teachers’ knowledge base. To recognize
how a particular pedagogical approach works, it is essential to observe students’ ICT capacity that will show the use of ICT in their studies. Students’ potential with ICT will influence independent learning, meta-cognition skill, learning objectives for a particular lesson and students’ observation gives assessment of ICT for their learning (Cox, et al., 2003).

3.4 Technological standards for teachers

The International Society for Technology in Education (ISTE) has been preparing teachers to use educational standards that shape teachers to teach with technology. These standards are related to “the fundamental concepts, knowledge, skills, and attitude for applying technology in educational setting” (ISTE, 2000). The six standards introduced by ISTE are:

- Technology Operations and Concepts;
- Planning and Designing Learning Environments and Experiences;
- Teaching Learning and Curriculum;
- Assessment and Evaluation;
- Productivity and Professional Practice;
- Social, Ethical, Legal and Human Issues (ISTE, 2000).

An effective teacher is expected to achieve a minimum standard in integrating technology across the various aspects of their teaching which has a wide sphere of influence as indicated by the list above. Jasman (2002, 2002a) outlines nine features related to professional proficiency of an effective teacher. They are:

- Theoretical, practical and pedagogical knowledge;
- Focus of concern on studies;
- Pedagogical reasoning;
- Understanding of context
- Reflection and research on their knowledge and practice;
- Collaboration with colleagues and community;
- Being a change agent; and
- Orientation towards improvement of student learning (Jasman, 2002).

The frameworks such as those developed by Shulman, and Jasman, along with the technological standards help contribute to the understanding of TPACK model.

3.5 Summary

The TPACK model with specific reference to the three knowledge domains, CK, PK and TK are explored within this chapter and also describes interactions of three domains such as PCK, TCK, TPK, and TPACK. The TPACK model further dissected and discussed within the context of secondary science education and an overview of the original TPACK research is undertaken. This chapter also included the researching of TPACK model and technological standards for teachers.
Chapter Four

The Role of Digital Technologies in Teaching and Learning

Science

“Today in the twenty-first century, teacher preparation methods courses must assume the task of guiding pre-service teachers toward the abilities, strategies, and ways of thinking for teaching today and tomorrow”. (Niess, Lee, & Kajder, 2008, p. 2)

4.1 Overview of Chapter Four

This chapter begins with an overview of the secondary science education system in Sri Lanka by describing the organisation of science subjects across grades and the recent changes to the science curriculum to include greater emphasis on constructivism and the Five-E instructional model. The focus of this chapter is the influence of digital technologies on the teaching and learning process, and in particular the way we, think, learn and undertake tasks.
Factors that influence the role of digital technologies in education and in teaching Science and the implications for the school learning environment are explored. While the digital resources in Sri Lanka are limited the pervasiveness of new technologies to influence teaching approaches is examined. Lastly this chapter discusses present trends of using ICT in science education.

4.2 Introduction

“If we did not have computers, life would be very difficult because they help a lot with all the difficult subjects and make you understand problems better” (a 13 year old boy, as cited in Cox, 2000 p. 59). This quotation reveals a typical student’s perception of the important role computers play in learning difficult concepts. During the last 30 years, the role of ICT in education has extended, occupied, and covered many subject areas including science (Angeli, 2005). ICT can be used in teaching and learning to help students understand difficult concepts (Robertson, Webb, & Fluck, 2007).

Science education is playing an important role in improving the capacity of the future generations. Through science education students gain scientific knowledge and skills as well as an understanding of the nature of science and how science is relevant to all aspects of our lives. Consequently we need science teaching to be of a very high standard so students can learn and understand the subject. Science teaching does not only enable children to undertake scientific activities but also provides opportunities to improve their skills in critical thinking. The process of critical thinking involves analysis, synthesis and evaluation. It has been shown that this skill of critical thinking can be developed in students by challenging them to think through open-ended activities (Rusbult, 2008) Similarly, the concept of developing critical thinking can occur through active engagement of students in the activities (Rusbult, 2008).
Technology is the most commonly used word in the field of education today. Technology refers to “the use of tools, materials and processes to perform tasks efficiently, to improve quality of life, and to meet human needs and wants” (Williams & Williams, 1996, p. 32). Technological tools include those that do not rely on micro-processors such as blackboards, chalks, pens, papers, textbooks, and overhead projectors, and extend to more sophisticated tools that such as video, data projectors, computer discs (CDs), digital video disc (DVDs) and computers. The technological tools are all useful in providing rich learning opportunities (Krause, Bochner, & Duchesne, 2006). There is an emphasis on Information Technology (IT) resources that includes computers both hardware and software, and capacity of Web 2.0 resources and the wide variety of applications. Information and Communication Technology (ICT) “refers to any technology used to access, gather, and manipulate information, such as electronic hardware, software, and network connectivity (Krause et al., 2006, p. 527). According to Trilling (2006) ICT define that is innovation, collaboration and transformation (Trilling, 2006). Innovation learning are learning that produces innovators, where the learning process is innovative, and where the learning product is innovative.

4.3 Secondary Science Education in Sri Lanka

In Sri Lanka secondary education is divided into two sections: junior secondary – consisting of students from Grade 6 to 9; and senior secondary – consisting of students from Grade 10 to 11, as demonstrated in Figure 2.1 (Ministry of Education, 2005a). In the primary schooling system an environmental science syllabus is offered to Grade 6 students, which focuses on basic and social sciences. The environmental science teachers teach nine, 40 minute, periods per week. General science is introduced from grade 7 onwards and this syllabus includes basic principles of science. The course objectives are shown in Figure 4.1. These objectives are
written in the national syllabus and in the teacher’s guide to the national syllabus. This syllabus explains to teachers how and what they are teaching in their science lessons. There are three primary areas: For example, water, air, and plants. The scientific concepts and ideas introduced in Grade 7 are explored in more depth and detail in Grade 8 and 9 respectively. This build up, allows students to engage in more complex scientific ideas and concepts as students’ progress through their education. Science classes for Grade 7 to 9 are timetables into six periods of 40 minutes per week. General sciences for Grade 10 and 11 are divided into three main subject areas within one syllabus, Biology, Chemistry, and Physics. These three subject areas can be taught by one teacher or three teachers. The biology syllabus for Grade 10 contains four main topics while Grade 11 has five main topics. Grade 10 and 11 science classes are timetabled into six periods of 40 minutes per week. In 2007, the Five E instructional model was introduced into the Grade 7 secondary science syllabus (Ministry of Education, 2006a). In 2008, it was introduced to Grade 8 and Grade 11 (Ministry of Education, 2006a). From Grade 6 to 11 subject teachers evaluate student performance through the use of school-based examinations. After completion of Grade 11 students have to sit for G.C.E. (O/L) examinations, conducted by the Department of Examination.
On completion of this course, the student will be able to:

- Development scientific concepts and principles systematically through a joyful learning environment.
- Develop competencies related to problems solving by using processes in science and scientific method appropriately.
- Develop competencies pertaining to managing environmental resources intelligently by understanding the potential of such resources.
- Develop competencies related to understanding the scientific basis of the natural phenomena and the universe.
- Use appropriate technology to maintain efficiency and effectiveness at an optimum level in utilizing energy and force.
- Develop competencies related to evaluation of day to day life experiences and information acquired through media by employing scientific criteria with a back ground of limitations and dynamic nature of science.
- Develop competencies related to understanding the scientific basis of the natural phenomena and the universe.
- Use appropriate technology to maintain efficiency and effectiveness at an optimum level in utilizing energy and force.
- Develop competencies related to evaluation of day to day life experiences and information acquired through media by employing scientific criteria with a back ground of limitations and dynamic nature of science.

Figure 4.1 Course Objectives for Grade 6-11 Science (Source: The teacher’s manual Science year 7, http://www.nie.sch.lk/pages/menu.php, accessed 24/1/2012)

4.3.1 Sri Lankan Curriculum in Secondary Science Education

Before 2007, all schools in Sri Lanka followed the old curriculum that focused primarily on content and pedagogical knowledge. In 2007, curriculum reforms were introduced across all subject areas for both junior and senior secondary levels of the Sri Lankan school system. This new curriculum is based on the Constructivist theory and Five-E instructional model (Ministry of Education, 2006a). “Constructivism is not a theory rather an epistemology or philosophical
expansion about the nature of learning” (Schunk, 2004, p. 286). Rodger Bybee, a principle investigator of the Biological Science Curriculum Study team, developed an instructional model for constructivism, known as the “Five E” (Bybee, 2006a). In this model, the five “E words” represent: Engage, Explore, Explain, Elaborate, and Evaluate. The Five E model is used in conjunction with group work and project based teaching methods (Ministry of Education, 2006a). Unlike the pre-existing curriculum, this new curriculum allows for the integration of CK, PK and TK (Mishra & Koehler, 2006). According to my point of view, the new Five E curriculum provides a place for ICT to function as a transformational tool. Section 2.3.2 of this thesis discusses the pre-service teacher training program, including instruction on the new curriculum and the focus on constructivism and the 5E as a pedagogical approach.

The curriculum in place prior to 2007 aimed at improving the teaching of secondary science through subject content, which was split into two key areas; environmental studies for grade 6, and science and technology for grade 7-11. The learning-teaching process primarily focussed on transmission of information through textbooks, rather than practical situations. Student level of comprehension was exam oriented, rather than exploratory based learning. This curriculum faced drawbacks as it provided fewer opportunities for students to engage in the learning-teaching process. As a result of these limited opportunities, student abilities to acquire internationally accepted science process skills were compromised. The curriculum structure allowed for the omission of some essential basic scientific concepts in the course, which hindered systematic development of scientific concepts. The consequences of this curriculum approach lead to unsatisfactory levels of competency in secondary school science, for example, the environmental science introduced in Grade 6 primary level did not contributed to comprehension of basic scientific concepts.
• According to the proposed curriculum reform five periods have been allocated to teach science for grades 6-9 and six periods for grades 10 and 11.
• The learning – teaching process has been designed on an activity based approach.
• The expected learning-teaching methodology will be in accordance with the transformation role of the teacher. Activities designed on 5-E model have been provided through the Teacher Instruction Manual in order to implement the transformation role at the classroom level.
• The prescribed time to conduct one activity at classroom level will be more than one period. Therefore, it is emphasized that the sectional heads and school management to should take in to account the importance of allocating two adjacent periods for the successful implementation of activities at classroom level.
• It is a crucial factor that there should be excellent planning at grade level for the successful implementation of activities. It is wise to organize the activities with participation of all the teachers who teach science in parallel classes of a particular grade level.
• Principals/Sectional Heads are expected to provide instructional leadership to the teachers on developing plans to identify and obtained quality inputs and utilizing them before the commencement of each term.
• Some activities in particular need specific experimental setup and printed materials. It is therefore advisable to prepare and maintain a reserve of these materials with the participation of teachers in the parallel classes of particular level to maintain learning-teaching process efficiently.
• According to the new approach, students are not engaged in separate theory and practical sessions. It is expected to establish concepts, principles and theories through hands on practical experiences by way of proposed activities.
• Laboratory equipment as well as improvised and adapted setups are needed to carryout proposed activities. School management is responsible in providing such services and assistance within the school and from outside resources.
• As a measure of recognition of the articles that students prepare during the course of proposed activities. School management is responsible in providing such services and assistance within the school and from outside resources.
• As a measure of recognition of the articles that students prepare during the course of proposed activities, it is recommended to organize term end or year end exhibitions. This will encourage the students on further inventions.

With a view to extend learning beyond the activities done at classroom level and to highlight the students’ special abilities, it is expected to involve students in co-curricular activities such as debates, wall newspapers, magazines, school science societies, science days, science exhibitions etc.

Figure 4.2 School policies and programmes copied from the Grade 7 Science teacher manual (http://www.nie.sch.lk/pages/menu.php, accessed 24/1/2012).
The prime objective of the new curriculum reform was to alleviate these shortcomings and to minimize the curriculum gap between G.C.E (O/L) and G.C.E. (A/L). In order to achieve, measures to avoid the separation of theoretical knowledge and practical activities in science is required. The present curriculum reform is expected to provide opportunities to amalgamate the theoretical aspects and practical activities. The new methodology is unique as the science curriculum has been developed according to three distinctive features; competency based, activity oriented and student centred.

The science curriculum initially introduces general science to Grade 6-9, which becomes more subject specific for Grade 10-13. The more subject specific curriculum levels separate science into three main categories; Biology, Chemistry and Physics. These categories are presented as equally weighted modules for the Grade 10-11 G.C.E. (O/L) examination. The Science syllabi for grades 6-9 has been developed as a spiral curriculum based on the broad themes of:

- Organisms and life processes
- Matter, their properties and interactions.
- Earth and space.
- Energy, force and work.

The new curriculum reform consists of a set of competency levels, a continuum of content knowledge together with a set of activities which provide opportunities to extend the learning-teaching process beyond the classroom environment, as can be seen in Figure 4.2.
4.3.2 The Science curriculum and the pre-service teaching training program

In 1997 new educational reforms were introduced in Sri Lanka according to the recommendations of the National Educational Commission. These recommendations were based on findings of a public wide survey of the existing problems and issues in the education sector. The recommendations covered general education, university education, technical education and vocational education (Ministry of Education, 2005a). However, the National Educational Commission did not give any recommendations to pre-service teacher training programmes. The pre-service teacher training is a vital component of education and therefore must be given consideration when undertaking educational reforms. One of the National Educational Commission’s recommendations highlights the importance of teacher training. The recommendation to introduce ICT was undertaken by the Sri Lankan government and formally introduced into the school system in 2000. However pre-service teachers were not trained to use ICT leading to significant issues in the integration of ICT within the classroom environment. Only recently ICT has been introduced in NCOE, many of which experience various technology and computer shortages.

Digital students live in a significantly different environment from that of past generations. Nowadays students’ can communicate and access information from multiple sources through the use of various technological devices, such as, computers, smart phones, pagers, instant messengers, personal digital assistants (PDAs) and other handheld devices. Students communicate or connect with their teachers, friends, family, and others in the community and all over the world. Digital students now have a virtual world at their fingertips (Shelly, Cashman, Gunter, & Gunter, 2006). Shelly et. al., (2006) defines these “digital students or digital kids as kids who are (1) hyper communicators who use multiple tools to communicate, (2) multitask
who do several things at once with ease, and (3) goal oriented as they pursue multiple goals at
the same time” (Shelly, et al., 2006, p. 7)

Table 4.1

A comparison of the characteristic of previous and present generations with regards
digital skill

(Shelly et al., 2006, p. 2)

<table>
<thead>
<tr>
<th>Previous Generation</th>
<th>Present Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive communication</td>
<td>Hyper communication</td>
</tr>
<tr>
<td>Single taskers</td>
<td>Multitask</td>
</tr>
<tr>
<td>Work oriented</td>
<td>Play oriented</td>
</tr>
<tr>
<td>Lineal thinking</td>
<td>Random access</td>
</tr>
<tr>
<td>Non relevancy learning</td>
<td>Learning has not be relevant-</td>
</tr>
<tr>
<td>Relevancy was not critical-</td>
<td>and becomes fun to learn</td>
</tr>
<tr>
<td>Single sensory input</td>
<td>Multisensory input</td>
</tr>
<tr>
<td>Text–based first</td>
<td>Digital and graphic first</td>
</tr>
<tr>
<td>Reality based</td>
<td>Fantasy based</td>
</tr>
<tr>
<td>Conventional speed</td>
<td>Twitch speed</td>
</tr>
</tbody>
</table>

Teachers and students do not belong to the same generation. Teachers are from the
previous generation, whereas, students are from the present generation. Table 4.1 shows some of
the differences between these two generations with regards to the way they approach learning
and undertaking tasks. Because of the generational differences, it is very important for teachers to understand and treat the students as digital students. Teachers have two approaches they can implement when trying to reach digital students; they can pull their students away from their native digital world, or alternatively, they can motivate their students by tapping into their digital world and allowing them to use their understanding of technology as a foundation for personal learning and communication (Shelly et al., 2006). Today’s school system is slowly changing and there is lack of interaction between how teachers teach and how student learn (Shelly et al., 2006).

Today’s children are spending hours interacting with technologies as part of their everyday lives- including playing video games, sending or receiving emails and instant messaging and talking on digital cell phones. They are the digital natives- accustomed to technology being a part of their everyday lives (Prensky, 2001). The availability and use of new technologies means that these students do things like learning, thinking and undertaking tasks differently from their digital immigrant parents or teachers, and this has implications for the classroom.

4.3.4 The place of ICT in 21st Century Education

In the 21st century, computer technology and digital media play an essential role in education. All schools, regardless of their size, rely on computers to help them operate more efficiently and effectively. People use computers at home and in the work place for education, entertainment, information management, and business purposes. In addition, people use computers as a tool, tutor and tutee to access information and to communicate with others around the world. Computers and the computer related technologies used in the classroom are having a profound influence on the way teachers instruct and student learns (Shelly et al., 2006).
Table 4.2

Comparison of digital native learner and digital immigrant teacher.

<table>
<thead>
<tr>
<th>Digital Native Learner</th>
<th>Digital Immigrant Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefer receiving information quickly from multiple</td>
<td>Prefer slow and controlled release of information from limited</td>
</tr>
<tr>
<td>multimedia sources</td>
<td>sources limited tasking</td>
</tr>
<tr>
<td>Prefer parallel processing and multitasking</td>
<td>Prefer singular processing and single or limited tasking</td>
</tr>
<tr>
<td>Prefer processing pictures, sounds, and video before text</td>
<td>Prefer to provide text before pictures, sound and video</td>
</tr>
<tr>
<td>Prefer random access to hyperlinked multimedia information</td>
<td>Prefer to provide information linearly, logically, and sequentially</td>
</tr>
<tr>
<td>Prefer to interact / network simultaneously</td>
<td>Prefer student to work independently with many others</td>
</tr>
<tr>
<td>Prefer to learn “Just-in-time”</td>
<td>Prefer to teach “Just-in-case” (It is on the exam)</td>
</tr>
<tr>
<td>Prefer instant gratification and rewards</td>
<td>Prefer deferred gratification and rewards</td>
</tr>
<tr>
<td>Prefer learning that is relevant, instantly</td>
<td>Prefer to teach to the curriculum guide and standardized tests</td>
</tr>
<tr>
<td>useful, and fun</td>
<td></td>
</tr>
</tbody>
</table>


Source: (Shelly et al., 2006, p. 7).

Most teachers practice the traditional twentieth-century educational practice. Today, the world is a highly technological place. Therefore, teachers have to adapt and develop necessary skills to teach effectively. Table 4.3 lists some of the characteristics representing the traditional
approach to learning and the corresponding strategies associated with new learning environment for students (Shelly et al., 2006).

*Table 4.3*

*The difference between the traditional learning environment and the new learning environment.*

<table>
<thead>
<tr>
<th>Traditional Learning Environments</th>
<th>New Learning Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-centred instructions</td>
<td>Student-cantered learning</td>
</tr>
<tr>
<td>Single-sense stimulation</td>
<td>Multi sensory stimulation</td>
</tr>
<tr>
<td>Single-path progression</td>
<td>Multi path progression</td>
</tr>
<tr>
<td>Single media</td>
<td>Multi media</td>
</tr>
<tr>
<td>Isolated work</td>
<td>Collaborative work</td>
</tr>
<tr>
<td>Information delivery</td>
<td>Information exchange</td>
</tr>
<tr>
<td>Passive learning</td>
<td>Active /exploratory /inquiry- based learning</td>
</tr>
<tr>
<td>Factual, knowledge-based learning</td>
<td>Critical thinking and informed decision making</td>
</tr>
<tr>
<td>Reactive response</td>
<td>Proactive /planned action</td>
</tr>
<tr>
<td>Isolated, artificial context</td>
<td>Authentic, real-world context</td>
</tr>
</tbody>
</table>

Source: (Shelly et al., 2006, p. 10)

Shelley, et al. (2006) proposes that if teachers are trained to use and integrate educational technology and digital media, they will change from adopting the traditional teaching and learning strategies to using technology that can enrich teaching and make use of the characteristics that the new technologies can provide. The surrounding environments of digital kids’ are generally rich in audio, video and interactive media. These digital kids come to school expecting to use technology within the classroom. Class teachers can access technology to enrich the learning opportunities available to their students, allowing students to build up their
technological skills that will prepare them for the technology-driven global economy (Cooper & Bolick, 2003).

4.3.4 Goals, Rationale and use of ICT in Sri Lankan Education

Education is different from continent to continent and from country to country. But all of them have a similar goal with regards to the use of technology, which is to integrate the use of technology into the teaching and learning occurring within the classroom. Sri Lanka is a developing country with limited technological resources; however this is rapidly changing with the increasing availability of technologies. Currently resource availability is very low and Internet usage is also very low in Sri Lanka. The UNESCO report reveals that 8% of the Sri Lankan population have access to the Internet (UNESCO, 2008). This is because of the high cost of computers and consequent limited availability, and the low computer literacy among the Sri Lankan population. There is evidence of the use of ICT in business, but little evidence of the use of the Internet for instructional purposes. According to researcher observations, there is little access to the available Internet in Sri Lanka schools and NCOE’s.

The emphasis on the effective use of technology in the classroom is not premature, because our goal is to prepare our society for the future and the desire is to give a computer based education for all students. The rationale is to identify the need that all citizens have to be technologically literate and have ICT skills. This idea is reflective of UNESCO’s Second Generation Teacher Project. This project involves training pre-service teachers in ICT within the Asia Pacific region, with the primary focus on the implementation of ICT in the classroom environment. In this project, they demonstrate the appropriate use of ICT and the relevance of ICT–based curriculum for formal and non-formal educational settings (UNESCO, Bangkok, 2006).
“It is hoped that this section of both formal and non-formal educational programmes work in order to increase ICT and networks, enhance educational quality, and improve learning perfectly and traditionally most excluded from education” (UNESCO Bangkok, 2007, p. 1).

Four major rationales for the use of ICT for educational purposes are present in the UNESCO quotation:

**Strength of ICT;**
- ICT is a potentially useful and powerful set of tools.
- Access to information is crucial for all citizens.

**Community expectation;**
- ICT is part of our world, and
  - the community expect it
  - we (school) need to be seen using it
  - computers in all classrooms are a basic learning tool
  - Children do (and show) some of their work using ICT.
- But also, ‘You don’t have too many computers. Do you?’

**Children need ICT**
- ICT is a part of our world – children need to experience and use it.
  - They need to be able to use ICTs for future employment.
  - ICT skills are basic skill similar to literacy and numeracy.
  - The curriculum should embed ICTs.
  - Classroom practices need to be aligned with common practices, such as using word processing and internet.
ICT is strategic to the school;

- ICT is strategic to school purposes. It underpins the development of practice we will require to provide learning for the future. This requires;
  - developing staff competence
  - rethinking and redeveloping classroom practices
  - preparing for different teaching and learning arrangements

(Robinson, Tibanyendera, & Seltzer-Kelly, 2007, p. 48)

4.3.5 The effects of ICT in teaching and learning

ICT can be observed as an “idea amplifier” (Brown, Bransford, Ferrara, & Campione, 1983, p. 26) that supports or increases the time span of students’ cognitive processes and presents a complete learning environment (Lewis, 2000). ICT can enhance creativity abilities, namely synthetic, analytical and practical. These skills have been shown to be necessary for creativity (Sternberg, 1985). These skills can be used to develop students’ creativity and critical thinking. Creativity is an important factor in gaining a better understanding of science (Rusbult, 2008). ICT can be used effectively to understand science if students have the creativity, widespread availability of ICT information, and computer based learning situations.

Many students have experience with computers as a gaming tool, especially in the primary education where playful approaches facilitated by computers help students to prepare for future computer use and stimulate their creativity and imagination. The computer gaming industry is a fruitful industry. Billions of money is earned and billions of children play computer games. The Army of the United State of America use computer games to train their soldiers to attack their enemies, as they believe that this is a very practical method to train soldiers in different situations in the world (Computer games, Channel Ten Programme, Australia, 10th
September, 2007). Similarly, engineering students who studied the video game ‘Dr. Monkey Wrench.’ are able to easily master CAD (Computer Assistance Design) software (Prensky, 2001). These examples show how the incorporation of computer games can develop computer skills and help to enhance students’ learning abilities (Prensky, 2001). The digital immigrant teachers to become digital native teachers need to have technological knowledge as well as technological skills.

4.3.6 Technology Enriched Schools of Tomorrow

ICT can be observed as an “idea amplifier” that supports or increases the time span of students’ cognitive processes and presents a complete learning environment (Brown, Bransford, Ferrara, & Campione, 1983; Lewis, 2000). ICT can enhance the three abilities that are, linked to creativity, namely synthetic, analytical and practical. These skills have been shown to be necessary for creativity (Sternberg, 1985).

“Over the past two decades, the United States has expended ever-increasing amounts on education. However, an increasing percentage of students have dropped out and failed to complete high school. Many children who remain in school are not mastering basic academic skills, nor are they gaining higher-order thinking skills, proficiency in the arts of learning, or the ability to adapt to change. On average, our students continue to perform poorly on standardized tests when compared to students from other countries or even when compared to earlier generations of our own students” (ISTE, 1992, p. 1)

At present the situation in Sri Lanka is similar to that of USA in 1990. According to 2006 G.C.E. (O/L) examination results 50% students failed (Department of Examinations, 2006). In this context there is still a clear need for restructure within the Sri Lankan school system. In order to achieve more desirable learning outcomes, the Sri Lankan government has to identify an approach that makes sense educationally and financially. The Sri Lankan government should
recognize the need for improvement in its educational system and optimise the opportunities offered by educational technology.

Educational technology provides opportunity for equity, curriculum, assessment, learning environment, at-risk student, and student computer ratio.

- **Equity**: Educational technology program can be planned without regard to gender, race, ethnicity, socioeconomic status, mental or physical limitations, geographic location, or national origin

- **Curriculum**: Technology integrated curriculums have to be used and students and teachers have to take maximum advantage of technology.

- **Assessment**: Educational technology provides new ways of learning, higher-order thinking skills development, and wide variety of learning styles enhances students’ understanding. New assessment techniques can be developed to be reflective of new learning environments and to replace unadventurous tests.

- **Learning environment**: Offer opportunity for creativity, critical thinking, information access and manipulation, communication, and multisensory stimulation.

- **At-risk students**: Sri Lankan government should be strongly focused on using technology to reduce drop-out rates in schools.

- **Student-computer ratio**: Sri Lankan schools student to computer ratio is 137:1

4.4 Chapter Four Review

This chapter described the effects of ICT on teaching and learning and its place within 21st Century Education. The ideas of ‘digital natives’ and ‘digital immigrants’ are explored as well as the present condition of pre-service secondary science teachers’ training in Sri Lanka. A description of current barriers that affect the use of ICT in secondary science education is visited. Finally, an overview of the technologically enriched schools of tomorrow are explored within the confines of secondary science education in Sri Lanka, as well as the present teaching methods of Secondary Science Education in Sri Lanka.
Chapter Five

Research Design and Methodology

Where, however, a practical activity like education is concerned, the place of theory is totally different, it is not end product of the pursuit, but is rather constructed to determine and guide the activity (Hirst, 1971 p. 342).

5.1 Introduction

This chapter focuses on the research design and methodology chosen to research the effectiveness of using the TPACK framework to enhance the teaching of science using technology by pre-service teachers in Sri Lanka. This chapter is organized in five main sections. The first section describes the research design and shows the links between the aim and purpose of the research and the research design. This section describes the research framework according to Twining’s (2007) that shows the linkages between the different terms relating to research in social sciences and describes the rationale for the research methodology. The second section describes the research method – with a justification of the case study strategy and an overview of
the research plan. The third section describes the setting of the research including and the scheduling of the research. A description of the design and validity of the data sources is presented in the next section. The fifth section examines the variety of data sources, their design and validity.

5.2 Links to the Aims of the Research to the Research Plan

The study is exploring how best to prepare future teachers to integrate technologies into science education; to promote deeper learning and understanding of science that will be reflected in greater exam performance by students in the future. Both the need for stronger science understanding and a response to the demands of digital technologies to be used in education provide the rationale for this research study. This research focuses on the integration of ICT into secondary science education in order to improve the standard of teaching and learning in Sri Lankan schools. From the aim, purpose and the rationale of the research, the research methodology develops. The TPACK model suggests that for effective use of technology in teaching that will promote learning, it is important for all teachers to not only have well developed technological knowledge, pedagogical knowledge and content knowledge but also to be able to appreciate the connection among these three knowledge areas. This research explores the pre-service teachers’ understanding of these three knowledge domains and seeks to identify evidence that the TPACK model can enhance pre-service secondary science teachers’ pedagogy when integrating ICT into the teaching of science. In this research, the newly emerging framework of TPACK model is being trialled as a framework for secondary science pre-service teachers to apply to their teaching practice. The research plan gathers data about the pre-service teachers ICT and pedagogical and technological skills, and it monitors the change that occurs to the pre-service teachers as they try to apply this model in their teaching
Overall, an interpretive inquiry approach is used in this study with the researcher immersed in the research. This immersive approach influences all the choices made about the research design. An interpretive inquiry assumes "an in-depth understanding and deep immersion in the environment of the subject" (Thomas, 2011, p.124). The researcher is a participant observer, so the design, data collection, interpretation and analysis is influenced by his role and participation. This interpretive research seeks to understand the overarching research question: "Can the TPACK model be applied to help Sri Lankan secondary science pre-service teachers to become effective in using ICT?" It does this by gathering data, interpreting the data, and reflecting on the case as a whole. Teddlie and Tashakkori (2003) assert that the research questions can be useful in determining the research method; with the phrase ‘the dictatorship of the research question’ suggesting that the choice of methods are determined by deciding how best to tackle the research questions. They suggest that when selecting a research method for the study, rather than considering on the basis of theoretical considerations, it may be more useful to select a method according to research questions (Symonds & Gorard, 2010). In relation to this approach, the five sub-research questions will be examined with consideration to the data that may be useful in addressing them. They are:

1. What are the secondary science pre-service teacher’s technological skills, technological knowledge, and pedagogical knowledge in teaching and learning science?

2. What pedagogical practices are used in National Colleges of Education in Sri Lanka?

3. What changes, if any, happened to secondary science pre-service teachers’ technological skills, technological knowledge, and pedagogical knowledge after instruction in the TPACK model and after applying the TPACK model in teaching secondary science?
4. How do secondary science pre-service teachers apply elements of the TPACK model in secondary science teaching after instruction in the model?

5. What are the implications (if any) of using a TPACK instructional model for pre-service science teachers on their teaching of science?

These research questions address both exploratory (sub question 4) and confirmatory (sub questions 1, 2, 3, 5) questions. Table 5.1 (Symonds & Gorard, 2010) describes arrange of data types and their categorization—illustrating possible multiple categorization depending on the context, structure and analysis. The data that will be collected in this study includes quantitative data including questionnaires and qualitative data such as recorded interviews, observations, field notes, and video data. By planning, designing and postulating the possible types of data that need to be collected to address the questions the first step in identifying the research methodology is made, but this has not identified or developed the research methodology or design. Besta, 2010, explains, “research in itself can be neither qualitative or quantitative; only data can be described as either qualitative or quantitative” (p. 98). Commonly, elements of qualitative and quantitative research approaches are mixed resulting in a mixed methods research methodology (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the wide range reasons of breadth and depth of understanding and collaboration (Johnson et al., 2007, p. 118).

Research design is complex and designing a research study in response to research questions is consistent with a pragmatic approach that “fits well with a traditional and largely linear process of research” (Clark & Baidee, 2010, p. 280) and suits this research study, however it is criticized for being too simplistic. Determining possible types of data, such as the quantitative and qualitative data sets and how it will be collected and analysed constitutes part of
the research method, whereas the research methodology describes the framework in which the research design is embedded. The research method could be a sequence of data collection, processing, analysis and conclusion and this is outlined later in this chapter, whereas the research methodology includes a philosophical and conceptual framework that directs the research process of data collection, processing, analysis and conclusion. To justify further the appropriate research methodology four components must be interrogated, namely: purposes, guiding theories and beliefs, methods and validity as suggested by Maxwell and Loomis’s interactive model (p. 279, Figure 12.2 Clark & Badiée, (2010))

Table 5.1

<table>
<thead>
<tr>
<th>Perceptions of qualitative and quantitative (QQ) approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection Tool</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Close-ended/structured Questionnaire</td>
</tr>
<tr>
<td>Interview</td>
</tr>
<tr>
<td>Systematic observation</td>
</tr>
<tr>
<td>Document analysis</td>
</tr>
<tr>
<td>Official Statistics</td>
</tr>
<tr>
<td>Types of Data produced</td>
</tr>
<tr>
<td>Numerical</td>
</tr>
<tr>
<td>Categorical</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Analytical Techniques</td>
</tr>
<tr>
<td>Counting</td>
</tr>
<tr>
<td>Comparing</td>
</tr>
<tr>
<td>Statistical analysis</td>
</tr>
<tr>
<td>Type of Information Produce</td>
</tr>
<tr>
<td>Source: Death of mixed methods? Or the rebirth of research as a craft (Symonds &amp; Gorard, 2010)</td>
</tr>
</tbody>
</table>
5.2.1 Purpose of the Research

The purpose of the research is to better understand the social domain in which the teaching and learning is occurring, with this investigation exploring the social ontology occurring as interpretations are made. As Biesta (2010) explains, “the ambition of interpretive research is to generate understanding through an articulation of the intentions and reasons for action” p.104. The research takes place in a natural setting, with data collected over a period of time, to monitor the development of the pre-service teacher’s knowledge, skills, and application of the TPACK model in their teaching of science. Because the research is restricted to a particular place and time, and it is a situation that the researcher is closely connected to, the research can be accurately described as a case study (Thomas, 2011). This case study approach will draw heavily on quantitative and qualitative data to present a complete and holistic picture of the teaching and learning by pre-service teachers and lecturers in the use of the TPACK framework using ICT in science teaching.

5.2.2 Guiding Theories and Beliefs

The research design and methodology is drawn from Twining’s (2007) research framework (see Fig. 5.1) and also from Robson’s (1993) assertion that the purpose of a research decides the most suitable research methodology and design. Robson (1993) claims that quantitative research is positivistic natural science based on hypothetic co-deductive, and scientific method. A quantitative research usually involves experiment and survey as its common method of data collection. He also recognizes that qualitative research can be interpretive and ethnographic and that data in this context can be collected as case study, observations, and interview. Further, both qualitative and quantitative research can be mixed and matched
(Underwood & Underwood, 1990). However, Scott and Usher (1999) argue that qualitative and quantitative research has different foundations about ontology and epistemology.

*Figure 5.1 Relationship between different terms relating to research in social sciences* (Twining, 2007, p. 3)

The overview of this researcher’s research methodology is illustrated in Figure 5.2 shows the interrelation ships between the different terms relevant to this research. It is based on Peter Twining’s general research framework. In Twining’s model, an approach means the broad intellectual stance that informs the research. Twining (2007) refers this to the use of empiricist and interpretivist paradigms. In this research, the researcher has chosen to use an interpretivist approach. The case study strategy aligns well within an interpretivist research methodology. The case study strategy uses qualitative and quantitative data sources. A case study is an appropriate strategy to investigate the teaching practice, because it may not be consistent, there will be
individual differences. To get a holistic picture of the case multiple data sources will be collected. There are a number of advantages in the case study research approach, particularly in using multiple data sources to seek answers for research questions. The case study will provide detailed information about the case, it will be unique for that case and it provides a complete picture of the case. The case study is a good approach to generate a rich and detailed picture of the research situation and context. In a mixed method approach “the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches and methods in a single study or programme of inquiry” (Atkins & Wallace, 2012 p. 200) and while this is not inconsistent with the case study, this approach does not extend to the breadth, interpretation and analyses particular to the case study. The research sub-question 4 is exploratory questions and it is the ontological and epistemological perspectives of the constructivist paradigm that should be useful here in the analysis of data case study method.

5.2.3 Research Method

Research methodologies are guided by a paradigm that can be described as the perspective and shared belief system on which it is founded. A post-positivist paradigm (see Figure 5.1) is associated with quantitative research and claims knowledge based on cause and effect, thinking, reductionism, observation and testing theories (Creswell & Clark, 2008, p. 40). This contrasts to a constructivist paradigm “associated with quantitative approaches” and an “understanding or meaning of phenomena formed through participants and their subjective view” (Creswell & Clark 2008 p. 40). Morgan (2008), cautions about defining boundaries around paradigms, recognizing overlap between paradigms and suggests that they are “dynamic systems
of belief within a community of scholars” (p. 46) and therefore the value is in the researcher defining the paradigm for their study and their context.

**Figure 5.2 Elements used from Twining’s model**

(Twining, 2007).

In Figure 5.1, the interpretivist and empiricists or positivists are visually aligned with qualitative and quantitative data sources respectively. According to Creswell, Tashakkori and Green (2007) the differences in the methodological perspectives and the relationship to qualitative and quantitative (QQ) approach are summarized in the Table 5.1.

The constructivist paradigm is consistent with the need in this research study to explore the process of learning and adapting the TPACK framework to the teaching of science using ICT. The researcher recognizes that this research study is not a pragmatic linear process but rather more complex process that will be influenced by the mixing of quantitative and qualitative
data. There are five types of qualitative methods described by Anderson (2004), namely, Applied, Case study, Ethnography, Ground theory, and Phenomenology. The researcher uses only case study for this research.

5.2.4 Validity

A research method describes how the research design addresses the research questions accurately; how the data that will be collected should answer the research questions and how multiple data sets should consistently, answer the research questions repeatedly throughout the research process. The approaches to validity need to be appropriate for the research paradigm e.g. the actions and responses required for a post-positivist paradigm would be different to that for a constructivist paradigm, and at the data level, processes required to ensure validity for quantitative data may be different to that required for qualitative data, so that the validity for each particular data source must be established. “Traditionally, internal validity means that a research instrument accurately measures what it purports to measure and, thus, that the data are an accurate reflection of the phenomenon studied: without this, the conclusions of research are thrown into doubt” (Anderson & Arsenaut, 2004, p.). The validity of the conclusions are dependents on the validity of each part of the research process.

5.2.5 Rationale for the Research Methodology

There are five aspects of the research study that needed to be accommodated in the research methodology. They are there research questions, the ethnographic and social context of the study, accommodating the participant researcher, investigating a particular instance in time and space, and collecting multiple data using multiple methods.
Interpreting and developing the research questions helped to identify the need for both quantitative and qualitative data. The research questions map to the investigation of the effectiveness of the instruction of pre-service science teachers in the use of Information Communication Technologies (ICT). The study involves lecturers and pre-service teachers and students in the classroom and their experiences over the time of the study. Consequently the research design had to collect data that could adequately capture these experiences. The participant researcher is a member of the community in which the research is taking place, so the case study design allows for the researcher to be personally connected with the study. While the case study design does not allow for generalities, it can provide a detailed and holistic representation of the study which does address the need to explore how the TPACK model is understood and used by the pre-service teachers in their teaching. The research design accommodates multiple data sources so that a fuller picture of the relationships and processes can be investigated.

5.3 Research Method

In this research a case study is an appropriate methodology to provide a detailed understanding of the factors impacting of the research questions. The justification for this strategy is discussed and then the next section and then details do the research plan are provided.

5.3.1 Strategy

In Twining’s model a strategy means a research design using certain types of reasoning (Twining, 2007, p. 3). The strategy of this research is a case study because the characteristics of the case study approach match to the needs of this study. A case study is a holistic research method that uses multiple sources of evidence to analyse or evaluate a specific phenomenon or instance (Anderson & Arsenaut, 2004, pp. 115-135). This research was conducted largely in-situ
(Neumann, 1989). Case study is a strategy which employs qualitative and quantitative instruments to provide data which is subsequently analyzed through interpretive analysis. According to Robson, case studies have six characteristics (Robson, 1993, p. 52), which are:

- A strategy - i.e. a stance or approach is rather than a method, such as observation;
- Concerned with research, taken in a broad sense;
- Empirical in the sense of relying on the collection of evidence about what is going on;
- About the particular study of a specific case;
- Focussed on a phenomenon in context;
- Using multiple methods of evidence or data collection.

*Table 5.2*

*Robson’s case study classes*

(Robson, 1993, p. 147)

<table>
<thead>
<tr>
<th>Class</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual case study</td>
<td>Detailed account of person examines contextual, antecedent, per captions or attitude.</td>
</tr>
<tr>
<td>Set of Individual case studies</td>
<td>As the above, but a small number of individuals with features in common.</td>
</tr>
<tr>
<td>Community studies</td>
<td>Studies of one or more local communities.</td>
</tr>
<tr>
<td>Social group studies</td>
<td>Studies of both small direct contact groups and longer more diffuse groups.</td>
</tr>
<tr>
<td>Studies of organizations and</td>
<td>Studies of firms, work places, schools and similar</td>
</tr>
</tbody>
</table>
Institutions

Studies of events and relations

Focus on a specific event's overlap with the last two categories

In addition, Stake (1996) notes that case study is defined by interest in individual cases, not by the method of inquiry used. Lightfoot (1963) also argues that case studies can be applicable to research related to systematic educational problems.

In this research, the case includes the three NCOE’s, the secondary pre-service teachers training to teach secondary science, and lecturers who volunteered to participate in the study. This case study uses an interpretivist inquiry that systematically inquires into contemporary phenomena. This case study has three stages. Stage one is followed by Stage two and then Stage three. At each stage, the researcher made observations and took field notes in order to inquire how pre-service teachers apply the TPACK model in their teaching. The major focus of this study is on issues related to the technology component of the TPACK model.

5.3.2. Research Plan

The research plan shows how the research method is related to the research objectives and the data sources and the research questions. The study will collect multiple data sources such as interviews, observations, audio, and video data, to provide a rich and robust picture of the learning environment. The case study should provide insight into the impact of pre-service science teachers using the TPACK model in their teaching of science in Sri Lankan schools. The overview of the research is presented in Table 5.3. It includes the detail of the intervention being introduced and monitored, the timing of the data collection, the details of the institution, the level of the students, and the sample size.
Table 5.3 Research diagram of the case study research

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Institution</th>
<th>Period of study</th>
<th>Research Question being addressed</th>
<th>Method</th>
<th>Instrument</th>
<th>Data source and sample size</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire-Sample 01</td>
<td>1. College of Education (NCOE 1, 2, 3)</td>
<td>Before the workshops</td>
<td>1 and 2</td>
<td>Quantitative</td>
<td>Questionnaire Pre-service teachers TPK</td>
<td>Pre-service teachers 68 Pre-service teachers 15 Pre-service teachers 15</td>
<td>Answered to research question 1 and 2</td>
</tr>
<tr>
<td>Questionnaire-Sample 02</td>
<td>2. Teaching in practice schools</td>
<td>After the teaching practice</td>
<td>1 and 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questionnaire-Sample 03</td>
<td>3. Field training in schools</td>
<td>Mid of field training in schools</td>
<td>1 and 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interview</td>
<td>NCOE 1</td>
<td>Before the workshop</td>
<td>2</td>
<td>Qualitative</td>
<td>Interview</td>
<td>2 NCOE lecturers 2 NCOE lecturers 3 NCOE lectures</td>
<td>Answered to research question 3, 4, and 5.</td>
</tr>
<tr>
<td></td>
<td>NCOE 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCOE 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work shop</td>
<td>NCOE 1</td>
<td>September 08</td>
<td>3, 4 and 5</td>
<td>Qualitative</td>
<td></td>
<td>Observations of lecturers and pre-service teachers field notes</td>
<td>Answered to research question 3, 4, and 5.</td>
</tr>
<tr>
<td></td>
<td>NCOE 2</td>
<td>September 09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCOE 3</td>
<td>September 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample 01</td>
<td>NCOE 1</td>
<td>Sept 13 to October 31, 2008</td>
<td>4, and 5</td>
<td>Qualitative</td>
<td>Observations interview video</td>
<td>8 NCOE lectures and 68 pre-service teachers</td>
<td>Answered to research question 3, 4, and 5.</td>
</tr>
<tr>
<td></td>
<td>NCOE 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCOE 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample 02</td>
<td>Teaching practice in schools</td>
<td>Sept 1 to Dec 1, 2008</td>
<td>3, 4, and 5</td>
<td>Qualitative</td>
<td>Observations interview video</td>
<td>Five pre-service teachers from each NCOE</td>
<td>Answered to research question 3, 4, and 5.</td>
</tr>
<tr>
<td>Sample 03</td>
<td>Field training in schools</td>
<td>Jan 1 to March 31, 2009</td>
<td>3, 4, and 5</td>
<td>Qualitative</td>
<td>Observations interview video</td>
<td>Five pre-service teachers from each NCOE</td>
<td>Answered to research question 3, 4, and 5.</td>
</tr>
</tbody>
</table>
5.4 Research Data

According to Twining’s model, the term ‘method’ means techniques for collecting and analysing data (Twining, 2007, p. 3). This research used qualitative and quantitative instruments to collect a wide variety of data about the components of TPACK, and potentially, more data about the finer grained elements. Table 5.6 summarizes the data sources. To achieve rich information, the following analytical methods were employed:

- Primary research analysing of original qualitative and quantitative data;
- Secondary analysis of original data;
- Narrative commentaries describing and critiquing studies without quantitatively summarizing them;
- Research syntheses and meta-analysis quantitatively summarizing results of studies.
- In relation to these four methods, an analysis on the original primary quantitative and qualitative data collected from a non-experimental study was conducted.

5.4.1 Pre-service teachers’ Technical and Pedagogical Knowledge (TPK) questionnaire

This questionnaire of Pre-service teachers TPK was developed by the researcher and revised by the researcher’s supervisor. Initially the researcher included science content knowledge, but the content varied according to the topic that was being taught, so it was decided to focus only on Technological knowledge and skills and Pedagogical knowledge. This instrument aims to investigate pre-service teachers’ and lecturers’ technological skills, pedagogical knowledge, and technological knowledge.
### Table 5.4

**List of data sources**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Strategy</th>
<th>Type of Data</th>
<th>Instrument</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Survey sample</td>
<td>Quantitative</td>
<td>Questionnaire</td>
<td>68 Pre-service teachers</td>
</tr>
<tr>
<td>2</td>
<td>Survey sample</td>
<td>Quantitative</td>
<td>Questionnaire</td>
<td>15 Pre-service teachers</td>
</tr>
<tr>
<td>3</td>
<td>Survey sample</td>
<td>Quantitative</td>
<td>Questionnaire</td>
<td>15 Pre-service teachers</td>
</tr>
<tr>
<td>2 and 3</td>
<td>Sampe01</td>
<td>Qualitative</td>
<td>Observation Interview Video</td>
<td>68 Pre-service teachers in the workshop observe how they reflect by using ICT with TPCK model</td>
</tr>
<tr>
<td>2 and 3</td>
<td>Sample 02</td>
<td>Qualitative</td>
<td>Observation Interview Video</td>
<td>15 Pre-service teachers to observe three lessons</td>
</tr>
<tr>
<td>2 and 3</td>
<td>Sample 03</td>
<td>Qualitative</td>
<td>Observation Interview Video</td>
<td>15 Pre-service teachers to observe three lessons</td>
</tr>
</tbody>
</table>

The technological knowledge items in the questionnaire were adapted from “How do you think ICT can be used as educational tool” or the items were developed by the researcher. I started preparing technological knowledge items in the questionnaire by using my experience and supervisor advice. The items are designed to provide an indication of the students’ access to computers both at the NCOE and outside the NCOE, and their computer literacy skills at using computers. For example, the questionnaire investigates student’s use of communication software e.g. e-mail, the Internet, and how they can manipulate digital data. The pedagogical knowledge items were developed from the pedagogical content that is included in the pre-service training. This questionnaire has three sections, section A measures pre-service teachers’ and lecturers’ technological skills, section B measures pre-service teachers’ and lecturers’ pedagogical knowledge, and section C measures pre-service teachers’ and lecturers’ technological
knowledge. The items include multiple choices, and short answer type questions. The researcher
did a trail at Sri Pada NCOE with pre-service teachers.

The questionnaire responses provide data to address research questions one and two and
three of this study. The quantitative data are analysed using SPSS 17 software package
(http://spss.en.softonic.com/) to prepare descriptive statistics of the data. The questionnaire
reports student’s perceptions of their skills. The validity of the items is dependent on the
student’s correct interpretation of the items, and also the researcher’s inference’s made from the
results. Some items in the questionnaire have been omitted because they are not valid with
respect to the assertion being drawn from them. For example the number of fingers a student
uses on the computer is not necessarily a measure of their competence.

The short answer items were examined and coded using N-Vivo by the researcher. The
researcher identified a number of themes in the responses and then used these to code all the
responses. This coding was given to the supervisor who coded a sample of data – to confirm that
the coding process was reliable. The results showed good consistency in the coding between the
researcher and the supervisor, to indicate a high level of reliability. The responses were
quantified according to the frequency and the number of themes that were identified. This cross
member checking is essential to provide reliability and validity to the coding and the conclusions
that are drawn from the data. A sample of the questionnaire is provided in Appendix 1.

5.4.2 Interviews

In this research semi-structured interviews were conducted with NCOE lecturers and pre-
service teachers. The semi-structure interviews created opportunities for close researcher-
informant interaction. During the semi-structured interview, while the researchers personal
feeling/subjectively was connected; it provides a meeting space for the researcher and the
informant (Bums, 1996). When the researcher was conducting the semi-structure interviews, there were often unanticipated situations. The researcher needs in depth data from semi-structure interviews and this has been achieved by the use of prompts such as "tell me more" and "explain" in following points of concentration and help to capture informants thinking (Glesne & Peshkin, 1992). The interviewing purpose is to permit researcher to enter to the other persons’ viewpoints. Researcher can penetrate to the interviewee’s mind; it is possible to discover interviewee’s attitudes and believes (Cohen, Manion, & Morrison, 2000, p. 268).

In this research, 15 pre-service teachers and seven NCOE lecturers were interviewed. All the interviews were recorded and analysed using NVivo8 software. Interviews were conducted after the pre-service teachers conducted their secondary science lessons in stage two and three. These interviews were intended to seek answer for the second research question. The first question I asked from pre-service teachers was “as a secondary science pre-service teacher, are you using ICT in your teaching practice?” The first question I asked from NCOE lecturers was “As a NCOE lecturer, are you using ICT in your lectures? Please describe”.

The interview questions were relevant to this study because they were related to the research questions of the study. The interviews were recorded. The researchers listened to the interviews and recorded. Interviews were transcribed into Singhalese. The researcher identified themes in the responses various questions and coded all the data according the themes. Similarly to the TPK instrument, a sample of data e checked by the supervisor with regards the themes and the coding, this was done to assure the validity and reliability of the data.

5.4.3 Observations

“Unstructured observation is used to investigate any behaviour or event relevant to answering the research questions. This process is much more open-ended as with much the
subset of data research” (Hettiarchige, 2005, p. 122). The adoption of observations in this study was to provide the actual context and the nature of the ICT integrated in secondary science education in Sri Lanka based on the TPACK model. In this research, observation has provided the answers for the third, fourth and fifth research questions. In this research, the researcher observed the NCOE lecturers’ workshops, pre-service teachers’ teaching practice lessons with ICT and their field training lesson with ICT. The NCOE lecturers did not give permission for the researcher to videotape the workshops, but all the lessons conducted by the pre-service teachers were videotaped.

5.4.4 Videotaping

45 lessons conducted by the pre-service teachers were videotaped but for the purpose of analysis, 15 out of the 45 lessons were selected based on how these pre-service teachers used the TPACK model when they were conducting the lessons. Only 15 lessons were selected for the analysis because most of the lessons were very similar. The criteria for the selection was on the use of ICT in the selected lesson, that usually showed the best example of the students and teachers ability to integrate ICT into the lesson. I also considered the need to provide a variety of examples of ICT being integrated into science lessons across the three science domains - chemistry, biology and physics. Data derived from direct observation and video-taped of the 15 lessons were qualitatively analysed using NVivo8 software. These 15 lessons were then categorized by using scale designed by the researcher.

5.4.5 Field Notes

In this research, field notes were also taken during each and every event. Field notes include two types of materials (Bogdam & Biklen, 1998). One is descriptive materials, the other one is reflective. Descriptive field notes consist of a picture of the setting. The reflective field
note is how the observer captures the field structure of the mind, idea and concern (Bogdam & Biklen, 1998). For this research, field notes were collected descriptively and full effort was made to collect all details in the field note. “A major strength of the field note approach is that it is not rigidly structured. However, it allows the researcher to record specific information relevant to reflect on during the interpretation phase of data analysis” (Hettiarachige, 2005, p. 124).

Surveys used as a tool to probe current level of ICT usage among pre-service secondary science teachers in Sri Lanka, and to investigate the usefulness of the model and the stage in which it might be possible for them to apply the TPACK model in their teaching. While the data collected in this study is from pre-service science teachers only, there are links to professional learning, science teaching and teachers use of technologies.

5.4.6 Collecting and Analysing Data

According to the research method, the researcher collected data at each of the three stages. The first stage involved collecting whole cohort data from 68 pre-service secondary science teachers and seven NCOE lecturers. The sources of the whole cohort data were from TPK questionnaire which were utilized in all the three stages. The second and third stages of the whole cohort data were collected from using the TPK questionnaire to 15 pre-services teachers who volunteered to participate in this research. Three NCOEs were purposely selected in this research, namely the Sri Pada NCOE (referred to as NCOE 1), Seyana NCOE (referred to as NCOE 2), and Nilwala NCOE (referred to as NCOE 3). They were purposely selected because secondary science teacher training programs are offered in these colleges.
5.5 The Setting for the Research

The research is situated in Sri Lankan NCOE's. To introduce TPACK model to the Sri Lankan school system this research is paramount importance because it is intended to provide to inform future policies and change in practice.

5.5.1 The Participants in the Research

There are seventeen Colleges of Education in Sri Lanka. These colleges train pre-service teachers and issue a certificate of National Diploma in Teaching. In this study researcher observed how they teach secondary science in the Colleges of Education and how they teach science in the schools during their practical sessions. In this study researcher provided workshops for NCOE lecturers on how to use ICT with the TPACK model in secondary science education. NCOE lecturers conducted workshops for pre-service secondary science teachers on how to use ICT with the TPACK model in secondary science education. After the workshops researcher observed, with the aim of introducing the TPACK model as a basis for their professional practice, how they used ICT to teach secondary science. To train the pre-service teachers, NCOE lectures used face to face workshops. In this study, researcher aims to identify the college of education lecturer's intentions about use of ICT to teach secondary science and train them to use ICT in their class and how pre-service teachers teach using ICT with TPACK model.

5.5.2 Research Sites

The research sites are at the three NCOEs. The three NCOEs that participated in this research are the Sri Pada College of Education, at Pathana, the Siyana College of Education, at Wayangoda and the Nilwala College of Education, at Matara, in Sri Lanka. The selection of the three colleges of education was based on the reason that they provide pre-service training to
secondary science teachers. In stage two of this research, the pre-service teachers conducted secondary science lessons at two schools near the NCOE, while in stage three they conducted secondary science lessons in their field training at selected schools. For the purpose of this research, these settings are labelled as NCEO 1, 2 and 3. The following section will provide the description of the three NCOEs involved in this research.

Table 5.5

<table>
<thead>
<tr>
<th></th>
<th>NCOE 1</th>
<th>NCOE 2</th>
<th>NCOE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Pathna Sri Lanka</td>
<td>Pathalagathera</td>
<td>Kaburupitiya</td>
</tr>
<tr>
<td>Province of the</td>
<td>Central Province</td>
<td>Western Province</td>
<td>Southern Province</td>
</tr>
<tr>
<td>location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>District of the</td>
<td>Nuwara Eliya</td>
<td>Gampaha</td>
<td>Matera</td>
</tr>
<tr>
<td>location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance from</td>
<td>140 km</td>
<td>45 km</td>
<td>150 km</td>
</tr>
<tr>
<td>Colombo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Pre-</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>service teachers in focus group</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.5.2.1 Data

In this research questionnaires are used to collect more information and also reliable, valid data in sample and cheap and time saving method (Anderson, 2004). In this quantitative instrument (questionnaires) to measure pedagogical knowledge, technological knowledge, and technological skills of lecturers and pre-service teachers to the use of ICT with TPACK model in science lessons in classrooms.

5.5.2.2 Setting of NCOE 1

NCOE 1 is Sri Pada National college of Education. This National College is located at central hills of Sri Lanka. Sri Pada National college of Education is 135 km away from
Colombo. This college is situated in between Hatton and Nuwara Eliya towns. This college of education was newly constructed in 1980 decade. This NCOE has been built with the aid of the German Republic aids programme. Sri Pada National College of Education is situated in a very beautiful location. In this college, the medium of instructions are Tamil and Sinhala. For this research, the 2nd year science Sinhala medium pre-service teachers were invited to participate in the research. During the period this research, there were only 25 pre-service teachers following the 2nd year science Sinhala medium teacher training programme. The pre-service teachers were between 20 to 23 years old and they all got through G. C. E. (A/L) examination in science stream.

NCOE 1 has only one big computer laboratory but most of the computers are between four to five years old. NCOE 1 has one computer with Internet connection which is very slow. The computer laboratory is also equipped with two printers; one is dot printer (ribbon) and other one is bubble jet printer. Printing is not allowed to pre-service teachers at NCOE 1.

5.5.2.3 Setting of NCOE 2

NCOE 2 is Seyna NCOE, located in Gumphia District in the Western Province. It is 45 km away from Colombo and situated between Nitambuwa and Weyangoda. NCOE 2 was previously a teacher training college and it was converted to NCOE in 1980. NCOE 2 has two well- equipped computer laboratories with all the facilities. However, the pre-service teachers were not given the permission to access these laboratories by two lecturers who controlled the laboratories. These laboratories are under responsibility of two lecturers. NCOE 2 also has multimedia projector. NCOE 2 has programmes for primary, secondary science, secondary maths, and ICT education courses for pre-service teachers which are conducted in either Sinhala or English languages (Ministry of Education, 2005a).
5.5.2.4 Setting of NCOE 3

NCOE 3 is Nilwala NCOE, located at Matara District and Southern Province. It is 170 km away from Colombo and situated in between Akkurassa and Hakmana towns. The NCOE 3 has programmes for primary, secondary science and secondary maths courses for pre-service teachers, delivered in Sinhala language (Ministry of Education, 2005b).

5.6 Stages of Research

The research collected data over a 12 month period. The research plan is divided into three stages. In stage one; the research was conducted at the NCOEs’ where lecturers and pre-service teachers at the selected institutions were introduced to the TPACK model and the use of ICT in their teaching practices. Then the second stage was conducted at the schools where the pre-service science teachers conducted their lessons using ICT with TPACK model. Finally, stage three was carried out at the schools where the pre-service teachers went for their field training. During the school teaching practices and the third stages, the researcher observed and video-taped how the pre-service science teachers conducted their lessons according to TPACK model. The next section outlines the research activities carried out in the three stages.

5.6.1 Stage 1

Figure 5.3 illustrates the research activities involved in stage one of this research. Specifically, the activities are indicated as follows.

- The researcher invited three NCOE institutions that train Pre-service secondary science teachers and NCOE lecturers to participate in this research.

- The researcher worked with the 8 NOCE lecturers, from three NCO’s and gave instruction on the introduction of the TPACK model.
• Each lecturer conducted a workshop on the implementation of the TPACK model for the pre-service secondary science teachers.

• After the lectures we had group discussion - myself, the lecturers, and the pre-service teachers had a discussion about TPACK model.

• The researcher invited 25 pre-service teachers randomly from each of these NCOEs. (They were studying in their 2nd year at the NCOE). The total participants were 75 pre-service teachers.

• The researcher prepared a questionnaire to measure their Pedagogy, Content, Technology, and Technological Pedagogical Content Knowledge and the researcher invited them to answer the questionnaire. The questionnaire was administered to lecturers and pre-service secondary science teachers. It was administered at three stages, at the beginning, middle and at the end of the research. The result of first survey would inform the method and approach to prepare the workshops for the eight NCOE lecturers and 68 pre-service secondary science teachers.

• The researcher organized three workshops for the eight NCOE lecturers.

• The NCOE’s lecturers organized workshops for the 68 pre-service secondary science teachers.

• At the same time, the researcher administered the questionnaires to 68 pre-service secondary science teachers and lecturers.

• The researcher had undertaken a case study when the NCOE lecturers conducted the workshop to the pre-service teachers.
5.6.2 Stage 2

The research activities conducted in Stage 2 are shown in Figure 5.4 below. The activities are as follows;

- The researcher randomly selected five pre-service teachers from each NCOE.

- When the pre-service science teachers were on teaching practice, the researcher invited them to conduct lessons using ICT with TPACK model.

- The researcher had undertaken my case study when the pre-service science teachers were conducting lessons using ICT with TPACK model.

- At the same time, the researcher distributed questionnaires to the five pre-service secondary science teachers and lecturers.
5.6.3 Stage 3

The respondents for this research during Stage 3 were the pre-service science teachers who had completed their two years pre-service and they were undergoing field training at schools. During their field training, these pre-service teachers had to conduct five lessons per week. Figure 5.5 illustrates the activities involved in Stage 3.

These activities are:

- The researcher observed the three classes of 15 pre-service secondary science teachers’ secondary science lessons and the researcher had undertaken my observations, took field notes, and videotaped the lessons.

- At the same time the researcher gave questionnaires to pre-service secondary science teachers and their lecturers.

*Figure 5.5 Stage three of the research*

5.6.4 Data Collecting and Analysing the Data

The site of the research is considered as appropriate because data collected was conducted at colleges where pre-service teachers are undergoing teacher training. The multiple data sources derived mainly from the subset of data provide a rich and robust picture of the
learning environment. In this research, the subset of data methods and varieties of empirical data such as interviews, observational, audio, and video texts were collected in three stages. In stage one, data were collected from the survey, observations, and interview. The researcher made direct observations and videotaped the NCOE lecturers after conducting workshops to introduce the TPACK pedagogical approach to the pre-service teachers. In stage two, the secondary science pre-service teachers undertook teaching practices in schools, and conducted classes according to TPACK model using ICT. During this stage, the researcher observed and videotaped their lessons. In stage three, while the secondary science pre-service teachers did their field training in schools, the researcher observed and videotaped their lessons. The collected videotapes were analysed using NVivo 8 software. The following section describes the sources of qualitative data collected for this research, namely the interviews, observations, and field notes.

In this case study, how pre-service teachers used ICT with the TPCK model was estimated. At the same time the advantages and disadvantages of the TPACK model were investigated. Specifically, the investigation focussed on the effectiveness of the TPACK model based on observations and analysis of data in relation to knowledge domains of the TPCK model:

- Effective use of ICT with the TPACK model in the class room.
- Pre-service teachers can use ICT with the TPACK model to enhance secondary science lessons effectively
- Learning and making of units of work and assessment linking to the relevant curricula or syllabuses.
- Potential opportunities for pre-service teachers to access through ICT with the TPACK model

5.6.5 Language

All instructions are in Sinhalese. The TPACK instruments were written in English and translated into Sinhalese for administration to the participants; the responses were processed and analysed in Sinhalese. Similarly the observations notes were all made in Sinhalese. The researcher has translated into English for the writing up of the results. The pre-service teachers conducted the secondary science lessons in Sinhalese school in Sri Lanka where 99% of students were Sinhalese. Throughout the research, every effort had been taken by the researcher to carry out this research without having any discrimination or racial segregation giving a genuine importance to protect humanity and equality. The researcher conducted the research in Sinhalese language and translated all the English language documents into Sinhalese language.

5.7 Data Analysis and Representation

After the analysis, the researcher interpreted the questionnaire data. The field notes and video tape were raw data and they were coded, analysed and triangulated, to make inferences and possible assertions. Careful observations of these triangulated data were conducted in order to derive logical assertions. The conclusions for this research were drawn based on the assertions made by the researcher see Figure 5.6.
Figure 5.6 Structure of this research

Five Research Questions

Whole Cohort data

TPACK Questionnaire
- Technological skills
- Pedagogical knowledge
- Technological knowledge

Selected subsets of data

- Classroom observations
- Field Notes
- Interview data
- 15 secondary lessons of 15 PST
- 15 PST
- 15 PST
- 15 PST

data to address RQ 1 and 2

data to address RQ 3, 4, 5

ANSWER THE FIVE RESEARCH QUESTIONS
5.8 Reliability and Validity of Data

In this research, both the quantitative data and the qualitative data were used. Questionnaire and case study procedures were used to collect data. In this case study, multiple data sources were used as well (Anderson & Arsenaut, 2004). The researcher collected data from questionnaire, observations, interviews, audio, and video recordings. The following table shows the validity and reliability of this research according to (Anderson & Arsenaut, 2004).

Table 5.6

<table>
<thead>
<tr>
<th>Approach</th>
<th>Reliability</th>
<th>Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire</td>
<td>In this research questionnaire direct forward multiple-choice questions are answered explaining why you selected the answer.</td>
<td>Pre-service teachers TPK was developed by the researcher and revised by the associated supervisor.</td>
</tr>
<tr>
<td>Interview</td>
<td>In this research researcher was the interviewer. The researcher has skills on interviewing people. The researcher conducted semi-structured interview. The researcher did an interview with the NCOE lecturers and pre-service teachers.</td>
<td>The researcher interview questionnaire if pre-service secondary science teachers answered less than 5% of questions. The researcher would omit these questions.</td>
</tr>
<tr>
<td>Observation schedule</td>
<td>The researcher did the observations - a single observer approached.</td>
<td>The researcher observation field notes and video</td>
</tr>
<tr>
<td>Participant observation</td>
<td>The researcher has experience doing participant observations in more than one year.</td>
<td>The researcher did the research in NCOE’s and schools. The researcher didn’t do any interpretation. The researcher’s supervisor cross checked the observations.</td>
</tr>
</tbody>
</table>
5.9 Ethical Issues

In this research, the researcher was responsible for research ethics. The term ethics is defined in the Webster’s new World Dictionary as reported in “conforming to the standards of conduct of a given professional group” (Fraenkel & Wallen, 2003, pp. 56-57). To ensure ethical conduct throughout the research process, the following guidelines posited by Fraenkel & Wallen (2003) were taken into consideration.

- When conducting research, the researcher has the responsibility to evaluate the research process with respect to any ethical concerns.

- According to recognized standards, a participant in a planned study is subjected to risk or minimal risk; the researcher to consider this as the primary ethics.

- Researcher has a responsibility in ensuring my research to conduct ethically. Also the researcher has a responsibility for ethical treatment of research participants, lecturers, pre-service teachers, students and employers.

- Except in minimal-risk research, all the participants in the research have to establish a clear and fair research agreement with the researcher. The agreement must be clarified the obligations and responsibilities of each party. The researcher has the obligation to honour all promises and commitment included in the agreement. The researcher has to make full disclosure, prior to obtain informed consent, which requires additional safety to protect the welfare and dignity of the research participants. Whether researching with children or with participants, the researcher would implement and limit understanding and/or communications that are required for special safeguard procedures.
• In this study, the researcher will not make necessary use of concealment or deception. The researcher has special responsibility to: (i) determine whether the use of such techniques are justified by the study’s prospective scientific or educational value; (ii) determine whether alternative procedures are available to use concealment or deception; (iii) to ensure that the participants provide sufficient explanations as soon as possible.

• The researcher respects the rights of any individual to refuse to participate in my study or to withdraw from participating at any time. The researcher’s obligation in this regard is especially important when he or she is in a position of authority or influence over the participant in a study. Such positions of authority include, but are not limited to, situation in which research participant is required as part of employment or in which the participant is a student, student teacher, lecturer or employee of investigator.

• The researcher’s responsibility is to protect all participants from physical and mental discomfort, harm, danger that may arise from participating in my study. In this research, the researcher informs all participants, how to conduct the research within a responsible time period. Participants should not have any stress or potential harm from the procedure.

• In this research after the data collection, the researcher will be responsible to provide all participants with information about the nature of the research and do his or her best to clear up any misconceptions that may have developed. The researcher make sure that scientific or human values justify delaying or withholding this information, and the researcher have special responsibility to observe carefully the research and to ensure that there is no significant damage for the participant.
• In these research procedures in case of objectionable effect for any participants, the researcher has the responsibility to detect, remove and correct this consequence, including long term effects.

• In this research, information obtained about the research participants during the course of investigation is kept private and confidential. In all publications relating to this research, will use pseudonyms to protect identity of the participants.

The above mentioned are the general ethics in this research but the researcher has considered the following ethics guidelines -:

• The researcher is responsible to inform the NCOE lecturers and presidents not to tell the pre-service teachers and the principals that the researcher is the project officer of the National Institute of Education in Sri Lanka and the researcher is not using his position as a power to conduct my research.

• The researcher is responsible to seek permission for this research from the Ministry of Education of Sri Lanka before conducting this research and also the researcher took consent letters from the presidents of the three NCOE’s, lectures of the three NCOE’s, pre-service teachers, principals of the schools and parents of the students.

• For this research project, the researcher has obtained ethical approval from the National Ethics Australian Foundation (NEAF). (EC00213) (ID: swarswar)
Table 5.7

**Proposed research plan according to TPACK model component**

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>TPACK model component</th>
<th>Researchers classroom observation</th>
<th>Researchers observation</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>Pedagogical Knowledge</td>
<td>How does a pre-service teacher use teaching methods in the classroom during the lesson? Their lesson plans and its standards. How do students construct their knowledge and acquire skills? How do they develop behaviour of mind and constructive dispositions towards learning?</td>
<td>Present teachers have pedagogical knowledge. They use at least a blackboard as the teaching aid.</td>
<td>Questionnaire, Case study, Interview, audio and video.</td>
</tr>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>Content Knowledge</td>
<td>How does a pre-service teacher use content according to the lesson and lesson plan? Pre-service teacher’s content knowledge is sufficient to conduct the lesson.</td>
<td>Teachers have content knowledge but it varies according to the educational situation and their interest.</td>
<td>Questionnaire, Case study, Interview, audio and video.</td>
</tr>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>Technological Knowledge</td>
<td>How does a pre-service teacher use ICT according to the lesson and lesson plan? How much are they familiar with ICT? How does a pre-service teacher use educational software in the classroom? How does a pre-service teacher use Internet for classroom teaching?</td>
<td>Most of the teachers do not have technological knowledge.</td>
<td>Questionnaire, Case study, interview, audio and video.</td>
</tr>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>Pedagogical Content Knowledge</td>
<td>How does a pre-service teacher interpret the subject matter? How does a pre-service teacher represent the lesson? What type of teaching aids does a pre-service teacher use during the lesson and does that match with the lesson content?</td>
<td>Most of the teachers use pedagogical content knowledge when they are teaching in the classroom but it varies from person to person.</td>
<td>Questionnaire, Case study, interview, audio and video.</td>
</tr>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>Pedagogical Technological Knowledge</td>
<td>How does teaching and learning changes when particular technologies are used? How does a pre-service teacher’s use of ICT Table 5.2. ICT for specific pedagogical purposes? How do Pre-service teachers use ICT for their own pedagogical purposes?</td>
<td>PTK is introduced newly but according to my knowledge, most of the teachers have pedagogy but when they use pedagogical technological knowledge they</td>
<td>Questionnaire, Case study, interview, audio and video.</td>
</tr>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>Content Technological Knowledge</td>
<td>How does a pre-service teacher use content of lesson and ICT according to lesson and lesson plan?</td>
<td>CTK is introduced newly but according to my experience, most of the teachers have content knowledge but they have lack of knowledge on ICT. Due to that, content technological knowledge is poor in most teachers.</td>
<td>Questionnaire, Case study, interview, audio and video.</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>01, 02, 03, 04, 05</td>
<td>TPACK</td>
<td>How about pre-service teachers’ understanding of teaching with technology? How do pre-service teachers teach successfully with technology creating, maintaining, and re-establishing a dynamic equilibrium between each component</td>
<td>As TPACK is introduced recently The researcher thought whether the research is applicable or not to Sri Lankan condition</td>
<td>Questionnaire, Case study, interview, audio and video.</td>
</tr>
</tbody>
</table>

5.10 Research Methodology

Table 5.7 provides a summary of the proposed research methodology. The table shows how the research questions relate to the TPACK theoretical framework and also how the various data sources connect to the various research questions. Multiple data sources are used to address each research questions, and provide greater reliability for the results.

5.11 Summary

In this chapter, the research methodology has been discussed. The research methodology includes the aims of my research and my research questions. To ensure goodness of fit of the research methodology, the description of the research methodology and design has been divided into three sections that are the approach, strategy and method. To seek answers for the research
questions, data were analysed from the whole cohort and the selected subset. This chapter also described the research site, research design, data collection, data analysing and representation, reliability and validity of data and ethical issue.
Chapter Six

Results and Analysis of Stage 1

The use of technology is so common that to compare its use to current non-technological practice would be equivalent to comparing instructions with books to the same amount of instructions without books 20 years ago.

(Berger, Lu, Belzer, & Voss, 1994, p. 486)

6.0 Overview Introduction

This chapter presents data to provide a picture of the case study using quantitative data and the qualitative data that are used to address the research questions 1, 2 and 3. This chapter focuses on Stage 1 of the research study. The following Chapter 7 looks at Stage 2 and Stage 3 of the research study. The results in both chapters are presented in a chronological manner, telling the story of the research process. Data is used to provide evidence to support the description for
each of the three stages of the research. In this chapter, the first section describes the facilities and the resources available at each NCOE where Stage 1 of the research initially takes place. Second section describes the instruction given to the lecturers at the NCOE and their technological skills and technological and pedagogical knowledge and attitude to introducing the TPACK framework. Pre-service teachers in stage 1, the following three sections look at the pre-service teachers knowledge and skills, at the beginning of the study, with the next section describing the pre-service teachers’ technological skills with data derived from Technology and Pedagogical Knowledge TPK questionnaire. Part B focuses on practice of pre-service teachers ICT application in 15 secondary science lessons. 15 pre-service teachers conducted 45 lessons in this research stage 2 and 3. Out of 45, 15 lessons according to their TPACK application were analysed. The fourth section describes the pre-service teacher’s technological knowledge, and then the next section describes the pre-service teacher’s pedagogical knowledge. This data presents the knowledge and skill level at the beginning of the research study and therefore provides useful baseline data so that a comparison can be made of their pedagogical and technological knowledge after Stage 2 and Stage 3 of the study.

6.1 The Facilities and Resources

The case study research begins at Stage 1 in three locations – at each of the NCOE’s (as described in Table 5.5). The research study is situated in Sri Lanka – a developing nation with limited technological facilities. Data in Table 6.1 show that the 84% of pre-service teachers surveyed use desk top computers in their daily activities. Half of the pre-service teachers surveyed have computers at home. More than half of the population of pre-service teachers accessed computers outside of the NCOE, but only 37% of pre-service teachers had computers at NCOE. Digital video cameras are very expensive so most of the NCOE’s had only one
instrument. Because of that, most of the pre-service teachers did not get the opportunity to operate them. In the interview data both the lecturers and pre-service teachers mentioned a lack of facilities and resources. According to Table 6.1, the percentage of pre-service teachers who have Internet access at NCOE and at home were, 40% and 31% respectively (item 5.7 and 5.8). The use of the Internet in Sri Lanka is very slow and expensive. The data indicates that the NCOE’s have limited ICT facilities available for teaching and learning process. The data for the three NCOE’s show that that the problem of limited facilities is similar at all three locations.

The data indicates that there are technologies available (see Appendix IV), although some are old technologies and in light of the government policy to include technologies in teaching, there is a need to prepare teachers to use technologies effectively in their teaching. The current lack of facilities and resources, while limiting is not an issue considering the importance of training future teachers in how to use the technologies effectively in teaching.

*Table 6.1*

*The percentage of pre-service teachers using hardware and accessing services (N=68)*

<table>
<thead>
<tr>
<th>Item No</th>
<th>Test Item</th>
<th>Total (Agree) %</th>
<th>NCOE 1 %</th>
<th>NCOE 2 %</th>
<th>NCOE 3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Using desktop computers</td>
<td>84</td>
<td>83</td>
<td>87</td>
<td>81</td>
</tr>
<tr>
<td>5.2</td>
<td>Using laptop computers</td>
<td>27</td>
<td>22</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>5.3</td>
<td>Using Scanner</td>
<td>32</td>
<td>22</td>
<td>52</td>
<td>23</td>
</tr>
<tr>
<td>5.4</td>
<td>Using Printer</td>
<td>41</td>
<td>39</td>
<td>43</td>
<td>41</td>
</tr>
<tr>
<td>5.5</td>
<td>Using Digital Camera</td>
<td>63</td>
<td>35</td>
<td>78</td>
<td>77</td>
</tr>
<tr>
<td>5.6</td>
<td>Using Digital Video Camera</td>
<td>32</td>
<td>26</td>
<td>44</td>
<td>27</td>
</tr>
<tr>
<td>5.7</td>
<td>Internet access at NCOE</td>
<td>40</td>
<td>30</td>
<td>48</td>
<td>27</td>
</tr>
<tr>
<td>5.8</td>
<td>Internet access at home</td>
<td>31</td>
<td>30</td>
<td>46</td>
<td>18</td>
</tr>
<tr>
<td>5.9</td>
<td>I have a computer at NCOE</td>
<td>37</td>
<td>39</td>
<td>52</td>
<td>18</td>
</tr>
<tr>
<td>5.10</td>
<td>I have a computer at home</td>
<td>50</td>
<td>65</td>
<td>78</td>
<td>68</td>
</tr>
</tbody>
</table>
6.2 Lecturers at the NCOE

In a train the trainer model, the researcher delivered a whole day seminar to the NCOE lecturers at each NCOE instructing them on the TPACK model (see Appendix VI). Then, the NCOE lecturers conducted workshops with the pre-service teachers at the selected NCOE’s on how to use the TPACK model in secondary science teaching and learning process. After they conducted the workshops, the lecturers invited five pre-service teachers from each NCOE to conduct three lessons of secondary science using the TPACK model over the next year. In September 2008, the five pre-service teachers from NCOE 1, NCOE 2, and NCOE 3 conducted the lessons while they were undergoing their teaching practice in schools. While they were conducting lessons, the researcher observed, took field notes and video-taped the lessons.

6.2.1 NCOE lecturers’ quantitative data analysis

In this research, a total of eight lecturers from the three NCOE participated in this research study. They completed the Pre-service teachers TPK questionnaire (this is the same questionnaire used to pre-service teachers and their lecturers). The NCOE lecturer participants were two lecturers from NCOE 1, three lecturers from NCOE 2, and three lecturers NCOE 3. The descriptive results of the NCOE lecturers’ TK, PK and TPK questionnaire administered to the eight NCOE lecturers in stage 1 of the research are presented below.

The level of ICT Training experienced by NCOE lecturers, out of eight NCOE lecturers, one had no previous ICT training, and seven had experienced with one ICT training course lasting three to six months. All the lecturers reported that they used computers much as I can.
Five of NCOE lecturers used the computer as an entertainment tool. Three NCOE lecturers use computers in their teaching practices. Three NCOE lecturers (50%) were confident to use keyboard with all fingers without looking. The items about software applications for communication showed that only one of the lecturers sent E-mail at the NCOE, and none of the lecturers had experience with using instant messaging, or creating webpages or blogs at the NCOE. The NCOE lecturers’ communication result reflects low level of skills because they did not have sufficient facilities and they were not trained to use ICT as a communication tool. Only two of the eight NCOE lecturers (25%) had used the Internet. This very low rate of use of the Internet reflects that NCOEs’ did not have facilities for the staff to search the Internet.

Five of the eight (65%) NCOE lecturers used computers to create diagrams at NCOE. Two of the NCOE lecturers (25%) used the computers to create slideshow and six reported creating presentations at NCOE (75%). Seven of NCOE lecturers (88%) used CDs and DVDs at NCOE. According to the data of these four items, three of them have high values because NCOE lecturers used these items at NCOE. Arguably, this kind of software can be used with minimal ICT training.

None of the lecturers were experienced in more advanced software applications such as create/edit moves. Fifty percent of NCOE lecturers (50%), were experienced in creating and using spread sheets at NCOE. The ability to create/edit movies needs good ICT knowledge, and these three NCOE have very limited resources. Use spread sheet and create spreadsheet shows the medium value because they used it if is necessary.

All the NCOE lecturers used desktop computers and laptop computers. Digital cameras and digital video cameras are very common today so all the NCOE lectures have experienced using them. The digital cameras and video cameras were personally owned by most of the NCOE lecturers and they use them in their teaching. All the NCOE lecturers use scanners,
printers. All the NCOE lecturers had Internet access at NCOE but only four of the eight had access at home. All NCOE lecturers have computers at home. All NCOE lecturers had access to the computers outside the NCOE.

Half of NCOE lecturers agreed that they are very confident to use ICT in their teaching (50%). Only one NCOE lecturer agreed with most of the time incorporate ICT in their teaching. Three NCOE lecturers are preparing class lessons using ICT in their teaching and one NCOE lecturer of them use ICT effectively to teach numeracy/literacy. These two items reveal that NCOE lecturers claimed that they were not confident of using ICT in the teaching and learning process. Seven NCOE lecturers were confident to answer students questions related to their ICT use. NCOE lecturers gave advice to students to make productive use of ICT in their class. All NCOE lecturers helped students to use ICT and motivate students to use ICT. Seven NCOE lecturers used a range of ICT in the class room. In these five items, NCOE lecturers agreed with the statement about using ICT in teaching and learning process.

The majority of NCOE lecturers were weak using keyboard, low levels of communication, low levels of the Internet usage, weak in using advance software, and not confident to use ICT in their teaching and learning process, but they were confident to responded and motivate pre-service teachers to use ICT in their teaching and learning processes.

6.2.2 NCOEs’ Lecturers’ TPK Questionnaire Section B.

Eight NCOE lecturers and the 68 pre-service teachers participated in the TPK questionnaire. According to the TPK questionnaire, section B (a) for the first question five lecturers responded, constructivism. Three NCOE lecturers did not answer. TPK questionnaire section B (b) for the first question, four NCOE lecturers did not answer, two NCOE lecturers
said that through the constructivism learning theory students can improve creativity and the other two NCOE lecturers said that students can develop knowledge.

TPK questionnaire section B second question first part (a) eight NCOE lecturers chose to use the 5Es approach, seven of them chose to prepare your own lesson plan, seven chose include educational tools to teach science, four chose plan based on the curriculum, three chose planning according to teachers guide, one chose plan according to learning theories (NCOE lecturers chose more than one answer).

TPK questionnaire section B second question first part (b) five NCOE lecturers responded, using curriculum prepared lessons according to 5E methods, and three answered lessons can be prepared in inventive ways.

TPK questionnaire section B second question first part (c) six NCOE lecturers answered 5Es method exploring new knowledge, and two chose can develop pre-service teachers' knowledge, skill and attitudes.

TPK questionnaire section B third question first part (a) four NCOE lecturers chose experimental work and practical activities, three chose group work and collaborative activities, two chose demonstrations, two chose discussions, two chose questioning from students and develop the lesson and one lecturer chose others. (NCOE lecturers chose more than one response)

TPK questionnaire section B third question first part (b) six NCOE lecturers responded, give more experience to pre-service teachers and two lecturers answered improve pre-service teachers' knowledge.

TPK questionnaire section B third question first part (c) five NCOE lecturers answered pre-service teachers can understand the concept correctly, three chose that the group work pre-service teachers gain knowledge.
TPK questionnaire section B fourth question first part (a) seven NCOE lecturers chose use visual representation like concepts maps, and Venn diagrams, seven chose use teaching aids e.g. models, demonstrations, six chose draw diagrams, three chose others and one chose dictate note and explain them.

TPK questionnaire section B third question first part (b) five NCOE lecturers answered pre-service teachers understanding can be develop using concept maps, Venn diagrams, draw diagrams and three answered learn through the activity.

TPK questionnaire section B third question first part (c) five NCOE lectures answered these methods provide opportunities to gain pre-service teachers knowledge, and three answered scientific concepts can be explained easily to pre-service teachers.

TPK questionnaire section B fifth question first part (a) eight NCOE lecturers chose PowerPoint presentation, eight chose textbook, five chose blackboards, three chose whiteboard, and three chose others.

TPK questionnaire section B fifth question first part (b) eight NCOE lecturers answered PowerPoint presentation.

NCOE lecturers appeared to be weak in learning theories because out of eight three lecturers did not respond to the question and only one lecturer chose learning theories to prepare lesson plan. While NCOE lecturers’ pedagogical knowledge seems strong, they appear to be weak in learning theories.

6.2.3 NCOE Lecturers TPK Questionnaire Section C

TPK questionnaire section C first question six of the eight NCOE lecturers answered using ICT as educational tool pre-service teachers understanding can be developed, two answered ICT is a good educational tool but there is a lack of facilities available in Sri Lanka.
TPK questionnaire section C second question eight NCOE lecturers answered yes can change way of teaching science. TPK questionnaire section C third question eight NCOE lecturers answered lack of ICT facility in Sri Lankan schools. TPK questionnaire section C fourth question part (a) eight NCOE lecturers answered to teach using ICT need technological skill and technological knowledge. TPK questionnaire section C fourth question part (b) five NCOE lecturers answered they do not have ICT skills and three answered have ICT skills. TPK questionnaire section C fifth question part (a) section (1) five NCOE lecturers answered they prepared class lessons using ICT, and three answered not prepared class lessons using ICT. TPK questionnaire section C fifth question part (a) section (2) five NCOE lecturers responded taking students into the computer laboratory and ask them to research content, and three responded not taking students into the computer laboratory and ask them to research content. TPK questionnaire section C fifth question part (a) section (3) five NCOE lecturers answered using computer software programs, and three answered not using computer software programs. TPK questionnaire section C fifth question part (a) section (3) five NCOE lecturers answered they are using Microsoft office programmes, and three were, not using Microsoft office programmes.

TPK questionnaire section C fifth question part (b) five NCOE lecturers answered that they used ICT in science lessons, and 3 answered they do use ICT in science lessons.

TPK questionnaire section C fifth question part (c) five NCOE lecturers answered they used Microsoft software and DVDs for preparing lessons and three answered give instructions to pre-service teachers to explore the content using computers. TPK questionnaire section C fifth question part (d) section (1) eight NCOE lecturers answered ICT promote learning. TPK questionnaire section C fifth question part (d) section (2) eight NCOE lecturers answered, enhance pre-service teachers’ understandings and knowledge.
TPK questionnaire section C fifth question part (d) section (3) five NCOE lecturers responded *pre-service teachers knowledge can be improved using Internet* and three responded *scientific concepts can be easily described*. TPK questionnaire section C fifth question part (e) section (1) eight NCOE lecturers answered *ICT can improve teaching*. TPK questionnaire section C fifth question part (e) section (2) six NCOE lecturers answered *pre-service teachers knowledge can be improved* and two lecturers answered *pre-service teachers can get live experience through ICT*. TPK questionnaire section C fifth question part (e) section (3) six NCOE lecturers responded *pre-service teachers can share the knowledge and experience* and two responded *they can do self learning through the ICT*.

NCOE lecturers’ response of the part C of the TPK questionnaire *ICT can enhance the pre-service teachers’ knowledge, skills, and attitudes*. According to TPK questionnaire *NCOE lecturers have technological knowledge*.

NCOE lecturers’ technological knowledge, technological skills, and pedagogical knowledge are very important because it directly affects to pre-service teachers’ teaching and learning process. Part B discussed pre-service teachers’ practice of ICT application in their secondary science lessons.

**6.2.4 NCOE 1 Lecturers Workshop to Pre-service Teachers**

Two lecturers conducted the workshop at NCOE 1. The first lecturer gave a long introduction about “digital kids” and “immigrant teachers”, the TPACK model, ICT, and secondary science education. The second lecturer gave a detailed description about the research, how data will be collected, and why the research is conducted. The lecturer also explained how this research might benefit Sri Lanka. Additionally, the pre-service teachers were shown how to
plan science lessons using the TPACK model. 23 secondary science pre-service teachers who were in their 2nd year program conducted in Sinhala language, participated in this workshop.

During the workshop, the pre-service teachers were very interested in the TPACK model. After the workshop, the two lecturers asked from the participants to volunteer to participate in this research. The volunteers were expected to use the TPACK model when they conducted lessons in their teaching practice. Five pre-service teachers from the workshop volunteered to participate in this research. The researcher also asked the other pre-service service teachers the reasons for them not wanting to participate in the research. Some of the responses that received did not have proper technological knowledge.

The reflection of the pre-service teachers on the workshop was positive. They were interested in these novel concepts. The two NCOE lecturers were also invited to conduct such science lessons with pre-service teachers (TPACK model) to pre-service teachers. However, these two lecturers did not participate in this stage of the research.

6.2.5 NCOE 2 Lecturers Workshop to Pre-service Teachers

There were five lecturers working in the science section at the NCOE 2. However, only two lecturers participated and conducted the workshop. 23 pre-service teachers participated in the workshop at the NCOE 2. The first lecturer gave an introduction of the research and described ‘digital kids’, ‘migrant teachers’, TPACK, ICT, and secondary science education. The second lecturer explained about the research and its benefits to Sri Lanka. The second lecturer also taught how to plan and conduct science lessons using TPACK model.

The pre-service teachers’ reflection on the workshop was very positive and they liked this type of novel concepts introduced. After the workshop, the pre-service teachers were invited to participate in the research. Five pre-service teachers voluntarily accepted the invitation to
conduct science lessons when they were at teaching practice in schools. The two lecturers were also invited to conduct science lessons using TPACK model. However, they did not participate at this stage of research.

6.2.6 NCOE 3 Lecturers Workshop to Pre-service Teachers

There are five lecturers in the science section at NCOE3. Three lecturers participated in this research and they conducted the workshops at NCOE 3. During the workshop, the first lecturer gave an introduction about research by describing “digital kids” and “immigrant teachers”, TPACK, ICT, and secondary science education. The second lecturer explained about the research and the benefits of this research to Sri Lanka. The second lecturer also taught how to plan and conduct science lessons using TPACK model.

Since the third lecturer is a new lecturer, he was only a participant in the workshop. 22 pre-service teachers participated in the workshop. The pre-service teachers’ reflection on the workshop was very positive and they liked this type of novel concepts. After the workshop, the pre-service teachers were invited to participate in this research and 5 volunteered to participate in this research. The three lecturers were also invited to conduct science lessons using TPACK model, but they did not participate in this research.

6.2.7 NCOE Lecturers Interview

In this research, eight NCOE lecturers were interviewed at the end of the workshop. This interview is face to face semi-structured and has six questions as outlined in Chapter 5. The responses to the interviews reveal that all the NCOE lecturers are capable of using ICT in their lectures but they were all restricted by the lack of ICT facilities available at the NCOE. The researchers observation confirmed this situation. All the NCOE lecturers had good pedagogical knowledge, content knowledge, and technological knowledge but they were not aware of the
TPACK model before the workshop. All of the NCOE lecturers said this is a novel concept to them. The teachers claimed that by using ICT in teaching science by secondary science pre-service teachers it is easy to understand the subject matter and concepts. NCOE 1 lecturer used her hand phone to video the pre-service teachers’ teaching practice, installed to computer and discussing among the lecturers and pre-service teachers. NCOE 2 lecturer said using ICT can minimize the misconceptions of pre-service teachers. All the NCOE lecturers said they are very confident to use ICT in their secondary science lessons. All the NCOE lecturers said all NCOEs’ need to provide all necessary ICT equipment and they need further ICT training. All the NCOE lecturers like to use Microsoft office software, PowerPoint presentation, slideshow with multimedia, VCDs and DVDs, and Video clips. They understood how technology could be used to enhance the teaching of science concepts and make it easier to explain the science concepts.

6.3 The Pre-service Teachers Technological skills

This section describes the pre-service teachers’ technological skills, previous experiences with computers and their proficiency in using computer technologies based on data from the TPK questionnaire that was collected at stage one of the study- at the beginning of the research study. The descriptive results are presented in Tables 6.2 to 6.8. The SPSS statistical package has been used to process the percentage frequency of responses (SPSS Statistics version 17).

6.3.1 Pre-service Teachers Previous Training and Experience in ICT

Out of the 68 pre-service teachers who undertook the questionnaire, 20 (29.4%) had no previous ICT training, 38 (55.9%) had experienced one course of ICT training lasting three-six months, 8 (11.8%) had experienced two ICT courses lasting more than six months, and only 2 (2.9%) had experienced three ICT courses of more than one year duration (see Table 6.2). It is notable that 70.5% of the pre-service teachers have experienced some form of ICT instruction
before starting at NCOE indicating the importance that they place on ICT skills. 70.5% of the pre-service teachers had ICT training before coming to NCOE but 29.5% had not had any ICT training. Approximately one third of pre-service teachers did not have any type of ICT training.

Table 6.2

The level of ICT training experienced by pre-service teachers at each NCOE (68)

<table>
<thead>
<tr>
<th>NCOE</th>
<th>Number of students</th>
<th>ICT Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Training</td>
<td>1 course</td>
</tr>
<tr>
<td>NCOE 1</td>
<td>23</td>
<td>21.7%</td>
</tr>
<tr>
<td>NCOE 2</td>
<td>23</td>
<td>34.8%</td>
</tr>
<tr>
<td>NCOE 3</td>
<td>22</td>
<td>31.8%</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>29.4%</td>
</tr>
</tbody>
</table>

6.3.2 Pre-service Teachers Use of Computers

The data shows that there is a little difference between the pre-service teachers’ use of computers inside the NCOE and outside the NCOE (Table 6.3). Among them, approximately 10% do not use the computer at all (Item 3.1) whereas 52% of them claimed that they have used computers as much as they could both in and outside the NCOE (Item 3.3). The responses to item 3.4 (Table 6.3) indicate that the pre-service teachers from NCOE 3 are less likely to use the computer as an entertainment tool as compared to the pre-service teachers from NCOE 1 and NCOE 2.
Table 6.3

*The percentage of pre-service teachers use computers (N=68)*

<table>
<thead>
<tr>
<th>Item No</th>
<th>Test Item</th>
<th>At the NCOE %</th>
<th>Outside the NCOE %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total (Agree)</td>
<td>1</td>
</tr>
<tr>
<td>I use the computer:</td>
<td></td>
<td></td>
<td>NCOE</td>
</tr>
<tr>
<td>3.1</td>
<td>Not at all</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>3.2</td>
<td>Only a little</td>
<td>34</td>
<td>26</td>
</tr>
<tr>
<td>3.3</td>
<td>As much as I can</td>
<td>52</td>
<td>48</td>
</tr>
<tr>
<td>3.4</td>
<td>For my entertainment</td>
<td>65</td>
<td>48</td>
</tr>
<tr>
<td>3.5</td>
<td>For my studies</td>
<td>69</td>
<td>65</td>
</tr>
<tr>
<td>3.6</td>
<td>For my teaching practices</td>
<td>46</td>
<td>57</td>
</tr>
</tbody>
</table>

The data also indicates that most of the pre-service teachers *use computers for their studies* but less than half of them (see item 3.1), *use computers for their teaching practices* (46% at NCOE and 43% outside NCOE) (Table 6.3 items 3.6). Table 6.3 also shows that the pre-service teachers use computers less in their teaching practice than in their own studies (Items 3.5 and 3.6). Specifically, 69% of them used computers for their own studies while only 46% of them used computers for their teaching purposes.

6.3.3 Pre-service Teachers’ Computer Keyboard Competencies

Only 15% of students were confident to “*use the keyboard with all fingers not looking*” (item 2.3), and the majority (60%) had limited keyboard skills being able to “*use only the keyboard with a few fingers*” (item 2.1, Table 6.4). Therefore, most of the pre-service teachers in
the NCOEs did not have the keyboard skills necessary to make effective use of computer programmes in their studies and teaching practice.

Table 6.4

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Total Agree %</th>
<th>NCOE 1 %</th>
<th>NCOE 2 %</th>
<th>NCOE 3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Keyboard with a few fingers</td>
<td>60</td>
<td>52</td>
<td>78</td>
<td>50</td>
</tr>
<tr>
<td>2.2</td>
<td>Keyboard with all fingers</td>
<td>31</td>
<td>30</td>
<td>17</td>
<td>46</td>
</tr>
<tr>
<td>2.3</td>
<td>Keyboard with all fingers not looking</td>
<td>15</td>
<td>26</td>
<td>4</td>
<td>14</td>
</tr>
</tbody>
</table>

6.3.4 Software applications of the pre-service teachers

The data in Table 6.5 shows the software applications among pre-service teachers inside the NCOEs and outside the NCOEs. Software applications can be grouped according to three major categories which are communication, Internet and the use of digital data.

Items 2.5, 2.6, 2.11 and 2.14 (Table 6.5) provide data about the level of communication using the computers among the pre-service teachers. Item 2.5, send E-mail inside the NCOE is 9% and outside NCOE is 32%, item 2.6, instant messaging inside the NCOE is 18% and outside NCOE is 31%, item 2.11, create webpage inside the NCOE is 3% and outside the NCOE is 10%, item 2.14, create blogs inside the NCOE is 0% and outside the NCOE is 4%. These percentages indicate that pre-service teachers’ communication use was at a low level because their pre-service teaching course was based overall residential training, that didn’t have sufficient facilities. Also, they were not trained to use ICT as a communication tools and they did not have time to use communication tool. Arguably, this might also indicate low level skills.
<table>
<thead>
<tr>
<th>Item No</th>
<th>Test Item</th>
<th>Inside of the NCOE %</th>
<th>Outside of the NCOE %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Agree 1 2 3</td>
<td>Total Agree 1 2 3</td>
</tr>
<tr>
<td>2.4</td>
<td>To create diagrams</td>
<td>52 65 48 41 68 78 70 55</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>To send e-mail</td>
<td>9 4 17 17 32 44 39 14</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>For instant massaging</td>
<td>18 22 26 5 31 39 48 5</td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>Create slide show</td>
<td>60 65 74 41 55 57 61 55</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>Create presentation</td>
<td>74 87 87 46 66 78 65 55</td>
<td></td>
</tr>
<tr>
<td>2.9</td>
<td>Create/edit Movies</td>
<td>12 22 13 0 15 30 9 5</td>
<td></td>
</tr>
<tr>
<td>2.10</td>
<td>Carryout Research on Internet</td>
<td>5 13 0 0 15 22 9 14</td>
<td></td>
</tr>
<tr>
<td>2.11</td>
<td>Create webpage</td>
<td>3 4.3 4.3 0 10 22 4 5</td>
<td></td>
</tr>
<tr>
<td>2.12</td>
<td>Use spreadsheet</td>
<td>31 26 48 18 29 22 35 32</td>
<td></td>
</tr>
<tr>
<td>2.13</td>
<td>Create spreadsheet</td>
<td>29 17 48 23 32 26 35 36</td>
<td></td>
</tr>
<tr>
<td>2.14</td>
<td>To create Blogs</td>
<td>0 0 0 0 4 9 0 4</td>
<td></td>
</tr>
<tr>
<td>2.15</td>
<td>Use CD’s and DVD’s</td>
<td>47 65 35 41 78 78 78 77</td>
<td></td>
</tr>
</tbody>
</table>

Item 2.10 focuses on coordinating research using Internet. It was found that 5% of the pre-service teachers conducted research using the Internet within the NCOEs and 15% outside the NCOEs. The low percentage value in the usage in the NCOEs is due to lack of facilities and lack of time to access the internet inside the NCOEs. For example, at NCOE 1, there was only one computer available to the Internet and the Internet connection was slow.

As presented in Table 6.5, Item 2.4, 52% of pre service teachers use software for creating diagrams inside the NCOE and outside NCOE 68%. The Item 2.7, for creating slideshow inside the NCOE was 60% and outside NCOE 57%. The item 2.8, for creating presentations inside the NCOE 74% and outside NCOE 66%. The item 2.15, using CDs and DVDs inside the NCOE 47% and outside NCOE shows 78%. According to this data, these four items have high values.
because pre-service teachers use these items inside the NCOE and outside the NCOE. Arguably, such software could be used with minimal extra ICT training. As expected for more advanced software application, a few pre-service teachers use item 2.9, 2.12, and 2.13. Item 2.9 shows create/edit movies inside the NCOE 12% and outside 15%, item 2.12, use spreadsheet inside the NCOE is 31% and outside NCOE is 29%, item 2.13, create spreadsheet inside the NCOE is 29% and outside NCOE is 32%. The create/edit movies needs a good ICT knowledge, and these three NCOE has very limited resources. Using spreadsheet and creating spreadsheet show a medium value because they only used it if it is necessary.

6.3.5 Pre-service teachers’ use of computers when teaching

Table 6.6

Pre-service teacher’s computer skills at related teaching and learning practice (N=68)

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Total %</th>
<th>NCOE1 %</th>
<th>NCOE 2 %</th>
<th>NCOE 3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agree</td>
<td>Disagree</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>I am very confident to use ICT in my teaching</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>I most of the time incorporate ICT into my teaching</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>I am preparing class lessons using ICT</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I use ICT effectively to teach numeracy/literacy</td>
<td>8</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>I am confident to answer students questions related to their ICT use</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I advise students to make productive use of ICT in my classes</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I help students to use ICT</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I motivate students to use ICT</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I use range of ICT resources in the classroom</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>


The above table (Table 6.6) shows the percentage of computer skills of pre-service teachers in teaching and learning practices. 44% agreed with very confident to use ICT in their teaching. 66% pre-service teachers were disagreeing to use ICT in teaching. 47% agreed that most of the time they incorporate ICT into their teaching practices. 63% disagreed with most of the time incorporating ICT into their teaching. 25% agreed with preparing class lessons using ICT in their teaching and 75% disagreed. 18% agreed with using ICT effectively to teach numeracy/literacy and 82% disagreed. These four items indicate that the pre-service teachers were not confident to use ICT in teaching and learning process. 50% have confident to answer students questions related to their ICT use. 72% agreed with giving advice to students to make productive use of ICT in their class. 66% agreed with help student to use ICT. 66% agree with motivating students to use ICT. 53% agree with using a range of ICT in the class room. Based on these five items, pre-service teachers in three NCOEs’ showed more than 50% agreed to use ICT in teaching and learning process.

6.3.6 Summary of the pre-service teachers technological skills

68 pre-service teachers participated in the stage 1 of the research. More than 70.6% of pre-service teachers had an ICT background, and 29.4% pre-service teachers did not have any type of ICT training. Half of the pre-service teachers used computers as much as they could. Pre-service teachers used computers for their entertainment and their studies more than for their teaching and learning. Pre-service teachers’ software application can be divided into three major categories; use of communication, the Internet, and using digital data. Pre-service teachers’ communication used was low because their teaching course was residential, lacked adequate ICT facilities; they were not trained to use ICT and a shortage of time to do so. Pre-service teachers’ Internet usage was also very low because they did not have Internet facility in the NCOE. Pre-
service teachers commonly used very popular and user-friendly software, but a few pre-service teachers used advance software (item 2.9, 2.12, and 2.13 are about advanced software).

6.4 Pre-service Teachers Technological Knowledge

Secondary science pre-service teachers’ TPK questionnaire section C which was administered to 68 pre-service teachers in stage 1 gives an insight into their technological knowledge. The items in the instrument- explore pre-service teacher’s opinions about, how the technology can be used as an educational tool (Q1 and Q2), how ICT is currently used in teaching science (Q3, Q5), what skills are needed to be able to use ICT in their teaching (Q4) why should ICT be integrated into teaching science (Q5).

6.4.1 How the technology can be used as an educational tool (Q1 and Q2)

The first question in the questionnaire is How you think ICT can be used as an educational tool? From the responses, four categories of explanations were decided. According to Table 6.7, out of 68 pre-service teachers 28 pre-service teachers chose that using ICT is a successful teaching method, it is more effective and more productive was chosen by 19 pre-service teachers, can change traditional classroom into student friendly classroom was chosen by 16 pre-service teachers, and lack of facility in Sri Lankan schools was chosen by 5 pre-service teachers. According to Table 6.8, out of 68 pre-service teachers 48 pre-service teachers chose ICT helps to explain lessons, 12 pre-service teachers chose students get worldwide knowledge. ICT helps to motivate students was chosen by 5 pre-service teachers. Three pre-service teachers did not answer to the question.
**Table 6.7**

*Pre-service teachers explained how ICT could be used as an educational tool (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a successful teaching method</td>
<td>28</td>
<td>ICT is an educational tool; it is a successful teaching and learning method.</td>
</tr>
<tr>
<td>It is more effective and more productive</td>
<td>19</td>
<td>ICT is more productive and effective method and it is essential equipment to classroom.</td>
</tr>
<tr>
<td>Can change traditional classroom into student friendly classroom</td>
<td>16</td>
<td>ICT can change traditional class room into students friendly classroom.</td>
</tr>
<tr>
<td>Lack of facility in Sri Lankan school</td>
<td>5</td>
<td>Sri Lankan schools ICT facility is very low.</td>
</tr>
</tbody>
</table>

**Table 6.8**

*Pre-service teachers explained how do you think ICT can use to change the way of teach science (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers’ comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT helps to explain lessons</td>
<td>48</td>
<td>Using ICT teachers can explain lessons very easily.</td>
</tr>
<tr>
<td>Students get worldwide knowledge</td>
<td>12</td>
<td>Students can get modern knowledge through ICT.</td>
</tr>
<tr>
<td>ICT helps to motivate students</td>
<td>5</td>
<td>ICT can motivate students.</td>
</tr>
</tbody>
</table>
6.4.2 The Use of ICT in Teaching Science (Q3, Q5)

From the responses by the pre-service teachers to the third question, in the TPK questionnaire section C: How ICT is currently used in teaching science? Four categories of explanations were decided and shown in Table 6.9.

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very few schools use Internet and most of school in Sri Lanka lack of ICT</td>
<td>18</td>
<td>Some schools use Internet and most schools as a not use ICT in Sri Lanka.</td>
</tr>
<tr>
<td>Urban schools use little bit of ICT but rural schools do not use ICT</td>
<td>16</td>
<td>Urban schools use little bit of ICT but rural schools still teach traditional methods.</td>
</tr>
<tr>
<td>Resources availability is very low</td>
<td>20</td>
<td>Lack of ICT recourses in Sri Lankan schools.</td>
</tr>
<tr>
<td>Very few teachers use ICT in their science lessons</td>
<td>12</td>
<td>Lack of computer skilled teachers.</td>
</tr>
</tbody>
</table>

According to Table 6.9, out of 68 pre-service teachers 18 pre-service teachers chose a very few schools use Internet and most of school in Sri Lanka lack ICT, resources availability is very low was chosen by 20 pre-service teachers. Town schools use little bit of ICT but rural
schools do not use ICT was chosen by 16 pre-service teachers and a very few teachers use ICT in their science lessons was chosen by 12 pre-service teachers. Two pre-service teachers did not answer to the question.

The fifth question on section C of the TPK questionnaire asked Do you prepare class lessons using ICT? Responses included taking students into the computer laboratory to research content, using computer software programmes, and using Microsoft office programmes.

*Table 6.10*

**Percentage of pre-service teachers' science lessons ICT applications (N=68)**

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>01</td>
<td>Preparing my class lessons using ICT</td>
<td>42</td>
<td>57</td>
</tr>
<tr>
<td>02</td>
<td>Tacking students into the computer lab and ask them to research content</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td>03</td>
<td>Using computer software programmes</td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>04</td>
<td>Using Microsoft office programmes</td>
<td>54</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 6.10 shows the applications of ICT in science lessons by pre-service teachers. According to results, 42%, of pre-service teachers used ICT to prepare their lessons, 38% referred to taking students into the computer laboratory and asking them to research content, 42% described using computer software programmes and 54% mentioned using Microsoft Office is 54%. According to the above results, the highest among the other programmes is using Microsoft office (54%).
41 pre-service teachers out of the 68 questioned had used ICT in science lessons when they were in schools. Pre-service teachers TPK questionnaire section C fifth question part (c) is describing ways they think ICT could be integrated into their teaching methods. Three categories of explanations were decided, see Table 6.11.

According to Table 6.11 pre-service teachers description on ways of ICT integrated into their teaching methods are as follows. 23 pre-service teachers use PowerPoint presentation DVDs and VCDs 13 pre-service teachers use software applications, 8 pre-service teachers use the Internet. 24 pre-service teachers did not answer to this question. This lack of response could indicate a limited knowledge of ways ICT can be integrated into their teaching methods.

Table 6.11
Pre-service teachers’ describing ways of ICT integrated into their teaching methods (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using PowerPoint presentations, DVDs and VCDs.</td>
<td>23</td>
<td>Using PowerPoint presentation</td>
</tr>
<tr>
<td>Software application</td>
<td>13</td>
<td>Using different type of software</td>
</tr>
<tr>
<td>Using Internet</td>
<td>08</td>
<td>Content can search through the Internet</td>
</tr>
</tbody>
</table>

6.4.3 What skills are needed to be able to use ICT in your teaching (Q4)

The TPK questionnaire, section C fourth question 4 parts (a) is which type of skills Do you think pre-service teachers need to be able to use ICT in their teaching of science? Three categories of explanations were decided that are shown in Table 6.12.
Table 6.12

Pre-service teachers needed ICT skills in their teaching of science (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers need internet proficiency</td>
<td>21</td>
<td>Teachers must need Internet proficiency.</td>
</tr>
<tr>
<td>Teachers ICT knowledge and Teaching ability</td>
<td>27</td>
<td>Teachers must have good knowledge on lesson planning and using ICT.</td>
</tr>
<tr>
<td>Teachers ICT knowledge of theoretical and practical ability</td>
<td>17</td>
<td>Teachers must need good theoretical and practical knowledge.</td>
</tr>
</tbody>
</table>

According to Table 6.12, out of 68 pre-service teachers 27 pre-service teachers chose teachers ICT knowledge and teaching ability, 21 pre-service teachers chose teachers need internet proficiency and 17 pre-service teachers chose teachers ICT knowledge of theoretical and practical. Three pre-service teachers did not answer to the question. A confident 55 of the 68 pre-service teachers, responded affirmatively when asked Do you have these skills to use ICT in teaching science? (Section C fourth question) Three pre-service teachers did not answer the question.

6.4.4 Why should ICT be integrated into teaching science (Q5)

While 89% of pre-service teachers agreeing with the statement that ICT can be used to promote learning, when asked how this could be achieved, TPK questionnaire section C fifth question part) 20 pre-service teachers did not answer to this question.
Table 6.13

Pre-service teacher’s how to promote learning using ICT (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance students understanding</td>
<td>16</td>
<td>Students gain a good understanding through ICT.</td>
</tr>
<tr>
<td>Using ICT motivates students</td>
<td>11</td>
<td>Using ICT motivates students to learn science.</td>
</tr>
<tr>
<td>Using ICT students can be more creative</td>
<td>07</td>
<td>ICT is more practical and more creative</td>
</tr>
<tr>
<td>Using ICT teachers’ knowledge can be</td>
<td>14</td>
<td>Using Internet teachers knowledge can be improved.</td>
</tr>
<tr>
<td>be improved</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Similarly, 88% of pre-service teachers said ICT could improve their teaching. When asked how this could be achieved, (TPK questionnaire section C fifth question part), Four categories of explanations were decided see Table 6.14.

Table, 6.14, shows pre-service teachers’ responses on how they think the use of ICT can improve their teaching. 16 pre-service teachers said ICT could motivate students. 14 pre-service teachers said ICT could gain students’ and teachers’ knowledge and experience. 12 pre-service teachers said through the Internet can gain knowledge. The Pre-service teachers’ TPK questionnaire section C fifth question part (i) is Why do you think the use of ICT can improve your teaching? Four categories of explanations were decided, see Table 6.15.
### Table 6.14

*Pre-service teachers’ how they think the use of ICT can improve their teaching (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers responses to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT can motivate students</td>
<td>16</td>
<td>Students like using ICT to teach lessons.</td>
</tr>
<tr>
<td>ICT can gain students and teachers knowledge and experience</td>
<td>14</td>
<td>Through ICT students’ and teachers can gain knowledge and experience</td>
</tr>
<tr>
<td>Using ICT students and teachers can be more creative</td>
<td>09</td>
<td>More creatively plan the lessons.</td>
</tr>
<tr>
<td>Through the Internet gain knowledge</td>
<td>12</td>
<td>Using the Internet, teachers can gain knowledge.</td>
</tr>
</tbody>
</table>

### Table 6.15

*Pre-service teachers why they use ICT to improve their teaching (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good method to teach science</td>
<td>22</td>
<td>It is a good method to teach science.</td>
</tr>
<tr>
<td>Using Internet teachers gain knowledge</td>
<td>12</td>
<td>Through the Internet teachers can get new knowledge.</td>
</tr>
<tr>
<td>Students get live experience through ICT</td>
<td>12</td>
<td>Teachers can give live experience to students through ICT.</td>
</tr>
<tr>
<td>Students can explore the content</td>
<td>5</td>
<td>Student can explore the new knowledge through ICT.</td>
</tr>
</tbody>
</table>

According to Table, 6.15, 22 pre-service teachers said *it is a good method to teach science*, 12 pre-service teachers said *using the Internet teachers gain knowledge*. 12 pre-service
teachers said *students get live experience through ICT*. Five pre-service teachers said *Students can explore the content*. 17 pre-service teachers did not answer to this question.

### 6.5 Pre-service Teachers Pedagogical Knowledge.

Secondary science pre-service teachers’ TPK questionnaire section B which was administered to 68 pre-service teachers in stage 1 gives some insight into their pedagogical knowledge. The questions provide some insight into the pre-service teachers’ understanding of learning theories, the planning a lesson, choice of teaching method, way of explaining scientific concepts and the aids used in teaching.

#### 6.5.1 Learning Theories

*Table 6.16*

*Percentage of pre-service teachers use learning theories to guide the way they teach students (N=68)*

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Total %</th>
<th>NCOE 1 %</th>
<th>NCOE 2 %</th>
<th>NCOE 3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constructivism</td>
<td>58</td>
<td>57</td>
<td>70</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>Behaviourism</td>
<td>8</td>
<td>0</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Cognitivism</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>No Answer</td>
<td>30</td>
<td>39</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Constructivism and</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Behaviourism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to Table 6.16, the response to the Pre-service teachers’ TPK questionnaire, first question in section B, is as follows. *Item 1, constructivism is 58%, item 4 no answer is 30%, item 2 behaviourism is 8%, item 3 cognitivism is 3%, and item 5 constructivism and
behaviourism is 8%. It was found that the majority of pre-service teachers used constructivism as a learning theory to guide the way they teach students. Comparing the three NCOEs’ response was constructivism, NCOE 1 is 57%, NCOE 2 is 70%, and NCOE 3 is 49%. Compared with the three NCOEs, none response to section B first question shows NCOE 1 is 39%, NCOE 2 is 20%, and NCOE 3 is 30%.

Table 6.17

Pre-service teachers describe constructivism learning theories approach to their learning (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers %</th>
<th>Examples of pre-service teachers comments to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students create own creativity and gain knowledge.</td>
<td>35</td>
<td>Give students to exploitive opportunities to and develop their creativity. It is a student based education.</td>
</tr>
<tr>
<td>Constructivism based on students’ centred education.</td>
<td>15</td>
<td>Constructivism is a student centred learning theory. Develop student’s self learning opportunities.</td>
</tr>
<tr>
<td>Constructivism learning theory Based on activity</td>
<td>4</td>
<td>Students learn through the experience</td>
</tr>
<tr>
<td>5E method help to develop students’ creativity</td>
<td>2</td>
<td>Students brainstorming.</td>
</tr>
</tbody>
</table>

According to Table 6.16 58% (36) pre-service teachers answered that they use the constructivist-learning theory. Of these students 56% explained why they selected constructivism-learning theory, and 44% did not explain. The explanations of why they chose constructivism as the best learning theory were examined, and are presented in Table 6.17 which
shows the categories, percentages and examples of the responses given by the pre-service teachers.

6.5.2 Planning a lesson

For Pre-service teachers, TPK questionnaire section B, the first part of the second question, seven options were given to the 68 pre-service teachers. Most of the pre-service teachers chose more than one answer. The number of times an option was selected is written in brackets next to the option. The seven options are:

- Planning according to teachers’ guide; (20)
- Plan based on curriculum; (15)
- Plan according to learning theories; (6)
- Prepare your own lesson plan; (21)
- Use the 5E approach; (49)
- Include educational tools to teach science; (38)
- Other (13)

For Pre-service teachers, TPK questionnaire sections B, the second part of the second question, following options were given by the 68 pre-service teachers.

The majority (74%) of pre-service teachers’ chosen answer was using the 5Es approach because of the introduction of the educational reform in 2008 which was based on 5Es approach. 58% included in using educational tools to teach science due to the fact that they were science teachers. They like to use audio and video demonstrations, experiments, and living and dead specimens. (Plan according to learning theories 6 pre-service teachers)
Pre-service teachers TPK questionnaire in section B, second part of the third question require respondents to explain how they plan an innovative science lesson. Six categories were derived from the responses and are explained below.

Table 6.18

*How pre-service teachers innovate science lessons? (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers %</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because of students creativity, students can independently acquire knowledge</td>
<td>12</td>
<td>A student behaviour change occurs according to teaching is good. Main goal of a lesson is students’ skill development and competency development.</td>
</tr>
<tr>
<td>5E’s teaching method</td>
<td>30</td>
<td>5E method is successful method to teach. According to 5E model prepare lesson plan.</td>
</tr>
<tr>
<td>Students activity, encouragedly and interestingly do their learning</td>
<td>8</td>
<td>Activity based education system that helps improve students’ knowledge, skills, and attitude. Activity based education motivate students’ learning.</td>
</tr>
<tr>
<td>Student- centred teaching and learning method</td>
<td>8</td>
<td>Students get firsthand experience. Innovative science lesson must teach student canter teaching method.</td>
</tr>
<tr>
<td>Present students live in technological world</td>
<td>8</td>
<td>Teaching and learning methods must incorporate technology.</td>
</tr>
<tr>
<td>Lesson is planned according to teachers guide and curriculum.</td>
<td>34</td>
<td>To conduct good lesson need good lesson plan. According to students’ knowledge they prepare lesson plan.</td>
</tr>
</tbody>
</table>
According to the Table 6.18, 34% of pre-service teachers chose lessons planned according to teacher’s guide and curriculum, 30% followed 5Es teaching methods and 12% chose because of students’ creativity and student can independently acquire knowledge. 24% pre-service teachers did not answer the question.

Pre-service teachers’ TPK questionnaire section B third part of the second question requested them to explain why they chose these methods. Four categories of explanations were decided.

Table 6.19
Percentage of pre-service teachers answered why you chosen these (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers %</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to present technical knowledge teaching must change</td>
<td>6</td>
<td>Integrating technology for teaching and learning.</td>
</tr>
<tr>
<td>Student- centred and student can understand the lesson</td>
<td>18</td>
<td>Student- centred teaching and learning process help students to motivate learning. Student- centred teaching and learning process, students gain knowledge.</td>
</tr>
<tr>
<td>5E’s method exporting new content knowledge by the students</td>
<td>18</td>
<td>Content of a lesson is easy to understand when 5E method used for to teaching and learning. 5E method exploring new knowledge and new concepts to the students.</td>
</tr>
<tr>
<td>Give direct experience to students</td>
<td>12</td>
<td>Students get knowledge through the experience.</td>
</tr>
</tbody>
</table>
According to Table 6.19, indicates the percentages of pre-service teachers’ answers why they choose these methods. 18% of pre-service teachers answered that it is student centered and students can understand the lesson, 18% chose 5E’s method exporting new content and knowledge by the students, 6% chose according to present technical knowledge teaching must change and 12% chose ‘give direct experience to students’.

6.5.3 Choice of Teaching Method

Pre-service teachers’, TPK questionnaire section B first part of the third question, seven choices were given and 68 pre-service teachers’ responses were given below. The number of times an option was selected is written in brackets next to the choice. The choices given are:

- Experiment work and practical activity; (35)
- Demonstrations; (25)
- Group work and collaborative activity; (15)
- Lectures; (4)
- Discussions; (8)
- Questioning from student and develop the lesson; (9)
- Other (6)

The most popular was 61% of pre-service teachers’ choosing experimental work and practical activity, followed by demonstrations because in these pre-service teachers are studying to become science teachers; science teachers regularly conduct experiment work and practical activity and demonstrations.
### Table 6.20

*Pre-service teachers reflection of which type of teaching method would be the best to promote (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers %</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental work and practical work</td>
<td>27</td>
<td>Experimental and practical activity will help o student to achieve high-level of knowledge. Student must have practical and theoretical knowledge.</td>
</tr>
<tr>
<td>Group work and collaborative activities</td>
<td>22</td>
<td>Develop creativity. Students like group work.</td>
</tr>
<tr>
<td>Questioning from students and develop the lesson</td>
<td>3</td>
<td>Students use their experience and explore the scientific concepts. Share knowledge among the students.</td>
</tr>
<tr>
<td>Using all the methods to develop the lesson</td>
<td>5</td>
<td>Using all these methods it is very easy to go to the subject goal.</td>
</tr>
</tbody>
</table>

Table 6.20 shows the type of teaching method that would be the best to promote among the students. According to pre-service teachers’ responses, 27 answers were experimental work and practical work, and 22 answered group work and collaborative activities. 6 pre-service teachers did not answer this question.

*Pre-service teachers’ TPK* questionnaire section B third part of the third question explained why, which type of teaching method would be best to promote learning among students. Four categories for the explanations were decided.
Table 6.21

Pre-service teachers’ reflection of why, which type of teaching method would be the best to promote (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers’ comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>All these methods help to develop students’ knowledge,</td>
<td>26</td>
<td>According to the lesson they have to select suitable methods.</td>
</tr>
<tr>
<td>attitudes, and skills.</td>
<td></td>
<td>Theoretical knowledge and practical knowledge must be developed.</td>
</tr>
<tr>
<td>Group work and collaborative activities</td>
<td>20</td>
<td>Through the activity, based education students learn many things.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group work and collaborative activity help to develop students’ exploration, society attitudes, and human values.</td>
</tr>
<tr>
<td>Experimental work and practical work</td>
<td>11</td>
<td>Experimental and practical knowledge can be used for day-to-day activities.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students’ motivation increase practical and experimental work.</td>
</tr>
</tbody>
</table>

Table 6.21 shows pre-service teachers answer to why which type of teaching method would be best to promote learning among students. 26 pre-service teachers answered, all these method help to develop students’ knowledge, attitudes, and skills, 20 answered group work and collaborative activities and 11 answered experimental work and practical work. 9 pre-service teachers did not answer this question. The choices are consistent with the constructivist approach.
6.5.4 Ways of explaining scientific concepts

Pre-service teachers’ TPK questionnaire section B first part of the fourth question asked the pre-service teachers to select a teaching approach and explain which method would best promote understanding among learners. Seven options were given. The number of times an option was selected is written in brackets next to the choice:

- I dictate notes and then I explain them; (2)
- I divide the class into groups to discuss the concepts; (17)
- I use visual representations like concepts maps, and Venn diagrams; (41)
- I use teaching aids. e.g. models, demonstrations; (45)
- Draw diagrams; (29)
- Others.

(Most of the pre-service teachers chose more than one answer).

TPK questionnaire section B second part of the fourth question asked the Pre-service teachers to select a method that best promotes understanding among students and explain why it is the best. Five categories of explanations were decided, these are presented in Table 6.22.

Table 6.22 shows, which type of teaching method, would be the best to promote among the students. According to pre-service teachers’ answers, 27 pre-service teachers’ answers are use teaching aids, and 23 answers are all these methods use to develop students’ knowledge, skills and attitudes. 6 pre-service teachers did not answer to this question.
Table 6.22

Pre-service teachers' answers which method(s) would be the best to promote understanding among the students (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>use visual representations like concepts maps, and Venn diagrams</td>
<td>8</td>
<td>Through the concept maps, Venn diagrams, and draw diagrams students’ memory can develop. Students’ reflection is very high.</td>
</tr>
<tr>
<td>Use teaching aids. e. g. models, demonstrations</td>
<td>27</td>
<td>Students’ logical thinking increasing Students explore the knowledge</td>
</tr>
<tr>
<td>Divided class into groups to discuss the concepts</td>
<td>4</td>
<td>Share knowledge among the students. Students’ exchange their knowledge among the peers.</td>
</tr>
<tr>
<td>dictate notes and then explain them</td>
<td>2</td>
<td>Easy to teach subject matter.</td>
</tr>
<tr>
<td>All these methods develop students’ knowledge, skills and attitudes.</td>
<td>23</td>
<td>It helps students to understand the students. Use all the methods easy to teach.</td>
</tr>
</tbody>
</table>

According to Table 6.23 pre-service teachers explained why, which type of teaching method would be the best to promote learning among students. According to pre-service teachers’ answers, 19 pre-service teachers’ answers are all these methods can be used to develop students’ knowledge, skills and attitudes, 16 use visual representations like concepts maps, and
Venn diagrams, and 13 pre-service teachers divide class into groups to discuss the concepts. 12 pre-service teachers did not answer to this question.

**Table 6.23**

*Pre-service teachers’ explanations of which type of teaching methods would be the best to promote learning (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers %</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>use visual representations like concepts maps, and Venn diagrams</td>
<td>16</td>
<td>Students can easily understand. Content knowledge understands very clearly.</td>
</tr>
<tr>
<td>Use teaching aids. e. g. models, demonstrations</td>
<td>4</td>
<td>Science class teaching aids are very useful to understand the content. Teaching aids motivate students.</td>
</tr>
<tr>
<td>Divide class into groups to discuss the concepts</td>
<td>13</td>
<td>Students can easily understand the concepts. To motivate the students to increase knowledge.</td>
</tr>
<tr>
<td>All these methods are used to develop students’ knowledge, skills and attitudes.</td>
<td>19</td>
<td>Students’ knowledge, skills, and attitude development occur. Using these entire methods teacher can achieve their goal.</td>
</tr>
<tr>
<td>Teacher is a facilitator</td>
<td>4</td>
<td>Teacher can provide lesson abstract. Teacher has to develop ha skills as a facilitator.</td>
</tr>
</tbody>
</table>
6.5.5 Aids Used in Teaching

Pre-service teachers’ TPK questionnaire section B first part of the fifth question provided six options of possible teaching aids. The number of times each option was selected is written in brackets (most of the pre-service teachers chose more than one answer). The aids listed were:

- Blackboard; (40)
- White Board; (36)
- PowerPoint; (42)
- Overhead projector (OHP); (19)
- Textbook; (37)
- Others; (11)

Pre-service teachers TPK questionnaire section B second part of the fifth question explained why you choose to use them. Four categories of explanations were decided as shown in Table 6.24. According to Table, 6.24 pre-service teachers explained why they chose to use these teaching aids. Pre-service teachers’ responses were as follows. 45 pre-service teachers’ answers are PowerPoint presentation and 12 pre service teachers’ answers are “all kinds of teaching aids”. 2 pre-service teachers did not answer to this question.

In response to the questions do you think the use of ICT can improve your teaching? (Pre-service teachers’ TPK questionnaire section C Fifth question part (g), 88% agreed with the statement that ICT can improve your teaching. Pre-service teachers’ TPK questionnaire section C fifth question part (h) is (do you think the use of ICT can improve your teaching?) How? Four categories of explanations were decided and are shown in Table 6.25.
### Table 6.24

**Why pre-service teachers explained choose these teaching aids (N=68)**

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerPoint’s presentation</td>
<td>45</td>
<td>It is easy to explain.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PowerPoint presentation helps students to understand.</td>
</tr>
<tr>
<td>Black board</td>
<td>7</td>
<td>Black board is the easily available teaching aid in most schools.</td>
</tr>
<tr>
<td>All teaching aids</td>
<td>12</td>
<td>All teaching aids help to students’ understandings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students like all teaching aids.</td>
</tr>
<tr>
<td>Overhead projector</td>
<td>2</td>
<td>All the textbook diagrams show in the overhead projector.</td>
</tr>
</tbody>
</table>

### Table 6.25

**How pre-service teachers think the use of ICT can improve their teaching (N=68)**

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT can motivate students</td>
<td>16</td>
<td>Students like using ICT to teach lessons.</td>
</tr>
<tr>
<td>ICT can gain students, and teachers’ knowledge and experience</td>
<td>14</td>
<td>Through ICT students’ and teachers gain knowledge and experience.</td>
</tr>
<tr>
<td>Using ICT, students and teachers can be more creative</td>
<td>09</td>
<td>More creatively plan the lessons.</td>
</tr>
<tr>
<td>Through the Internet, gain knowledge</td>
<td>12</td>
<td>Using the Internet, teachers can gain knowledge.</td>
</tr>
</tbody>
</table>
Table 6.25, shows pre-service teachers responses on how they think the use of ICT can improve their teaching. 16 pre-service teachers said *ICT could motivate students*. 14 pre-service teachers said *ICT could gain students and teachers knowledge and experience*. 12 pre-service teachers said *through the Internet gain knowledge*. Eight pre-service teachers said *using ICT students and teachers can be more creative*. 17 pre-service teachers did not answer this question.

*Pre-service teachers TPK questionnaire* section C fifth question part (i) is (Why do you think the use of ICT can improve your teaching?). Four categories of explanations were decided.

**Table 6.26**

*Why pre-service teachers why they use ICT to improve their teaching (N=68)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good method to teach science</td>
<td>22</td>
<td>It is a good method to teach science.</td>
</tr>
<tr>
<td>Using Internet, teachers gain knowledge</td>
<td>12</td>
<td>Through the Internet, teachers can get new knowledge.</td>
</tr>
<tr>
<td>Students get live experience through ICT</td>
<td>12</td>
<td>Teachers can give live experience to students, through ICT.</td>
</tr>
<tr>
<td>Students can explore the content</td>
<td>5</td>
<td>Student can explore the new knowledge through ICT.</td>
</tr>
</tbody>
</table>

According to Table, 6.26, 22 pre-service teachers said *it is a good method to teach science*, 12 pre-service teachers said *using the Internet teachers' gain knowledge*. 12 pre-service
teachers said *students get live experience through ICT*. Five pre-service teachers said *students can explore the content*. 17 pre-service teachers did not answer to this question.

### 6.6 Chapter 6 Review

This chapter focused on Stage 1 of the Secondary science pre-service teachers’ and NCOE lecturers’ research study of technological skills, technological knowledge, and pedagogical knowledge measured by using TPK questionnaire. Secondary science pre-service teachers’ and NCOE lecturers’ technological skills divided and measured using TPK questionnaire. NCOE lecturers’ attitudes are TPACK knowledge and TPK questionnaire results.

Majority of NCOE lectures have ICT skills but they are weak on in using advance software. Only half of the NCOE lecturers are confident to use ICT in the teaching and learning process but agreed with using ICT in teaching and learning process. NCOE lecturers appear to be weak in learning theories and they are good in technological knowledge. Approximately one third of pre-service teachers did not have any type of ICT training. 69% of pre-service teachers use computers for their studies but only 46% of them use computers teaching purpose. They are weak in keyboard skills and in using advanced software. Only 50% of pre-service teachers agree to use ICT in teaching and learning process. Pre-service teachers’ technological knowledge is good but they are facing lack of facilities. Pre-service teachers are weak in learning theories.
Chapter Seven

Results and Analysis of Stage Two

Where, however, a practical activity like education is concerned, the place of theory is totally different, it is not end product of the pursuit, but is rather constructed to determine and guide the activity (Hirst, 1971 p. 342)

7.1 Chapter Overview

This chapter presents data about the focus group of pre-service teachers and their use of ICT in their science teaching during Stage Two and Stage Three of the research that took place in Sri Lankan secondary schools. In the first three sections of the chapter there are detailed descriptions of lessons planned and delivered by each of the fifteen pre-service teachers in the focus group - five from each of the NCOE’s. This data is considered along with interview data to provide insight into the pre-service teacher’s use of technology in their teaching of science, and their chosen pedagogical approaches and is relevant particularly to research questions four and five. The second half of the chapter examines the pre service teacher’s responses to the post-TPK questionnaire that was administered to the focus group after Stage Two and Stage Three.
This data is used to provide a comparison to the results of the TPK questionnaire from before to after their instruction in TPACK model and teaching with technology.

7.2 Observing and Videoing the Pre-Service Teachers

For Stage Two and Three of the research, the primary data source was in monitoring the pre-service teachers in their teaching. Stage Two occurred in the second year of the three year teaching qualification, and Stage Three was in the third year of the training where pre-service teachers undertake teaching practice in selected NCOE’s schools for the year. As the researcher, I observed 15 volunteer participants in the focus group, during their teaching and observed and videoed 45 lessons. Each pre-service teacher in the focus group conducted 3 teaching lessons throughout Stage Two and Stage Three. My observations were recorded in my field note book while I was looking at the lesson, as well as looking at the video. While 45 lessons were videoed, observed and a record kept, I selected a video for each student for further analysis. This selection was based on both the focus on 15 for the detailed analysis. The criteria for the selection as on the use of ICT in the lesson the selected lesson usually showed the best example of the pre-service teacher’s ability to integrate ICT into the lesson. I also considered the need to provide a variety of examples of ICT being integrated into science lessons across the three science domains - chemistry, biology and physics. Section 7.2, 7.3 and 7.4 presents a rich description of 15 lessons of the pre-service teachers teaching experiences during which time they attempted to integrate ICT into their science teaching.

7.2.1 Common Technological and Pedagogical Aspects of the Lessons

There are a number of technological and pedagogical aspects that are highlighted in the descriptions and evaluations of the lessons in the previous three sections. The technological aspects include accessibility to computers, the use of technology to allow measurement – faster
and more accurately than without it, the use of media to engage students and illustrate e.g. representing concepts in a number of ways, the reliability of the internet, and having students use the technology – e.g. to report, measure or interact with information. The pedagogical aspects focussed on the importance of the pre-service teacher’s questioning technique, their engagement of students, through approaches such as personalizing the learning experience, making the lesson relevant and challenging the students. Additional pedagogical aspects include the use of group work, the way science concepts were explained by the pre-service teacher, with some good examples of analogies and conducting experiments, the need to provide opportunities for students to apply what they have learnt to other situations or settings, the following up on students understandings, checking, consolidating, giving and getting feedback and responding to the student’s needs, and using a variety of ways for students to interact with ideas - such as written and oral. As the researcher, I evaluated the class on the interaction by the students, their participation and engagement and evidence of the learning and understanding.

7.3 Pre-service Teachers’ Secondary Science Lessons NCOE 1

The setting of the pre-service teacher who conducted secondary science lessons was at Sri Pada Central College, Hatton. This school is located at Hatton town. It is a mixed school of 1600 students studying up to Grade 1 to grade 13. All the pre-service teachers’ practice classes were conducted in the computer laboratory. This school did not have a Multimedia projector. However, its computer lab was equipped with ten very old Pentium 3 computers in which only five of the computers were working. The Internet connection was not working.

The five pre-service teachers prepared the lesson plans and used PowerPoint presentations, video clips and demonstration to deliver the lessons. The descriptions of the lessons are presented below.
7.3.1 Pre-service Teacher Number 1

NCOE 1, Pre-service teacher 1

Date: - 8th September 2008.

Time: - 8.45 a.m. to 9.30 a.m.

Subject: - General Science Grade 9.

Unit: - Investigation on constellation

Lesson: - Stars and Zodiac

Number of Students Participated in the lesson: - 20 (Boys and girls)

Pre-service teacher gender: - Female

The pre-service teacher started the lesson with inquiry questions. The questions were “Have you looked at the sky at night? What can you all see at the sky at night?” 17 out of 20 students responded to these questions. Before performing the computer presentation she asked questions from the students and explained the content of the lesson. Strong teaching methods were used to conduct the lesson. After that, the class was divided into five groups and students were given a blank table to be completed using PowerPoint presentation, students were explained on how to complete the exercise. In the PowerPoint presentation, the pre-service teacher explained how to find a person’s star sign using Zodiac by showing a man standing on the Globe and the sun was rising from the east and using this diagram. The pre service teacher asked the students to find man’s star sign. Different diagrams were used to show the different positions of the man in relation to the Globe. During the lesson, the pre service teacher conducted group and individual work. The pre service teacher also described the subject matter using very simple
teaching methods to make sure that everybody understands the lesson. Every group managed to complete the exercise. After the exercise, the pre service teacher summarised the lesson and forwarded verbal questions to the students to check their understanding of the lesson. All of the students actively participated to the lesson and gave positive responses to the teacher’s questions.

7.3.2 Pre-service Teacher Number 2 lesson

<table>
<thead>
<tr>
<th>NCOE 1, Pre-service teacher No 2,</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date:</strong> - 8th September 2008.</td>
</tr>
<tr>
<td><strong>Time:</strong> -11.30 a.m. to 12.45 p.m.</td>
</tr>
<tr>
<td><strong>Subject:</strong> - General Science Grade 9.</td>
</tr>
<tr>
<td><strong>Unit:</strong> - Animal Kingdom.</td>
</tr>
<tr>
<td><strong>Lesson:</strong> - Special adaptation of the animals.</td>
</tr>
<tr>
<td><strong>Number of Students participated in the lesson:</strong> 22 (Boys and girls)</td>
</tr>
<tr>
<td><strong>Pre-service teacher gender:</strong> - Female</td>
</tr>
</tbody>
</table>

The pre-service teacher conducted the lesson by first showing video clips on to students on different types of animals in different environments. After showing the video clips, the pre service teacher posed questions to students. Examples of the questions are, “Have you seen animals? Where do fish live? Where do birds live? Where do elephants live?” During the questions and answers session, 16 out of 22 students responded to these questions. After that the pre service teacher distributed handouts to students. The handouts contained a blank table with three columns in which the students were going to complete the table with correct information on the adaption of the animals. The pre service teacher presented the same table on the computer and explained to them how to complete the table. The pre service teacher used a PowerPoint
presentation to show different animals and asked students the following questions: “What is the name of this animal? Where do they live? Which methods are used to protect them from their natural enemies?” Students then completed the table as the pre-service teacher showed the slides. At the end of the slide show, the pre-service teacher showed again the PowerPoint presentation and discussed the answers with the students. Out of 22 students, 19 students responded to her questions. The lesson ended with a summary of the lesson and oral questions to each of the groups.

7.3.3 Pre-service Teacher Number 3 lesson

<table>
<thead>
<tr>
<th>NCOE 1, Pre-service teacher no 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: - 8th September 2008.</td>
</tr>
<tr>
<td>Time: - 9.45 a.m. to 11.15 a.m.</td>
</tr>
<tr>
<td>Subject: - General Science Grade 11.</td>
</tr>
<tr>
<td>Unit: - Periodic table</td>
</tr>
<tr>
<td>Lesson: - Identify position of element in the periodic table using proton</td>
</tr>
<tr>
<td>Number of Students Participated in the lesson: - 20 (Boys and girls)</td>
</tr>
<tr>
<td>Pre-service teacher gender: - Female</td>
</tr>
</tbody>
</table>

This pre-service teacher conducted grade 11 chemistry lessons. 20 students participated to this lesson (boys and girls). In the lesson, the pre-service teacher prepared PowerPoint presentation using flash software and used periodic table. The aim of this lesson was to identify the position of element in a periodic table using the proton number of the element. The pre-service teacher showed the periodic table through the computer and asked students questions about the table. All students responded to the questions and they were able to name the element
correctly. Then the students were asked about the position of the Hydrogen. All students managed to answer the question. Then, the pre-service teacher continued the lesson by inquiring about the rows and columns of the periodic table. After the students’ responses, the pre-service teacher defined what the rows and columns are. Then, the class was divided into groups and students were requested to write ten elements with proton number and to find the position of the elements in the periodic table. After that, the pre-service teacher asked questions about the electronic structure of the atom of element and instructed them to draw the electronic structure of the atom of given elements. All the students drew the given elements of the atoms electronic structure. After that, students were asked to locate the position of the elements in the periodic table. To do that, the pre-service teacher asked questions about what the energy levels of each element are. The pre-service teacher also questioned them about each row energy levels and the elements in the row. The pre-service teacher explained by inquiring the students how to find the periodic table rows and element position in the row. Then the pre-service teacher explained the columns and the relevant places of the elements. Students’ reactions were good. According to the researcher’s field notes, all the students understood the lesson. The pre-service teacher conducted the lesson well, but the application of ICT in the lesson was low level. During the lesson, students’ attention was maintained very well and teaching and learning process was very good. Even though there was low level of ICT application, the lesson was conducted very well.

**7.3.4 Pre-service Teacher Number 4 lesson**

<table>
<thead>
<tr>
<th>NCOE 1, Pre-service teacher no 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: - 8th September 2008.</td>
</tr>
<tr>
<td>Time: - 1.00 p. m. to 1.45 p. m.</td>
</tr>
<tr>
<td>Subject: - General Science Grade 7</td>
</tr>
</tbody>
</table>
The pre-service teacher started the lesson by showing video clips containing different type of animals eating different foods. In the video clips, some animals were eating plants, some of them were eating fish, and some were eating all sorts of things. After the slide show, the pre-service teacher asked students questions about the animals’ eating patterns. The students’ responses were good and they answered the questions well. Then the pre-service teacher divided the students into groups. For each group, the pre-service teacher gave a handout with table for students to complete. Then the pre-service teacher showed the slide show and the pre service teacher asked students to fill the table by referring to the slideshow. This table has three questions to complete. “The questions are what the name of the animal is?” “What type of eating pattern do they have?” And “what type of organs do these animals have to be able to eat different types of food?” The pre-service teacher showed the slide show and students were instructed to complete the table as they watched the slideshow. After that the pre-service teacher showed the slideshow again and invited students to ask questions. During this session, the pre-service teacher discussed the correct answers with the students by checking and correcting students’ answers. The main aim of this lesson was to introduce students the words carnivorous, herbivorous and omnivorous. The pre-service teacher also described some parts of appendages of the animal that suits to the nature of the food they eat. For example, the appendages of herbivores are adapted to suit the nature of the parts of the plant they eat. According to the researcher’s field notes, this lesson was not very well presented because the teaching method and
content delivered in this lesson was viewed to be insufficient because her pedagogy is not sufficient and student responses are very low.

7.3.5 Pre-service Teacher Number 5 lesson

<table>
<thead>
<tr>
<th>NCOE 1, Pre-service teacher No 5 (Stage One)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: - 9th September 2008.</td>
</tr>
<tr>
<td>Time: - 8.45 a. m. to 9.35 a. m.</td>
</tr>
<tr>
<td>Subject: - General Science Grade 10.</td>
</tr>
<tr>
<td>Unit: - Motion</td>
</tr>
<tr>
<td>Lesson: - Calculation of speed</td>
</tr>
<tr>
<td>Number of Students Participated in the lesson: 24 (Boys and girls)</td>
</tr>
<tr>
<td>Pre-service teacher gender: - Male</td>
</tr>
</tbody>
</table>

To demonstrate how to calculate the speed of a moving object, the pre-service teacher prepared a car moving in a distance on the computer screen. Distance is divided by the time and measure the speed. Using flash software, the pre-service teacher prepared a computer program which showed cars moving in the computer screen. The pre-service teacher started the lesson by seeking students’ prior knowledge about the different speed cars perform on the roads. After the students’ responses, the pre-service teacher gave exercises on how to measure the time and distance using the computer program. Students were instructed to measure the time, when the car is moving to 1km and after those students were asked to measure the speed. The pre-service teachers discussed with the students and gave examples, how to calculate speed based on this equation.

\[ \text{Speed} = \frac{\text{travelled distance}}{\text{time}} \]
After giving examples to the students, the pre-service teacher gave a lot of exercises to the students for practice. Students managed to complete the exercise very well. In this lesson, the pre-service teacher used very good computer program using flash. This computer program shows car racing that travelled at different distances and students had to measure the time and calculate the speed. According to researcher’s observation, ICT application is very good.

7.4 Pre-service Teachers’ Secondary Science Lessons NCOE 2

The setting of the pre-service teacher who conducted secondary science lessons was at three locations. Pre-service teacher no 6 lesson was conducted at Ranvala Mahavidyalaya, Ranvala, Kegalle, is situated in Sabaragamuwa Province in Kegalle District. It is 80 km away from Colombo and it is situated at Kandy Colombo main road and 3 km away from Kegalle. This school is a mixed school with 1500 students ranging from grade 1 to 13. At the time of this research it had 15 computers, and Internet was also available in the computer laboratory.

Pre-service teacher no 7 lesson was conducted at Maliyadeva Girls’ College Kurunagale. This school is situated in Kurunagala town and it is 110 km away from Colombo. Located at North Central Province and Kurunagala District, this school is one of the leading girls’ schools in Sri Lanka. There are more than 5000 students ranging from grade 1 to grade 13. This school is a National school and has extensive facilities. This lesson conducted at audio visual room.

Pre-service teacher lesson no 8 was conducted at Baduragoda Maha Vidyalya, Baduragoda. It is a rural school which is situated at Mirigama Divulapitiya road, 7 km away from Mirrigama. This school is situated at Western Province in Gampaha District which is 60 km away from Colombo. It had 20 Pentium 4 computers and the computer laboratory was equipped with multimedia projector. It is a co-education school and has 1600 students.
Lesson number 9 and 10 were conducted at D. S. Senanayaka Central College, Merigama. The lessons were conducted at D. S. Senanayaka Central College, Merigama, Sri Lanka. This school is located in Merigama town. It is a mixed school and has 2600 students ranging from Grade 1 to Grade 13 classes. The school has Multimedia projector 20 Pentium 4 model computers and Internet connection was available.

7.4.1 Pre-service Teacher Number 6 lesson

<table>
<thead>
<tr>
<th>NCOE 2, Pre-service teacher no 1, lesson 1 in Stage Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: - 6(^{th}) February 2009.</td>
</tr>
<tr>
<td>Time: -10.00 a. m. to 11.00 a. m.</td>
</tr>
<tr>
<td>Subject: - General Science Grade 9.</td>
</tr>
<tr>
<td>Unit: - Gases</td>
</tr>
<tr>
<td>Lesson: - Gases related Exercise</td>
</tr>
<tr>
<td>Number of Students Participated in the lesson: 40 (girls and boys)</td>
</tr>
<tr>
<td>Pre-service teacher” gender: - Female</td>
</tr>
</tbody>
</table>

The lesson was mainly focussed on students’ activities. The previous week, the pre-service teacher prepared Oxygen, Hydrogen, and Carbon Dioxide in the laboratory with the students. The pre-service teacher prepared ten questions with diagrams in a PowerPoint presentation. The class was divided into groups and was instructed to do an exercise with the PowerPoint presentation. After answering the questions, each group had to do a presentation. At the beginning of the lesson, students were interested to do the exercise. However, towards the end of the exercise, some male students seemed to be uninterested with the lesson. The questions were structured, very clear, and content-based. Most of the students’ presentations were good.
The teaching method was weak because the pre-service teacher did not explain the lesson in interesting and attractive ways, for the students to understand the lesson. However, the uses of ICT for the class exercise, after the practical session was viewed to facilitate the understanding of the content of the lesson. In other words, students appeared to understand the content quite easily with the use of ICT.

### 7.4.2 Pre-service Teacher Number 7 lesson

<table>
<thead>
<tr>
<th>NCOE 2, Pre-service teacher no 2, lesson 1 in Stage Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: - 9th February 2009.</td>
</tr>
<tr>
<td>Time: - 10.00 a. m. to 11.00 a. m.</td>
</tr>
<tr>
<td>Subject: - General Science Grade 7.</td>
</tr>
<tr>
<td>Unit: - Focuses attention on the environment quantitatively</td>
</tr>
<tr>
<td>Lesson: - Solid, Liquid, and Gasses.</td>
</tr>
<tr>
<td>Number of Students Participated to lesson: 48 (girls)</td>
</tr>
<tr>
<td>Pre-service teacher’s gender: - Female</td>
</tr>
</tbody>
</table>

The pre-service teacher started this lesson by asking several questions. However, only few students responded to the questions. The pre-service teacher then continued talking about the content of the lesson. Throughout the lesson, there were very few responses from the students. The beginning of the lesson was mainly teacher-centred and the pedagogy employed was not effective. In the multimedia PowerPoint presentation although some slides were lacking, the pre-service teacher had included solid, liquid, and gas atom structure in the PowerPoint presentation. The content subject was presented very fast. Based on the researcher’s observation, some students did not understand the lesson. The pre-service teacher appeared to
teach without having any interactions with the students and did not interact with the students. The pedagogy employed was not good. The technology used also lacked important slides that could help students' understanding of the lesson. Teacher centred, content approach was evident and appropriate pedagogical knowledge was lacking. Teacher's control was significant in this lesson.

7.4.3 Pre-service Teacher Number 8 lesson

<table>
<thead>
<tr>
<th>NCOE 2, Pre-service teacher no 3, lesson 1 in Stage Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: 10th February 2009.</td>
</tr>
<tr>
<td>Time: 10.00 a.m. to 11.00 a.m.</td>
</tr>
<tr>
<td>Subject: General Science Grade 10.</td>
</tr>
<tr>
<td>Unit: Living Organisms</td>
</tr>
<tr>
<td>Lesson: Classification of living organisms.</td>
</tr>
<tr>
<td>Number of Students Participated to lesson: 45 (girls and boys)</td>
</tr>
<tr>
<td>Pre-service teacher's gender: Male</td>
</tr>
</tbody>
</table>

The lesson was about the classification of living organisms. The lesson began with a demonstration on showing triangles, squares, and rounds and how these were classified. The teacher demonstrated how triangles, squares, and round and classified. Then the teacher moved on to the slide shows. The slide show was about living organisms' classification. When the slide show was moving from one slide to other, the teacher used inquiring questions about the content of the slide and described the content. Similar teaching method was used throughout the lesson. This was not a good lesson. The pedagogy employed was weak because his lesson was
conducted teacher centred way. Content and technology were fair because his slide show had lot of content not explain the lesson and used basic technology.

7.4.4 Pre-service Teacher Number 9 lesson

<table>
<thead>
<tr>
<th>NCOE 2, Pre-service teacher no 4, lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: - 12th February 2009.</td>
</tr>
<tr>
<td>Time: - 10.00 a.m. to 11.00 a.m.</td>
</tr>
<tr>
<td>Subject: - General Science Grade 7</td>
</tr>
<tr>
<td>Unit: - Living Organisms</td>
</tr>
<tr>
<td>Lesson: - Snakes in Sri Lanka</td>
</tr>
<tr>
<td>Number of Students Participated in the lesson: 48 (girls and boys)</td>
</tr>
<tr>
<td>Pre-service teacher gender: - Male</td>
</tr>
</tbody>
</table>

This lesson was conducted using multimedia projector with slide shows. The lesson was about snakes in Sri Lanka. The lesson started with slideshows and during the slideshows, students were allowed to read the slides. After that, the pre-service teacher explained the slides throughout the lesson. Towards the end of lesson, students were not paying attention in the lesson. They were talking to each other, even though there were good pictures in the slide show. Although the pre-service teacher used very high content but the pedagogy was weak because the pre-service teacher repeated what was written in the slide show. Technology was found to be strong but the pre-service teacher did not use effective way to give better understanding to students.

7.4.5 Pre-service Teacher Number 10 lesson

| NCOE 2, Pre-service teacher no 5 lesson 1. |
The pre-service teacher started his lesson by showing paper chains to the students. Then the pre-service teacher showed a slideshow about various food chains and discussed the food chain with students, using questioning method. After that, students were given a chart and they were instructed to complete the chart, using the information from the slideshow. The pre-service teacher used multimedia projector. With the help of the slide show, the pre-service teacher discussed with students the various levels of living organism in the food chain. During the discussion, students were asked to draw a diagram of the food chain. Using the computers, the pre-service teacher showed the various types of food chains and discussed with students. Finally, the pre-service teacher asked verbal questions from the students. Their reaction was very good because students’ responses to verbal questions are very strong.

7.5 Pre-service Teachers’ Secondary Science Lessons NCOE 3

In the context of NCOE 3, all the science secondary lessons were conducted at Godapitiya Central College, Akkurassa, Sri Lanka. This school is located in Akkuressa town and it is a mixed school with 2400 students ranging from Grade 1 to grade 13. All the lessons were conducted at the computer laboratory. This school had a Multimedia projector. The
computers were very old Pentium 4 model. Five pre-service teachers prepared the lesson plan and they generally used PowerPoint presentations, video clips and demonstration during the lessons.

7.5.1 Pre-service Teacher Number 11 lesson

<table>
<thead>
<tr>
<th>Date:</th>
<th>18th September 2008.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time:</td>
<td>8.45 a.m. to 9.30 a.m.</td>
</tr>
<tr>
<td>Subject:</td>
<td>General Science Grade 8.</td>
</tr>
<tr>
<td>Unit:</td>
<td>As a scientist, looking at environment.</td>
</tr>
<tr>
<td>Lesson:</td>
<td>Using International sings to avoid hazards</td>
</tr>
<tr>
<td>Number of Students Participated in the lesson:</td>
<td>43 (Boys and girls)</td>
</tr>
<tr>
<td>Pre-service teacher’s gender:</td>
<td>Female</td>
</tr>
</tbody>
</table>

The pre-service teacher began the lesson by showing photocopies of a few sign boards in to the class room. Students were asked to give meaning of the particular sign boards. Most of the students described the meaning of sign boards. Then, the pre-service teacher showed a slide show to the students and described the signs in the slide show. Her presentation was not given in an attractive way. Then the class was divided into groups. Each group was given a set of questions and they were asked to do the exercise with the help of the slide show. The pre-service teacher showed the sign boards by using slide show and discussed with the students on the meaning of the sign boards and the questions from the exercise. The pre-service teacher discussed a lot of signs related to Grade 8 curriculum. According to researcher observation her pedagogy is weak but content is good. This lesson was considered weak and her presentation did not explain the lesson.
7.5.2 Pre-service Teacher Number 12

NCOE 3, Pre-service teacher no 2 lesson 2

Date: - 18th September 2008.

Time: - 9.45 a. m. to 10.30 a. m.

Subject: - General Science Grade 8.

Unit: - Observe environment as a scientist

Lesson: - Production of compost.

Number of Students Participated in the lesson: 41 (Boys and girls)

Pre-service teacher gender: - Male

The pre-service teacher came to class with different types of plant leaves, cow dung, lime, water and compost and displayed them on a table in front of the class. Students were invited to identify these materials. Most of the students managed to identify these materials. Then, in groups, students were asked to watch the video clip using multimedia projector. This video clip showed the different types of compost and how to make different types of compost. After the video clip, each group was given a topic and were asked to prepare a short description about compost. After preparing the description, two students from each group presented their work. At the end of the lesson, the pre service teacher summarised the lesson and asked some verbal questions. His presentation is very good. His pedagogy, content, and technology were good. This was a strong lesson because his student centred and students’ reaction was very high.

7.5.3 Pre-service Teacher Number 13 lesson

NCOE 3, Pre-service teacher no 3 lesson 1

Date: - 18th September 2008.
This pre-service teacher started the lesson using video clip about food chain and asked few questions about food chain. Students responded by answering the questions. Students’ prior knowledge about food chain was good. Then, students were instructed to watch a slide show about food webs. While showing the slide show, the pre-service teacher discussed with the students about food webs. After the slide show, the class was divided into groups and each group was asked to draw at least three food webs. After that, each group presented their food webs. During the class presentation, the pre service teacher discussed the subject matter with whole groups and some misconceptions were corrected. At the end of lesson, the pre-service teacher summarised the lesson. This was a strong lesson because during the lesson students’ response to the lesson was so good.

7.5.4 Pre-service Teacher Number 14 lesson

NCOE 3, Pre-service teacher no 4

Date: - 18th September 2008.

Time: - 11.45 a. m. to 12.30 p. m.

Subject: - General Science Grade 6.

Unit: - Diversity in the external features of animals
Lesson: - Appendages of animals.

Number of Students Participated in the lesson: 37 (Boys and girls)

Pre-service teacher gender: - Male

The lesson began with the pre-service teacher brought two animals of locust and earthworm specimens into the class. The class was divided into groups and each group was provided with specimens of locust and earthworm. Students were then asked to identify the animals’ appendages. The pre-service teacher also asked questions about the differences between the two animals. During the discussion, students identified the differences between these two animals. After that, a slide show about different animals, like butterfly, spider, prawn, etc, was shown to the students. Students were then asked to make a table about these animals’ appendages. Each groups presented the table they had completed. While they were presenting, the whole class discussed their answers. Finally, the pre-service teacher summarised the lesson and asked a few questions about animals’ appendages. Students’ reflection was medium. This lesson was considered as fairly weak because his teaching method was not suited to most students.

7.5.5 Pre-service Teacher Number 15 lesson

NCOE 3, Pre-service teacher no 5 lesson 1.

Date: - 19th September 2008.

Time: - 8.45 a. m. to 9.30 a. m.

Subject: - General Science Grade 6.

Unit: - Diversity in Plants

Lesson: - Diversity of plants leaves.

Number of Students Participated to lesson: 41 (Boys and girls)
Pre-service teacher gender: - Female

The pre-service teacher divided the class into groups and asked the students to go to the school garden and collect different types of plant leaves. Duration of 10 minutes was given to the students to complete the task. After that, students were asked to organise the leaves according to their different features such as shape, colour, and types of margin. After that activity, a slide show on different leaves in the flowering plants was shown to the students. Then, the students were asked to make a table according to the different leaves and each group presented their work to the class. The pre-service teacher also discussed with the whole class when the students did their presentation.

7.6 Pre-service Teachers’ Interviews

In this research, the researcher interviewed the 15 pre-service teachers in the focus group at the end of the Stage Three, after the completion of three teaching lessons. The secondary science pre-service teachers were interviewed using six semi-structured questions. A representative sample of answers provided by the pre-service teacher was described.

All of the secondary science pre-service teachers stated that they liked to use ICT in their lessons but there were problems such as the difficulty in getting access to the computer lab. This was necessary because there were no computers available in the classrooms.

All of the secondary science pre-service teachers responded that they had two years of training at NCOE, in the teaching and learning processes during which time they had studied applications of pedagogical knowledge and content knowledge, but they did not have the training application of technological knowledge in teaching and learning processes.
All the secondary science pre-service teachers said that they understood the purpose of ICT better as a result of having learnt about the TPACK model. The majority of the secondary science pre-service teachers said that they understood the use of ICT with the TPACK model for preparing science lesson and also they understood ICT is a powerful tool to teach secondary science.

In response to the question: “How does using ICT with TPACK model help to develop understanding of secondary science in students?” There were generally four explanations among the pre-service teacher’s responses:

- Using Internet, pre-service teachers get lot of knowledge of teaching;
- Using ICT, subjective concepts can be explained that and students can easily understand;
- Using ICT, students get live experience;
- Using ICT can visualise the subject matter.

When asked about their confidence to use ICT in the classroom, all the secondary science pre-service teachers were very confident to teach secondary science using ICT. They said that they had the ability and knowledge to use ICT in their secondary science lessons.

The most popular examples of ICT that the pre-service teachers had used were PowerPoint and video clip with multimedia presentation. They also like to use DVDs and VCDs to enhance the students’ science concepts.

7.7 Changes to Pre-service Teachers Technological Skills from Stage One to Stage Three

The initial results of the TPK questionnaire for the whole cohort (N=67) are reported in Chapter 6. The TPK questionnaire was re-administered to pre-service teachers who were in the
focus group (N=15) after Stage Two and Stage Three. These three data sets for the TPK Questionnaire are used to identify any changes that occurred in the pre service teacher's responses over the time of the research study. Because the quantity of data from the focus group is small being from 15, the results are discussed. The tables are used to compare differences across the three stages of the research.

All of the pre-service teachers in the focus group totally agree with using computers as much as they can at the NCOE and outside the NCOE at Stage Two and Three. This is not surprising since the pre-service teachers voluntarily participated in this research and their interests in ICT were high. This impacts on all the comparative analysis of the results. All the pre-service teachers in Stage Two and Three were using desktop computers and scanners, printers, and digital video cameras. All the pre-service teachers in the focus group (n=15) were using computer as an entertainment tool, for their studies, and using computer for teaching practice. Stage Two and Stage Three had equal response with regards to computer use at the NCOE and outside the NCOE (see Table 7.1)

Table 7.1 shows the use of computers in three stages of pre-service teachers. According to Table 7.1, there was an improvement in the usage of computers in Stage Two and three as compared Stage One in Item 3, pre-service teachers used computers as much as they could in Stage One is 52% and in stages 2 and 3 it is 100%. For my entertainment it is 65% in stages 1, 2 and in Stage Three it is 100%. For my studies it is 69% in Stage One, 2 and in Stage Three it is 100%. For my teaching it is 46% in stages 1, 2, and in Stage Three it is 93%. Stage two and three pre-service teachers show high because they have some kind of ICT training.
### Table 7.1
The percentage of computer use of pre-service teachers at NCOE and outside NCOE (N= 68 Stage One, N=15 Stage Two and Three)

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>At the NCOE</th>
<th>Outside the NCOE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>01</td>
<td>Not at all</td>
<td>12</td>
<td>00</td>
</tr>
<tr>
<td>02</td>
<td>Only a little</td>
<td>34</td>
<td>00</td>
</tr>
<tr>
<td>03</td>
<td>As much improve as I can</td>
<td>52</td>
<td>100</td>
</tr>
<tr>
<td>04</td>
<td>For my entertainment</td>
<td>65</td>
<td>100</td>
</tr>
<tr>
<td>05</td>
<td>For my studies</td>
<td>69</td>
<td>100</td>
</tr>
<tr>
<td>06</td>
<td>For my teaching practices</td>
<td>46</td>
<td>93</td>
</tr>
</tbody>
</table>

The pre-service teachers in the focus group showed some improvement in the overall computer-typing skills, with the increase in all levels of using the keyboard (see Table 7.2).

### Table 7.2
Pre-service teachers’ computer typing skills (n=15)

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Stage One Total Agree</th>
<th>Stage Two Total Agree</th>
<th>Stage Three Total Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Keyboard with few fingers</td>
<td>60</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>02</td>
<td>Keyboard with all fingers</td>
<td>31</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>03</td>
<td>Keyboard with all fingers not looking</td>
<td>15</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>
There was improvement in Stage Two and Stage Three for the pre-service teacher’s perceptions of their communication skills with usage such as, e-mail and blogs improving slightly, and also with their Internet usage. With regards the use of software, the focus group, show higher values as the project proceeded, e.g. Item 2.4, create diagrams at NCOE is 100% and Item 2.7, create slideshow at NCOE is 93% and Item 4.8, create presentations at the NCOE is 100% (see Table 7.3). According to Table 7.3 pre-service teachers’ software application proficiency is high in Stages Two and Three as compared with Stage One.

Table 7.3

The percentage of pre-service teachers who agree that they can use software applications proficiency at Stage One Two and Three (N=15)

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Stage One N=68</th>
<th>Stage Two N=15</th>
<th>Stage Three N=15</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>To create diagrams</td>
<td>52</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2.5</td>
<td>To send E-mail</td>
<td>9</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>2.6</td>
<td>For instant messaging</td>
<td>18</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>2.7</td>
<td>Create slide show</td>
<td>60</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>2.8</td>
<td>Create presentation</td>
<td>74</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2.9</td>
<td>Create/edit Movies</td>
<td>12</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>2.10</td>
<td>Carryout Research on Internet</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>2.11</td>
<td>Create webpage</td>
<td>3</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2.12</td>
<td>Use spreadsheet</td>
<td>31</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>2.13</td>
<td>Create spreadsheet</td>
<td>29</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>2.14</td>
<td>To create Bloggs</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>2.15</td>
<td>Use CD’s and DVD’s</td>
<td>47</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
The data in Table 7.4 shows the pre-service teachers’ perceptions of their computer skills. There is a marked improvement in the results from Stage One to Stage Three for all items. This improvement in confidence level is expected since the pre-service teachers have had instruction in using ICT and have been involved in this project.

**Table 7.4**

*Percentage of pre-service teachers' skills when they are in teaching and learning (N=15)*

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Stage One</th>
<th>Stage Two</th>
<th>Stage Three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Agree</td>
<td>Total Agree</td>
<td>Total Agree</td>
</tr>
<tr>
<td>6.1</td>
<td>I am very confident to use ICT in my teaching</td>
<td>44</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6.2</td>
<td>I am most of the time incorporating ICT into my teaching</td>
<td>47</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>6.3</td>
<td>I am preparing class lessons using ICT</td>
<td>25</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>6.4</td>
<td>I am using ICT effectively to teach numeracy/literacy</td>
<td>18</td>
<td>87</td>
<td>100</td>
</tr>
<tr>
<td>6.5</td>
<td>I am confident to answer students questions related to their ICT use</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6.6</td>
<td>I advise students to make productive use of ICT in my classes</td>
<td>72</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>6.7</td>
<td>I help students to use ICT</td>
<td>66</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6.8</td>
<td>I motivate students to use ICT</td>
<td>61</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6.9</td>
<td>I use range of ICT resources in the classroom</td>
<td>53</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
7.8 Pre-service teachers’ pedagogical knowledge

*For Pre-service teachers, TPK questionnaire section B, the first part first question asks about learning theories that guide the way we teach student. According to Table 7.5, there were more consistent results among the pre service teachers at Stage Three.*

*Table 7.5*

*Percentage of pre-service teachers use learning theories to guide the way they teach students (N= 68, 15)*

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Stage One</th>
<th>Stage Two</th>
<th>Stage Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Constructivism</td>
<td>58</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>02</td>
<td>Behaviourism</td>
<td>8</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>03</td>
<td>Cognitivism</td>
<td>3</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>04</td>
<td>No Answer</td>
<td>30</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>05</td>
<td>Constructivism and Behaviourism</td>
<td>2</td>
<td>00</td>
<td>00</td>
</tr>
</tbody>
</table>

*Table 7.6*

*Pre-service teachers’ response when planning a secondary science lesson they might consider the following approaches.*

<table>
<thead>
<tr>
<th>Item No</th>
<th>Response</th>
<th>Stage One</th>
<th>Stage Two</th>
<th>Stage Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Planning according to teachers’ guide</td>
<td>20</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>02</td>
<td>Plan based on curriculum</td>
<td>15</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>03</td>
<td>Plan according to learning theories</td>
<td>6</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>04</td>
<td>Prepare your own lesson plan</td>
<td>21</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
The majority of pre-service teachers’ chosen answer was using the 5E approach in all three stages because of the introduction of the educational reform in 2008 which was based on 5E approach (see Table 7.6). In all three stages the majority of pre-service teachers’ using educational tools to teach science due to the fact that they were science teachers. High responses are from all three stages to “prepare your own lesson plan”. They like to use audio and video demonstrations, experiments, and living and dead specimens. In stages 2 and 3 the link between learning theory and teaching practice appears to be good.

*Pre-service teachers TPK questionnaire* in section B, second part of the second question require respondents to explain how they plan an innovative science lesson. Six categories were derived and explained below in Table 7.7.

**Table 7.7**

*How Pre-service teachers innovate science lesson all three stages (N=68, 15)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>Because of students’ creativity, students can independently acquire knowledge</td>
<td>12</td>
<td>00</td>
</tr>
<tr>
<td>5E’s teaching method</td>
<td>30</td>
<td>74</td>
</tr>
</tbody>
</table>
According to the Table 7.7, in all three stages of pre-service teachers followed 5E teaching methods and lessons planned according to teacher's guide and curriculum.

Pre-service teachers TPK questionnaire section B third part of the second question requested them to explain why they chose these methods. Four categories of explanations were decided, as shown in Table 7.8. According to Table 7.8, indicates the percentages of pre-service teachers' answers why they choose these methods. Of all three stages, most of the secondary science pre-service teachers chose 5E method, exporting new content and knowledge by the students.

**Table 7.8**

*Percentage of pre-service teachers answered why you chosen these*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>Student’s activity, encouragingly and interestingly do their learning</td>
<td>8 00 00</td>
<td>Activity based education system helps improve students’ knowledge, skills, and attitude.</td>
</tr>
<tr>
<td>Student-centred teaching and learning method</td>
<td>8 06 04</td>
<td>Students get firsthand experience.</td>
</tr>
<tr>
<td>Present students live in technological world</td>
<td>8 00 00</td>
<td>Teaching and learning methods must incorporate technology.</td>
</tr>
<tr>
<td>Lesson is planned according to teacher’s guide and curriculum.</td>
<td>34 20 20</td>
<td>To conduct good lesson need good lesson plan.</td>
</tr>
</tbody>
</table>
According to present technical knowledge teaching must change 6 00 00 Integrating technology for teaching and learning.

Student-centred and student can understand the lesson 18 01 01 Student-centred teaching and learning process help students to motivate learning. Student-centred teaching and learning process, students gain knowledge.

5E method exporting new content and knowledge by the students 18 14 14 Content of a lesson is easy to understand when 5E method used for to teaching and learning. 5E method exploring new knowledge and new concepts to the students

Give direct experience to students 12 00 00 Students get knowledge through the experience.

Pre-service teachers, TPK questionnaire section B first part of the third question, seven choices was given as shown in Table 7.9. In all three stages pre-service teachers chose the experiment work and practical activity, and demonstration. (Most of the pre-service teachers choose more than one answer). In all stages most of the pre-service teachers’ choice is using the experiment work and practical activity, and demonstrations because NCOE curriculum develops to achieve to this level.

Table 7.9
Percentage of pre-service teachers answered why you chosen these (N=68, 15)

<table>
<thead>
<tr>
<th>Item No</th>
<th>Responses</th>
<th>Stage One</th>
<th>Stage Two</th>
<th>Stage Three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experiment work and practical activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>01</td>
<td>Demonstrations</td>
<td>25</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>02</td>
<td>Group work and collaborative activity</td>
<td>15</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>03</td>
<td>Lectures</td>
<td>4</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>04</td>
<td>Discussions</td>
<td>8</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>05</td>
<td>Questioning from student and develop the lesson</td>
<td>9</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>06</td>
<td>Other</td>
<td>6</td>
<td>00</td>
<td>00</td>
</tr>
</tbody>
</table>

Pre-service teachers’ TPK questionnaire section B second part of the third question explained which type of teaching method would be best to promote learning among students. Four categories of explanation were developed, as shown in Table 7.10.

**Table 7.10**

*Pre-service teachers reflection of which type of teaching method would be the best to promote (N=68, 15)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers %</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
</tbody>
</table>
| Experimental work and practical work | 27 | 13 | 15 | Experimental and practical activity will help student to achieve high-level of knowledge.  
Student must have practical and theoretical knowledge. |
| Group work and collaborative activities | 22 | 13 | 14 | Develop creativity.  
Students like group work. |
Questioning from students and develop the lesson 3 00 00 Students use their experience and explore the scientific concepts. Share knowledge among the students.

Using all the methods develop the lesson 5 00 00 According to the class situation teachers have to use all these methods. Using all these methods it is very easy go to the subject goal.

Table 7.10 shows the type of teaching method that would be the best to promote among the students. According to pre-service teachers’ responses, in all three stages answers were experimental work and practical work, and group work and collaborative activities.

Pre-service teachers’ TPK questionnaire section B third part of the third question explained why, which type of teaching method would be best to promote learning among students. Four categories for the explanations were decided as shown in Table 7.11.

Table 7.11

Pre-service teachers’ reflection of why, which type of teaching method would be the best to promote (N=68, 15)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>All these methods help to develop students, knowledge, attitudes, and skills.</td>
<td>26 15 15</td>
<td>According to the lesson they have to select suitable methods. Theoretical knowledge and practical knowledge must develop.</td>
</tr>
</tbody>
</table>
Group work and collaborative activities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Through the activity, based education students learn many things. Group work and collaborative activity help to develop students’ exploration, society attitudes, and human values.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>00</td>
<td>00</td>
<td></td>
</tr>
</tbody>
</table>

Experimental work and practical work

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Experimental and practical knowledge can use day-to-day activity. Students’ motivation increase practical and experimental work.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>00</td>
<td>00</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.11 shows pre-service teachers answer to why which type of teaching method would be best to promote learning among students. In Stages of Two and Three pre-service teachers answered all these methods help to develop students’ knowledge, attitudes, and skills.

Pre-service teachers TPK questionnaire section B first part of the forth question and six options were given. The question is, are there many ways of explaining scientific concepts?

Table 7.12

Pre-service teachers have many ways of explaining scientific concepts

<table>
<thead>
<tr>
<th>Item</th>
<th>Response</th>
<th>Stage One</th>
<th>Stage Two</th>
<th>Stage Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>I dictate notes and then I explain them</td>
<td>45</td>
<td>02</td>
<td>03</td>
</tr>
<tr>
<td>02</td>
<td>I divide the class into groups to discuss the concepts</td>
<td>41</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>03</td>
<td>I use visual representations like concepts maps, and Venn diagrams</td>
<td>29</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>04</td>
<td>I use teaching aids. e.g. models,</td>
<td>17</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>
demonstrations

<table>
<thead>
<tr>
<th></th>
<th>Draw diagrams</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>16</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>06</td>
<td>Others.</td>
<td>2</td>
<td>00</td>
</tr>
</tbody>
</table>

In Stages Two and Three the majority of pre-service teachers chose the *Divide the class into groups* to discuss the concepts, use visual representation like concepts maps, Venn diagrams and use teaching aid, and draw diagrams. (Most of the pre-service teachers chose more than one answer).

*Pre-service teachers’ TPK questionnaire* section B second part of the fourth question explained which method(s) would be best to promote understanding among students. Five categories of explanations were decided.

*Table 7.13*

*Pre-service teachers’ answers which method(s) would be the best to promote among the students* (*N*=68, 15)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers’ comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>use visual representations like concepts maps, and Venn diagrams</td>
<td></td>
<td>Through the concept maps, Venn diagrams, and draw diagrams students’ memory can develop. Students’ reflection is very high.</td>
</tr>
<tr>
<td>Use teaching aids. e. g. models, demonstrations</td>
<td>27</td>
<td>Students logical thinking increasing Students’ explore the knowledge.</td>
</tr>
<tr>
<td>Divided class into groups to discuss the concepts</td>
<td>4</td>
<td>Shear knowledge among the students. Students’ exchange their knowledge among the peers.</td>
</tr>
<tr>
<td>dictate notes and then</td>
<td>2</td>
<td>Easy to teach subject matter.</td>
</tr>
</tbody>
</table>
Table 7.13 shows, which type of teaching method, would be the best to promote among the students. In Stage Two and Three according to pre-service teachers’ majority of answers, all these methods used to develop students’ knowledge, skills and attitudes, used teaching aids, and divided class into groups to discuss the concepts.

*Pre-service teachers’ TPK* questionnaire section B third part of the fourth question explained why, which type of teaching method would be best to promote learning among students. Four categories of explanations were decided.

**Table 7.14**

*Pre-service teachers explanations of which type of teaching methods would be the best to promote learning (N=68, N=15)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>use visual representations like concepts maps, and Venn diagrams</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Use teaching aids. e.g. models, demonstrations</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Divide class into groups to discuss the concepts</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>All these methods used to develop students knowledge, skills and</td>
<td>19</td>
<td>15</td>
</tr>
</tbody>
</table>
attitudes. achieve their goal.

Teacher is a facilitator 4 11 13 Teacher can provide lesson abstract. Teacher has to develop their skills as facilitator.

According to Table 7.14 pre-service teachers explained why, which type of teaching method would be the best to promote learning among students. In stages of Two and Three according to pre-service teachers’ answers all these methods can be used to develop students’ knowledge, skills and attitudes, use visual representations like concepts maps, and Venn diagrams, and divide class into groups to discuss the concepts are the best.

Pre-service teachers TPK questionnaire section B first part of the fifth question, six answers were given in three stages. The question is, circling the teaching aids you use when you are teaching?

Table 7.15
Pre-service teachers circling the teaching aids you use when they are teaching

<table>
<thead>
<tr>
<th>Item No</th>
<th>Response</th>
<th>Stage One</th>
<th>Stage Two</th>
<th>Stage Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Black board</td>
<td>42</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>02</td>
<td>White Board</td>
<td>40</td>
<td>07</td>
<td>07</td>
</tr>
<tr>
<td>03</td>
<td>PowerPoint</td>
<td>37</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>04</td>
<td>Overhead projector (OHP)</td>
<td>36</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>05</td>
<td>Textbook</td>
<td>19</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>06</td>
<td>Others</td>
<td>11</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
In Stage Two and Three pre-service teachers chose the *PowerPoint, black board and text book*. (Most of the pre-service teachers chose more than one answer).

*Pre-service teachers TPK* questionnaire section B second part of the fifth question explained why you choose to use them. Four categories of explanations were decided.

**Table 7.16**

*Pre-service teachers explained why choose these teaching aids (N=68, 15)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers’ comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>PowerPoint’s presentation</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black board</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>All teaching aids</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead projector</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

According to Table, 7.15 pre-service teachers explained why they chose to use these teaching aids. In stages of 2 and 3 pre-service teachers’ responses were as follows. All pre-service teachers’ answers are *PowerPoint presentation, all kinds of teaching aids and using of black board*. 
7. 9 Pre-service teachers’ Computer Technology Knowledge

The analysis of the results of the Pre-service teachers’ TPK questionnaire Stage Two and Three provide some insight into their technological skills, technological knowledge and pedagogical knowledge. 15 pre-service teachers agreed to participate in the second and third stage of this research project. This research, their technological skills, technological knowledge and pedagogical knowledge results were taken after Stage Two and Stage Three after completion of the research. (15 pre-service teachers were included in the 68 samples).

7.10 Pre-service teachers’ TPK questionnaire section C

Pre-service teachers’ TPK questionnaire section C. The first question is on how you think ICT can be used as an educational tool. Four categories of explanations were decided.

Table 7.17

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers’ comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage 1</td>
<td>Stage Two</td>
</tr>
<tr>
<td>It is a successful teaching method</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>It is more effective and more productive</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Can change traditional classroom into student</td>
<td>16</td>
<td>14</td>
</tr>
</tbody>
</table>
friendly classroom  classroom.
Lack of facility in Sri Lankan  5  15  15  Sri Lankan schools ICT facility is
school  very low.

In Stage Two and Three pre-service teachers chose it as successful teaching method, it is
more effective and more productive, can change traditional classroom into student friendly
classroom, and lack of facility in Sri Lankan schools.

*Pre-service teachers’ TPK questionnaire* section C The second question is how you think
ICT could be used to change the way you teach science. Four categories of explanations were
decided.

*Table 7.18*

*Pre-service teachers explained how you think ICT can use to change the way to teach
science (N=68, 15)*

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers’ comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT helps to explain lessons</td>
<td>Stage One 48  Stage Two 13  Stage Three 14</td>
<td>Using ICT, teachers can explain lessons very easily.</td>
</tr>
<tr>
<td>Students get worldwide knowledge</td>
<td>Stage One 12  Stage Two 12  Stage Three 12</td>
<td>Students can get modern knowledge through ICT.</td>
</tr>
<tr>
<td>ICT helps to motivate students</td>
<td>Stage One 5  Stage Two 14  Stage Three 13</td>
<td>ICT can motivate students’ knowledge.</td>
</tr>
</tbody>
</table>

According to Table 7.18, in Stage Two and 3, pre-service teachers chose ICT helps to
explain lessons, students get worldwide knowledge. ICT helps to motivate students.
Pre-service teachers TPK questionnaire section C third question is on how ICT is currently used in teaching science in Sri Lanka. Four categories of explanations were decided.

Table 7.19

Pre-service teachers explained how ICT is currently used in teaching science in Sri Lanka (N=68, 15)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>Very few schools use Internet and ICT in Sri Lanka</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Urban schools use little bit of ICT but rural schools do not use ICT</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Resources availability is very low</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Very few teachers use ICT in their science lessons</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

According to Table 7.19, In Stage Two and Three pre-service teachers chose a very few schools use Internet and ICT in Sri Lanka, resources availability is very low, town schools use little bit of ICT but rural schools do not use ICT and a very few teachers use ICT in their science lessons.
Pre-service teachers TPK questionnaire section C fourth question part (a) is which type of skills do you think pre-service teachers need to be able to use ICT in their teaching of science? Three categories of explanations were decided.

Table 7.20

Pre-service teachers needed ICT skills in their teaching of science (N=68)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>Teachers need internet proficiency</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Teachers’ ICT knowledge and Teaching ability</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td>Teachers’ ICT knowledge of theoretical and practical settings</td>
<td>17</td>
<td>14</td>
</tr>
</tbody>
</table>

According to Table 7.20, In Stage Two and Three pre-service teachers chose teachers ICT knowledge and teaching ability, teachers need internet proficiency and teachers’ ICT knowledge of theoretical and practical setting.

Pre-service teachers’ TPK questionnaire section C fourth question part (b) is Do you have these skills? Two answers were received and they were yes or no response answers.
### Table 7.21

**Pre-service teachers’ ICT skills (N= 68, 15)**

<table>
<thead>
<tr>
<th>Question</th>
<th>Stage One</th>
<th></th>
<th>Stage Two</th>
<th></th>
<th>Stage Three</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-service teachers need to be able to use ICT in their teaching of science?</td>
<td>55</td>
<td>10</td>
<td>15</td>
<td>00</td>
<td>15</td>
<td>00</td>
</tr>
</tbody>
</table>

According to the answers given by the pre-service teachers in the Table 7.21, *TPK* questionnaire section C fourth question part (b) in Stage Two and 3, all pre-service teachers said ‘yes’.

Pre-service teachers’ *TPK* questionnaire section C Fifth question part (a) is on ICT prepare my class lessons using ICT, Taking students into the computer laboratory and ask them to research content, using computer software programmes, and using Microsoft office programmes.

### Table 7.22

**Percentage of pre-service teachers’ science lessons ICT applications (N=68, 15)**

<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Stage One</th>
<th></th>
<th>Stage Two</th>
<th></th>
<th>Stage Three</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>01</td>
<td>Preparing my class lessons using ICT.</td>
<td>42</td>
<td>57</td>
<td>15</td>
<td>00</td>
<td>15</td>
<td>00</td>
</tr>
<tr>
<td>02</td>
<td>Taking students into the computer lab and ask them to research content.</td>
<td>38</td>
<td>62</td>
<td>15</td>
<td>00</td>
<td>15</td>
<td>00</td>
</tr>
<tr>
<td>03</td>
<td>Using computer software programmes.</td>
<td>42</td>
<td>58</td>
<td>15</td>
<td>00</td>
<td>15</td>
<td>00</td>
</tr>
</tbody>
</table>
Table 7.22 shows the applications of ICT in science lessons by pre-service teachers. According to that, preparing their class lessons using ICT in Stage Two and Three, taking students into the computer laboratory and ask them to research content, using computer software programmes, and using Microsoft office to teaching and learning process.

*Pre-service teachers’ TPK questionnaire section C* Fifth question part (b) is when you are in school do you use ICT in science lessons and the researcher received yes or no responses.

*Table 7.23*

*Pre-service teachers’ using ICT in science lessons.*

<table>
<thead>
<tr>
<th>Question</th>
<th>Stage One</th>
<th></th>
<th>Stage Two</th>
<th></th>
<th>Stage Three</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>When you were in schools, did you use ICT in science lessons?</td>
<td>41</td>
<td>27</td>
<td>15</td>
<td>00</td>
<td>15</td>
<td>00</td>
</tr>
</tbody>
</table>

Table 7.23 shows, in Stage Two and Three all pre-service teachers, used ICT in science lessons when they were in schools. This is not surprising since they were part of the volunteer who had selected to include ICT in their teaching.

*Pre-service teachers’ TPK questionnaire section C* fifth question part (c) is describing ways you think ICT could be integrated into your teaching methods. Three categories of explanations were decided.
Table 7.24

Pre-service teachers’ describing ways of ICT integrated into their teaching methods
(N=68, 15)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>Number of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One Stage Two Stage Three</td>
<td></td>
</tr>
<tr>
<td>Using PowerPoint presentations, DVDs and VCDs.</td>
<td>23 15 15</td>
<td>Using PowerPoint presentation</td>
</tr>
<tr>
<td>Software application</td>
<td>13 15 15</td>
<td>Using different type of software</td>
</tr>
<tr>
<td>Using Internet</td>
<td>08 15 15</td>
<td>Content can be searched through the Internet</td>
</tr>
</tbody>
</table>

According to Table 7.24 pre-service teachers’ description on ways of ICT integrated into their teaching methods are as follows. In Stage Two and Three all pre-service teachers use PowerPoint presentation DVDs and VCDs, use software applications, use the Internet.

Pre-service teachers’ TPK questionnaire section C Fifth question part (d) is ‘Do you think the use of ICT can promote learning?’ Answers were ‘yes’ or ‘no’.

Table 7.25

Percentage of pre-service teachers’ idea about the use of ICT to promote learning
(N=68, 15)

<table>
<thead>
<tr>
<th>Question</th>
<th>Stage1 %</th>
<th>Stage Two %</th>
<th>Stage3 %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes No</td>
<td>Yes No</td>
<td>Yes No</td>
</tr>
<tr>
<td>Do you think the use of ICT can</td>
<td>88 11</td>
<td>100 00</td>
<td>100 00</td>
</tr>
</tbody>
</table>
promote learning.

Table 7.25 shows in Stage Two and Three pre-service teachers’ idea on the use of ICT to promote learning. 100% of pre-service teachers agree with use of ICT to promote learning.

Pre-service teachers’ TPK questionnaire section C fifth question part (e) is (Do you think the use of ICT can promote learning?) How? Four categories of explanations were decided.

Table 7.26

Pre-service teacher’s how to promote learning using ICT (N=68, 15)

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>Enhance students understanding</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Using ICT, motivate students</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Using ICT students can be more creative</td>
<td>07</td>
<td>14</td>
</tr>
<tr>
<td>Using ICT teachers’ knowledge can be</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>improved</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.26 provides pre-service teachers’ description how promote learning using ICT. In Stage Two and Three pre-service teachers said it enhances students’ understanding, using ICT
teachers’ knowledge can be improved, that by using ICT, students can be motivated and using ICT students can be more creative.

Pre-service teachers TPK questionnaire section C fifth question part (f) is, Why do you think the use of ICT can promote learning? Three categories of explanations were decided, as shown in Table 7.27.

Table 7.27

<table>
<thead>
<tr>
<th>Why Pre-service teachers’ promote using ICT for learning (N=68, 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanations of category</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>Students more attractive to ICT</td>
</tr>
<tr>
<td>ICT more productive</td>
</tr>
<tr>
<td>Using Internet, students get more knowledge</td>
</tr>
</tbody>
</table>

Table 7.27 shows pre-service teachers’ reasons on why ICT promote learning. In Stage Two and Three students are more attractive to ICT, using ICT is more productive, and the Internet students get more knowledge.
Pre-service teachers' TPK questionnaire section C Fifth question part (g) is 'Do you think the use of ICT can improve your teaching?' Answers were 'yes' or 'no'. The results are presented in Table 7.28. Table 7.28 shows pre-service teachers' opinion on whether using ICT can improve their teaching. In Stage two and three all pre-service teachers said ICT could improve their teaching.

**Table 7.28**

Pre-service teachers think ICT can improve their teaching

<table>
<thead>
<tr>
<th>Question</th>
<th>Stage One</th>
<th></th>
<th>Stage Two</th>
<th></th>
<th>Stage Three</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the use of ICT can improve your teaching?</td>
<td>Yes 88</td>
<td>No 12</td>
<td>Yes 100</td>
<td>No 00</td>
<td>Yes 100</td>
<td>No 00</td>
</tr>
</tbody>
</table>
ICT can gain students and teachers knowledge and experience

Using ICT students and teachers can be more creative

Through the Internet, they gain knowledge

Table 7.29, shows pre-service teachers responses on how they think the use of ICT can improve their teaching. In Stage Two and Three, pre-service teachers said *ICT could motivate students, ICT could gain students' and teachers' knowledge and experience, through the Internet they gain knowledge, and using ICT students and teachers can be more creative.*

*Pre-service teachers' TPK questionnaire section C fifth question part (i) is (Why do you think the use of ICT can improve your teaching?)*

*Table 7.30*

**Why Pre-service teachers use ICT to improve their teaching (N=68, 15)**

<table>
<thead>
<tr>
<th>Explanations of category</th>
<th>No of pre-service teachers</th>
<th>Examples of pre-service teachers comment to support the coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage One</td>
<td>Stage Two</td>
</tr>
<tr>
<td>Good method to teach science</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Using Internet, teachers gain knowledge</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Students get live experience</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>
According to Table, 7.30, in Stage Two and Three all pre-service teachers said it is a good method to teach science, using the Internet, teachers gain knowledge, students get live experience through ICT and Students can explore the content.

### 7.11 A Discussion of the Results

The interpretation of the data from the video and observations of the pre-service teachers in the lessons, and the interview data was initially recorded by the researcher and then translated by the researcher so that the interpretation could be discussed and undergone member checking with the supervisor.

The data for the TPK instrument comes from a large group of pre-service teachers in Stage one, whereas the data from stage 2 and 3 is from a select group of pre-service teachers who volunteered to try and use ICT in their teaching. This needs to be kept in mind when considering the results because it does impact on the result. Comparing the three data sets at Stage 1, 2, and 3, therefore makes interpretation and drawing conclusions difficult. The comparison provides some indicators that can be useful. Also the questionnaire asks for the pre-service teachers’ opinions, and perceptions. The video data can be used to confirm this data. In stage 2 and 3 all the pre-service teachers used desktop computers and scanners, printers, and digital video cameras compared to stage one when not all students used this equipment. There was no change in the use of computers as entertainment tool across all three stages. All pre-service teachers’ computer use at the NCOE and outside the NCOE (see Table 7.1) is equal in stage two and three. Pre-service
teachers used computers as much as, for my entertainment, for my studies, and for my teaching are equal in stage two and three. These pre-service teachers had ICT training before entering to NCOE because of that in stage two and stage three pre-service teachers have high technological skills.

Pre-service teachers’ pedagogical knowledge describes in TPK questionnaire section B. In stage two and three all pre-service teachers say that they practise constructivist learning theory (see Table 7.5). Majority of pre-service teachers are practising 5E approach because of the introduction of the educational reform in 2008 which was based on 5E approach. Majority of pre-service teachers’ using educational tools and high responses are from all three stages to “prepare your own lesson plan” (See Table 7.7) according to teacher’s guide and curriculum, using educational tools such as audio and video presentations, experiments, and living and dead specimens (see Table 7.9). In stages 2 and 3 there is link between learning theory and teaching practice. All three stages pre-service teachers’ response was experimental work and practical work, and group work and collaborative activities (see Table 7.10). In Stages two and three the majority of pre-service teachers, divide the class into groups to discuss the concepts, use visual representation like concepts maps, Venn diagrams and use teaching aid, and draw diagrams. Pre-service teachers’ response was all teaching methods help to develop students’ knowledge, attitudes, and skills. In stage two and three all pre-service teachers use PowerPoint presentation, all kinds of teaching aids and black board.

Pre-service teachers’ technological knowledge of stage two and three describes TPK questionnaire section C. In stage two and three all pre-service teachers use ICT as a successful teaching method. It is more effective and more productive, can change traditional classroom into student friendly classroom, but there are lack of facilities in Sri Lankan schools (see Table 7.17).
In stage two and three, pre-service teachers describe ICT helps students to get worldwide knowledge. ICT helps to motivate students (see Table 7.18). Pre-service teachers describe, a very few schools use Internet and ICT in Sri Lanka, resources availability is very low, town schools use little bit of ICT but rural schools do not use ICT and a very few teachers use ICT in their science lessons in stage two and three (see Table 7.19). In Stage two and three pre-service teachers need ICT knowledge and teaching ability, internet proficiency and ICT knowledge of theoretical and practical setting (see Table, 7.20). Pre service teachers taking students into the computer laboratory and ask them to research content, using computer software programmes, and using Microsoft office to teaching and learning process (see Table, 7.22). In Stage Two and Three all pre-service teachers, used ICT in science lessons when they were in schools (see Table, 7.23). Pre-service teachers’ description on ICT integrated into their teaching methods in stage two and three use PowerPoint presentation DVDs and VCDs, software applications, and the Internet (see Table, 7.24). In Stage two and three pre-service teachers use of ICT promote learning and use ICT to promote learning (see Table, 7.25). In Stage two and three pre-service teachers describe ICT enhances students’ understanding, using ICT, teachers’ knowledge can be improved, using ICT, students can be motivated and using ICT, students can be more creative (see Table 7.26). In Stage two and three, students are more attractive to ICT. Using ICT is more productive, and the Internet students get more knowledge (see Table, 7.26). In Stage two and three, pre-service teachers describe ICT could motivate students, ICT could gain students’ and teachers’ knowledge and experience, through the Internet they gain knowledge, and using ICT students and teachers can be more creative (see Table, 7.29). In above evidence it shows in stage two and three pre service teachers change their technological skills, technological knowledge, and pedagogical knowledge.
7.12 Review of Chapter 7

This chapter provides descriptions of 15 Pre-service teachers’ secondary science lessons in which the pre-service teachers have incorporated ICT into their teaching in Sri Lanka. The descriptions show a range of subject areas age groups and technologies. The chapter provides a summary of the data collected during interviews with the pre-service teachers how that the pre-service teachers’ could provide reasons for the use of ICT in teaching science. The chapter summarised the changes to pre-service teachers’ technological skills from Stage One to Stage Three. Also describes pre-service teachers’ pedagogical knowledge at stage two and three and also technological knowledge at stage two and three. This data provides indicators of increased use of ICT by the students in the focus group, and improved ability to describe how they would use the technologies in their teaching form Stage 1 to Stage 3.
Chapter Eight

Discussion of the Findings

For Ryle, and for Schon, the existence and importance of “knowing how” What we call craft knowledge – is central to the matter of learning a practice. This is not to say that “learning by doing” without analysis is a substitute for “learning by doing” with a theory. Rather, it is to say that “learning by doing” mitigates some of the difficulties that arise when a practitioner is unable to analyse competent performance and articulate its future.

(Grimmett & Mackinnon, 1992, p. 394)

8.1 Overview of Chapter 8

Chapter eight presents an analysis of data from the research study to address the research questions. It begins by recognizing the limitations of the study, including the lack of ICT resources, the limited background and pedagogical knowledge of the pre-service teachers and the limited experiences with technologies that may influence the ability of the pre-service teachers to demonstrate the impact of using the TPACK model. Following this, the data that provides evidence of the technological skills and technological and pedagogical knowledge of the pre-
service teachers is summarized. This addresses RQ 1 and how these have. The teaching by individual teachers in the focus group is analysed using the TPACK model to make a comparable measure. This coding is original and a creative and to make comparison, that has been developed by the researcher and is used to generate a TPACK score, and TPACK integration index. This summative approach - provides possible indicators of the result of integrating of the three TPACK components and the impact and effectiveness of the lesson.

8.2 Introduction

The data collected during the research study are used to address the research questions 1, 2, 3, 4, and 5. Specifically, the responses to research questions 1, 2 and 3 are derived from the quantitative data analysis and the response to research questions 4 and 5 are based on the data analysis of the qualitative data.

The limitations of the research include the fact that given the pre-service teachers very limited background knowledge and understanding of pedagogy, that a one day workshop, may not have been sufficient these pre-service teachers to totally understand the TPACK model, and the fact that the pre-service teachers’ lack of experience in teaching and learning may have impacted on their ability to implement the TPACK model in their teaching and that the very limited ICT resources made implementing the TPACK model difficult. Before the researcher conducted the TPACK model presentation, the pre-service teachers did not have any idea about TPACK model. A one day seminar may not be sufficient time for pre-service teachers to gain deep understanding about TPACK model.

Research question one draws on data primarily from the TPK questionnaire. The Research question asks “What are the secondary science pre-service teacher’s technological skill, technological knowledge, and pedagogical knowledge in teaching and learning science?” The
analysis and discussions of each domain is discussed in turn. 8.2. Technological Skills of pre-service teacher not using ICT as a communication tool. NCOEs should provide ICT facilities and appropriate ICT training to improve communication.

Software to create diagrams, slideshows, and presentations, and using CDs and DVDs and software are the most common used activities. The knowledge to use the four genres requires minimal ICT training. However, the value of using software that relates to using spreadsheets, creating spreadsheets, and use software was very low because the pre-service teachers did not use them very often. The pre-service teachers' hardware applications include using desktop computers, laptop computers, digital cameras, scanners, printers, and digital video. The pre-service teachers used a higher ratio of desktop computers than laptop computers because desktop computers are less expensive as compared to the laptop computers. Pre-service teachers also used digital cameras frequently because most of them have their own digital cameras. Scanners, printers, and digital video cameras are expensive and most of the NCOEs had only one of these instruments. Thus, most of the pre-service teachers did not get the opportunity to operate them. The hardware knowledge is very important to pre-service teachers because they can use this knowledge in their teaching and learning process.

Using the Internet in Sri Lanka was not favourable due to its slow connectivity and high cost. The pre-service teachers' use of the Internet and computers is very important because this knowledge can be utilized in their teaching and learning process. Pre-service teachers Internet access at NCOE and at home are 40% and 31% respectively. Only 37% pre-service teachers have computers inside the NCOE. Half of the pre-service teachers' population has computers at home. More than half of the population of the pre-service teachers can access computers outside the NCOE. According to the above data, NCOEs do not have enough facilities to facilitate them use technology in the teaching and learning process. Internet is content reliable, but it is slow
and expensive. At present, the broad band high speed Internet and less expensive packages are available; thus, the Ministry of Education should provide broad band high-speed Internet facilities to all NCOEs. Pre-service teacher’s use of computer in teaching is shown in Figure 7.2.

The pre-service teachers’ computer skills in teaching and learning practice is low with respect to use of ICT effectively to teach numeracy/literacy, and preparing class lessons using ICT into their teaching. This is perhaps due to their lack of sufficient knowledge in ICT. However, most of the pre-service teachers were confident to teach using ICT. According to the researcher’s observation, they have some basic knowledge, but they need further ICT training.

With regards to the pre-service teachers having a computer inside the NCOE, 87% agreed and have computer at home, 87% agreed. Specifically, the majority of these pre-service teachers have computers inside the NCOE and at home. The high degree of accessibility of computer can help them to develop their teaching and learning skills.

In summary, these secondary science pre-service teachers perceive their own technological skills to be quite good. The skills that rewire investigated included typing skills, ability to use software, various hardware’s, etc… The results are pre-service teachers’ perceptions. This is here skill level does vary across the group. The skills of the pre-service teachers in the focus group are generally better than those of the whole cohort as expected the volunteers are interested. There is corroborating evidence of the skills of the focus group because their lesson using technology confirmed the pre-service teachers’ skill level.

All students are at a skill level that reflects the low level of availability of technologies in Sri Lanka. The pre-service teachers are young and the data suggests that the pre-service teachers have a positive attitude to the use of computers technology in their teaching. They are as skilled as their access to the technologies allow.
8.3 Pedagogical Knowledge

Section B of the TPK questionnaire aims to elicit responses from the pre-service teachers about their knowledge and application of learning theories, their planning of innovative lessons and their teaching methods. According to Table 6.20 the majority of pre-service teachers’ answers were constructivist. Only 56% pre-service teachers responded and explained why they selected constructivist learning theory which is not surprising considering that they were still training. The pre-service teachers are inexperienced in the application and understanding of the learning theories and this was evident in their responses.

Pedagogy is not a simple concept Loughran in describes pedagogy as being concerned with “understanding the relationship between teaching and learning in ways that foster development and growth” (Loughran et. al., 2008, p. 4). Pedagogy is a complex concept, and is developed over time with professional knowledge and experience. Driel and Berry (2012) emphasize the complexity of developing teachers’ pedagogical content knowledge when they explain the need “opportunities to enact certain instructional strategies and to reflect individually and collectively on their experiences” p. 26. In this research study, pre-service teachers have shown limited knowledge and experience and their understanding of pedagogy but there is evidence from the data that it is developing, as they are introduced to instructional frame works like the 5E. The pre-service teacher were immature in their pedagogical understandings and this is understandable considering their limited experience in teaching. The pedagogies that the teachers demonstrated greater confidence with were the 5E model probably because this is a straightforward model and NCOE teaching practice done according to this model. Within the limitations of the research study, the pre-service teachers have demonstrated reflective practice
which is needed for development of pedagogical understanding. The pre-service teachers were encouraged to be applying the TPACK model to their own teaching and also be reflective.

Researcher observation shows by participating in the research study, the pre-service teachers in the focus group, tried to apply the TPACK model to their teaching and were reflective practitioners. Despite the limitations, introducing the pre-service teachers to the TPACK framework, has forced them to consider the three different domains and the interconnection between them.

This applies particularly to the focus group. This is worthwhile, even if they don’t really develop a full understanding- because as Van Driel and Berry (2012, p. 26) explain when talking about pedagogical content knowledge “it takes time to develop this sort of understanding because it is embedded in their own practice e. it isn’t something that you can just teach or rote learn”.

8.4 Technological Knowledge

“Technology knowledge (TK) is knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video” (Mishra & Koehler, 2006, p.1027). The technologies can be categorized into three groups- namely software, hardware and technology on the web (Web 2.0).

Table 8.1

Technologies commonly used in Teaching

Hubber & Chittleborough (2011) (Switched on Secondary Science Module 6)

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Software</th>
<th>Online</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive whiteboard</td>
<td>PowerPoint, Excel, Word, Access</td>
<td>E-mail.</td>
</tr>
<tr>
<td>Computer</td>
<td>Digital-Story, Photo story, Kidpix</td>
<td>Blogs.</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Camera</td>
<td>Edit images/Videos, Podcasts</td>
<td>Wikis.</td>
</tr>
<tr>
<td>Internet</td>
<td>Application- iPhone</td>
<td>Podcasts.</td>
</tr>
<tr>
<td>I-Phone</td>
<td>Web quest, Web page, editing, wiki, Inspiration</td>
<td>You-Tube clips.</td>
</tr>
<tr>
<td>Scanner</td>
<td>Animation – Software, Slow-motion</td>
<td>ESS feeds.</td>
</tr>
<tr>
<td>Voice recorder</td>
<td>Software for the Data loggers</td>
<td>Twitter.</td>
</tr>
<tr>
<td>Data-logger</td>
<td>Email</td>
<td>Clip-art.</td>
</tr>
<tr>
<td>Digital Microscope</td>
<td></td>
<td>Glogster- online poster</td>
</tr>
</tbody>
</table>

8.5 The pre-service teachers’ knowledge of the characteristics of technology

For example Internet can help teachers to gain knowledge, students get live experience through ICT, and students can explore the content (Jang & Chen, 2011) so its inclusion in educational programs is worthwhile. The pedagogical domain provides teachers with ways of using technology- technology alone is not always effective, the pedagogical approach must suit the available resources, the teacher the students and the content. This is discussed in the next section on Pedagogy.

Most of the pre-service teachers suggested that ICT is a successful teaching method because ICT helps to explain lessons, motivate students, more students’ participation and more individualized. Pre-service science teachers’ knowledge of technology is initially as based on their own personal experience. The pre-service teachers suggested that teachers need ICT knowledge of theoretical, practical and teaching ability, and internet proficiency. Most of the pre-service teachers used ICT in science lessons when they were in school. Most pre-service
teachers believed that ICT can promote learning, with majority of pre-service teachers agreed that ICT promotes learning.

8.6 ICT in the Teacher Training program

All the NCOE lecturers like to use ICT in their teaching and learning process but they are facing a problem with a lack of facilities. NCOE lecturers know about PK, and CK but they do not know about TK and TPACK model. After the workshop, they understood the TK and TPACK model. NCOE lecturers’ response was using ICT with TPACK model students can easily understand the science concepts and subject matter. All the NCOE lecturers are confident to use ICT in their secondary science lessons. NCOE lecturers like to use MS office, PowerPoint, and slide show with multimedia, DVD’s, VCD’s and Video clips.

The second research question is, “What current pedagogical approaches are taught to secondary science pre-service teachers in Colleges of Education in Sri Lanka?”

Secondary science pre-service teachers have four components in their three years teacher training programme. Two components are involving current pedagogical approaches that taught at College of Education. Two components are, component B-deals with the nature of science and learning of science, and component C considers the implementation of the secondary science curriculum (National Institute of Education, 2007). Pre-service teachers’ first two years they are learning above two components and gain pedagogical approaches. First two years they learned pedagogical knowledge and field training period they go to the school and apply their pedagogical knowledge. Pre-service teachers had two year in-service teacher training program and they learned to use pedagogical and content knowledge in their secondary science lessons but they are not trained to use technological knowledge in their secondary science lessons (Pre-
service teachers’ interview response). In third year pre-service are use pedagogical knowledge to teaching and learning process in their field training.

Secondary science pre-service teachers’ TPK questionnaire section B in stage 1 their current pedagogical knowledge level describes as follows: 58% pre-service teachers follow constructivism 8% behaviourism, 3% cognitivism, 8% constructivism and behaviourism learning theories. Pre-service teachers’ explanations on why they chose constructivism as the best learning approach explained four categories. 35% students create own creativity and gain knowledge, Constructivism based on students’ centred education, 4% Constructivism learning theory based on activity, and 2% 5E method help to develop students’ creativity. Pre-service teachers who answered behaviourism provided explanation of practical and explanation programmes help science teachers, according to behaviour of students, teachers can focus the teaching and learning process, and according to behaviour of students, teachers can focus the teaching and learning process. Pre-service teachers who answered cognition provided explanation of brainstorm as an activity that can promote cognitive learning and according to students; teacher has to plan teaching and learning process. Pre-service teachers who answered behaviourism and constructivism not provided any explanation.

8.7 Changes to Secondary Science Pre-Service Teacher’s Technological Skills, Technological Knowledge, and Pedagogical Knowledge

Research question three states: “What changes, if any, happened to secondary science pre-service teacher’s technological skills, technological knowledge, and pedagogical knowledge after instruction in the TPACK model and after using TPACK model in teaching secondary science?”
After using TPACK model in teaching secondary science pre-service teachers gained some kind of knowledge of how to use technological knowledge, pedagogical knowledge, and content knowledge but they are not integrated these knowledge in their lessons. Lessons 1, 5, 12, and 13 were identified as very strong lessons, lessons 1, 5, 12, and 13 were identified as strong lessons, lessons 3, 6, 9, and 15 were identified as medium lessons, and lessons 2, 4, 7, 8, 10, 11, and 14 were identified as weak lessons.

After using TPACK model in teaching secondary science pre-service teachers identified three components of the Mishra & Koehler, (2006) TPACK model and used content, pedagogy, and technology in their lessons but they have some limited to intergrate these three component.

After having to implement and apply ICT in their teaching the pre-service teachers demonstrated technological knowledge such as, e.g. motivating students with images like the snakes lesson; and prompting collaboration e.g. periodic table lesson; and having students do their own presentations e.g. lesson no 5. This is evidence that the technological knowledge improved over the period of the research study. However, to effectively use TPACK model with ICT in their teaching and learning process, they need more ICT training. Pre-service teachers’ pedagogical knowledge is highly variable but their knowledge on learning theory knowledge is weak.

To good understanding of integrating three knowledge domains, pre-service teachers need good understanding of TPACK model but researcher conducted only one day seminar that is not enough to gain technological pedagogical knowledge, pedagogical content knowledge, technological content knowledge, and technological pedagogical content knowledge. They have only limited knowledge that is not sufficient to integrate the three knowledge constructs.

This research analysis has looked at each component individually, but the real strength in the TPACK model is the overlap across the three domains. T, P, C.
8.8 Analysis and Discussion of the Qualitative Data findings

This section answering research questions of 4, and 5. Research question 4: How do secondary science pre-service teachers apply elements of the TPACK model in secondary science teaching after instruction in the model?

In this research, 45 lessons conducted by the pre-service teachers were observed by the researcher. These lessons were observed based on the three components of TPACK model developed by Mishra & Koehler (2006). Teaching is a complex profession that needs an interweaving of many kinds of specialized understanding (Koehler & Mishra, 2009). Science teachers who teach science content need to use technology in their teaching and learning process at secondary and primary class (Irving, 2004). Out of the 45 lessons, only 15 lessons were selected for analysis. This was because most of the lessons did not represent the TPACK model, and some of them had the same pattern. The selected 15 lessons comprised of different lessons in terms of their design and delivery, the TPACK model application in these lessons, and content subject such as Biology, Chemistry, and Physics lessons. These lessons provided further analysis on the basis of having some observable aspects of the TPACK model in the lessons (The other lessons did not achieve valuable the TPACK model content). These lessons were categorised according to the formulated scale. In this scale, five categories were used. The categories are very strong, strong, medium, weak, and very weak. After the categorization, certain values are given to the scale. This scale was prepared according to rubric value.

To prepare the Rubric, the following categories were used. If all these following categories are represented in the lesson that lesson is categorized as a very strong lesson. Based on the researcher’s experience, the researcher scored the lessons using content, pedagogy, and technologies and following categories are prepared for the rubrics.
A very strong pedagogical lesson was calculated based on ten observable aspects performed by the pre-service teacher during the delivery of the lesson. The pedagogical observable aspects are:

- Teaching approach in the lesson;
- Management of group work in the class;
- Presentation done in the lesson;
- Expressions in the lesson;
- Implementation of the lesson plan;
- Work relationship with students (Student Centred);
- Management of teaching resources;
- Time management;
- Classroom management;
- Students’ understanding of the lesson (relationship between content, technology, and pedagogy).

A very strong content can be divided when the pre-service teacher deliver 75% to 100% of the content of the lesson in class (all the lesson content are listed). A very strong technology is calculated based on the following aspects:

- The type of technology used in the lesson;
- The relevance of technology in relation to the content and pedagogy. Used technology match with content;
- The technology used complement with the content;

- The technology used to describe the content facilities students’ understanding;

- The application of technology during the lesson;

- The manner in which technology is used to present the lesson.

This rubric was prepared subjectively and the lessons were scored according to my experience as an expert science educator. Based on my experience TPACK strong lessons are needed interaction of PK, CK, and TK. Some pre-service teachers used good CK, and PK but weak TK. Others used strong TK and strong CK and weak PK. Some TK, pedagogy is strong but content is weak. The pre-service teachers’ lessons score were estimated by my professional experience. The use of the rubric is an attempt to be able to implement different lessons contents effectively.
<table>
<thead>
<tr>
<th>Criteria in PK, CK, and TK</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedagogical Knowledge</td>
<td>Pre-service teacher’s lesson teaching methodology is very weak because their teaching methodology is not sufficient to explain the lesson. (0%-12.5% of pedagogy is used to explain the lesson) At the same time there is a very weak relationship between pedagogy content and technology.</td>
<td>Pre-service teachers’ lesson teaching methodology is weak. Pre-service teachers used teaching methodology that lead to weak understanding of the lesson. (12.5%-25% pedagogy is used to explain the lesson)</td>
<td>Pre-service teachers’ lesson teaching methodology is medium. Pre-service teacher’s lesson teaching process is neither good nor bad, but it is medium. (25%-50% pedagogy is used to explain the lesson)</td>
<td>Pre-service teachers’ lesson teaching methodology is strong. In this situation pre-service teacher’s use of teaching method lead to 75% students can understand the lesson. (50%-75% pedagogy is used to explain the lesson)</td>
<td>Pre-service teachers’ lesson teaching methodology is very strong. In this situation all the appropriate teaching method is used to describe lesson. (75%-100% pedagogy is used to explain the lesson)</td>
</tr>
<tr>
<td>Content Knowledge</td>
<td>Pre-service teachers’ lesson content is very weak because it represents few facts.</td>
<td>Pre-service teachers’ lesson content is weak because it represented facts that</td>
<td>Pre-service teachers’ lesson content is medium. Pre-service teachers’ lesson</td>
<td>Pre-service teachers’ lesson content is strong because 75% of the content is</td>
<td>Pre-service teachers’ lesson content is very strong because all the content is relevant to</td>
</tr>
<tr>
<td>Pre-service teacher used content not sufficient to the lesson.(0%-12.5% of the content is used to explain the lesson)</td>
<td>are not enough to fulfill the content of the lesson. (12.5%-25% of the content is used to explain the lesson)</td>
<td>content is neither good or nor bad, but it is medium. (25%-50% of the content is used to explain the lesson)</td>
<td>the lesson used. (50%-75% of the content is used to explain the lesson)</td>
<td>Pre-service teachers’ lesson not used proper technology or used technology but it is not sufficient to explain the lesson.(0%-12.5% of technology used to explain the lesson)</td>
<td>Pre-service teachers’ lesson used weak technology or it is not sufficient to explain the lesson. (12.5%-25% of the technology is used to explain the lesson)</td>
</tr>
</tbody>
</table>

Table 8.2

Rubric – Application of PK, CK, and TK
Table 8.3

**TPACK domains (PK, CK, and TK) scale**

<table>
<thead>
<tr>
<th>TPACK components</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Knowledge</td>
<td>1 to 5</td>
</tr>
<tr>
<td>Pedagogical Knowledge</td>
<td>1 to 5</td>
</tr>
<tr>
<td>Technological Knowledge</td>
<td>1 to 5</td>
</tr>
</tbody>
</table>

Scale 1 – Very Weak; 2 – Weak; 3 – Medium; 4 – Strong; 5 – Very Strong

Zero values are not included in the scale for the rubric because all pre-service teachers included some PK, CK, TK, into their lessons. The 15 lessons conducted by the pre-service teachers were analysed using NVivo 8 software. Using the formulated scale of the TPACK model, the three basic components of PK, CK, and TK were evaluated. Table 8.4 was developed based on the analysis of the lessons following the scale developed for PK, CK, and TK. According to Table 6.44, it was found that four lessons were strong (Lessons 01, 05, 12, and 13), three lessons were medium (Lesson 03, 06, 09, and 15), and seven lessons were weak (Lessons 02, 04, 07, 08, 10, 11, and 14).

This section focuses on the nature of the qualitative data collected from the secondary science lessons conducted by the 15 pre-service teachers. The TPACK model was used as a formulated to analyse the observable aspects of the secondary science lessons. The TPACK model scale is based on the following aspects:

- PK, CK, and TK integrated or not – observed the integration of the elements;
- TPACK score – a subjected observed in the 15 lessons;
- Pre-service teachers TPACK knowledge in the 15 lessons;
- A TPACK rubric
8.8.1 TPACK Rubric

According to the researcher’s observation, the researcher needed to know how the pre-service teachers integrated or use these three elements together to design functionally effective lessons. The case study provides insight into the various aspects of science lessons using ICT. It is not possible to ascertain the impact of the TPACK model directly. Teaching is complex and catering for individual learning needs, means that the answer is not definitive. But the case study does provide some insight into the use of ICT and the importance of connecting to the three domains and the knowledge of pre-service science teachers. The case study has data for a particular item, particular students and particular available resources. The measure is for comparison purposes and helps identify differences.

The integration of the three components does not imply that the integration of the three elements necessary results in the pre-service teachers developing a deep knowledge on the TPACK model. The integration of the elements is more rather mechanistic in that it is not a necessary focus the only one component on improving learning. Here, it is seen as an indicator for being prepared and able to work with the TPACK model in future.

Based on the analysis of 15 lessons, the researcher did not observe the integration of PK, CK, and TK. In the lessons, these pre-service teachers always try to use a mixture of PK, CK, and TK. In the teaching and learning process, the pre-service teachers could not teach using either pedagogy or content or technology. They had to mix the pedagogical knowledge, content knowledge, and technological knowledge but they most of the time used TPACK thin model.

8.8.2 TPACK Integrations Index

Initially, researcher planned to use the TPACK score in order to investigate the application of the TPACK integration index in the lessons conducted by the pre-service teachers.
The integration index will be measured by calculating the PK and CK integration, PK and TK integration, CK and TK integration, and PK, CK, and TK integration.

They are termed as follows:

PK and CK integration = PCK index.

PK and TK integration = TPK index.

CK and TK integration = TCK index.

PK, CK, and TK integration = TPACK index.

Initially, this research planned to use all the seven components of the TPACK model but it was argued that the quality of the model used by the research pre-service teachers in their lessons was a thin TPACK model. The integration of three domains in the TPACK model was hardly observed in the lessons. However, it was found that the application of the TPACK integration index in the teachers’ lessons varied according to the combination of PK, CK, and TK. This provides avenues to investigate the quality of the lessons, particularly the nature of integration of the three main domains in the TPACK model. The investigations on the nature of integration of the TPACK model can then be used to categorize the lessons as thin TPACK model or thick TPACK model. Lessons categorized as thin TPACK model are lessons that do not synchronously integrated in relation to the three main domains of the TPACK model. Meanwhile, lessons that categorized as thick TPACK model are those lessons that have all the three domains of the TPACK model synchronously integrated with each other.

Teachers are encouraged to employ thick TPACK model for better quality lessons. Based on the findings of this study, most of the teachers are applying thin TPACK model. It is suggested that these teachers should be given additional training focussing on the adoption of thick TPACK model.
This TPACK integration index was prepared by the researcher based on his personal experience. This is a working instrument to find out the integration of TPACK model in the lessons. Although this TPACK integration can be measured using the index, it is considered as subjective or inferred.

8.8.3 Calculating TPACK score

The assessments of the three main components in the TPACK model are calculated by using PK, CK, TK scales. For example, based on the first lesson, the calculation is

PCK = 4+4=8, TPK = 4+4=8, TCK = 4+4=8, TPACK = 4+4+4=12. TPACK score is PK, CK, TK, PCK, TPK, TCK, and TPACK scale values. TPACK score varies according to the lesson main domains variation. Table 6.44 shows the TPACK scores of the 15 lessons conducted by the pre-service teachers. TPACK scores also very important to measure the lesson standard and they can be used to compare the lessons conducted by other teachers.

Based on the observations and measurement in this research, the researcher introduced PK, CK, and TK integration index, and TPACK score. It is viewed that there is potential of using PK, CK, and TK integration index and TPACK score. This can be extended further for future researches and gain knowledge for educational researches.

According to Table 8.4, PK, CK and TK scale values vary according to the lessons. These values can be used to identify the quality of the lessons. No 1, 5, 12, and 13 lessons are considered as strong lessons, and it gives idea about how TPACK thin model varies according to PK, CK, and TK variation in the lesson.

According to researcher’s observation, some of pre-service teachers mix these domains mechanistically. Most of the lessons were the TPACK thin model and only on a few occasions, the mix domains were characterised as the TPACK thick model.
### Table 8.4

**Pre-service teachers TPACK score in their 15 lessons**

<table>
<thead>
<tr>
<th>Pre-service teacher No</th>
<th>PK</th>
<th>CK</th>
<th>TK</th>
<th>PCK</th>
<th>TPK</th>
<th>TCK</th>
<th>TPCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>02</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>03</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>05</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>06</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>07</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>08</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>09</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 8.5

**Pre-service teachers PK, CK, TK observations about their 15 lessons**

<table>
<thead>
<tr>
<th>Student No</th>
<th>TPACK Score</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>C</td>
</tr>
</tbody>
</table>
The pre-service teacher used group and individual approach in the lesson. The subject matter was also described using very simple teaching methods and everybody understands the lesson. Every group completed the exercise after the exercise the pre-service teacher summarized the lesson and asked verbal questions from the students. Students answered to all questions The PowerPoint presentation was also strong and relevant to the lesson.

The pre-service teacher used video clip at the beginning of the lesson. This video clip was not relevant to the lesson because she showed animals that were not relevant to the lesson. In this situation, there were a mismatch between content, pedagogy, and technology. However, the PowerPoint presentation was relevant to lesson. The PK and CK were at medium level but TC was weak.

The lesson was very good but there were very low ICT applications. In the lesson, the pre-service teacher used PowerPoint presentation. This PowerPoint presentation had very few slides and the teacher mainly did explanations throughout the whole lesson. In this lesson CK, PK, are very good. Technology application in this lesson was very weak.

The lesson was ill-structured lesson. There was a mismatch between the video clip and the lesson. The lesson also lacked of content and pedagogy. The lesson lacked of CK, PK, TK,. This lesson was a weak lesson.

In this lesson, the pre-service teacher used technology quite well. The pre-service teacher prepared the lesson using flash software showing car racing where different cars were moving at different speed. In this presentation, students were given direct absorption of knowledge. Students were instructed to calculate the speed of a car travelling for 1km, 2 km in different speed in computer program and to calculate the time when car is moving. This was
very good and students’ understanding was very high. In this lesson, the TPACK presentation was very high.

The lesson mainly focused on exercises. The pre-service teacher prepared ten questions using diagrams in a PowerPoint presentation. At the beginning of the lesson students did the exercise with interest but towards the end of the exercise some male students lost their interest. These questions were structured very clearly, and content-based. Most of the student presentation was good. The teaching method was weak but the use of ICT during the exercise after the practical session, according to my observation made it easy for students to understand. The PK was weak, whereas CK and TK were strong.

The pre-service teacher started this lesson by asking some questions. Few students responded to the questions. The pre-service teacher continuously explained the content but the pedagogy was not good. Very few students responded to the lesson. The beginning of the lesson was teacher cantered. The multimedia PowerPoint presentation was good but lacked of some slides. The pre-service teacher has also included solid, liquid, and gas atom structure in the PowerPoint presentation. The content presentation was very fast. In my observation, some students did not understand the lesson. The teaching technique was weak, and did not respond to the students. The pedagogy was weak. The use of technology also lacked of slides. The lesson was teacher cantered and content-based.

This lesson was about Living organisms’ classification. The pre-service teacher started the lesson by showing triangles, squares, and rounds and how they are classified. The pre-service demonstrated how the triangles, squares, and round are classified. Then the pre-service teacher moved on to the slide shows. When
the slide show was moving one slide to other, the pre-service teacher inquiring questions about the information on the slide. The pre-service teacher also described the subject content. Throughout the lesson, the pre-service teacher did the same teaching method. This was not a good lesson. The pedagogy was weak. The content and the technology were fair.

This lesson was conducted using multimedia projector with slide show. The lesson is about snakes of Sri Lanka. The pre-service teacher started the lesson by showing slides and allowed student to read from the slides. After that the pre-service teacher explained the slide during the whole lesson. At the end part of lesson, students’ attention were not in the lesson, they were talking with each other. The uses of pictures in the slide show were very good. The content was medium content but the pedagogy was low. Technology was strong.

The pre-service teacher started the lesson by showing paper chains to the students. Then the pre-service teacher showed the slideshow about various food chains and used questioning techniques to discuss with students about food chain. The pre-service teacher gave a chart to the students and asked them to fill the chart by referring to the slideshow. The pre-service teacher used a multimedia projector. Using the slide show, the pre-service teacher discussed with students about various levels of living organism in the food chain. Based on the discussion, students were asked to draw a diagram of food chain. Using computer, the pre-service teacher showed the various types of food chains and discussed with students. Finally, the pre-service teacher asked verbal questions from the students. Students managed to answer most of the questions. The content and pedagogy were low but the technology was medium.
In this lesson the presentation of the lesson was weak. The description did not use day to day activity to describe sign boards. This lesson was mainly content based lesson but the content of the lesson was missing. The pre-service teacher’s content knowledge was weak. The ICT application was medium. The pedagogy was also Medium. This lesson is considered as a weak lesson.

This lesson was very good because the pre-service teacher showed a real compost preparing materials, video clip of preparing compost, and prepare a paper of different methods on the preparation of compose. In this lesson the pedagogy, content, and technological knowledge were strong.

This lesson was very good. The pre-service teacher used pedagogy; technology and content quite well. The beginning of the lesson, development of the lesson, and end of the lesson were strong. He used technology in a proper way.

This lesson was about animals’ appendages. The pre-service teacher began the lesson in a very interesting way. The presentation of the lesson was weak. The slide show missed good examples. The content also lacked some factors. The pedagogy was weak. The content was medium and technology was weak.

This lesson was about types of flowering plant leaves. The pre-service teacher asked students to collect leaves from the school garden. This was a very interesting way to start a lesson. After that students were asked to organize the leaves according to their different features. Then students were asked to watch the slide show. The pedagogy was medium; content was medium, and technology was strong. This lesson was a medium lesson.
8.9 Pre-service teachers TPACK knowledge in 15 lessons

There are four lessons that scored more than 12. The lessons are 1, 5, 12, and 13. The four lessons are considered strong lessons in this research. These lessons pedagogy, content, and technology are strong. Because these lessons also have strong pedagogy, strong content and strong integration with appropriate technology. Even though these lessons were considered as strong, they were not categorized as thick TPACK model. Several factors may contribute to the pre-service teachers’ inability to apply thick TPACK model in their lessons. One of the factors is that they are still undergoing teacher training programs. They are also lack of sufficient knowledge and experience on the application of TPACK model. It is anticipated that this condition may improve and they may be able to apply thick TPACK model as the pre-service teachers gain more experience and training in the application of the TPACK model. Once they are able to apply the thick TPACK model they can improve the passing rate of the secondary science education.

The coding meant that as a researcher identified aspects of the lesson that correlated with the various domains. Experienced Teachers may do teaching automatically without thinking of each domain- this is their professional knowledge – that teaches develop with experience – time and training. Teachers don’t necessarily break their professional knowledge down into the component parts. Even though this can be the found data not the bedrock for how the teachers teach. This is similar to pedagogical knowledge – built up over many years – and very individual for the teacher, and the content knowledge and their students in particular time and place. Considering the TPACK model in this way- its usefulness Technological knowledge to train teachers about various components has a value.
8.10 TPACK Rubric

Pre-service teachers’ effective integration or use of these three elements together can help to design functionally more effective lessons. The integration of the three components does not imply that the integration of the three elements is necessary to gain results in the pre-service teachers to develop a better knowledge of the TPACK. The integration of the elements in this study is more rather mechanistic, in that, it is not necessarily focussed on improving learning. That is, it is only seen as an indicator or being prepared and able to work with a TPACK model in future.

This research shows that pre-service teachers can be trained to use thick TPACK model with ICT. However, comparing Sri Lanka with the USA; Sri Lanka is at present, using educational technology at its initial stage which is the Technology Literacy stage (“New Growth” Economic UNESCO 2008 model). It is anticipated that within 5 to 10 years in future, Sri Lanka should be able to reach the third stage which is the Knowledge Creation stage. Because of this reason, it is anticipated that thick TPACK model can be adapted to Sri Lanka secondary science education by the year of 2015 to 2025, considering that Sri Lankan ministry of Education prepares an appropriate programme to adopt thick TPACK model into Sri Lankan secondary science education. However, to reach this stage, proper policy, planning and infrastructure development are needed. Additionally, improvement in the education sector plays a pertinent role in moving forward to the third stage. In this context, teacher training programs should be geared towards training teachers to apply the thick TPACK model in their secondary science education.

This study found that application of TPACK model varies widely and the connections between the key domains of TPACK vary widely as well. Based on the findings the research, it is proposed that two new measures are needed, which are TPACK score, and TPACK integration
index. These two measures are believed to provide a better illustration of the integration of the TPACK domains.

TPACK model is a developing model of knowledge that incorporates all three domains (content, pedagogy, and technology). TPACK is an understanding that emerges from the relations of content, pedagogy, and technology knowledge (Mishra & Koehler, 2006). TPACK is truly a meaningful and deeply skilled teaching with technology and it is different from knowledge of all the three concepts individually. Teachers need to build up their fluency and cognitive flexibility not just in each of these key domains (T, P, and C) but also in the manner in which these domains are interconnected, so that they can affect solutions that are responsive to specific contexts (Mishra & Koehler, 2006).

In this study, the TPACK model was used by the pre-service teachers to teach secondary science. When the pre-service teachers teach secondary science subjects, the three domains (T, P and C) were either treated independently or in integrated manner. Therefore, this model can be used in the teaching of secondary science in Sri Lanka, the level of technology used in their teaching is considered not as advanced as those used in the USA. This is due to the fact that the development of technology used for teaching in Sri Lanka is comparatively lower than those in the USA.

Using technology in teaching is a very difficult thing to do well. The TPACK framework shows that Content, Pedagogy, and Technology have roles to play individually and together. The data presented supports the TPACK model and provides evidence from each of the three aspects of the model, in a variety of cases. This suggests that teaching with technology requires equilibrium between each component.

Capability in teaching is reliant on flexible access to and appliance of highly organized systems of knowledge (Shulman, 1986, 1987) that must continually move and progress based on
the contexts within which they are applied (Mishra & Koehler, 2006). Teachers perform in a highly complex, active atmosphere (Leinhardt & Greeno, 1986) that requires them to join together the knowledge of student accepted wisdom and learning, knowledge of the subject matter, and increasingly, knowledge of technology (Mishra & Koehler, 2006). The development of Internet browsers provide teachers/student aid for finding, organizing and understanding science and technology materials (Budenske, Bonney, Newhouse, & Judt, 2000).

Most of the teachers in Sri Lanka appears to have adequate pedagogical knowledge and content knowledge but lack technological knowledge. According to the Ministry of Education (2006), 35% of teachers have basic computer literacy and the rest of the 65% teachers have not achieved basic computer literacy (Ministry of Education, 2006). The TPACK model is a framework that could help teachers identify gaps in their knowledge. TPACK is a construct developed by Mishra & Koehler (2006) to explain features of the professional knowledge and expertise developed by teachers (Mishra & Koehler, 2006). In this research the pre-service teachers from three NCOEs were required to use the three major components of (T, P, C) the model to investigate if they are at a stage where they might apply the model in Sri Lankan science education. In other words, it is to investigate whether the teachers are able to use part of the three components in a lesson. This does not necessarily imply that they are working in the TPACK model but rather that they understand the basic principle at a level related to their ICT knowledge and skills.

Figure 8.1 TPACK thin and thick model (Warnakulasuriya & Nicholson, 2010)
Warnakulasuriya & Nicholson, have coined the working term “Thin” and “Thick” TPACK to indicate the extent of effective integration of each of its 3 major components (T, P, C) is in Figure 8.1 (Warnakulasuriya & Nicholson, 2009) when Teachers use PK, CK, and TK they are teaching secondary science. They use the combination of PK, CK, and TK in their lessons. All of the pre-service teachers used aspects of the TPACK model with ICT for the first time in their teaching career. It is very hard to separate the individual components of the model in Sri Lanka. Even though ICT was introduced to Sri Lankan schools in 2000, ICT facilities are still lacking in Sri Lanka (Ministry of Education, 2005b). In this research, I anticipate that this model can be implemented in Sri Lankan schools but it is like that taking more than five years for its full implementation. In the USA the TPACK model can be implemented without few problems because they have advanced technology in their schools and their teachers are familiar with teaching using ICT in their lessons. Comparing the USA and Sri Lanka, there is a vast difference in using the technology in education but the TPACK model can still be applied in Sri Lanka. The main problem is the lack of ICT equipment in Sri Lankan schools but teachers’ can perform their teaching using the TPACK model. It was very difficult to observe the interaction of the TPACK model during the science secondary teachers’ conducting lessons.
Figure 8.1 shows the difference between the TPACK model implication between Sri Lanka and USA. The application of ICT in schools at Sri Lanka is at its initial stage of ICT, however, in the USA, ICT has been used for the last 30 years. The Sri Lankan teachers can be identified at a stage in which the TPACK model is not fully utilized and this could be a key aspect of their professionalism.

The researcher used a selected subset (approximately 1/3) of the whole lessons observed in this study. The 15 lessons selected analysed uses indicated the potential use of the TPACK thin model. These lessons were analysed according to the TPACK thin model domains of PK, CK, and TK representation in the lessons. The researcher prepared the rubrics according to his observations and experiences on how the TPACK thin model domains of PK, CK, and TK were represented in the lessons. These lessons vary according to the variations of PK, CK, and TK representation in the lessons. These lessons also conform to the TPACK thin model and very few have the potential of the TPACK thick model. These pre-service teachers’ TPACK thin model lessons were analysed according to a prepared rubric scale. The researcher evaluated the lessons according to scale. The following table shows the evaluation of the 15 lessons. All these observations are subjective.

It is concluded that the TPACK thick model can be introduced to Sri Lankan secondary science education and that pre-service teachers can be trained to use the TPACK thick model with ICT. However, in compare USA as a developed country, Sri Lanka is at the initial stage in terms of the usage comparison to the technology in education. Because of this reason, if Sri Lanka Ministry of Education decided to introduce the TPACK thick model into Sri Lankan secondary science education, it is anticipated that the TPACK thick model can adopted in be Sri Lankan secondary science education by the year 2015.
8.11 Review of Chapter 8

This chapter has presented the discussion of the findings of quantitative data and qualitative data in this research. First, it discussed the data findings according to research questions 1, and 2. Secondly, it discussed the data based on the findings derived for research questions 3, 4, and 5. This chapter describes research question 1 that includes technological skills, technological knowledge, and pedagogical knowledge. After that it describes ICT in the Teacher Training program that includes 2nd research question. At last this chapter describes analysis and discussion of the qualitative data findings it includes research questions 4 and 5.
Chapter Nine

Conclusion and Recommendations

9.1 Overview of the Chapter

This chapter articulates the conclusions in relation to the major research questions. It also discusses practical and policy issues that relate to the implementation of these conclusions. This is followed by recognition of the limitations of the study in terms of its practice and results and its contribution to new knowledge. Although there are limitations, the study contributes to existing knowledge and provides recommendations for future research.

9.2 Review of the Study

Chapter one articulated the TPACK model with ICT use in the teaching and learning process of the secondary science pre-service teachers. This research explores the use of the TPACK model assesses in matching judgments about practise. This chapter also gives main research question and sub research questions with a brief outline of the thesis. Specifically, the study sought to determine the potential of the TPACK model to improve the use of ICT in secondary science education in order to address the failure rate of G. C. E. (O/L) examination.
Quantitative data presented in chapter 6 used the TPK questionnaire to assess pre-service teachers’ technological skills, technological knowledge, and pedagogical knowledge. In the qualitative data, 15 lessons using ICT with the TPACK model was conducted by 15 pre-service teachers were analysed to describe how the main three domains of the TPACK model were represented in these lessons, the lessons were analysed using scales designed by the researcher. The researcher has 15 years teaching experience, five year’s experience as an assistant director and three years as a project officer. Throughout the researchers’ career, he had observed more than 2000 secondary science lessons. The rubrics for the scales were prepared based on the researcher’s experience in the area of science education.

The researcher examined the pre-service teachers’ technological skills, technological knowledge, and pedagogical knowledge using the TPK questionnaire and observed 15 pre-service teachers’ secondary science lessons. The conclusions of the research are given below. It was found that majority of the pre-service teachers’ technological skill was adequate but they were weak in advanced software applications, ICT as communication tool, keyboard typing skills and Internet usage. All of the pre-service teachers Internet usage was very low, thus they used limited Internet-based resources in their teaching and learning processes. It is concluded that pre-service teachers need further technological skill training. Pre-service teachers’ Technological knowledge is very important. A functional level technological knowledge is one of the domains of the TPACK model. Based on the results from the TPK questionnaire, distributed to the pre-service teachers, the majority of them had a functional level technological knowledge but some did not. They also had difficulties in integrating technological knowledge with the other two domains. It was also found that only two thirds of the pre-service teachers responded that they used ICT in their secondary science lessons and one third did not use ICT in their secondary science lessons. These findings also draw the same conclusion that they lacked technological
knowledge. Two thirds of pre-service teachers claimed that ICT enhance students' understandings, improves teachers' knowledge, motivate students and makes students more creative. One third of pre-service teachers did not respond to the questions and arguably this implies that they are lacking in technological knowledge. Based on the above findings, it can be concluded that the majority of pre-service teachers had technological knowledge. They also believed that technological knowledge can promote learning and improve their teaching. These pre-service teachers are new and lack experience in teaching. The TPACK model workshop was not enough for them to have gained sufficient knowledge in integrating technological knowledge with the other two domains. These pre-service teachers need further technological knowledge training to improve their skills to integrate technological knowledge with the other two domains.

In terms of pedagogical knowledge, the findings above indicate that these pre-service teachers received their pedagogical knowledge from the training they had at the NCOEs. They claimed that they employed constructivist learning theory but they were found to be weak in their knowledge of learning theories. This is due to lack of emphasis on this aspect during their teacher training programme. As science pre-service teachers, they were familiar with experiments and demonstrations, as well as group and collaborative work. A blackboard was used by majority of the teachers in the classroom, due to the fact that blackboard is the most common facility available in the classrooms. They also preferred to use PowerPoint presentations. Pedagogical knowledge is also considered as an important domain of the TPACK model. Pre-service teachers were trained to employ pedagogical knowledge in their teaching and learning process. They have strong pedagogical knowledge, but they are weak in learning theories.
9.3 Issues with Observations

This research is not experimental in nature. The researcher had done a large number of secondary science lesson observations in his career. Using the researcher's experience, these 15 lessons observations were done to identify how pre-service teachers used ICT with the TPACK model. The researcher had made the following observations.

- These pre-service teachers used ICT with the TPACK thin model but within the lesson very few can achieve the TPACK thick model.

- These pre-service teachers used ICT with the TPACK thin model for first time in their life.

- Although there was lack of ICT facilities in schools, the pre-service teachers managed to conduct the lessons successfully.

- A-one day workshop on the introduction of the TPACK model given to the lecturers was found to be insufficient for them to disseminate the knowledge on the TPACK model to the pre-service teachers at the selected NCOEs. Further training on the TPACK model is needed in order for the lecturers and particularly to the pre-service teachers to apply the TPACK model in the secondary science lessons.

9.4 Limitations of the Study

It is important to emphasise the case study nature of this research. Limitations indicate the limited number of people involved in the research as participants. The results are not generalisable, but rather apply only to the situation in which the data was collected. However the results of this research study can have implications for other situations. The ICT resources are limited in this research because of that all the pre-service teachers in their lessons used only
PowerPoint presentation and video clips. In Sri Lanka ICT is not commonly used in teaching and learning practice. However, the lack of ICT resources is not a limitation to the validity of the study. The pre-service teachers applied the TPACK model to their situation- with the limited resources. Despite this the TPACK model was used to design lessons using PowerPoint presentations and video clips. The use of only three locations in this research, as opposed to a large number indicates that this study is only a case study.

9.5 Recommendations

This study has identified that the secondary science pre-service teachers’ technological skills and technological knowledge in which some areas were weak, especially in software applications, and using typing skills. To improve the pre-service teachers’ technological skills and technological knowledge of ICT, they need to be given appropriate ICT related training.

This research has identified the potential strengths and values of the use of the TPACK model in secondary science education. It is recommended that the TPACK model should be adopted in all pre-service education, and in-service teacher training programmes.

This study has identified the shortage of ICT facilities in the NCOEs involved in this study. It is recommended that the Ministry of Education in Sri Lanka should provide necessary ICT facilities to all NCOEs.

This study has identified that the NCOE’s general component curriculum lacks coverage of learning theories. It is recommended that a unit on learning theories is included in the all of the NCOE teacher’s training curriculum.

All the NCOE lecturers should be trained on how to use ICT with the TPACK model in their teaching and learning processes. It is recommended that the NIE has to upgrade the NCOE’s general component curriculum.
ICT education is at present practising the initial stage of the UNESCO 2008 “New growth” Economic model initial stage (Technological Literacy). It is argued that the pre-service teachers practised the TPACK thin model. To introduce the TPACK thick model, the government of Sri Lanka needs proper policy and implementation of ICT education in their education system.

Figure 9.1 UNESCO 2008 “New growth” Economic model

9.5.1 Proposed Strategies to Improve Science Education in Sri Lanka

UNESCO 2008 “New Growth” Economic model defines the Technology Literacy level: “increasing the technological uptake of the workforce by incorporating technology in the curriculum” (UNESCO, 2008). In this stage teachers need to develop basic knowledge about curriculum, integrating technology into their teaching and learning process, basic ICT skills, organise a stranded class room, and teachers have to train use of the TPACK thick model.

Table 9.1 shows the UNESCO 2008 “New Growth” Economic three-stage model in relation to the policy and vision of Sri Lanka. Specifically, it provides guide lines on how these stages can be developed towards achieving the advanced stage which is the knowledge creation stage. To achieve the new growth economy, it is recommended that, both pre-service teachers and in-service teachers should improve their technological skill and knowledge. Based on the model, it is suggested that Sri Lanka education system should be developed from Technology Literacy level to Knowledge Deepening level and from Knowledge Deepening level to Knowledge creation level. It is believed that Sri Lankan government can achieve this
development by following these steps. To move from Technology Literacy level to Knowledge Deepening level the government should allocate five years, money, and teacher training. Additionally, to move from Knowledge Deepening level to Knowledge creation level, the government should allocate additional five years, and more money, and teacher training. The researcher has pointed out that spending money to move from Technology Literacy level to Knowledge Deepening level to Knowledge creation level is essential as the government is losing on the investment due to the 50% students’ failure in science, students go to society without competencies and government has lost their expectations of future citizens.

Table 9.1

UNESCO 2008 “New Growth” Economic three-stage model

<table>
<thead>
<tr>
<th>Policy and Vision</th>
<th>Technology Literacy</th>
<th>Knowledge Deepening</th>
<th>Knowledge Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum and Assessment</td>
<td>Basic Knowledge</td>
<td>Knowledge Application</td>
<td>21st Century Skills</td>
</tr>
<tr>
<td>Pedagogy</td>
<td>Integrate Technology</td>
<td>Complex Problem Solving</td>
<td>Self management.</td>
</tr>
<tr>
<td>ICT</td>
<td>Basic tools</td>
<td>Complex tools</td>
<td>Pervasive tools</td>
</tr>
<tr>
<td>Organizational and Administration</td>
<td>Stranded classroom</td>
<td>Collaborative groups</td>
<td>Learning organization.</td>
</tr>
<tr>
<td>Teachers professional development</td>
<td>Digital Literacy</td>
<td>Manage and guide</td>
<td>Teachers as Model Learners.</td>
</tr>
</tbody>
</table>

The researcher’s final recommendation is that the Sri Lankan government has to prepare policies and practical programmes to implement the TPACK model in secondary science
education. Table 9.2 shows how these three stages can be applied in Sri Lanka for future development in future.

**Table 9.2**

*UNESCO 2008 “New Growth” Economic model application in Sri Lanka*

<table>
<thead>
<tr>
<th>Technology Literacy</th>
<th>Knowledge Deepening</th>
<th>Knowledge Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy &amp; Vision</strong></td>
<td>Prepare workforce abilities and capabilities to work with new technology to improve economic productivity. Improve the new technology application of teachers and students in their teaching and learning process.</td>
<td>Demonstrate application of advanced software and describe content area. Using ICT with the TPACK thick model simulate, visualization, data collection tool and data analyse software support students to understand content. High Students understanding can be seen due to teachers understanding increase in content area because of the use of different kind of advanced software in this stage.</td>
</tr>
<tr>
<td><strong>Curriculum &amp; Assessment</strong></td>
<td>Prepare a curriculum that integrates ICT with the TPACK thick model applied in teaching and learning process.</td>
<td>Prepared curriculum that suit to use ICT with The TPACK thick model that identify key concepts and process in the subject area. Using ICT-based curriculum, the TPACK thick model with ICT can help students to understand the content knowledge. Teachers have high knowledge of using ICT with the TPACK thick model in their teaching and learning process.</td>
</tr>
<tr>
<td><strong>Pedagogy</strong></td>
<td>Use appropriate teaching method to integrate equally PK, PC, and TK domains of TPACK thick model. Prepare appropriate lesson plan to integrate equally PK, PC, and TK domains of TPACK thick model.</td>
<td>Teachers equally integrating PK, CK, and TK in the TPACK thick model. High level of TK, PK, and CK integration can be seen in the lessons. Teacher has high knowledge of ICT with the TPACK thick model using teaching and learning process. Students understanding are high.</td>
</tr>
<tr>
<td><strong>ICT</strong></td>
<td>Teachers need to develop high level technological skills as才知道</td>
<td>Use high technology in secondary science lessons and increase Using high slandered software. Students’ subject matter</td>
</tr>
</tbody>
</table>
well as technological knowledge. Also, teachers need to use their technological knowledge as well as technological skills to select appropriate technology to use to secondary science lessons. To gain high level of technological skills and technological knowledge, teachers need training programmes.

Organizational & administration
Ministry of Education of Sri Lanka, NGOs and other organizations should facilitate schools with ICT equipment and Internet. Prepare a program to train all secondary science teachers to use ICT with TPACK thick model within two years.

All schools in Sri Lanka should be provided with technology enhance environment.

All the technological equipment should be provided to classroom.

Provide facility to increase students and teachers’ understanding.

Teachers' professional development
Teachers should be trained to use ICT with the TPACK thick model within two years. At the same time teachers should be facilitated to use technology in their lessons.

Ministry of Education should provide all software and hardware related to teaching and learning process. Internet facility should be provided to all teachers.

Teachers' use of ICT to access to their own professional development.

Using Internet, teachers develop their own professional development.

More teachers training provide effective use of TPACK thick model.

Continuing teacher training to use high technology in their teaching and learning process. More teachers training provide effective use of TPACK thick model.
9.6 Contributions of this Study

There are five primary contributions that this study has contributed with new knowledge in the area using the TPACK model in evaluating the effective integration of technology in science lessons prepared by pre-service teachers. They are the TPACK scale, TPACK integration index, TPACK score and the TPACK thin and thick models.

9.6.1 TPACK Scale

The TPACK scale was prepared to measure the TPACK model lessons with respect to the elements of PK, CK, TK, PCK, PTK, CTK, and TPACK in the lessons. In other words, the TPACK scale measured the domains of PK, CK, and TK using the prepared rubric as depicted in Table 8.1. In this scale, the maximum value is 5 and the minimum value is 1. Using the PK, CK, and TK scale values, the combinations in terms of PCK, PTK, CTK and TPACK scale values were derived. According to the researcher’s experience using this scale, the TPACK model can be assessed and observed in the lessons conducted by the pre-service teachers. This is the researcher’s initial findings and considered as one of the areas for future research.

9.6.2 TPACK Integration index

In the planning, it was thought that the TPACK integration index would be observed, but the researcher could not observe it because the majority of pre-service teachers used the TPACK thin model. If the teachers use the TPACK thick model, the TPACK integration index can be observed in the lessons. The PK, CK, and TK integrations can be termed as follows.

- PK and CK integration = PCK integration
- PK and TK integration = TPK integration
- CK and TK integration = TCK integration
• PK, CK, and TK integration = TPACK integration

This is also considered as the researcher’s findings and areas for future research.

9.6.3 TPACK score

The TPACK score is the summation of the scale values of three TPACK domains which are PK, CK, and TK. The scale values of assigned to each of the 15 lessons with respect the three domains are depicted in Table 9.1. Based on these scales, the TPACK score for each of the lessons can be calculated. The TPACK score is very important to evaluate TPACK model lessons. This is also one of the researcher’s findings and can be considered as areas for future research.

9.6.4 A TPACK Rubric

According to researcher’s observation, the researcher needs to know how the pre-service teachers effectively integrate or use all of these three domains together to design functionally effective lessons. The integration of the three domains does not imply that the pre-service teachers have developed a deep knowledge on the TPACK model. These integrations are considered mechanistic in nature and to be able to design functionally effective lessons, the pre-service teachers have to develop deep knowledge of the TPACK model. It is argued that a deep knowledge of TPACK model exists when the pre-service teachers apply the TPACK thick model. The TPACK thick model exists when they synchronously integrate the three domains that result in functionally effective and efficient lessons.

9.6.5 The TPACK Thin and Thick Models

The TPACK thick model is effectively integrated main three domains in the TPACK model in the lesson. The TPACK thin model is not effectively integrated main three domains in the TPACK model in the lesson.
9.7 Review of Chapter Nine

This chapter discussed the conclusions, findings, and recommendations of this study. Specifically, the answers for five research questions were presented in the conclusions. The findings were TPACK score, TPACK integration index, “TPACK thin” and TPACK thick model, A TPACK Rubric, thin TPACK model and thick TPACK model and a rubric prepare to evaluate pre-service teachers TPACK model secondary science lessons. This research also included seven recommendations based on the findings of this research.
Reference


Biesta, G. J. J. (2010). Good Education in an Age of Measurement; Ethics, Politics, & Democracy: Paradigm Publisher.


http://science.education.nih.gov/houseofreps.nsf/b82d55fa138783c2852572c9004f5566/$FILE/Appendix%20D.pdf


Auastalia,Unit 4, Leaval 3, 14 Aquatic Drive, Frenchs Forest, NSW 2086.


Wallongong.


Rose, C. M. (2007). Developing Pedagogical Content Knowledge in Pre-service Teacher Through Microteaching Lesson Study. The Florida State University, Florida.


http://www.unesco.org/education/information/wer/PDFeng/wholewer98.PDF


http://www.unescobkk.org/ict/project


Appendix 1

Code:-

Secondary Science Student Teachers ICT Skill Testing Questionnaire (1)

This is my research Questionnaire, not a test, it is not assessable. I am interested in your views. Please answer the questions according to the instruction.

Name…………………………. NCOE………………………….

Section A

1. Describe any ICT training you have had?

Please tick (✓) if you agree, if not agree (✗)

2. I use computer to do following:

<table>
<thead>
<tr>
<th></th>
<th>at NCOE</th>
<th>outside NCOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyboard with a few fingers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keyboard with all fingers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keyboard with all fingers, not looking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create diagrams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To send emails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For instant Massaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create slide show (kid pix or power point)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create presentation (PowerPoint, Flash)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create/edit movies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To carry out research on Internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create web page</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To use spreadsheets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create spreadsheets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To create Blogs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I use CD’s and DVD’s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. I use computer

<table>
<thead>
<tr>
<th></th>
<th>at NCOE</th>
<th>outside NCOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Only a little</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>As much as I can</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>For my own entertainment</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>For my studies</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>For my teaching practices</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

4. I use or have used

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop computer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Laptop computer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A scanner</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A printer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A digital camera</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A digital video camera (for moves)</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

5. Internet capacity

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I have internet access at NCOE</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I have internet access at home</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you have a computer at NCOE?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you have a computer at home?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I access computer outside of NCOE</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I have no computer outside NCOE</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

6. MY computer skills

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I am very confident to use ICT in my teaching</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I am most of the time in cooperating ICT into my teaching</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
I am preparing class lessons using ICT  
I am using ICT effectively to teach numeracy/literacy  
I am confident to answer students questions related to their ICT use  
I advice to students to make productive use of ICT in my classes  
I help students to use ICT  
I motivate students to use ICT  
I use a range of ICT resources in the classroom

Section B

1. Learning theories guide the way we teach students e.g. Constructivism, Behaviourism, Cognitivism, Instructivism. Which learning theory describes your approach to learning? Why?

2. When planning a secondary science lesson you might consider some of the following approaches:
   a. Plan according to Teachers guide
   b. Plan based on curriculum
   c. Plan according to learning theories
   d. Prepare your own lesson plan
   e. Use the 5 E’s approach
   f. Include educational tools to teach science
   g. Other

Explain how you would plan an innovative science lesson and why you have chosen these methods.
3. There are many different teaching methods used in science teaching such as:
   a. Experimental work and practical activities
   b. Demonstrations
   c. Group work and collaborative activities
   d. Lectures
   e. Discussions
   f. Questioning from students and develop the lesson
   h. Other

In your opinion, which type of teaching method would be best to promote learning among students? Why?

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................

4. There are many ways of explaining scientific concepts for example:
   a. I dictate notes and explain to them
   b. I divide class into groups to discuss the concepts
   c. I use visual representations like concepts maps, and Venn diagrams
   d. I use teaching aids e.g. models, demonstrations
   e. Draw diagrams
   f. Others

Please explain which method(s) you think would be the best to promote understanding among students?
Why?
........................................................................................................................................
........................................................................................................................................
5. Circle the teaching aids you use when you are teaching? List any other. Explain why you choose to use them?
   a. Blackboard
   b. Whiteboard
   c. PowerPoint’s
   d. Overhead projectors OHP
   e. Textbook
   f. Others

Section C

1. How do you think ICT can be used as an educational tool?

2. How do you think ICT could be used to change the way you teach science? Please explain.

3. How is ICT currently used in teaching science in Sri Lanka?
4. What skills do you think teachers need to be able to use ICT in their teaching of science?

Do you have skills?

5. ICT included in science lessons in many ways such as

- Preparing my class lessons using ICT
- Taking students into the computer lab and ask them to research content
- Using Microsoft office programs – e.g. Word, Excel, PowerPoint

a. When you were in school, did you use ICT in science lessons?
b. Please describe ways you think ICT could be integrated into your teaching methods?
c. Do you think the use of ICT can promote learning? How? Why?
d. Do you think the use of ICT can improve your teaching? How? Why?

<table>
<thead>
<tr>
<th>Question</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sect A Q1</td>
<td>Background knowledge of students</td>
<td></td>
</tr>
<tr>
<td>Sect A Q2</td>
<td>Students computer skills</td>
<td></td>
</tr>
<tr>
<td>Sect A Q3</td>
<td>Computer exp</td>
<td></td>
</tr>
<tr>
<td>Sect A Q4</td>
<td>Computer exp/availability</td>
<td></td>
</tr>
<tr>
<td>Sect A Q5</td>
<td>Computer exp/availability</td>
<td></td>
</tr>
<tr>
<td>Sect A Q6</td>
<td>Students perceptions of their own skills</td>
<td></td>
</tr>
<tr>
<td>Sect B Q1</td>
<td>Learning theories</td>
<td></td>
</tr>
<tr>
<td>Sect B Q2</td>
<td>Lesson plan</td>
<td></td>
</tr>
<tr>
<td>Sect B Q3</td>
<td>Teaching methods</td>
<td></td>
</tr>
<tr>
<td>Sect B Q4</td>
<td>Explaining scientific concepts</td>
<td></td>
</tr>
<tr>
<td>Sect C Q1</td>
<td>ICT use as educational tool</td>
<td></td>
</tr>
<tr>
<td>Sect C Q2</td>
<td>ICT could be used to change the secondary science</td>
<td></td>
</tr>
<tr>
<td>Sect C Q3</td>
<td>ICT currently used in teaching science in Sri Lanka</td>
<td></td>
</tr>
<tr>
<td>Sect C Q4</td>
<td>Teachers need to be able to use ICT in their teaching of science</td>
<td></td>
</tr>
<tr>
<td>Sect C Q5</td>
<td>ICT is included in science lesson</td>
<td></td>
</tr>
</tbody>
</table>
Appendix II

Secondary Science Pre-Service Teachers Interview Questionnaire (Unstructured)

As a pre-service science teacher, are you using ICT in your teaching practice? Please describe.

What do you know about pedagogical knowledge, content knowledge and technical knowledge?
Please describe.

After the workshop, do you better understand how to use ICT with technology? Please describe.

How does ICT with technology help to develop understanding of secondary science in studies? Please
explain

Why you select a or b

Are you confident to teach by using ICT technology in secondary science class? Please describe.

What type of ICT do you use in your lessons? Please describe.

Appendix III

NCOE Lecturers Interview Questionnaire(Unstructured)
As NCOE lecturer are you using ICT lecturers? Please describe.

Do you know about technological, pedagogical and content knowledge? Please describe.

After the workshop, do you understand how to use ICT with technology? Please describe.

How does ICT with technology help to develop understanding of secondary science in student teachers? Please describe.

Are you confident to teach, by using ICT with technology in secondary science? Please describe.
What type of ICT do you use in your lessons? Please describe.

Appendix IV

Photos taken from the pre-service teachers video tapes
## Appendix V

<table>
<thead>
<tr>
<th>Competency</th>
<th>Competency Level</th>
<th>Subject Content</th>
<th>Teaching Learning Methods</th>
<th>TIME</th>
</tr>
</thead>
</table>
| 4. Learning theories and teaching principles teach according to teaching and learning methods. | 4.1 Teaching and learning procedure to introduce philosophical approach. | • Learning theories development and distribution.  
  ➢ Trial and error theory-Pavlov’s approach.  
  • Conditioned stimulus and response and  
  • Unconditioned stimulus and response skill.  
  • Social learning theories.  
    ➢ Observation learning theory Bandura.  
  • Cognitive learning theories- Step1  
    ➢ Gestol theory-Wertheimer.  
    ➢ Cofca, Kohaler signal theory-Troman.  
    ➢ Field theory-Katilovin.  
  • Cognitive learning theories- Step2  
    Bruno, Ganae, Duvi, Mary, Montessori.  
  • Humanistic learning theory.  
    Call poper, Abram Maslow, Malkam Nols.  
  • Ganease structural theory. | Assignment and group discussions.       | 15 hrs. |
Appendix VI


Sarath Warnakulasuriya
PhD Candidate
Faculty of Arts and Education,
Deakin University

ICT in the secondary science classroom

Why use it?
When to use it?
How to use it?
What does it include?
What skills do I need?

Why use it?
- Digital age
- Digital Kids
- Digital Immigrant Teachers
- Digital Native Learner

Digital Kids
- Hypercommunication
- Multitaskers
- Play oriented
- Random Access
- Learning has not relevant and becomes fun
- Multisensory input
- Digital and Graphic first
- Fantasy Based
- Twitch speed
Digital Immigrant Teachers

- Prefer slow and controlled release of information from limited sources and limited tasking
- Prefer singular processing and single tasking
- Prefer to provide test before pictures, or limited tasking video and sound
- Prefer to provide information linearly, logically, and sequentially
- Prefer student to work independently rather than network and interact
- Prefer to teach “Just-in-case” (it is on the exam)

Prefer deferred gratification and different rewards
- Prefer to teach the curriculum guide and standardized test

Digital Native Learner

- Prefer receiving information quickly from multiple multimedia sources
- Prefer parallel processing and multitasking
- Prefer processing pictures, sound, and video before text
- Prefer random access to hyperlink multimedia information
- Prefer to interact/network simultaneously with many others
- Prefer to learn “Just-in-time”

Prefer instant gratification and instant rewards
- Prefer learning that is relevant, instantly useful, and fun.

Using ICT to enhance teaching and learning by
- Providing opportunity for learning
- Save time
- ICT enhance explanation of abstract topics in secondary science
- Visualizations tool
- Modeling tool
- Present data in a variety of formats
- Provide easy access to lot of data
- Allows easy manipulation of large amount of data

Interactive learning environment
- Opportunities for students to get feedback on their input
- Engaging, interactive, responsive, challenging
- Multimedia formats
- More stimulating
- Fashionable
- Use current technology
Multimodal
- Caters for a variety of learning styles
- Presents information in a multiple representation forms
- Consistent with the science reform agenda
- Emphasis on the individual

What is ICT?
ICT encompasses a wide variety of hardware and software that enhance communication through the digital form.
ICT has enormous capacity to provide enhanced visual learning tools that are most valuable for explaining the abstract subject of chemistry through various forms:
- Video
- Internet
- Web pages
- E-mail
- Blogs
- CD-ROMS
- Simulations
- Animations
- Word processing
- PowerPoint presentations
- Data loggers
- Spreadsheets – Excel calculations, identifying trends etc

Multimedia authoring
- Scanner
- Digital cameras
- Hyperlinks

When to use it?
- Making the best use of the available resources, providing opportunities
- Not overusing any one technology
- Being knowledgeable about the variety and purpose of a variety of forms
- Selecting a form of ICT when it is appropriate and best suited to the learning task e.g., interactive PT on Internet.

How to use ICT in Secondary Science education?
Some examples:
- Internet sites
- Current data – e.g., emerging sciences
- Interactive games
- Balancing equations
- Properties of elements
- Websites
- Research
- E-mail

CD – stand-alone programs, plus accompanying text blogs, often come with video clips, great images and animations
- Data logging – computer interface in laboratory, collecting a lot of data quickly, easily, accurately, cheaply
- Using Excel sheets for data analysis – allows for easy calculations
- PowerPoint presentations – with images + animation + hyperlinks + print forms etc
- Video clips
- Modeling – animation, chemicals, etc.
What skills do I need?

My ability to:

1. Use e-mail and the internet for communication.
2. Use electronic information sources (e.g., library systems, internet sources).
3. Word process scientific reports effectively.
4. Use computer to prepare presentations.
5. Use data processing methods (e.g., spreadsheets).

Using Information Communication Technology (ICT) Skills in Teaching:

- Orient for selecting materials
- Integrated
- Meaningful
- Add value
- Enhances learners skills
- Provides visualisation
- Provides explanations
- Interactive

Figure 1: VICK framework and its knowledge components (Mitchel, 2006).

The teacher had set up an ICT learning environment that was engaging, challenging, supportive, creative, thinking-oriented. It supported and motivated the learners, regardless of their skill levels.

Set task outcomes be specific task for Year 11 class.
Main factors effect on teachers adoption of new technology and pedagogy:

- Time: For learning new skills, experimenting with new technologies, for students and other teachers to learn from them, for reflection, for trying new approaches and pedagogies.

- Preparedness to take risks: Teachers need to be supported in taking risks to improve learning in the way they do things. They need to take risks in building and expanding their pedagogical toolboxes.

- Adequate resourcing: Needs to be made in infrastructure and equipment that works, is reliable, is accessible, is up to date.