



**QUALITY OF INFORMATION
AND COMMUNICATION
TECHNOLOGY (ICT)
EDUCATION AT GCE (O/L) IN
SRI LANKAN SCHOOLS**



M.G.N.A.S. Fernando
2007/MPhil/PhD/004

A thesis submitted to the Faculty of Graduate Studies, University of Colombo in fulfilment of the requirements for the Doctor of Philosophy Degree

November 2015

Acknowledgement

First and foremost, I would like to express my sincere gratitude to my Supervisor Dr MB Ekanayake for his immense knowledge and continuous support given to my research, for his patience, motivation and enthusiasm shown. His expert guidance helped me throughout the whole period I spent on this research.

I am grateful to people who spend their lives absorbed in productive research with innovations to make the world a better place for humanity. If it were not for their serious commitment to work, I would have been in great trouble with this research.

I am truly grateful for the invaluable guidance and assistance provided by Professor Sunil Chandasiri, Dean / Faculty of Graduate Studies, and Mr S.Vidanagamage, Coordinator, MPhil/PhD program (OLD), for their invaluable advice, continuous encouragement, provision of appropriate facilities and constructive feedback towards the improvement of this study. I also wish to thank the other members of the Faculty of Graduates studies, especially Mr UW Kumara who provided tremendous support towards the success of this thesis.

My special thanks go to Prof GN Wickramanayake, Director/UCSC, who provided facilities to conduct the research work at the UCSC, providing laboratory facilities and other special equipment to implement and test the suitability of the proposed application model. Further, I especially acknowledge the financial and other facilities given by Prof Wickramanayake, to present and publish six papers at different international conferences in different countries, throughout the research study.

I am truly grateful for the invaluable support provided by Mr Nalaka Ilapperuma, Provincial Director of Education, Western Province, for providing facilities to conduct a sample survey in 35 schools in 5 different districts and for allocating 3 schools, 10 ICT teachers and one ICT instructor to implement and test the model successfully.

Various members of different organizations provided information and guided me along the correct path to successfully complete the research study: They are: The National Institute of Education, The Ministry of Education, The National Education Commission, Selected

Institutes of National Colleges of Education and selected Computer Resource Centers (CRC). I sincerely thank these members for their cooperation and contributions.

Special thanks are due to Prof. Indralal De Silva, Senior Professor of Demography/University of Colombo, Dr. Chaminda Jayasundara, University of Colombo, Ms Nimalika Herath, Dean's office/ Faculty of Arts, University of Colombo for guidance and help with the research study.

I would like to thank the principals of the three selected schools: the Principal of Thurstan College, Colombo 3, The Principal of Samudra Devi Balika Vidyalaya, Nugegoda, and the Principal of Anula Vidyalaya, Nugegoda for the release of ICT teachers to participate in the model implementation and testing and for granting permission to test the model in their schools' environment. Further, I would like to thank all ICT teachers and students who helped me with the research study by helping with the survey activities and by participating in the model implementation and testing processes.

Mr.KDD Percival and Ms. Vineeta Goonetilleke supported me with language editing throughout the project. I am grateful for their assistance.

Last but not least, I thank my family: my wife Mallika Fernando for the understanding shown and for encouraging and supporting me during the entire process of the study. My three daughters were no exception. They actively supported me in every possible way.

M.G.N.A.S. Fernando

ABSTRACT

The focus of this study is on improving the quality of ICT education in Sri Lankan schools and about necessary enhancements to achieve international standards. The specific objectives of this study were to: (i) determine the factors that affect ICT education according to international perspectives (ii) investigate the present status of ICT education in Sri Lanka compared to international standards and those in the Asian region (iii) recognize the gap that appears to affect the quality of ICT in Sri Lankan schools (iv) suggest possible enhancements to fill the gaps with ICT education in Sri Lanka, and (v) use the outcomes of the objectives mentioned to develop a feasible application model towards enrichment of the ICT specialization subject for the GCE(O/L) curriculum in Sri Lankan schools.

For this purpose, a researchable framework was developed and used, utilizing the existing resources. Activities based on blended learning and pedagogical techniques were built in. This study was carried out in two phases. Phase I, focused on the achievement of the specific objectives (i)-(iv) mentioned above. Phase II achieved the fifth objective of the study. Three tier architecture was used as the design architecture of the study. The first two tiers cover Phase I while Tier 3 covers Phase II. Based on multi-stage sampling techniques, a survey was administered in 35 randomly selected schools in five purposively selected districts to find the present status in relation to ICT education. 48 ICT teachers, 32 principals and 1295 students participated in this survey. Further, in-depth data were collected from responsible officers of different responsible organizations (e.g. Ministry of Education, National Institute of Education) using structured interviews, questionnaires, and observations and other reliable sources. Gap analysis and other theoretical aspects were used as the theoretical foundation for both Phases I and II of the study. Descriptive and inferential statistical techniques were used in data analysis to derive the outcomes. On the whole, 31 hypotheses were tested.

Based on the outcomes of the first tier of the research design through various activities, it was found that nine factors contributed towards maintaining quality ICT education. These factors are (i) National goals and budget allocations (ii) Infrastructural facilities (iii) Curriculum development and related activities (iv) Software (v) Hardware maintenance based on

sustainability plans (vi) Human resource development (vii) Research and development (viii) Support from and supportive initiatives (ix) Policy guidelines and monitoring plans.

In the second tier, the quantitative as well as qualitative strengths of the nine factors currently in Sri Lankan schools were determined. The outcome from this tier led to the development of a set of criteria to improve the quality of ICT education. A few important findings from Phase I include that on average 23 computers are available for use in schools. The present student: computer ratio is 12:1 while the estimated requirement remains at 24:1 for the ICT specialization subject (GCE (O/L) in Sri Lankan Schools. The important outcomes collected from inferential statistics of the study are as follows: Infrastructure facilities are sufficient to implement the ICT specialization subject in Sri Lankan schools while support from the administration and supportive initiative are marginally satisfied. No disparities in both infrastructure and support from the administration and supportive initiative, were seen between different districts and schools' category-wise. Further, human resource facilities and their strength, maintenance and sustainability plans, and curriculum implementation facilities are not found to be at a satisfactory level to implement the ICT specialization subject in Sri Lankan schools. Findings also reveal that stakeholders were not satisfied about the usage of only commercial software products and the study reveals that stakeholders are willing to use open source software to fulfil the software requirements related to the smooth functioning with ICT education in Sri Lankan schools.

A key finding in in Phase I reveals that the development of ICT pedagogical skills has been neglected or was not recognized in all districts as a need towards quality improvement in comparison with other requirements related to ICT education like: hardware, software, infrastructure, curriculum, and teacher training. Lack of pedagogical skills, derived particularly from theoretical foundations like Kolb's Experiential Learning Circle, Bloom's Taxonomy, Blended learning approaches, Role model, Stakeholders feedback and classroom observation, was evident.

The outcomes and recommendations from Phase I were used in Phase II to design an application model to develop the pedagogical skills of ICT teachers and students. Then the application model was validated with a suitable platform, and tested with an expert panel. Comprising an ICT expert, an ICT instructor and nine ICT teachers. The feedback and

suggestions from ICT Teachers and other stakeholders and outcomes from the facial expression emotional model applied to the participant teachers were used to smarten and fine-tune the experimental application model. In the implementation of the facial expression emotional model, on average, 74% teachers demonstrated 'Happily Feature'. This application model was once again implemented on and tested in with 61 students from three different schools. The analysis of outcomes shows that the students' academic performance with problem solving capabilities increased by 19.5% gradually due to the different treatment levels in the activity model in this study. The study also proved that the Programming and Problem Solving unit showed high correlation with other course units in the curriculum. The embedded techniques of the application model helped prove that Peer Learning, Blended Learning, Kolb's Experiential Learning Circle, Bloom's Taxonomy, Role Model and Activity Based Learning, contribute towards maintaining the quality of ICT education. However, support from higher authorities is essential to maintain the quality of the application model as well as to maintain the expected quality level of ICT education.

The outcome from implementation of the application model was supportive towards evidence to increase student performance to a satisfactory level. The study helped realize that both teachers and students welcomed the use of the application model towards motivation, problem solving and critical thinking, teamwork and reflection compared to face-to-face traditional teaching and learning. Therefore, Free and Open Source Software or Open Source Software is recommended as sufficient for the implementation of the ICT curricula in Sri Lankan Schools. The study recommends that all ICT teachers need well organized ICT teacher training programs embedded with adoptive learning and activity based learning programs. Teachers and students need more skills development activities in selected areas with the ICT subject (e.g. Programming and Problem Solving).

In summary, this experimental study helped determine that guidance to use open source software to adopt learning techniques (e-learning and activity based learning) and pedagogical techniques with proper evaluation, are also required to achieve international standards with the ICT specialization subject in Sri Lankan schools.

Contents

Declaration	
Acknowledgement	2-3
Abstract	4-6
Abbreviations	
List of Tables	
List of Figures	
Chapter 1 - Introduction	26-38
1.1 Background	
1.2 Backgrounds to General Education	
1.3 The Influence of ICT in Everyday Life	
1.4 ICT Education in Sri Lankan Schools	
1.5 Significance of the Research	
1.6 Research Problem	
1.7 Objectives of the Study	
1.8 Research Methodology	
1.9 Limitation of the Study	
1.10 Chapter outline of the Study	
Chapter 2 – Theoretical Foundation	39-61
2.1 Introduction	
2.2 Quality of Education	
2.3 Statistical Theory Foundation	

- 2.4 ICT Education Pedagogy
 - 2.4.1 Bloom's Taxonomy
 - 2.4.2 The Digital Learning Environment
 - 2.4.3 Role Model
 - 2.4.4 Gap Analysis
 - 2.4.5 Three Tier Architecture
 - 2.4.6 Reflective Practicing
 - 2.4.7 Evaluation of Quality in ICT Education
- 2.5 Conceptual Framework of the Research Study

Chapter 3 - Literature Review

62-106

- 3.1 Introduction
- 3.2 Introduction to General Education in Sri Lanka
- 3.3 Overview of Education in Selected Countries
- 3.4 Importance of Implementing ICT Education through the General Education Platform
- 3.5 Comparison of ICT Education in Selected Countries
- 3.6 ICT Curricula in Lankan School
- 3.7 Facilities provided to improve ICT Education in Sri Lankan Schools
- 3.8 Policy Proposal for ICT Education in Sri Lankan Schools

Chapter 4 Research Methodology **107-144**

- 4.1 Introduction
- 4.2 Research Design
- 4.3 Sources of data
- 4.4 Data collection
- 4.5 Mixed methods used to develop the study including the survey
- 4.6 Data analysis and interpretation
- 4.7 Justification of methodology

Chapter 5 Analysis and results presentation of phase I **145-215**

- 5.1 Introduction
- 5.2 Results related to the survey analysis
- 5.3 Nature of the sample
- 5.4 Results pertaining to the phase 1 (objectives 1 to 4)
- 5.5 Infrastructure facilities (X₁)
- 5.6 Human resource issues (X₂)
- 5.7 Maintenance and sustainability plans (X₃)
- 5.8 Software (X₄) to implement ICT education for
GCE (O/L curriculum
- 5.9 Curriculum implementation facilities and issues (X₅)
- 5.10 Policy matters (X₆)
- 5.11 Support from the administration and supportive initiative (X₇)
- 5.12 Research and development (X₈)

5.13	Budget allocation and country expectations (X ₉)	
5.14	Enhancement possibilities to fill gaps in ICT specialization subject	
Chapter 6	Implementation of proposed application model	216-245
6.1	Introduction	
6.2	Conclusions on quality factors for ICT education (objective 1)	
6.3	Conclusions regarding current quality status related to ICT specialization subject for GCE (O/L) in Sri Lanka (objective 2 to 4)	
6.4	Recommendation of proposed application model for quality improvement (phase II)	
6.5	Theoretical foundation and literature review	
6.6	Design methodology	
6.7	Data collection (phase II)	
6.8	Try out the application model	
6.8.1	Try out model with selected ICT teachers	
6.8.2	Teachers try out model in school with their students	
6.9	Results related to the proposed application model	
6.9.1	Master-trainer and teacher model and the peer-to-peer teacher model	
6.10	Outcomes of the activity model 1	
6.11	Implementation of the proposed model in respective schools	

6.12	Evaluation of the proposed application model	
Chapter 7:	Summary and conclusions (phase II)	246-251
7.1	Introduction	
7.2	Summary and conclusion of the teacher training and student application model	
7.3	Recommendations	
7.4	Difficulties, issues in the implementation of the model and suggestions to improve the model	
7.5	Limitations of the research study	
7.6	Recommendations for future work	
List of References		252-260
Appendixes		261-381
Appendix 1:	Student's Questionnaire	
Appendix 2:	Principal's Questionnaire	
Appendix 3:	Teacher's Questionnaire	
Appendix 4:	Case study schedule for NIE Authorities	
Appendix 5:	Case study schedule for MOE Authorities	
Appendix 6:	Case study schedule for CRC officers and Provincial/ Zonal officers / ICT center coordinators	
Appendix 7:	Informal Interview Schedule for NEC Officers	
Appendix 8:	Informal Interview Schedule for ICT experts in Universities	
Appendix 9:	Informal Interview Schedule for ICT Industry experts	

Appendix 10: Class room observation from

Appendix 11: Workshop observation schedule

Appendix 12: Supplementary survey outcomes

Appendix 13: Flexibility of Free and Open Source Usage, Financial investigation
and alternative solution for software

Appendix 14: Activity Models

Appendix 15: Sample Answers of the Activity model

Appendix 16: Course material for Fundamental of Python Programming

Language and enhancement of Problem Solving using

Blended Learning approach

Appendix 17: Model implementation request Letter

Appendix 18: List of Publications

List Of Abbreviations

A/L	-	G. C. E (Advanced Level)
ADB	-	Asian Development Bank
BOOT	-	Build, Own, Operate and Transfer Model
CAL	-	Computer Assisted Learning
CD	-	Compact Disk
CDL	-	Contents Development Labs
CEP	-	Computer Education Programme
CLASS	-	Computer Literacy and Studies in Schools
CLC	-	Computer Learning Centers
CRC	-	Computer Resource Center

D/SE&L	-	The Department of School Education & Literacy
DEMP	-	Distance Education Modernization Project
FOSS	-	Free and Open Source Software
GCI	-	Global Competitiveness Index
GEP	-	General Education Project
GIT	-	General Information Technology
ICDL	-	International Computer Driving License
ICT	-	Information and Communication Technology
ICTA	-	Information and Communication Technology Agency
IT	-	Information Technology
ITERCs	-	Information Technology Education Resource Center
IP –VPN	-	Internet Protocol – Virtual Private Network
IRQUE	-	The Improving Relevance and Quality of Undergraduate Education
LEARN	-	Lanka Education and Research Network
LKG	-	Lower Kinder Garden
MIS	-	Management Information System
MMV	-	Madhya Maha Vidyalaya
MOE	-	Ministry of Education
MSP	-	Multi–Stakeholder Partnerships
NAC	-	Node Access Center
NIIT	-	National Institute of Information Technology
NOC	-	Network Operational Center

NCOE	-	National Colleges of Education
NEC	-	National Education Commission
NIBM	-	National Institute of Business Management
NIE	-	National Institute of Education
NIIT	-	National Institutes of Information Technology-India
NODES	-	National Online Distance Education Service
NVQ	-	National Vocational Qualification
O/L	-	G. C. E (Ordinary Level)
O/S	-	Operating System
OSS	-	Open Source Software
OLPC	-	One Laptop per Child
PDN	-	University of Peradeniya
PPI	-	Public and Private Institutes
PSTN	-	Public Switched Telephone Network
ROM	-	Read Only Memory
SEMP	-	Secondary Education Modernization Project
SBM	-	School Based Management
SDP	-	School Development Plan
SLT	-	Sri Lanka Telecom
SWOT	-	Strengths, Weaknesses, Opportunities and Threats
TVE	-	Technical and Vocational Education
UKG	-	Upper Kinder Garden

UGC - University Grants Commission

UPS - Uninterrupted Power Supply

WAN - Wide Area Network

List Of Tables

Chapter 1

Table 1.1 Students, Teachers and Student/ Teacher Ratio

Chapter 2

Table 2.1 Stages of revised Bloom's taxonomy and its sample activities

Table 2.2 Kolb's experiential learning Circle

Table 2.3 Learning theory of Kolb's experiential learning Circle

Table 2.4 Different learning aspects of Kolb's experiential learning Circle

Table 2.5 Operational approach of the study

Chapter 3

Table 3.1 Infrastructure Facilities of the Government Schools

Table 3.2 ICT Professional Development

Table 3.3 Summary of indicators and methodologies used in quality ICT education on International recommendation, selected Asian countries and Sri Lanka

Chapter 4

Table 4.1 Table of the gap elimination guidelines

Table 4.2 Selected schools for the sample survey

Table 4.3 Questionnaire sample completed by students

Table 4.4 Attributes in quality factors

Table 4.5 Possible minimum and maximum rank sum of variables

Table 4.6 Possible minimum and maximum rank sum for a person

Chapter 5

Table 5.1.1 Composition of the sample by district

Table 5.1.2 Composition of the sample by school type

Table 5.1.3 Composition of the sample by gender

Table 5.1.4 Nature of students

Table 5.1.5 Total number of students who follow ICT specialization subject
at Grade 10 and Grade 11 in selected schools

Table 5.1.6 Composition of the sample by school grade

Table 5.1.7 Total number of students in school

Table 5.1.8 Total Student population in selected schools

Table 5.1.9 The total number of students following ICT literacy subject
in grade 6 in the selected schools

Table 5.1.10 Distance from school to home

Table 5.1.11 Composition of the sample in terms of the time taken to travel
from school to home and vice versa

Table 5.1.12 ICT teachers' information; gender-wise and district-wise

Table 5.1.13 The number of ICT teachers in schools

- Table 5.2.1 Kruskal-Wallis test for total rank sum versus district on
Infrastructure -ICT teachers' point of view
- Table 5.2.2 Kruskal-Wallis test for rank sum versus district on infrastructure –
Principal's point of view
- Table 5.2.3 Kruskal-Wallis test for rank sum versus school type on infrastructure–
Principal's point of view
- Table 5.2.4 Kruskal-Wallis Test on total ranks for human resource facilities
and its strength – ICT teachers' point of view
- Table 5.2.5 Kruskal-Wallis Test on total ranks for human resource facilities/
strength – Principals' point of view
- Table 5.2.6 Kruskal-Wallis test on total ranks versus School Type for human
resource facilities -Principal's point of view
- Table 5.2.7 Kruskal-Wallis Test on total ranks for human resource facilities
and its strength – ICT teachers' point of view
- Table 5.2.8 Kruskal-Wallis test on total ranks for maintenance and sustainability
mechanism – Principal's point of view
- Table 5.2.9 Kruskal-Wallis test on total ranks versus school type for maintenance
and sustainability mechanism -Principal's point of view
- Table 5.2.10 Kruskal-Wallis Test on expectation on usage of software
– ICT teachers' point of view
- Table 5.2.11 Kruskal-Wallis Test on expectation on usage of software
– ICT students' point of view
- Table 5.2.12 Kruskal-Wallis Test on total ranks for curriculum implementation

facilities /techniques – ICT teachers’ point of view

Table 5.2.13 Kruskal-Wallis Test on total ranks for usage of pedagogical techniques under the curriculum implementation facilities /techniques – ICT teachers’ point of view

Table 5.2.14 Kruskal-Wallis Test on total ranks versus district for curriculum implementation issues – Principal’s point of view

Table 5.2.15 Kruskal-Wallis Test on total ranks versus school type for infrastructure – Principals’ point of view

Table 5.2.16 correlation between the programming and problem solving unit (Q6.2) with other course units in Grade 11 curriculum (Q6.1, Q6.3.Q6.4, and Q6.5).

Table 5.2.17 Kruskal-Wallis Test on total ranks for Support from administration and supportive initiative – ICT teachers’ point of view

Table 5.2.18 Kruskal-Wallis Test on total ranks versus district for support from administration and supportive initiative – principals’ point of view

Table 5.2.19 Kruskal-Wallis Test on total ranks versus school type for support from administration and supportive initiative – principals’ point of view

Table 5.2. 20 Kruskal-Wallis Test on total ranks for infrastructure – ICT teachers’ point of view

Table 5.2.21 Kruskal-Wallis Test on total ranks versus district on the impotence of adopting research and development activities to enhance ICT specialization subject – principals’ point of view

- Table 5.2.22 Kruskal-Wallis Test on total ranks for impotence of adopting research and development activities to enhance for ICT specialization versus school type for infrastructure – Principals’ point view
- Table 5.2.23 Recognition of the gaps and limitations that might affect the quality of ICT specialization subject in grade 10 and in Sri Lankan schools
- Table 5.2.24 The recommendation of the enhancement possibilities of the study in connection with the ICT specialization subject for GCE (O/L) in Sri Lankan schools

Chapter 6

- Table 6.1 Experimental activities
- Table 6.2 Number of participants who participated in the series of workshop
- Table 6.3 Proposed customized reflective experimental learning circle for implementation of the activity model
- Table 6.4 Selected number of students for the implementation of the Application model
- Table 6.5 Output of the seven universal facial expressions of emotional methodology
- Table 6.6 Mean marks of each block at each treatment
- Table 6.7 Paired T- test for Face-to Face and Activity Level 1
- Table 6.8 Paired T- test for Activity Level 1 and Activity Level 2.....
271
- Table 6.9 Paired T- test for Activity Level 2 and Activity Level 3.....
272

- Table 6.10 Paired T- Activity Level 3 and Level 4
- Table 6.11 Paired T- Activity Level 4 and Activity Level 5
- Table 6.12 One –way ANOVA: marks versus school

List Of Figures

Chapter 2

- Figure 2.1 Aristotle's influential categorization of knowledge
- Figure 2.2 Outliers determination process
- Figure 2.3 Revised Bloom's Taxonomy
- Figure 2.4 Role Model in the implementation of education
- Figure 2.5 Gap Elimination process.
- Figure 2.6 Three Tire Architecture for ICT development methodology
- Figure 2.7 Kolb's experiential learning Circle
- Figure 2.8 An example of the seven stages of the universal facial emotional Model
- Figure 2.9 Conceptual Framework of the Study

Chapter 3

- Figure 3.1 Model depicts a continuum of approaches to ICT development in Schools.
- Figure 3.2 Model of stages of teaching and learning with and through ICT

Chapter 4

- Figure 4.1 Complete design frameworks for the study
- Figure 4.2 Three tier architecture of the proposed research design model

- Figure 4.3 First tier of the research design
- Figure 4.4 Second tier of the research design
- Figure 4.5 Basic structure of the preliminary survey
- Figure 4.6 Gap eliminating process

Chapter 5

- Figure 5.1.1 Pie chart of distance from school to home
- Figure 5.1.2 Time spend on the journey
- Figure 5.2.1 Summary statistics for total rank sum on infrastructure (X_1)
– ICT teachers' point of view
- Figure 5.2.2 Summary statistics for rank sum ratio on infrastructure (X_1)
– ICT teachers' point of view
- Figure 5.2.3 Summary statistics for rank sum on infrastructure (X_1)
– Principals' point of view
- Figure 5.2.4 Summary statistics for rank sum ratio on infrastructure (X_1)
– Principals' point of view
- Figure 5.2.5 Summary statistics for rank sum on infrastructure (X_1)
– Students' point of view
- Figure 5.2.6 Summary statistics for rank sum ratio for infrastructure (X_1)
– ICT Students' point of view
- Figure 5.2.7 The ICT Teachers' qualification
- Figure 5.2.8 student intake at Lumbini Computer Resource Center
- Figure 5.2.9 Summary statistics for human resource (X_2) on rank of sum

– ICT teachers’ point of view

Figure 5.2.10 Summary statistics for human resource facilities and its strength (X_2)

- on rank of sum ratio – ICT teachers’ point of view

Figure 5.2.11 Summary statistics for human resource facilities and its strength (X_2)

on rank of sum – ICT principals’ point of view

Figure 5.2.12 Summary statistics for rank sum ratio on human resource facilities

and its strength (X_2) – ICT principals’ point of view

Figure 5.2.13 Summary statistics for human resource facilities and its strength (X_2)

on rank sum –Students’ point of view

Figure 5.2.14 Summary statistics for rank sum for maintenance and sustainability

mechanism(X_3)- ICT teachers’ point of view

Figure 5.2.15 Summary statistics for rank sum ratio for maintenance and sustainability

mechanism(X_3) – ICT teachers’ point of view

Figure 5.2.16 Summary statistics for maintenance and sustainability mechanism(X_3)

On rank of sum– principals’ point of view

Figure 5.2.17 Summary statistics for maintenance and sustainability mechanism(X_3)

On rank sum ratio – principals’ point of view

Figure 5.2.18 Recommendation of the teacher about willingness in software usage

Figure 5.2.19 Summary statistics for rank of sum for expectation of software

usage (X_5) – ICT teachers’ point of view

Figure 5.2.20 Summary statistics for software (X_4) on rank ratio

– ICT teachers’ point of view

Figure 5.2.21 Usage of different Operating system in Sri Lankan schools

Figure 5.2.22 Usage of different basic software categories in Sri Lankan Schools

Figure 5.2.23 Summary statistics for the usage of software (X_1) on rank of sum
– Students' point of view

Figure 5.2.24 Summary statistics for rank sum ratio for usage of software (X_4)
ratio – ICT Students' point of view

Figure 5.2.25 Summary statistics for curriculum implementation facilities (X_5)
on rank of sum – ICT teachers' point of view

Figure 5.2.26 Summary statistics for curriculum implementation facilities /
techniques (X_5) on rank of sum ratio – ICT teachers' point of view

Figure 5.2.27 Summary statistics for rank sum on curriculum implementation
facilities as pedagogical techniques usage ($X_{5.1}$)
– ICT teachers' point of view

Figure 5.2.28 Summary statistics for curriculum implementation
facilities/techniques as pedagogical techniques usage ($X_{5.1}$)
on rank ratio – ICT teachers' point of view

Figure 5.2.29 Summary statistics for curriculum implementation
facilities (X_5) on rank of sum – principals' point of view

Figure 5.2.30 Summary statistics for curriculum implementation
facilities (X_5) on rank of sum ratio – principals' point of view

Figure 5.2.31 Summary statistics for rank sum for curriculum implementation
facilities and its strength (X_5) – students' point of view

Figure 5.2.32 Summary statistics for curriculum implementation

facilities (X_5) on rank sum ratio – students’ point of view

Figure 5.2.33 Students’ attitudes towards the status of programming and problem solving techniques

Figure 5.2.34 Summary statistics for support from administration and supportive initiative (X_7) on rank of sum – ICT teachers’ point of view.

Figure 5.2.35 Summary statistics for support from administration and supportive initiative (X_7) on rank sum ratio– ICT teachers’ point of view.

Figure 5.2.36 Summary statistics for support from administration and supportive initiative on rank of sum– Principals’ point of view.

Figure 5.2.37 Summary statistics for support from administration and supportive initiative on rank sum ratio– Principals’ point of view.

Figure 5.2.38 Summary statistics for support from administration and supportive initiative on rank of sum– Students’ point of view.

Figure 5.2.39 Summary statistics for Support from administration and supportive initiative on rank sum ratio– ICT Students’ point of view.

Figure 5.2.40 Difficulties of implementation of Blended Learning

Figure 5.2.41 Summary statistics of the importance to adopting research and devolvement activities on rank of sum- ICT teachers’ point of view

Figure 5.2.42 Summary statistics for importance of adopting research and development activities on rank sum ratio– ICT teachers’ point of view..

Figure 5.2.43 Summary statistics for the importance to adopt research and

development activities to enhance the ICT specialization subject (X_8)

on rank of sum– Principals’ point of view..

Figure 5.2.44 Summary statistics for the importance to adopting research and

development activities to enhance the ICT specialization subject to

grade 10 and 11 students (X_8) on rank of sum ratio

– Principals’ point of view..

Chapter 6

Figure 6.1 Third tier of the research design.

Figure 6.2 Demonstration of how to use blended learning (e-learning)
approaches

Figure 6.3 Stack chart to represent Students’ performance in different activities
in three schools

Figure 6.4 Bar chart to represent Students’ performance in different activities
in three schools

Chapter 1: Introduction

1.1 Background

Information and Communication Technology (ICT) has become an important aspect of most organizations and businesses. ICT applications, in particular with the education system, might change the future of the less developed world, fundamentally through connections to ‘the flat world’. However, there are some challenges, the developing world faces in adopting ICT to the education sector. These challenges relate to: limitation of funds, Internet access, trained staff and adequacy of policy.

ICT arrived in schools more than 37 years ago. Several researchers and educationists have suggested that ICT would be an important part of education for the next generation too. As modern technology offers many means to improve the teaching and learning process in the classroom.

The use of ICT was initiated in Sri Lankan schools in 1982. Although the Ministry of Education (MOE) of Sri Lanka introduced ICT education 28 years ago, there has been no comparative improvement evident in the schools’ system when compared to the developed and some other developing countries. Based on experience from developed countries, as well as with instructions and guidelines from both local and international experts, responsible implementers have carried out several activities to enhance ICT education. The literature review, reveals several such studies from both foreign and locally funded projects to enhance the process of ICT education. However, there are no records to prove the implementation, the monitoring and the evaluation activities accomplished with the adoption of ICT education in Sri Lanka. Further, 85 % of e-government for development projects are reported to have been failures or partial failures. Considering these facts, investigating into the quality, improvement and exploration of research possibilities related to ICT education in the Sri Lankan educational system is felt to be appropriate.

Sri Lanka is a rapidly developing country in Asia. ICT is a major ingredient towards rapid development and needs to be implemented through the schools’ system. Therefore, investigation possibilities towards the improvement of ICT education are considered very important in this era as ICT is essentially related to most human day-to-day activities. Accordingly, this study explores the present status of ICT education in Sri Lankan schools and suggests modalities towards successful implementation of ICT education to face future challenges in the country.

1.2 Backgrounds To General Education

Most developing countries, including Sri Lanka, are constantly struggling with issues related to poor economic performance, poor productivity and ineffective governance. Further, the process of e-governance does and needs to play a vital role in enhancing quality of the life of a nation. ICT is a key ingredient in this process and hence, the need to equip educating the citizen with ICT education. This education needs to be through the general education system and is considered to be of timely importance. It has also been reported that there is an ever widening gap between the urban and rural areas with respect to economic standards in Sri

Lanka. This gap can be eliminated by introducing an ICT culture to the Sri Lankan educational system as an initial driving force.

The quality of ICT education in schools depends on a well-defined and planned curriculum, ICT policies and human resources such as: qualified teachers, teacher trainers, professionals, and infrastructural facilities such as: electricity, communication facilities and computer laboratories. Therefore, to develop ICT education, rapid, planned and sustainable ICT education programs need to be implemented through the general education system to achieve the expected national goals.

In enhancing ICT education in any country, awareness of the internal structure of its schools system is most appropriate. Therefore, investigating the schools' structure of the Sri Lankan educational system is important to this study. Administratively, the Sri Lankan schools system is divided into two categories. They are National Schools, controlled by the Ministry of Education (MOE) and Provincial Schools, controlled by the Provincial Councils. Further, considering streams and the maximum number of grades available in the school, another set of school categories is declared as follows:-

- 1 AB - Schools with Advanced Level Science Stream classes.
- 1 C - Schools with Advanced Level Arts or Commerce stream(s)
- Type 2 - Schools with classes up to grade 11
- Type 3 - Schools with classes up to grade 8

In addition to the above categories, there are new categories also introduced (e.g. schools that conduct the technical stream). Dependent on the above categorizations, disparities may occur in different ways based on control, teacher allocation, teacher training methods, resource allocations, etc.

The following statistics are very useful for this study given that the ultimate goal of the study is to develop a researchable framework for the improvement of ICT education in Sri Lanka. The figures relate to: school types, schools, students and teacher ratio.

Table 1.1 Students, Teachers and Student/ Teacher Ratio (Ministry of Education [MOE], 2011).

Type	Schools	Students	Teachers	Student/Teacher Ratio
1 AB	716	1396304	60247	23
1C	2027	1297300	70383	18
Type 2	4045	904126	67071	13
Type 3	2943	376117	22185	17
Total	9731	3973847	219886	18

Table 1.1 shows the number of schools, students, teachers and student/teacher ratio among the different categories of schools. Even though such categories exist, there is evidence that within a particular category, the quality of education (due to infrastructure and other facilities) differs from district to district, zone to zone etc. within a category.

According to the above facts, there is evidence to show that there are several disparities in the school system. From time to time, the government of Sri Lanka has adopted different policies to remove these inequalities through various methods. One method suggests the use of ICT education and the use of ICT based devices to remove the inequalities in the distribution of education. In fact, ICT has enabled numerous possibilities for interaction between students, schools, teachers and parents over any distance. ICT has become one of the most attractive and effective technologies that could be used to transform education. Eighty six percent (86%) of teachers in Europe state that pupils are more motivated and attentive when computers and the Internet are used in the class.

The government of Sri Lanka implements various projects to improve the quality of education including ICT education (e.g. General Education Project (GEP2), Secondary Education Modernization Project (SEMP), SEMP2 and indirect involvement in Distance Education Modernization Project (DEMP) and the Improving Relevance and Quality of Undergraduate Education (*IRQUE*) project etc.).

As a result of the above, the MOE introduced the following ICT activities to the school system.

- i. Introduction of ICT as a subject to the G.C.E. (O/L) and G.C.E. (A/L) curriculum, and the introduction of ICT education for grades 3 to 9.
- ii. Use of ICT in the classroom to study other subjects, and
- iii. Use of ICT in the management of the education system

This research pertains to the success with ICT education. It is evident that there is no proper methodology used to investigate the success of ICT education in Sri Lanka. Therefore, investigation is immensely important in this study. Further, identifying the existing weaknesses (if any) and determining what methodologies can be used to overcome such situations are a timely and important aspect in the study.

1.3 The Influence of ICT in Everyday Life

Most developed and developing countries use ICT in their day-to day activities. Some of the main areas in which ICT is used are: Education, Banking and Accounting, Transportation, Medicine, Engineering, Security and Defense, Natural Science, Entertainment, Research and Development. Sri Lanka also has been using ICT in the fields mentioned above. Currently, one of the fastest growing fields in consumption, is the use of ICT. The integration of ICT in social practices is a part of the wide-ranging transition processes of constructing new 'normal standards' in everyday life. This technology has enabled dramatic changes in the job market and the way workers communicate with each other. ICT has been identified worldwide as a tool that can be used to improve productivity, efficiency and effectiveness of organizational activities and the daily activities of individuals. Therefore, providing an adequate level of

ICT skills at different levels of education is important for students to progress and contribute towards national development. If our students are empowered with new skills in ICT, we, as a country will be able to face dramatic changes in the job market and improve the processes of work to meet global needs. Hence, it will, in turn, increase the efficiency, productivity and social development of the country for the present and the future.

Mobile phones and computers are adopted by all age groups; analogue equipment has been replaced by digital equipment, and microprocessors are integrated in many categories of consumer goods. The government of Sri Lanka is also moving towards an era of mobile devices with the help of research development activities at National Universities, other research and scientific organizations, and the Information and Communication Technology Agency (ICTA) etc.

Considering the above facts, ICT can be accepted as a powerful tool towards development of the country. Therefore, developing countries, including Sri Lanka should develop ICT applications and ICT education up to some affordable extent. The urban rural gap can be minimized through ICT.

The introduction of an ICT culture into Sri Lanka or any county in the world should be initiated through the general education system. As one of the developing educational activities of any country, it is recommended that the country obtains exposure and experience from developed countries. Therefore, in any attempt to enhance the quality of life, ICT education in schools can play a prominent role.

To maintain competitiveness and face the 21st century, a country should be empowered with an ICT globalized paradigm. For further development and maintenance of sustainability a strengthened ICT should be ensured through the general education platform.

ICT has numerous potentials in schools. These potentials include:(i) Making learning more interesting ,especially hard-to-understand issues (ii) Bridging distances – e.g. using e-mail, phone, video conferencing etc.(iii) Breaking literacy barriers in communication – e.g. using video and radio.(iv)Research and Information sharing (v)Access to information on jobs/internships (vi)Creation of new employment opportunities (via ICTs/with ICTs) (vii) Enhance interaction with peers over long distances (viii) Create entertainment opportunities (games, music, and video) (ix) Provide more realistic information on other lifestyles, people, cultures, etc. (x) Provide educational information (distance learning) (xi) Provide health information.

With the introduction of ICT education to the schools' system, the above mentioned benefits can be obtained and hence national integrity can be enhanced. Therefore, as a solution to national integrity, ICT education should be embedded in the general education system.

To achieve the above goals, a rapid, sustainable, mechanism needs to be embedded in the general education system. Most developed countries have adopted ICT to empower their general education system. The rapid advancement of science and technology has made the

world smaller. With the passage of time, the world citizen in a global village has become a pervasive concept.

To survive within globalization as evident in many parts of the world, the use of advanced technology for Sri Lanka should be accepted.

There is evidence that ICT plays a major role in the rapid advancement of society. The MOE initiated ICT enhancement programs in the Sri Lankan educational system and its limited Human and Physical resources do not fulfill this requirement. From a human development perspective an individual has many facets other than academic excellence. Personality attributes such as: critical and analytical thinking, problem solving, decision making, interpersonal relations and team work, responsibility and human values are essential to ensure effective performance in the work place while a multifaceted quality of life can be improved through education. An international standard says that the above personality attributes can be improved through ICT education. Therefore, ICT education should be initiated through the educational platform to achieve national goals of promoting a sustainable life style based on respect for human values, concern for limited resources, development of human resources for productive work that contribute to the economic development of a country and a liberated modern world view.

1.4 ICT Education in Sri Lankan Schools

In 2004, the General Information Technology (GIT) programme was introduced by the National Institute of Education (NIE) and the MOE for all streams of GCE (A/L)'s as an additional subject in Sri Lanka (MOE, 1999). ICT has been included under the technical subject area for Grades 10 and Grade 11. The first national examination in ICT subjects was held in December 2007. Several teacher training programmes were implemented to support the above programmes. The complete curriculum (Web based materials and other necessary guideline documents) is available and accessible to the students and the teachers (www.nie.lk). Computer resources, network facilities, Internet facilities and other requirements are available to some extent. The GCE (O/L) ICT national level evaluation was carried out on eight occasions up to 2014. The MOE and the NIE implemented several programmes such as the General Education Project (GEP2), Secondary Education Modernization Project (SEMP), and SEMP2 for the development of ICT education.

By 2009, government authorities had implemented three major (03) ICT programmes, i.e. ICT specialized subject for GCE (A/L), One Laptop per Child (OLPC) pilot programmes in selected schools and computer awareness programmes among 100,000 Teachers, island-wide. From 2006 to-date, several teacher training programmes have been implemented. Several programmes have been implemented through the general education system even though there is no proper census mechanism to evaluate the progress and as such there is a need to determine the present status.

Even though the government or foreign funded projects provided such facilities, ICT education in Sri Lanka is still lagging behind when compared to other countries.

In the Sri Lankan educational system a few ICT course modules (ICT for O/L, ICT for A/L, GIT for A/L etc.) are functioning and one of the most successful ICT course modules in Sri Lanka is the ICT specialization for GCE(O/L) (MOE, 2009).

Course objectives of the ICT specialization subject for the GCE (O/L) curriculum

The main objective of this syllabus is to develop the competencies of the students to use ICT tools and to build a basic theoretical base for them to pursue studies with ICT. Course objectives of the ICT specializations subject for GCE (O/L) curriculum are: (i) Impart basic computer literacy and develop a base for further studies in ICT (ii) Develop understanding of the use of different types of ICT applications and the effects of their use (iii) Develop the concepts and principles related to ICT (iv) Improve the skills necessary for the development of ICT based solutions for real world problems (v) Create awareness of the benefits and problems of ICT use.

There are a limited number of students who will be admitted to the ICT course unit due to the limitation of ICT resources in schools. Selection criteria include marks for the year 9 mathematics paper or some evaluation criteria defined by the respective school (National Institute of Education [NIE], 2006). But different schools use different methodologies. As with other subjects, ICT is also taught in three languages (Sinhala, Tamil and English) and technical terms are in English. At the end, students can choose their medium of instruction for the GCE (O/L) examination. In Sri Lankan schools, the module for Grade 10 & 11, ICT subject comprises eight (08) units.

If one compares the content the UNESCO proposed model for computer literacy and ICT specialization subject for GCE (O/L) curriculum, the following factors can be observed.

All the concepts in the UNESCO literacy model are included in the model for ICT (O/L) in Sri Lanka. But the UNESCO ICT literacy model includes social and ethical aspects as the main sections, while in the Sri Lankan curriculum it appears as ICT and Society. Further, the Sri Lanka ICT (O/L) curriculum has the following activities which are not in the UNESCO literacy model: Information systems (especially development life cycle), Programming; Website development and a Group Project.

If one compares the entire UNESCO curriculum model with the ICT for GCE (O/L) in Sri Lanka, Information systems, programming and Website development fall into the ICT specialization category, while the group project in the Sri Lankan curriculum is compatible with the application of ICT in subject areas. But the UNESCO model provides examples of specific application areas, while the Sri Lankan model provides selection flexibility to students. According to the current position in Sri Lanka, the ICT specialization subject for GCE (O/L) is the initial course unit for Sri Lankan students. It includes different levels of skills together at an initial stage.

General Information Technology (GIT) Curriculum

General Information Technology (GIT) was implemented in 2004 (MOE, 2004) and was introduced as a subject to the schools' system in 2004. GIT is taught only in Grade 12 i.e.

First year GCE (A/L) to students following any stream of studies, at two (02) periods per week. Although the medium of instruction is English, where necessary, Sinhala and Tamil are used for the purpose of explanation. The objectives of the GIT are as follows:

Identify relevant computer applications for day-to-day work, interpret events in day-to-day work, use ICT for day-to-day work, and interpret events in the day-to-day world in terms of ICT, evaluate ICT tools, appreciate the role of ICT in development and use ICT tools with due respect to ethical and social norms.

If authorities set the above objectives, the contents of the syllabus are as follows: Unit 1: Explores the computer and its potential to reap timely benefits (11 periods), Unit 2: Uses information and communication efficiently and effectively in day-to-day life (2 periods), Unit 3: Uses Internet efficiently and effectively to access and communicate information (3 periods), Unit 4: Uses computers efficiently and effectively with awareness of operating system (OS) (4 periods), Unit 5: Word processing software to create various types of documents (4 periods), Unit 6: Makes electronic presentations to enhance attractiveness (4 periods), Unit 7: Uses spreadsheet software to solve simple statistical problems and present findings (4 periods), Unit 8: Uses Data Base Management Systems software (DBMS) to manage information (6 periods), Unit 9: Uses selected high level language effectively to solve simple problems (14 periods), Unit 10: Uses ICT effectively and efficiently to be successful in life (6 periods).

After a detailed investigation of the GIT syllabus and its contents, it was evident that most of the contents (e.g. operating systems, database management system, word processing, programming and ethical aspects etc.) are repeated in the GCE (O/L) curriculum. If one student followed an ICT specialization subject for GCE (O/L) course at Grade 10 and Grade 11, he/she will repeat the same contents at Grade 12. This is an important aspect for ICT curriculum designers. At the beginning it allows a percentage (MOE, 2007) of students who followed ICT specialization subject to sit ICT (O/L), while GIT (A/L) is a compulsory unit that will not be considered as a subject for university admission (University Grants Commission [UGC], 2007). Further, according to statistics, (MOE, 2008) a low percentage of students sat the GIT (A/L) examination. Further, the first national examination was conducted in August 2005. After that, in a few subsequent years, the examination was delayed by a few months due to administrative problems. After a critical detailed investigation and comparison (MOE, 2004, MOE, 2006; MOE, 2008), it was clearly evident that the contents of ICT education (ICT (O/L) and GIT for ICT) in Sri Lanka followed the guidelines given by United Nations Educational, Scientific and Cultural Organization [UNESCO] (2002). Furthermore, some curricula, especially ICT specialization subject for GCE (O/L) and General Information Technology (GIT) courses consist of more than one category of UNESCO guidelines. For example in the GCE (ICT) O/L curriculum, Programming and Web designing are under the ICT specialization category, while Generic Software applications and other fundamental applications belong to ICT literacy. But both categories were embedded in one curriculum unit (MOE, 2006; UNESCO, 2006).

ICT for GCE (A/L) Curriculum in Sri Lanka

According to NIE (2009) sources, objectives of ICT for GCE (A/L) are as follows: (i) Establish the foundation for ICT education leading to higher education (ii) Provide students with ICT knowledge that can be applied in other fields (iii) Provide students with ICT knowledge to improve the quality of life in general (iv) Improve the skills required for the development of ICT based solutions for real world problems (v) Provide awareness of the importance of computer networking for communication (vi) Provide awareness of the new trends and future directions of ICT (vii) Enable students to use ICT for innovation and research (viii) Develop appreciation of the role of ICT in a knowledge-based society.

To achieve the above objectives, the titles of the syllabi are given as follows (NIE, 2009): Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society, Explores the evolution of computers so as to be able to describe and compare the performance of a Modern computer, investigates how data are represented in computers and exploits them in arithmetic and logic operations, Use logic gates to design basic digital circuits and devices in computers, uses memory management to improve performance of a computer, uses operating systems to manage the overall functionality of computers, uses Programming languages to program computers to solve problems, explores the use of data communication & computer network Technologies for effective communication of data & voice and resource sharing, designs and develops database systems to manage data efficiently and effectively, develops websites incorporating multi-media technologies, Explores the systems concept and uses Structured System Analysis and Design Methodology (SSADM) in developing information systems, explores applicability of ICT to today's business organizations in the competitive marketplace, explores new trends and future directions of ICT, and designs and implements a simple information system as Project.

According to the guidelines given by UNESCO (2004) for the development of ICT curricula for developing countries, the ICT for GCE (A/L) course in Sri Lanka incorporates features of application of ICT and ICT specialization components. If one compares ICT for GCE (A/L) course module with UNESCO (2004) guidelines, the following disparities are observed.

UNESCO guidelines have provisions to cater to ICT specialization subjects for all disciplines such as: Business, Computer Science, Engineering and plans for other disciplines in Higher education, but the curriculum ICT for GCE (A/L) in Sri Lanka ICT caters only to Computer science, ICT and Engineering environment and Higher education in the above fields (business related ICT modules in the Sri Lankan curriculum).

If students offer ICT as a subject, their university education is restricted to the field of Medicine, Engineering, and Management, Physical sciences, Biological Sciences and other more important courses conducted by national universities of Sri Lanka (UGC, 2009). The quality curricula will help achieve the expected goals (UNESCO, 2002; UNESCO, 2006). This section describes the design strategies, contents of ICT curricula and implementation procedures of other selected countries and Sri Lanka. Some developed countries use pedagogical techniques (UNESCO, 2007) to improve the quality of educational activities.

1.5 Significance Of The Research

In the modern world, a majority of human activities function with the aid of ICT. ICT plays a key role in the social and economic development of a country. Direct and indirect ICT related jobs are booming and the ICT industry is expanding rapidly. ICT is making a significant contribution to the ongoing phenomenon of globalization. In addition, ICT has become a part of human culture. Further, it is argued that ICT education is a human right for those who live in modern society. Therefore, the national education system in any country has the duty to provide opportunities for ICT education. The quality of ICT education should be compatible with international standards. Therefore, as a sustainable future development mechanism of any country, ICT education should be initiated and embedded in the education platform. In addition to this, when one country or government is implementing ICT education through the general education platform, the quality of such program pays a major role. Literature reveals that, the Sri Lankan research community and educationists have not sufficiently addressed means to enhance the quality of ICT education in Sri Lankan Schools. Therefore, this study focuses on the present quality determination and improvement possibilities of the quality of ICT education in Sri Lankan schools.

There are several aspects of ICT such as: Internet, multimedia technology, and wireless communication, electronic and embedded systems that have greatly influenced education technology. However Sri Lanka, due to its current socio-economic situation, shortcomings in co-ordination, lack of connectivity, and disparities in the facilities available in different schools, have all slowed down the pace of incorporating education technology within the learning environment.

Even when the authorities have been provided with facilities, there has been no concrete evaluation, progress monitoring, or a sustainability monitoring plan. This study attempts to provide a clear picture of the present status or competence of ICT education in the Sri Lankan schools system compared to that of selected, developed and developing countries and proposes enhancement possibilities under the empirical research environment for ICT education in the Lankan schools system. This study and its findings will help relevant authorities in the enrichment of ICT education in Sri Lankan schools.

1.6 Research Problem

Although ICT Education started in Sri Lanka, as early as 1982 in a limited number of selected schools, it was not taught in a formal manner until 2004 when the subject General Information Technology (GIT) was introduced into the schools' curriculum. Thereafter, in the year 2007, ICT was integrated into the GCE (O/L) curriculum as an elective subject falling into the Technical Subjects Basket. Subsequently, ICT was introduced to the GCE (A/L) curriculum in 2009.

Throughout this era of evolution, the authorities initiated the provision of several support factors such as equipment, infrastructure, and teacher training to improve the quality status of ICT education. To carry out these initiatives, several foreign funded projects such as (GEP 2, SEMP, SEMP2, One Laptop per Child (OLPC), Education for Knowledge Society Project (EKSP) contributed heavily. Meanwhile, infrastructure and other facilities were provided by

other organizations (national government, provincial government, NGOS, etc.). The curricula were developed by the National Institute of Education whereas the evaluation of achievement came to be the responsibility of the Department of Examinations of Sri Lanka. For the purpose, the Department of Examinations had to conduct a summative evaluation.

Research literature on the topic reveals that there is an overdue problem pertaining to the quality of ICT education in Sri Lanka. This section will present some important information related to this problem. Liyanage (2004) asserts that although Sri Lanka pioneered the introduction of ICT to the schools' system 32 years ago, the quality of ICT education provided in Sri Lanka lags behind other countries that also introduced ICT into their schools' systems in the same time span. Further, De Mel (2005) states that the quality of ICT education in Sri Lanka is relatively low in comparison to other Asian countries.

Another contributory factor was student achievements. The status of ICT education in Sri Lanka and the achievements of students at the examination showed that the initiatives provided by the authorities have not helped raise the quality of ICT education to expected standards (MOE, 2007). Meanwhile, international quality indicators also suggest that Sri Lanka needs more improvement (Dissanayake, 2007), against a background where Student computer literacy rate remains at 1:57 and computer laboratory percentage is 59.5% (Dissanayake, 2007), along with computer awareness of teachers standing at 40.0% (Mapatuna & Premaratna, 2008).

As such, a critical review and appropriate action is required to address the quality issues related to ICT education in Sri Lanka. The problem may be complex to study.

As De Silva (2009) points out that there are no scientific investigations carried out to identify the causes, underpinning drawbacks and make necessary suggestions to increase the quality. Appropriate in-service training and innovative applications are still needed for teaching and teacher education activities to enhance the quality ICT education (Martin, et al., 2007). This requires consideration of local needs and facilities available at national level. Sadly, such studies are somewhat lacking in the existing Sri Lankan context.

The quality of the aforementioned curricula (GIT, ICT specialization subject for GCE (O/L) and GCE (A/L)) and related implementation issues have not yet been evaluated so far through a formal research to determine shortfalls and reasons underpinning exploration in the Sri Lankan context. Therefore, identifying the reasons for the failure to achieve the required quality and the necessity for appropriate measures to achieve international standards using the existing resources effectively by acquiring necessary resources, remain imperative.

This study is an empirical investigation into the quality status of GCE (O/L) ICT curriculum and the status of its implementation issues in Sri Lankan schools. The main objective of the study is to investigate the quality of ICT education in Sri Lankan schools within a researchable framework and provide quality improvement possibilities under a testing environment. The overall direction of the study is to identify the quality factors which affect the quality of ICT education, investigate the present quality status of ICT education in Sri

Lankan schools and propose improvement possibilities under the theoretical platform through a practical tryout in the real school setting.

1.7 Objectives Of The Study

The main objective of the study was to identify the quality status of ICT education in Sri Lankan secondary school education with respect to recommended quality indicators and suggest researchable improvement possibilities, thereby, introducing a quality framework through an experimental prototype approach to face the technological challenges in society in connection with the field of ICT through the general education platform

Specific objectives of the proposed study are:

1. To identify the international standards (related to the factors, indicators and methodologies) being used to maintain the quality of ICT education.
2. To identify the present status of the quality of ICT education in the Sri Lankan schools system using the standards identified in Objective 1.
3. To recognize the gaps and limitations that might affect the quality of ICT education in secondary education in the Sri Lankan schools system using outcomes of Objectives 1 and 2 above
4. To suggest possible researchable enhancements to fill gaps in ICT specialization subject for GCE (O/L) for Sri Lankan schools using outcomes of Objectives 2 and 3 above.
5. To derive a researchable framework with selected dimensions to enhance the quality of ICT specialization subject for the GCE (O/L) curriculum using the outcomes of Objective 1-4 and evaluate the suitability of the researchable framework with a small group.

1.8 Research Methodology

This research process was conducted based on the approaches of both deductive and inductive methodologies because the study incorporates both processes of theory testing and theory building activities. Further, quantitative methodologies were used for the deductive approaches whereas qualitative methodologies were used for inductive approaches. The entire research study process was designed using the three tier architecture philosophy.

Based on empirical philosophy and international benchmarks, the indicators for ICT education were identified and subsequently the status of ICT education in the Sri Lankan schools system based on international indicators was investigated. All the objectives of the study were mapped on to the three-tier architecture. This study was carried out in two phases.

Phase I was focused to capture the requirements for the transformation of the current system to reach international standards by achieving the first four research objectives stated above. The design performed to achieve the objectives was as follows: objective one was achieved from the literature review while objective two was achieved through the literature review and the survey. The third and fourth objectives were designed with the aid of gap analysis, descriptive and inferential statistics techniques and the other associated theoretical aspects of the modern teaching and learning process and through feedback, observation and evaluation

techniques. The sample survey was designed to obtain information from 5 districts, 35 schools, 35 principals, 1295 students and 48 ICT teachers.

In addition to this, the varieties of stakeholders (MOE, NIE, and National Collage of Education (NCOE), National Educational Commission (NEC), Computer Resource Centers (CRC), Universities and ICT industry experts) in ICT education and different methodologies (classroom observation and workshops) were also used in the survey. In terms of data collection instruments: questionnaires, unstructured interview schedules, classroom observation sheets and workshop monitoring sheets were designed and used. To analyze the data, descriptive and inferential statistics were used. The overall percentages, other descriptive statistical summary (median, first quartile, third quartile, confidence interval levels) and, ranges (where applicable) were presented in tables and/or chart forms. Further, as inferential statistics, hypotheses were used. Hypotheses were tested through Kruskal-Wallis, Paired t-testing and corrections coefficient with appropriate confidence intervals. As the main techniques of data presentation and visualization; data reduction, data organization and data interpretation were performed using the CS-Package, MININITAB and SPSS packages since all the features mentioned above are incorporated in the packages. Further, gaps in ICT education in the Sri Lankan Schools' context were investigated using the theory of gap analysis and the expected and required level of indicators in the Sri Lankan context compared to the international indicators for ICT education, were investigated. The outcome of phase I was used to achieve the fifth specific objective of the study (Phase II). Further, objective 5 was achieved applying the theoretical framework as in Kolb's experiential learning circle, Bloom's Taxonomy, Blended learning approach, role model considering the real feedback of stakeholders, analyzing the emotional level of stakeholders using the universal facial expression of emotional model, open source software and evaluation mechanisms when trying out the prototype enhancement framework in the implementation and testing processes of the study. Then the enhanced framework was validated with a suitable platform, and tested along with an expert panel comprising an ICT expert, an ICT instructor and 9 ICT teachers. Based on their suggestions the model was improved. This model was once again implemented and tested with 61 students from three different schools.

1.9 Limitation Of The Study

The enhancement framework approach was created and tested only on one course unit of the ICT specialization subject for the GCE (O/L) curriculum in Sri Lankan schools. The trial implementation and testing process of the enhanced framework approach was carried out with selected teachers from three different schools that belonged to IAB schools' categories from the Western province national and provincial schools.

To try out the enhancement framework approach in schools a limited number of students (61) were selected from the three different schools. The survey was limited to 5 districts, 35 schools, 1295 students, 48 ICT teachers 32 principals and a limited number of other stakeholders. Further, analysis of the universal facial expression of the emotional model was tested manually. In addition, selected researchable dimensions (quality factors) were used to create and test the enhancement framework approach.

1.10 Chapter Outline Of The Study

Achievement of objectives of this study is covered in two phases. Phase 1 covers objectives 1 to 4 and is presented in chapters 2 to chapter 5. Phase II covers the achievement of objective 5 and is presented in Chapter 6 and 7. Chapter 2 provides the theoretical foundation and conceptual framework of the study. This chapter includes: international benchmarks and indicators for ICT school education and theoretical aspects used in the study. Further, this chapter presents how the analyzing techniques, Digital Learning Environment, Role Model, Gap Analysis Theory, Three Tier Architecture, Kolb's Reflective Learning Circle, Bloom's Taxonomy, stakeholders Feedback, Evaluation Techniques and other theoretical aspects are useful to enhance the quality of ICT education in Sri Lankan schools. Chapter 3 consists of a comprehensive literature review of the study including international, Asia region and Sri Lanka ICT educational prospects in relation to the quality factors. Chapter 4 presents information regarding how the study was planned and the action taken to achieve the above mentioned research objectives as the research methodology. Chapter 5 provides the presentation of the entire results up to objective 4. Chapter 6 presents findings and conclusions of the research objectives 1 to 4 discussion, and finally derives a framework for the improvement of ICT education in Sri Lankan schools. Further, this chapter shows how objective 5 of the research study is achieved. This includes designing, testing and evaluation of the enhancement framework according to the 3rd tier of the proposed architecture. Finally, Chapter 7 presents key findings related to the tryout of the proposed enhanced framework approach in the real environment and the final conclusions based on key findings of the study on how to enhance the quality of ICT education in Sri Lankan schools. Further, this chapter discusses recommendations, future development possibilities and limitations of the study.

Chapter 2: Theoretical Foundation

2.1 Introduction

The quality of ICT education in schools depends on a well-defined and planned curriculum, ICT policies, human resources such as qualified teachers, teacher trainers, professionals, and infrastructural facilities such as electricity, communication facilities and computer laboratories etc. (UNESCO, 2007). Therefore, to develop ICT education, rapid, planned and sustainable ICT education programs must be implemented through the general education system to achieve the expected national goals (Gunawardene, 2008).

All of the above activities tie in well with the theoretical foundation. Therefore, this chapter explores the theoretical foundation that can be used to maintain and enhance the quality of ICT education.

2.2 Quality Of Education

There is no general theory to determine the quality of education that has been validated by empirical research (UNESCO, 2005). However, several organizations have used some indicators or features to explain the quality of education. The following section provides some useful information regarding such attributes.

United Nations Children's Fund [UNICEF] (2000) states that quality education includes: (i) Learners who are healthy, well-nourished, ready to participate and learn, and are supported in learning by their families and communities, (ii) Processes through which trained teachers use child-centered teaching approaches in well-managed classrooms, schools and skillful assessment to facilitate learning and reduce disparities, (iii) Outcomes that encompass knowledge, skills and attitudes, and are linked to national goals for education and positive participation in society.

Therefore, UNICEF categorizes the quality indicators as inputs, process, and outputs (UNICEF, 2000) and defines quality education as (International Bureau of Education, United Nations Educational, Scientific and Cultural Organization [IBE UNESCO], 2002): Quality that pertains to the relevance of what is taught and learned - to how well it fits the present and future needs of the particular learners in question, given their particular circumstances and prospects. It also refers to the significant changes in the educational system itself, nature of its inputs (students, teachers, facilities, equipment, and supplies), its objectives, curriculum, educational technologies and its socioeconomic, cultural and political environment.

UNESCO (2002) also highlights the quality of education by inputs, processes and outputs while the Malawi Ministry of Education (Isaacs, 2007) states that there is no agreed definition of the quality of education, but the qualities of education may be related to the same processes: teaching, learning, testing, resource allocating and managing with in-depth investigation. Some possible factors that can affect the quality of education could be (Ministry of Education, Australia [MOE-Australia], 2009): (i) Quality of teachers, (ii) Quality of the classroom setting, (iii) Curriculum (iv) Quality of supervision and monitoring of the teaching learning process (v) Quality of teacher preparation for curriculum implementation (vi) Quality of support from the administration.

Quality of teachers may include their competencies i.e. the integration of knowledge (qualifications), skills (practical experience, and professional experience etc.), and attitudes (perspectives and appreciation of the profession etc.). Classroom setting covers the appropriateness of the working space, atmosphere, including light, ventilation and minimal disturbance.

Education is a field with drastic changes (Chapman & Adams, 2002). The academic qualifications earned before joining teaching is not sufficient for the entire service period. Therefore, regular updates through processes like in-service education, supervision, and monitoring are important (UNESCO, 2007). These processes are important not only to update but also to maintain uniformity across the schools.

According to Chapman and Adams (2002) the precise meaning of quality education is often unexplained. Examined within context, quality education apparently may refer to inputs (numbers of teachers, amount of teacher training, number of textbooks), processes (amount of direct instructional time, extent of active learning), outputs (test scores, graduation rates), and outcomes (performance in subsequent employment). Additionally, quality education may imply simply the attainment of specified targets and objectives. More comprehensive views are also found, and interpretation of quality may be based on an institution's or program's reputation, the extent to which schooling has influenced change in student's knowledge, attitudes, values, and behavior, or a complete theory or ideology of acquisition and application of learning.

According to the research study on factors influencing educational quality and effectiveness of developing countries (Abby, 2008) the following three factors contribute to quality education: (i) the availability of textbooks and supplementary reading materials (ii) teachers' subject knowledge and verbal abilities and (iii) instructional time and the work demands placed on students. Considering the above evidence and exploration, it shows that there are no specific theories to determine the quality of education on the empirical research environment and also it is not stated as to how much the above factors contribute to maintain the quality of education. Further, there is no threshold value for each variable and the quality of education seems subjective and relative (Wagner & Day, 2005). Further, the study justifies that quality education is based on three groups of processors as input, process and output.

Inputs

According to the above discussion the following factors can be considered as inputs to quality education: required Goals (skills standards and expected outcomes), quality of students and teachers, quality of curricula, quality of infrastructural facilities, other related facilities (e.g. computers, networks etc.) and support from administration and funding sources.

Some factors (e.g. health of students, support in learning by their families and communities) are not considered under the input category of the study because these factors are not directly measurable educational activities and are secondary factors involved in the development of quality education in schools. This study is limited to the primary factors.

Process

The following major categories can be considered as stages of the processing task: design and implementation procedures of curricula, training and updating procedure of teachers and education leaders, evaluation procedure of students and teachers, monitoring, supervision and maintenance of educational activities. Further, quality of curricula can be considered as one of the most important factors for ICT education.

Quality of Curricula

Curriculum can be considered as a framework or guideline (Smith, 2000; Mansfield, 2007) to obtain expected skills through the curriculum using theory with practice. To achieve the expected goals of ICT education, the curriculum can be considered as a four way approach as follows (Smith, 2000): (i) Curriculum as a body of knowledge to be transmitted (ii) Curriculum as an attempt to achieve certain end product of students (iii) Curriculum as process (iv) Curriculum as praxis. It is helpful to consider these ways of approaching curriculum theory and practice in the light of Aristotle's influential categorization of knowledge into three disciplines: the theoretical, the productive and the practical that can be represented graphically as shown in Figure 2.1 below :

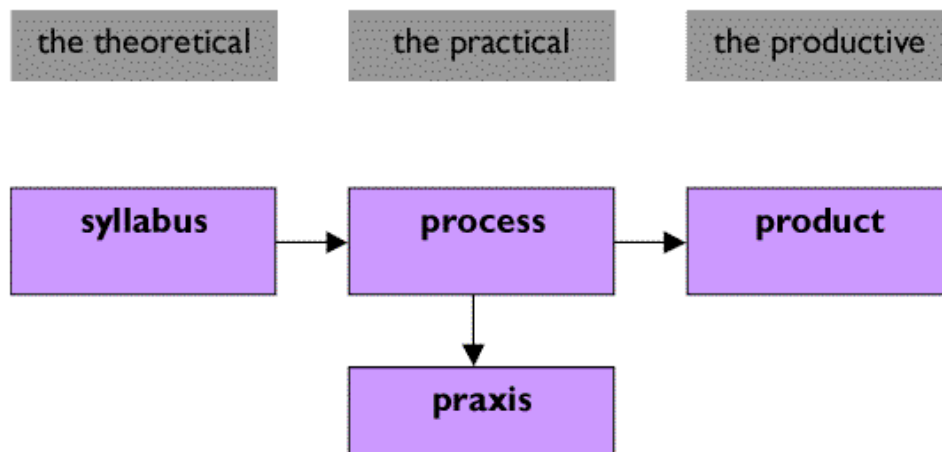


Figure 2.1 Aristotle's influential categorization of knowledge. Source: (Smith, 2000)

Further, the guidelines given by UNESCO (2006) for the development of ICT education in developing countries shows the ICT curriculum development framework as a continuum of approaches to ICT development model containing the following four stages: (i) ICT Literacy (where ICT skills are taught and learned as a separate subject) (ii) Application of ICT in Subject Areas (where ICT skills are developed within separate subjects) (iii) Infusing ICT across the Curriculum (where ICT is integrated or embedded across all subjects of the curriculum) (iv) ICT Specialization (where ICT is taught and learned as an applied subject or to prepare one for a profession).

According to the above, there are several guidelines available in a theoretical framework for the development of the ICT curriculum. Further, based on the quality of curricula, expected goals can be achieved (Mansfield, 2007).

One other major essential component for successful ICT is infrastructure (Abby, 2008). Developed countries like Australia, UK and USA considered computer students ratio as 1:5, computer teacher ratio as 1:1 or 1:2 and usable age period of a computer is 3 years to 3.5 years (Alexandra House, 2009). Furthermore, investigation of the availability of sufficient infrastructural facilities is immensely applicable in this study. Further, the following resources greatly contribute to the development process of ICT education in any country (Abby, 2008) ICT hardware especially Personal Computers (PCs), Software and Connectivity.

Outputs

The output quality depends on the following facts: skills, attitudes, performance (test score, graduation rate etc.), employment, foundation for further studies and subsequent need to be a good citizen. The above section identifies the ultimate and highly related factors that affect quality education. This study is focused on the enhancement of the quality of ICT education and, therefore, it is very appropriate to investigate how these identified factors contribute to the maintenance of the quality of ICT education. Further, when enhancing the quality of education with the use of ICT involvement, ICT becomes a major tool in improving the quality of education (Tinio, 2003; Pásztor & Molnár, 2013). Therefore, it is very important to investigate the advantages of implementing of ICT education through the general education platform.

ICT education is to be implemented through the general education platform (Tinto, 2007). In most of the countries in the world, ICT education is implemented through the general education platform (Abby, 2008). Strengths and weakness of ICT education in any school depends upon the structure of the education system, rural and urban disparities, number of students, number of teachers in a school, the number of class rooms, quality of teachers, distance from school to residence etc. (Alexandra House, 2009). As an initial attempt, the structure of the general education system of Sri Lanka will be investigated.

Quality education supports a rights-based approach to all educational activities (Philips & Nehal, 2005). Education is a human right, every citizen has the right to obtain a quality education, and quality education is based on four pillars - learning to know, learning to do, learning to do together with others and learning to be (Philips & Nehal, 2005). In this view, the learner is considered as an individual, a family member, a community member, and a global citizen and hence a learner should be educated to develop individual competency in all four roles (Philips & Nehal, 2005).

This view also upholds and conveys the idea of a sustainable world, a world that is just, equitable, and peaceable, in which individuals who care for the environment can contribute to intergenerational equality. It takes into consideration the social, economic, and environmental contexts of a particular place and shapes the curriculum or programmes to reflect these unique conditions. Quality education is locally relevant and culturally appropriate.

A quality education is informed by the past (e.g. indigenous and traditional knowledge), is relevant to the present, and prepares the individual for the future. A quality education builds knowledge, life skills, perspectives, attitudes and values.

Education has turned into a large global market with aggressive players in place for countries willing to invest in e-learning, hardware, software and networks (Pedro, 2004). In the modern world, ICT is an essential tool for the development of education. ICT is incorporated in all the disciplines (Alexandra House, 2009). Therefore, there is a need to explore the present contribution of ICT to school education in Sri Lanka. Furthermore, the government of Sri Lanka has accepted that education is a fundamental right (De Mel, 2005). ICT is an essential tool for education in modern society. It is stated that ICT education is a human right of people who live in modern society (Prpad, 1999). Therefore, any citizen should be equipped with education as well as with ICT education to live in the modern society and face global challenges. Further, this study used inferential statistics and descriptive statistics in both phase I and II. Therefore, the theoretical foundation of statistics is greatly useful in this study.

2.3 Statistical Theory Foundation

Sampling

A sample is a subset or subgroup of the population. It comprises some members selected from the population. Only some and not all elements of the population would form the sample. When selecting a sample, the sample should represent the entire population as much as possible (Ken, 2009). Finally, the researcher would draw conclusions about the entire population.

Researchers use sampling for several reasons (Gibbons, 1976), such as: (i) lower cost: the cost of conducting a study based on the sample is much less than the cost of conducting the census study. (ii) greater accuracy of results: It is generally argued that the quality of a study is often better with sampling data than with a census. Research findings also substantiate this opinion. (iii) Greater speed of data collection: Speed of execution of data collection is higher with the sample. It also reduces the time between the recognition of a need for information and the availability of that information (Brandimonte, et al., 2014). According to the above, when selecting a sample, the following sampling techniques were greatly useful in the study. In this study, Multi-Stage sampling techniques were used and the three most applicable sampling techniques for the study are Random Judgment Sampling, Stratified Random Sampling and Cluster Sampling.

Random Judgment sampling

Judgmental sampling is a non-probability sampling technique where the researcher selects units to be sampled based on their knowledge and professional judgment. Further, the researcher relies on his or her own judgment when choosing members of the population to participate in the study (Ken, 2009). Judgment sampling occurs when “elements selected for the sample are chosen by the judgment of the researcher. Researchers often believe that they can obtain a representative sample by using sound judgment” (Eberly College of Science, 2012). Advantages of judgment sampling include low costs and less time needed to select perspective sampling group members compared to many other alternative methods.

Stratified Random sampling

This involves the division of a population into smaller groups known as strata. In stratified random sampling, the strata are formed based on members' shared attributes or characteristics

(Ken, 2009). A random sample from each stratum is taken in a number proportional to the stratum's size when compared to the population. These subsets of the strata are then pooled to form a random sample.

Stratified random sampling is a technique which attempts to restrict the possible samples to those that are "less extreme" by ensuring that all parts of the population are represented in the sample in order to increase the efficiency (that is to decrease the error in the estimation). In stratified sampling the population of N units is first divided into disjoint groups of N_1, N_2, \dots, N_L , units, respectively. These subgroups together comprise the whole population, so that $N_1 + N_2 + \dots + N_L = N$. From each stratum a sample, of pre-specified size, is drawn independently in different strata. Then the collection of these samples constitutes a stratified sample. If a simple random sample selection scheme is used in each stratum then the corresponding sample is called a stratified random sample.

Cluster Sampling

In cluster sampling, instead of selecting all the subjects from the entire population right off, the researcher takes several steps in gathering his /her sample population. First, researcher selects groups or clusters, and then from each cluster, the researcher selects individual subjects by either simple random or systematic random sampling. The researcher can even choose to include the entire cluster and not just a subset from it. The most common cluster used in research is a geographical cluster. The important thing to remember about this sampling technique is to give all the clusters equal chances of being selected.

An outlier is an observation that lies an abnormal distance from other values in a random sample of a population. In a sense, this definition leaves it up to the analyst (or a consensus process) to decide as to what will be considered abnormal. Before abnormal observations can be singled out, it is necessary to characterize normal observations (Gibbons, 1976). There are two graphical techniques for identifying outliers- scatter plots and box plots, along with an analytic procedure for detecting outliers when the distribution is normal.

Group-Administered Survey

A group-administered survey can be defined as a questionnaire that is given to a group of people who are participating in a research experiment with hopes of generating many different types of answers and opinions that have a general focus on the topic that is being measured (Wood, 2003). Group-administered questionnaires are helpful in the sense that they cut back on time it takes to get responses from all of the participants and usually to get all of the responses within that allotted time. A challenge to group-administered surveys is that you would have to work at getting all the participants together. Things to be taken into consideration at that point is where they live, a set time on when everyone can meet, and a place to reserve to help monitor the survey. Group-administered questionnaires are the best type of survey to get consistent responses (Wood, 2003).

Boxplot Graphical Tool for identifying outliers

The box plot is a useful graphical display to describe the behavior of the data in the middle as well as at the ends of the distributions. The box plot uses the median and the lower and upper

quartiles (defined as the 25th and 75th percentiles). If the lower quartile is Q1 and the upper quartile is Q3, then the difference (Q3 - Q1) is called the interquartile range or IQR. The boxplot is based on the interquartile range (IQR). The range of the “box” is the IQR, the line through the box is the median. The whiskers describe the location of the data in the exterior regions. Their end points are given by ± 1.5 IQR beginning at both ends of the box. All values outside the whiskers are labeled as outliers (Magri, 2014). The Figure 2.2 shows the outliers clearly and it can be easily identified and removed.

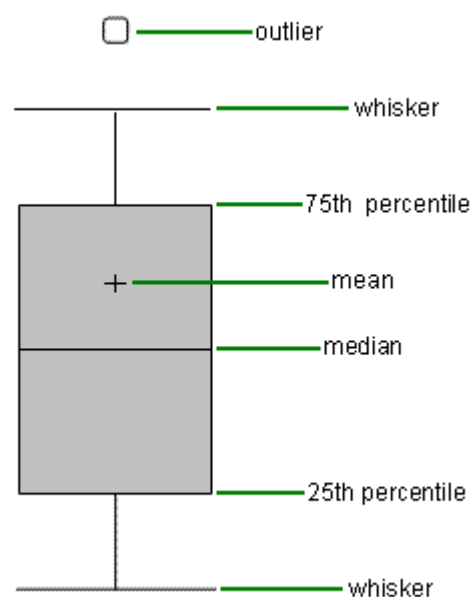


Figure 2.2 outliers determination process (Gibbons, 1976)

This study used several hypothesis tests. Further, some of the data analysis are based on categorical and non-parametric testing. Therefore, the Kruskal Wallis test is an important methodology which can be used in the analysis phases of the study.

Kruskal-Wallis Test

A collection of data samples is independent if they come from unrelated populations and the samples do not affect each other. Then using the Kruskal-Wallis Test, one can decide whether the population distributions are identical without assuming them to follow the normal distribution (Yau, 2013). Further, the Kruskal Wallis test is a popular nonparametric test to compare outcomes among more than two independent groups. The Kruskal Wallis test is used to compare medians among k comparison groups ($k > 2$) (Gibbons, 1976).

The null and research hypotheses of the Kruskal Wallis nonparametric test are stated as follows:

H_0 : The k population medians are equal versus

H_1 : The k population medians are not all equal

The procedure for the test involves pooling the observations from the k samples into one combined sample, keeping track of which sample each observation comes from, and then ranking lowest to highest from 1 to N, where $N = N_1 + N_2 + \dots + N_k$.

Test Statistic for the Kruskal Wallis Test

The test statistic for the Kruskal Wallis test is denoted H (Boston University, 2013) and is defined as follows:

$$H = \left(\frac{12}{N(N+1)} \sum_{j=1}^k \frac{R_j^2}{n_j} \right) - 3(N+1)$$

Where k=the number of comparison groups, N= the total sample size, n_j is the sample size in the j^{th} group and R_j is the sum of the ranks in the j^{th} group.

It should determine whether the observed test statistic H supports the null or research hypothesis. Once again, this is done by establishing a critical value of H. If the observed value of H is greater than or equal to the critical value, we reject H_0 in favor of H_1 ; if the observed value of H is less than the critical value we do not reject H_0 (Gibbons, 1976).

It was revealed that the quality of ICT education depends on several quality factors. Therefore, to find the correlation between such attributes, correlation analysis became an important tool in this study.

Correlation Analysis

Correlation analysis measures the relationship between two items. The resulting value (called the "correlation coefficient") shows that changes in one item will result in changes in the other item (Gibbons, 1976). When the correlation between two items is compared, one item is called the "dependent" item and the other the "independent" item. The goal is to see if a change in the independent item will result in a change in the dependent item. The correlation coefficient can range between ± 1.0 (plus or minus one). A coefficient of +1.0, a "perfect positive correlation," means that changes in the independent item will result in an identical change in the dependent item. A coefficient of -1.0, a "perfect negative correlation," means that changes in the independent item will result in an identical change in the dependent item, but the change will be in the opposite direction. A coefficient of zero means there is no relationship between the two items and that a change in the independent item will have no effect on the dependent item.

The Spearman's rank-order correlation is the nonparametric version. Spearman's correlation coefficient, (ρ , also signified by R_s) measures the strength of association between two ranked variables (Barcelona Field study Centre, 2015). where d is the difference of two variables ranks and square of d removes the negative value and then sums them as the differences ($\sum d^2$).

The correlation coefficient can be calculated using the following formula:

$$(R) = 1 - \frac{6 \sum d^2}{n^3 - n}$$

Where R is the correlation coefficient. The answer will always be between 1.0 (a perfect positive correlation) and -1.0 (a perfect negative correlation).

In the Phase II of the study, different treatment levels are included. Therefore, the Paired T-test becomes a worthwhile tool to test the improvement of the different treatments in the study.

Paired T-Test

A paired t-test is used to compare two population means where you have two samples in which observations in one sample can be paired with observations in the other sample. (E.g. students' diagnostic test results before and after a particular module or course). This is a comparison of two different methods of measurement or two different treatments where the measurement /treatments are applied to the same subjects. Given two paired sets x_i and y_i of n measured values, the paired t-test determines whether they differ from each other in a significant way under the assumptions that the paired differences are independent and identically normally distributed (Gibbons, 1976).

To apply the test, let

$$\hat{X}_i = (X_i - \bar{X})$$

$$\hat{Y}_i = (Y_i - \bar{Y}),$$

Then define t by

$$t = (\bar{X} - \bar{Y}) \sqrt{\frac{n(n-1)}{\sum_{i=1}^n (\hat{X}_i - \hat{Y}_i)^2}}$$

This statistic has $n-1$ freedom. A table of Student's t -distribution confidence intervals or any statistical software package can be used to determine the significance level at which two distributions differ. This will give the p -value for the paired t-test. The null hypothesis is that the mean difference between paired observations is zero. When the mean difference is zero, the means of the two groups must also be equal. Because of the paired design of the data, the null hypothesis of a paired t -test is usually expressed in terms of the mean difference.

2.4 ICT Education Pedagogy

ICT teaching & learning methods and methods of teacher training are highly important to maintain the quality of ICT education. Subject matter and pedagogical training are important concepts in the design of teacher training programmes (Chai, et al., 2013). In most of the ICT teacher training programs in developing countries a robust theoretical framework is lacking (Osmani, 2010). Therefore, pedagogical techniques have to be embedded in ICT training programs to obtain expected outcomes (Lai, 2011). The quality methods of teaching and teacher training to achieve the learning outcomes are essential to maintain international quality standards. One of the internationally accepted quality educational methodologies of teaching and learning is Bloom's taxonomy. Also other pedagogical techniques can be used for the development of quality ICT education.

2.4.1 Bloom's Taxonomy

One of the internationally accepted quality educational methodologies of teaching and learning is Bloom's taxonomy. The following explored the theoretical foundation of the revised Bloom's taxonomy. The following levels of learning and similar useful and appropriate verbs (as shown in Table 2.1) of the revised Bloom's taxonomy can be used when implementing quality teaching and learning processes.

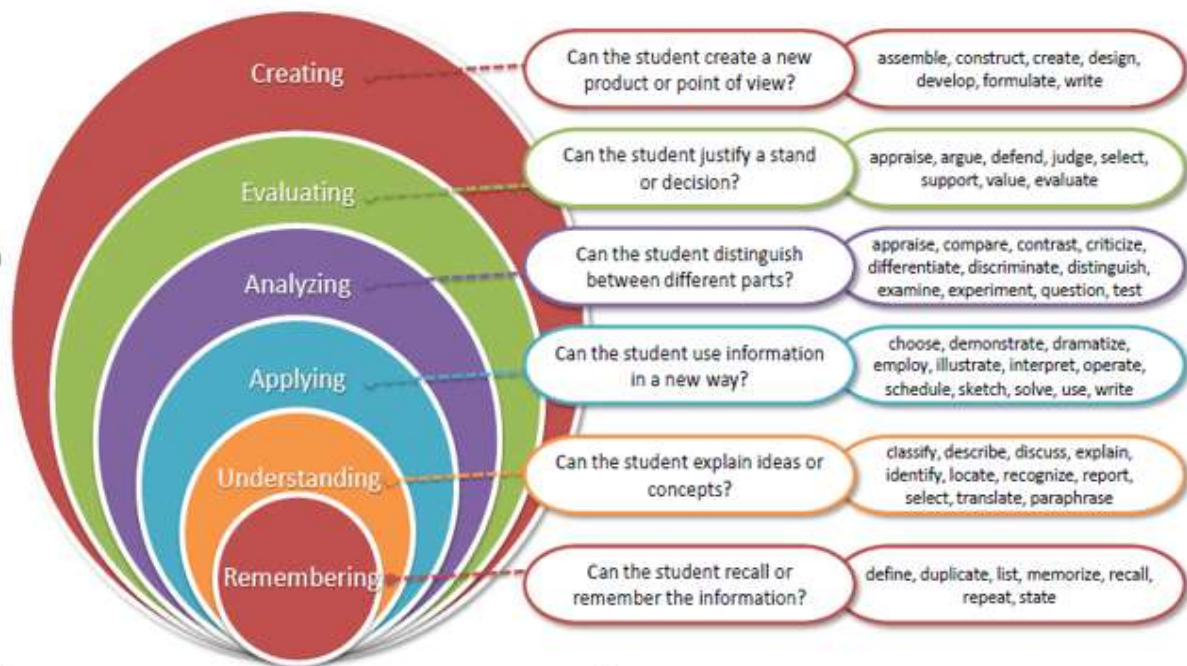


Figure 2. 3: Revised Bloom's Taxonomy (Josh, Jewell, Christina, & Christina, 2014)

Table 2.1 Stages of Bloom's taxonomy and its sample activities (Josh, Jewell, Christina, & Christina, 2014)

Levels of Learning	Useful Verbs
1. Remembering	define, duplicate ,list, memorize, recall, repeat, etc.
2. Understanding	explain, describe, discuss ,recognize, interpret, etc.
3. Applying	apply, demonstrate, illustrate, solve, write, etc.
4. Analyzing	analyze, distinguish, examine, compare, contrast etc.
5. Evaluating	evaluate, argue, defend, Judge, distinguish Arrange, Assemble, etc.
6. Creating	create, design, formulate, develop, construct, develop

The developed countries use pedagogical methodologies (Chai, et al., 2013) like Bloom's taxonomy (Churches, 2009) to enhance the quality of their teaching and learning processes. Further, Phase II of the study was designed and tested to enhance the quality framework for ICT education in Sri Lankan schools in an empirical manner. During the process of designing and testing, Bloom's taxonomy provided a concrete development and testing environment for the study.

2.4.2 The Digital Learning Environment

The Digital learning environment is a successful technique to acquire the required skills in teacher training programs as well as in the teaching and learning paradigm (Sara, et al., 2010; Emily, et al., 2012) in the modern world. In this era, ICT education and general education are equipped with a digital leaning environment (Ololube, Uboru, & Egbezor, 2007; Emily, et al., 2012). An examination of the literature on ICT for education reveals that the quality of one's education tends to improve particularly through continuing existing face-to-face learning and distance education which involves blended learning. (Alice & Kolb, 2005). Blended learning refers to designing and delivering the right content in the right format using the right mix of media (Debande & Ottersten , 2004).Further, blended learning covers face-to-face traditional learning, e-leaning and teaching and learning process through new trends (virtual class room concept, video conference, etc.) In the last three decades, there have been great changes in the education landscape in economically advanced countries. For example, increasing access to education has resulted in the diversification of student populations that have a wide range of learning styles and learning needs which are quite different from the traditional, elitist student populations. At the same time, education institutions are asked to respond to the demands of globalization and the knowledge economy, to prepare students with 21st century skills and competencies for the labor markets, which require changes in the curriculum and teaching practices. There are demands for increased efficiency, more transparent accountability and better performance in both research and teaching. Some policy makers see digital technology as a tool to help manage some of these changes, and in particular, to use it as a transformative tool in teaching and learning (Boitshwarelo, 2009). Further, developed economies use the blended approach while in developing countries its usage is minimal (Abby, 2008). Therefore, by introducing blended learning approaches to the teaching and learning paradigm, quality ICT education can be achieved (Boitshwarelo, 2009). Accordingly, blended leaning techniques (e-books, Learning Management Systems (LMS) activities, e-discussion forum, etc.) are highly useful techniques and Phase II of the study has used such techniques.

2.4.3 Role Model

Most educationists believe that the new visions of learning that have surfaced over the last decade (Miekle & Lindblom , 2007) should lead to important changes in teaching. This means that approaches are needed in teacher education that will help future teachers to translate such new views and theories about learning into actual teaching practices in schools. However, review studies on the impact of teacher education, teachers' beliefs and behavior show that the effects of teacher preparation are often meager. According to the social learning theory (Bandura, 1971), human behavior is transmitted largely through exposure to role models, that is, modeling phenomena. Teachers identified by students as models in an educational context may play a particularly important role in students' learning process (Lashley & Barron, 2006). The teacher educators, as a professional collective, need to work more intently to build on what has been learned about developing stronger models of teacher preparation, including the much stronger relationships with schools that press for mutual transformations of the teaching and learning process. In most teacher training programs, the role model plays a vital role of knowledge transmission as a pedagogical concept in accruing quality education (Chai, et al ., 2013) and hence embedding of such models give more

benefits to the developing countries(Alice & Kolb, 2005). The following Figure 2.4 shows a sample graphical representation of the role model.



Figure 2.4 Role Model in the implementation of education (Chai, et al., 2013)

If Bloom’s taxonomy is embedded in the process of the role model, knowledge transmission from teacher to student, more benefits can be obtained. Therefore, in teacher development programs such techniques should be embedded for greater success. Accordingly, this study was designed and tested with the guidance of the role model in the operation of the enhanced framework of the study.

2.4.4 GAP Analysis

Gap Analysis is a strategic planning tool to help one understand where one is, where one wants to be and how one is going to get there (Charles, 2004; Landrum & Prybutok, 2009). Figure 2.5, below, shows the gap elimination process.

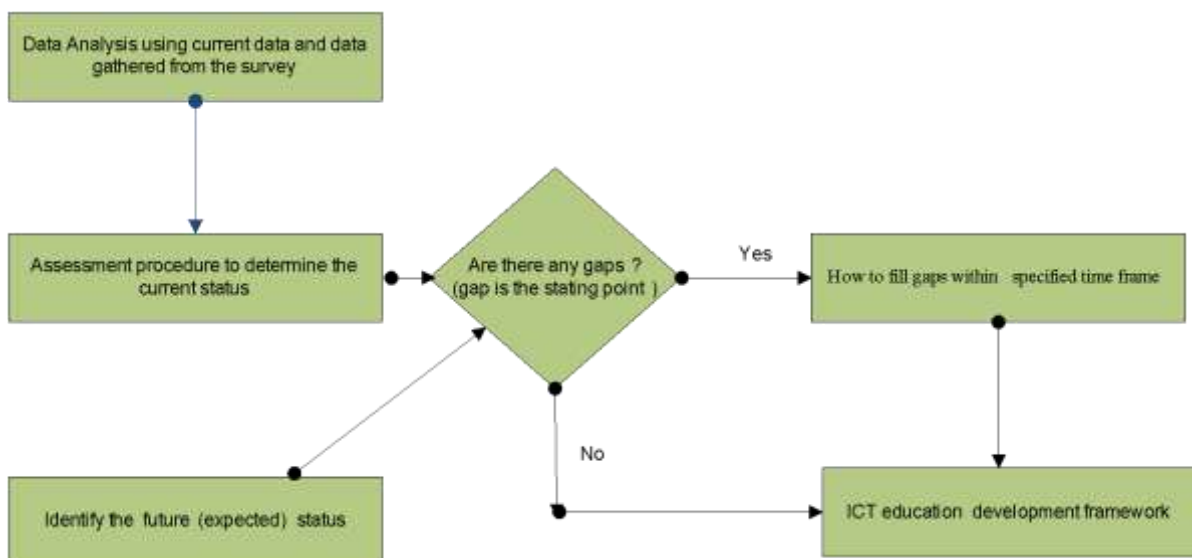


Figure 2.5 Gap Elimination process (Charles, 2004)

The process that involves the identification of gaps between the current state and the future or desired state is the beginning point for the implementation of the school improvement process. When the process of identifying gaps includes a deep analysis of the factors that have created the current state, the groundwork has been laid for improvement of planning. The gap analysis process can be used to ensure that the improvement process does not jump from the identification of problem areas to proposed solutions without understanding the conditions that created the current state. As in developed countries, gap analysis provides guidance to a great extent to achieve learning outcomes and to maintain a sustainable quality environment. Further, the theoretical foundation of the gap analysis was used to determine the present gap of ICT education in Sri Lankan schools with respect to international and regional standards.

2.4.5 Three Tier Architecture

Traditional wisdom says that 3-tier architecture is "good" in reducing the complexity and in modular engineering when designing a system with three stages (Gray, 2000). The applications that use a 3-tier architecture consist of physically separate stages as the first tier, middle-tier and the top tier and an example of such an application systems is shown in Figure 2.6, below.

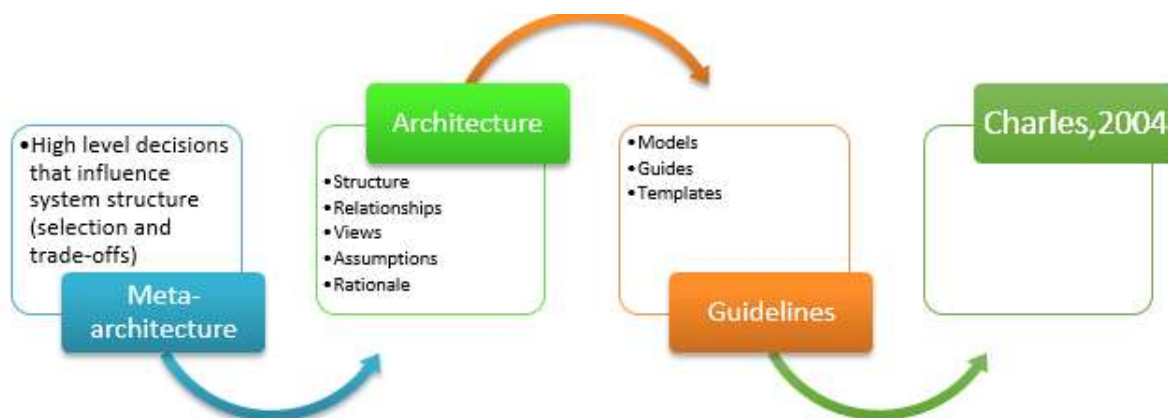


Figure 2.6 Three- Tier architecture for ICT development methodology (International Telecommunication Union, 2015)

As a way of reducing the design complexity and to introduce modular engineering in a variety of areas, the three-tier Architecture is used (Mingxing, et al., 2009) in design activities. The study was designed with the three tier architecture to reduce the complexity, embed the modular engineering techniques and to map all activities in the two phases of the study.

2.4.6 Reflective Practicing

Reflection might be seen as both an approach and a method for improving the quality and the depth of student learning (Chai, et al., 2013; Hinett, 2011). Reflection is a way of thinking about learning and helping individual learners to understand what, how and why they learn. It is about developing the capacity to make judgments and evaluating where learning might take you (Hinett, 2011). Reflective practicing experimental model helps to enhance the quality of

general education as well as ICT education. Further, the experimental model includes the following four major strategies. (i). Taking stock of existing knowledge (What do I know?) (ii) Identifying the gaps in learning (What do I need to know?) (iii) Feedback and evaluation (How does what I now know contribute to what I already knew?) (iv) Evaluation of the integration of new knowledge into existing knowledge (How well and how much do I now understand?). As implementation and evaluation are techniques of quality ICT education, reflection provides a great contribution for its success and sustainability (Vassilios & Nelly, 2012; Syed & Amin, 2012). Developed countries allocate funds for research and development and one of the major enhancement tools used is reflection (Magdeleine & Henk, 2007) which has made a great contribution for their success. If developing countries are provided such facilities for enhancing ICT education through reflective activities, they could also obtain more benefits as it is a low cost solution (Abby, 2008). Therefore, the ICT development model should be embedded with reflective practicing to acquire global expectations. Reflection is greatly important to design the ICT quality framework of the study. This experiential study was designed, tested and implemented in two stages with different stakeholders in an incremental enhancement approach.

Kolb's Experiential Learning Circle

Kolb's experiential learning circle will provide much support in the educational development process in several situations (Hinett, 2011). Figure 2.7 shows the four-stage process of Kolb's experiential learning circle.

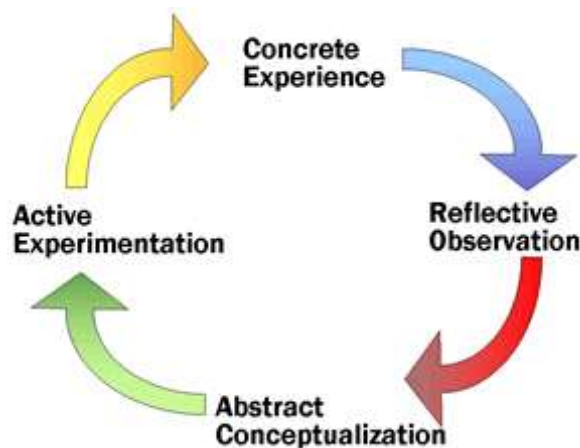


Figure 2.7 Kolb's experiential learning Circle :(Healey & Jenkins, 2000)

Kolb's experiential learning theory (Healey & Jenkins, 2000) is described as follows:

Table 2.2 Kolb's experiential learning Circle (Healey & Jenkins, 2000)

Stage	Description
Concrete Experience (CE) – DO	where the learner is actively experiencing an activity (e.g. a laboratory session, field class)
Reflective Observation (RO) - OBSERVE	where the learner is consciously reflecting back on that experience
Abstract Conceptualization (AC) – THINK	Where the learner is being presented with/or tries to conceptualize a theory or model of what is (to be) observed.
Active Experience (AE) – PLAN	where the learner is trying to plan how to test a model or theory or plan a forthcoming experience

In experiential research, the most widely used learning theory was Kolb's experiential learning cycle due to the implementation feasibility in educational activities. The abstract basic principle of Kolb's reflective process for education development (Svinicki & Dixon, 1987; Kolb, 1984) is shown in Table 2.3.

Table 2.3 Learning theory of Kolb's experiential learning cycle

Stage	Description	Activities to help
Concrete experience	Kolb's cycle starts with a concrete experience. In other words it begins with doing something in which the individual, team or organization is assigned a task. The Key to learning, therefore, is active involvement. In Kolb's model one cannot learn by simply watching or reading about it; to learn effectively the individual, team or organization must actually do	Laboratory experience, reading team games, problem solving, discussion, practical exercises, field work
Effective observation	The second stage in the cycle is that of reflective observation. This means taking time-out from "doing" and stepping back from the task and reviewing what has been done and experienced. At this stage lots of questions come out from "doing" and stepping back from the task and reviewing what has been done and experienced. At this stage lots of questions are asked and communication channels are opened to other members of the team. Vocabulary is very important and is needed to verbalize and discuss with others.	Ask for observation, write a short report on what took place, give feedback to other participants, brainstorming sessions, rhetorical and thought

		questions, completing learning logs or diaries.
Abstract conceptualization	Abstract Conceptualization is the process of making sense of what has happened and involves interpreting the events and understanding the relationships between them. At this stage the learner makes comparisons between what they have done, by reflecting and by what they already know. They may draw upon theory from textbooks for framing and explaining events, models they are familiar with, ideas from colleagues, previous observations, or any other knowledge that they have developed.	Lecture, papers, present models, give theories, give facts, project and analogies
Active experimentation	The final stage of the learning cycle is when the learner considers how they are going to put what they have learnt into practice. Planning enables taking the new understanding and translates it into predictions as to what will happen next or what actions should be taken to refine or revise the way a task is to be handled. For learning to be useful most people need to place it in a context that is relevant to them. If one cannot see how the learning is useful to one's life then it is likely to be forgotten very quickly.	Give learners time to plan, use case studies, use role play, ask learners to use real problems

The Table 2.4 summary table shows the activities that support the different aspects (Healey & Jenkins, 2000) of Kolb's experiential learning circle.

Table 2.4 Different learning aspects of Kolb's experimental learning circle (Kolb, 1984)

Concrete experience	Reflective observation	Abstract conceptualization	Active experimentation
readings examples fieldwork laboratories problem sets trigger films observations simulations/games text reading	logs journals discussion brainstorming thought questions rhetorical questions	Lecture papers projects analogies model building	projects fieldwork homework laboratory case study simulations

Each activity model in the development framework used Bloom's Taxonomy. Further, each activity level in Bloom's taxonomy was tested and implemented with all four levels in Kolb's experiential learning circle of the study. Therefore, Kolb's Experiential Learning Circle made a great contribution to the development process of the enhancement framework of the study.

2.4.7 Evaluation Of Quality In Ict Education

The universal 'Facial Expression of Emotion' model and stakeholders feedback plays a major role in quality evaluation of the teaching and learning paradigm (Manas, et al., 1998) . Developed countries use evaluation of quality through facial behavior of teachers in teacher training programs as well as implementing such programs in their schools. Their success is evaluated through applying the model to their students (Mansfield, 2007; Hinnett, 2011). Although well developed countries and some selected countries use this model to evaluate the performance of the training and teaching activities (Belawati, 2002; Ainley, et al., 2006), there is no indication in the literature review to reveal that this model or this type of application is implemented in the Sri Lankan schools' system (De Mel, 2005) to evaluate the success of the teaching- learning process.

The Universal Facial Expression of Emotion Model

The Universal Facial Expression of Emotion Model and stakeholders' feedback plays a major role in quality evaluation of the teaching and learning paradigm (Manas, et al., 1998). Developed countries use evaluation of quality through facial behavior of teachers in teacher training programs and implement such programs in their schools. Figure 2.8, shows the sample example of seven different stages of the facial expression of emotion model.



Figure 2.8 an example of the seven stages of the universal facial emotional model. (VisualEmotion , 2010)

The Universal Facial Emotional Model might be very useful to determine the quality of the teaching and learning process in ICT education. Researchers, through over 40 years of investigation have identified seven “basic” emotions with corresponding universally displayed and understood facial expressions. Therefore, this methodology is greatly applicable to determine the quality of ICT specialization with teachers' and students' training programs. All the stages of activities corresponding to the Universal Facial Expression of Emotion Model are described as follows:

Happy/Joy

The expression of joy communicates a state of happiness, pleasure, enjoyment and ecstasy. A true expression of happiness involves both the upper part and lower part of the face. Whereas most of us relate happiness with a pull up and back of the lip corners, a critical element to the emotion is also the contraction of the orbicularis oculi, the muscle surrounding the eyes. This true smile, also known as the Duchenne smile, is anatomically distinct and indicates a genuine feeling of happiness.

Sadness/Distress

Expressions of sadness communicates a message related to loss of someone or something valued. Sadness is a very difficult expression to feign because of the inner brow raise, in addition to lip corner depressing that occurs with sadness. Only a small percentage of the population can raise their inner brows on demand but inevitably this raising of the inner brow occurs in everyone who experiences a genuine feeling of sadness.

Anger

Anger can range from annoyance to outright rage. Although there are many different intensities of anger they all carry a similar expression. In anger we often see a lowering of the brows and glaring of the eyes. Tightened lips are also a common factor in angry faces. Anger serves as a warning to others about our current emotional state. Anger also serves as a motivator to work through obstacles and to reach our desired goals.

Fear

The expression of fear is a warning signal and is triggered in situations where there is a threat of danger. Fear is also part of the freeze, fight or flight response system that humans and animals alike have developed as a survival mechanism. When we feel fear, our bodies respond by shutting down unnecessary systems and rushing blood to the larger muscles in our legs in preparation for defense.

Disgust

This powerful emotion evolves from a feeling of aversion towards an object or a person. Sometimes just the thought of something repulsive can bring on the emotion and expression of disgust.

Contempt

A feeling of condescension towards another person, or a feeling of moral superiority is the root of the emotion of contempt. The expression of contempt is unique in that it requires a symmetry. While all the above emotional expressions can be bilateral, contempt is the only emotion that has to occur on only one side of the face.

Surprise

The expression of surprise is the briefest of all the emotions. It occurs in response to an unforeseen event. Surprise will usually be followed immediately by another emotion such as anger if the surprise was unwanted, joy if the surprise is a welcome one or fear if there is danger accompanying the unanticipated event. Surprise can also turn into shock, a more

enduring emotion. The seven stages of universal facial emotional model is a good visual feedback tool which can be used to determine the level of learning in their learning process. In addition to the above mentioned major theoretical aspects, the following theoretical background was used to achieve the research objectives: Quality indicators for ICT education, Moore’s Law, Metcalf’s Law, UNESCO guidelines for ICT education, Singapore MP models for ICT education, Curriculum theory and practice, mode of ICT curriculum development and BOOT Methodology. Further, e-learning material with blended learning approaches and activities based learning concepts used in different models in different countries were used as theoretical guidance to achieve the research objectives.

2.5 Conceptual Framework Of The Research Study

The conceptual framework includes a group of concepts that has been broadly defined and systematically organized to provide a focus, a rationale and a tool for the integration and interpretation of information. Further, the conceptual framework includes the theoretical structure of assumptions, principles and rules that hold together the ideas comprising broad concepts (Jabareen, 2009). Accordingly, the conceptual framework of the study is developed and represented as shown in Figure 2.9.

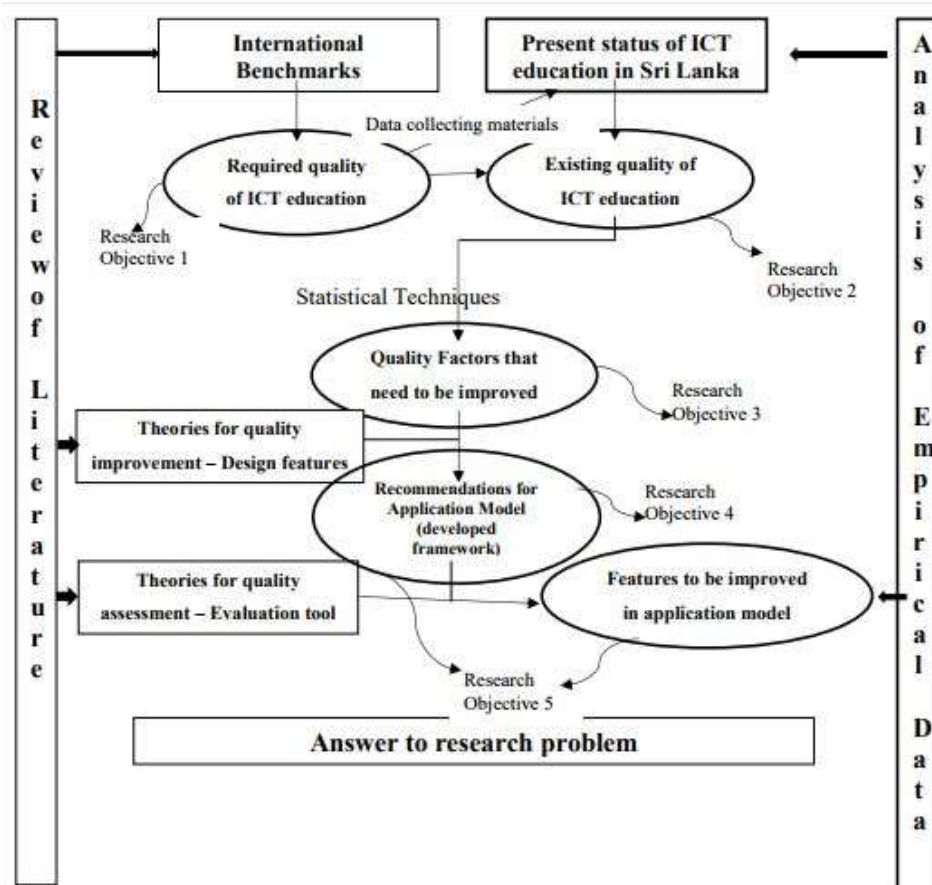


Figure: 2.9 Conceptual Framework of the Study

Figure 2.9, describes the conceptual framework of the study. Based on the concepts built in, the quality factors that affect the quality of ICT education in Sri Lanka are determined using international benchmarks, drawing comparisons, analyzing and agreeing with what needs to be included. International benchmark/quality factors for quality ICT education were identified through an extensive review of literature. Policy documents and recent research were also used for the purpose (Anindya, 2007; Abby, 2008). The framework highlights a brief description about how research objective 1 can be achieved.

Keeping to international benchmarks, the present status of ICT education in Sri Lankan schools is determined based on an investigation. For this purpose, basic facts were gathered through the literature review and, thereafter, a survey was designed to investigate the present status of such indicators in the Sri Lankan context. Data were collected from different stakeholders in the system, inclusive of students, ICT teachers and principals of selected schools taking part in the implementation of ICT as a specialization subject for the GCE (O/L) curriculum in Sri Lankan schools. The outcome collected from the data analysis reveals the status regarding the quality of ICT Education in Sri Lanka. Objective 2 of the research is realized through this attempt.

Proceeding statistical techniques and gap analysis (Charles, 2004) were used to identify more significant factors that could affect the quality of ICT Education. In this regard, a series of hypotheses were tested through statistical techniques such as Kruskal-Wallis Test and correlation coefficient with appropriate confidence intervals. This process filters the significant quality factors i.e. the quality factors that need to be improved (Research Objective 3) from the factors derived in Objective 2.

Taking into consideration the outcome realized from the first three objectives, possible researchable enhancements towards a framework to fill gaps in the ICT specialization subject for GCE (O/L) were also identified. This enhanced framework was considered as the initial recommendations for the Application Model.

In addition, success stories from the Sri Lankan ICT educational system and other guidance from successful models in different countries, along with pedagogical techniques (Chai, et al., 2013) and blended learning approaches (Boitshwarelo, 2009) provided vital data towards improvement of the present system. Collected data provides a comprehensive theoretical foundation, helpful to develop the framework to enhance the quality of ICT education in Sri Lankan schools. Finally, embedded in a theoretical foundation, a suitable application model was developed using the enhanced framework.

The empirical data collected through a pilot run of the application model would be important towards testing and evaluation of the proposed application model (Alice & Kolb, 2005). The methods for assessing suitability would be identified from a literature review (Emily, et al., 2012). This is likely to generate features to be improved in the application model (Objective 5).

As the ultimate outcome of the study, the findings and the recommendation of the application model provide the information for the proposed quality improvement framework (Objective 5) of the study shown in Figure 2.9.

According to the above mentioned conceptual framework, the following operational approach of the study in connection with the achievement of the research objectives were used and are presented in Table 2.5.

Table 2.5 Operational approach of the study

Specific Objective	Research Questions	Methodologies
(1) To identify the international standards (related to the factors, indicators and methodologies) being used to maintain the quality of ICT education).	<p>What are the factors involved in maintaining ICT education of quality level?</p> <p>What are the international indicators specified to maintain quality ICT education?</p> <p>What are the theories that could be used to enhance the quality of ICT education?</p> <p>What are the methodologies used to enhance the quality of ICT education in Sri Lankan schools, some selected Asian countries and developed countries?</p>	<p>From the literature review, nine pillars were identified as quality indicators for ICT education. Further, Moore's Law, Metcalf's Law, UNESCO guidelines provided for ICT development in developing countries, Singapore MP models for ICT education, need of ICT policy framework, Role model, Curriculum theory and practice, Aristotle's influential categorization of knowledge continuum approach mode of ICT curriculum development, Cascade model for professional development, Smart school concept in Malaysia, BOOT Methodology, Pedagogical application (Kolb's experiential learning circle, Bloom's taxonomy, etc.), gap analysis, classroom observation, adoptive learning technologies and feedback were used to determine the quality indicators of ICT education</p>
(2) To identify the present status of the quality of ICT education in the Sri Lankan school system using the standards identified in Objective 1	<p>What is the present status of ICT education in the Sri Lankan schools system with respect to the identified international indicators?</p>	<p>A Survey was conducted to determine the present status of ICT education in Sri Lankan schools from the selected students, teachers and principals. Further, structured interviews were conducted with relevant stakeholders in the system. Theory components and their usages were investigated from the literature review. Surveying methodologies, comparison techniques and data analysis methodologies including inferential</p>

		<p>statistics were used in analyzing the collected data. Finally the present status of ICT education in Sri Lankan schools against the international standard derived from the literature review was determined. Further, using descriptive and inferential statistics techniques the present status of ICT education in connection with nine pillars was presented.</p>
<p>(3) To recognize the gaps and limitations that might affect the quality of ICT education in secondary education in the Sri Lankan schools system using outcomes of Objective 1 and Objective 2 above.</p>	<p>How to identify the factors and indicators which could be improved to maintain the quality of ICT education in Sri Lankan schools system in an internationally acceptable manner to suit the country's requirements?</p>	<p>The gap in the present ICT education system against the achievable level of international standards was determined using the outcomes of the first two objectives of the research study and gap analysis techniques.</p>
<p>(4) To suggest possible enhancements to fill gaps in ICT education in secondary schools in Sri Lanka using outcomes of Objectives 2 and 3 above.</p>	<p>How to fill the gaps existing in the ICT education system in Sri Lanka? What are the identified factors and indicators to be used to maintain the quality of ICT education in Sri Lanka?</p>	<p>By providing a criterion for the development of ICT education in Sri Lankan schools using a suitable discourse with justification according to the findings and outcomes of the three objectives above.</p>
<p>(5) To derive an application model/enhancement framework with selected dimensions to enhance the quality of ICT specialization subject for the GCE</p>	<p>How could a framework be developed to enhance the quality of ICT education in Sri Lankan schools? How can the proposed framework or application model be tested in the real environment? How can the application</p>	<p>An enhancement framework is developed according to the ICT development criteria provided above and the findings of the first four objectives. Bloom's Taxonomy, Kolb's Experiential Learning Circle, Role Model and other Pedagogical Techniques, Adoptive Learning Technologies, Classroom Observation and Feedback</p>

<p>(O/L) curriculum in Sri Lankan schools using the outcomes of Objectives 1-4 and evaluate the suitability of the proposed application model with a small group.</p>	<p>model based on a conceptual framework be fine-tuned with a small group of stakeholders?</p>	<p>were incorporated in the development process of the enhancement framework. Initially, the framework was tested with the help of an ICT expert and an ICT instructor. Secondly the framework approach was implemented with a selected group of ICT teachers, and according to their feedback, the framework approach was enhanced further with guidance given by the above pedagogical and other techniques. The application model was tested with students in selected schools. Then it was enhanced further using real feedback from students and their teachers. Further improvement of the application model was tested through descriptive and inferential statistical techniques.</p>
---	--	---

In this study, all the research objectives were achieved in Phase I and Phase II using the above mentioned theoretical foundation. Further, Table 2.5 shows in a detailed format, the appropriate research questions and the methodologies embedded with theoretical aspects used to achieve the research objectives.

Chapter 3: Literature Review

3.1 Introduction

This chapter describes the introductory investigation of formal education in Sri Lanka and other selected countries. Further, this chapter covers the history of ICT education, facilities provided to enhance ICT education in Sri Lankan schools, and ICT policy status and involvement for ICT education. In addition, it includes teaching methodologies and professional development activities related to ICT education in use to enhance the quality of ICT education in the international community, in selected countries and in Sri Lanka. Moreover, this chapter discusses modeling of ICT development and different alternative methodologies (e.g. blended learning, Bloom's taxonomy, reflective practicing, and role model approach, and universal Facial Expression Emotion model) used for ICT development in other selected countries.

Finally, this chapter explores the following aspects in development requirements for ICT education related to: (i) methodologies implemented to accrue infrastructure facilities; computers and related equipment and software in selected countries and in Sri Lanka (ii) investigating the models and methodologies used in ICT curricula already developed, content and implementation of curriculum procedures according to international guidelines including investigations into ICT curricula in selected countries and Sri Lanka. (iii) international exploration of recommended implementation models for ICT education and ICT implemented Technologies in selected countries and Sri Lanka.(iv) human resource development methodologies for the enhancement of ICT education in selected countries and Sri Lanka (v) policies developed for the enhancement of ICT education in selected countries and Sri Lanka (vi) maintenance, evaluation, research and development and supportive activities and other activities (e.g. administrative barriers) used in selected countries and Sri Lanka (vii) identifying the strengths and weaknesses, improvement possibilities of ICT education in Sri Lanka; exploring gaps in quality ICT education in Sri Lanka against the international standards benchmarks in selected countries, (viii) investigations regarding usage of pedagogical techniques in the Sri Lankan ICT educational system and other selected countries.

At the commencement of the exploration, it is appropriate to discuss important matters related to the quality of education and the quality of ICT education as the ICT education concern in this study is a part of a general education, therefore which contribute to achievements of national goals.

3.2 Introduction To General Education In Sri Lanka

In 1938, the Minister of Education, the late Hon. CWW Kannangara took the initiative to enhance opportunities for free education (De Mel, 2005). Under this initiative, the government established Central Colleges located all over the island and a scholarship scheme to ensure the education of clever children born to deprived families that could not afford an English education in private schools.

Since English is essential with ICT, this type of model is useful with regard to quality education; in 1942 a special committee was appointed to review the education system. The following were listed as recommendations of the committee and among the suggestions that were implemented, the following still play an important role (De Mel, 2005) to: (i) make available to all children a good education free of charge, so that education ceases to be a commodity purchasable only by the urban affluent (ii) make the national language the medium of instruction in place of English so that opportunities for higher education and lucrative employment, then open only to a small number of the urban affluent, would become available to others as well (iii) rationalize the school system so that the provision of education would be adequate, efficient and economical (iv) ensure that every child is provided with instructions in the religion of his/her parents (v) protect teachers from exploitation by managers of schools; and, (vi) make adequate provision for adult education.

Since independence in 1948, the Sri Lankan Government has given the highest priority to education (MOE, 2007). Within a period of less than 40 years the number of schools in Sri Lanka increased by over 50%, the number of students increased by more than 300%, and the number of teachers increased by more than 400%. The literacy rate has grown correspondingly and by the mid-1980s, over 90% of the population was literate (the Highest in South Asia).

Overview of the General Education System of Sri Lanka

Pre-School Education, Primary Education, and Secondary school education

In Sri Lanka, Pre-school education is not compulsory (De Mel, 2005). Different institutes have their own or group syllabuses. Typically, a Pre-school class would contain children of 2 ½ to 5 years of age. Primary education lasts from five to six years (Grades 1-5). A considerable number of primary schools are small schools in which the student population is less than 100 (MOE, 2006). These schools typically have no electricity and have limited facilities including teachers. After primary education, the junior secondary level (referred to as the middle school in some institutions) lasts 4 years (Grades 6-9), followed by 2 years (Grades 10-11) at the senior secondary level, which is the preparatory period for the General Certificate of Education, (G.C.E) Ordinary Level (O/Ls) (De Mel, 2005). According to Sri Lankan law, it is compulsory that all children go to school till grade 11, (age 16) at which point they can choose to continue their education leading to university education through GCE (A/L) (UGC, 1987). However, the Ministry of Education strongly advises all students to continue with their studies at least till the G.C.E Advanced Level (MOE, 2009). Further, one outcome of GCE A/Ls is categorized as the university entrance exam and University education is also free in Sri Lanka (UGC, 1984).

The above facts clearly show that the government of Sri Lanka provides free education for all up to GCE (A/L) and university education, to those who are qualified for university education (MOE, 2011). The quality of ICT education depends on the quality of the general education system (Werner & Korte, 2006). The quality of education affects the educational structure, curricula, teachers, number of students, number of classrooms and school categorizations and other infrastructural facilities (Khalid, 2009). When one discusses the quality of education, it

is necessary to investigate the standard and benchmarks for quality education. Hence standards and benchmarks should be investigated in comparison with the successful countries. But this cannot be compared with developed countries like USA; UK etc. because Sri Lanka is not economically strong and as such implementation would create practical difficulties (Gunawardene, 2008). Therefore, determining the status level of ICT education is more meaningful if one compares it with countries of the same region. Therefore, the comparison of this study is limited to selected countries in Asia. (Liyanage, 2004).

ICT education was introduced in Sri Lanka in 1982. India is a country among South Asian countries where ICT education is advanced (Philips & Nehal, 2005). India introduced several methodologies for the rapid development of ICT education (Information Communication Technology for Development [ICTD], 2007). Therefore, it is intended to study the structure and process of the formal education system in India since this is greatly important in this study.

3.3 Overview Of Education In Selected Countries

The literature review explores the education background in selected countries. The selected countries in this study are India, Thailand, Malaysia and Singapore.

Overview of Education in India

The Indian education system consists of several phases including Pre-school, primary and secondary education.

Primary (Elementary) School Education

Primary education is of 5 years in duration; Grades 1-5. During the 8th five-year plan, the target of "universalizing" elementary education was divided into three broad parameters: Universal Access, Universal Retention and Universal Achievement (Ministry of Education, India [MOE-India], 2007). As a result of these education programs, by the end of 2000, 94% of India's rural population had primary schools within one km of one's residence and 84% had upper primary schools within 3 km. Enrollment in primary and upper-primary schools has increased considerably since the first five-year plan (Philips & Nehal, 2005). As such, the Indian education system has an adequate number of primary and upper-primary schools. In 1950-51, only 3.1 million students had enrolled for primary education. In 1997-98, this figure was 39.5 million. The number of primary and upper-primary schools was 0.223 million in 1950-51 and 0.775 million in 1996-97 (MOE-India, 2007). In 2006-7, an estimated 93% of children in the age group of 6-14 were enrolled in school. The Government of India aims to increase this to 100% by the end of the decade (MOE-India, 2009).

Secondary (lower Secondary & Higher Secondary) School Education

Secondary education serves as a bridge between primary (elementary) and higher education and prepares young people between the age group of 14-18 for entry into higher education. However, enrolment figures show that only 27 million children were attending secondary schools, which means that two thirds of the eligible population remains out of the secondary school system (Philips & Nehal, 2005). As such a large number of students were out of the secondary school and the MOE of India implemented ICT education through the general

education system (Arivanandan, 2007) because India wanted to introduce and improve the quality of general education through ICT education.

India shows a structure generally similar to that of Sri Lanka. But some strategies are different. To comment on this it is worth studying other variations as well. When the quality of education is critically analyzed, it is very important to observe the educational structures and behaviors of different countries.

Overview of Education in Thailand

In Thailand, the new educational system that implements lifelong learning comprises formal education, non-formal education, and informal education (Minsistry of Education, Thiland [MOE-Thailand], 2011). Formal education includes basic education and higher education (MOE-Thailand, 2007).

According to the facts above, India, Thailand and Sri Lanka have fairly similar general educational systems. To compare them, one needs different structures, implementation details and information regarding successes/ failures. The educational structure of some countries like Malaysia and Singapore SLT is different from those of Sri Lanka, India and Thailand. When compared with these three countries, the Malaysian education system follows a different direction. The secondary education system in Malaysia consists of different directions such as academic schools, technical & vocational and religious schools. Therefore, to obtain different observations from different angles, the Malaysian educational structure can be considered.

Overview of Education in Malaysia

In Malaysia, pre-primary education is not compulsory (Ministry of Education, Malaysia [MOE-Malaysia], 2007). The course of study at the primary level is planned for the duration of six years, but may be completed in five to seven years. (MOE-Malaysia, 2007). Secondary education consists of lower secondary education and upper secondary education. The Secondary education system consists of: (i) academic schools (ii) technical and vocational schools and (iii) religious national schools (MOE-Malaysia, 2007). To get a clear idea, it is necessary to study the same pattern further. Singapore shows patterns similar to those of Malaysia (MOE-Malaysia, 2007). Therefore, the general education system in Singapore can be considered for further overview.

Overview of Education in Singapore

Primary Education consists of a 4-year foundation stage from Primary 1 to 4 and a 2-year orientation stage from Primary 5 to 6. The overall aim of primary education is to give students a good grasp of English language, Mother Tongue and Mathematics (Ministry of Education, Singapore [MOE-Singapore], 2005). Secondary Education places students in the Special, Express, Normal (Academic) or Normal (Technical) course according to how they perform at the Primary School Leaving Examination (PSLE). Different curricular emphases are designed to match their learning abilities and interests through 4-5 years of education (MOE-Singapore, 2005). Pre-University Education prepares students for the GCE "A" Level examination at the end of the 2-year junior college or a 3-year centralized institutional course.

Students who complete their pre-university education will receive a School Graduation Certificate after 2-3 years of education (MOE-Singapore, 2005).

In most of the countries, ICT education in the general education system was developed making it possible for general education to be enhanced by ICT education. Therefore, when one discusses ICT education, knowledge of general education is essential for a successful study. In summary, the following facts are listed, because they give quality indicators for ICT education.

At the end of year 2000, 94% of India's rural population had primary schools within one km and 84% had upper primary schools within 3 km of residence. The above factor is very important due to the following reasons: students' prior preparation will affect quality education. Prior preparation at home (leisure time when they can freely think and increase their thinking ability) is essential for quality education. Extensive traveling may indirectly affect the quality of education.

Malaysian and Singaporean general education systems follow several directions within the general education system; they are technical, vocational and religious schools. But in the Sri Lankan education system, vocational and religious ministries are different entities and their activities are independent. Malaysian and Singaporean education systems direct students to different disciplines within the educational system. They encourage students to other technical and vocational areas. But the Sri Lankan educational system encourages students towards higher education even though adequate facilities remain absent. For example, approximately 250,000 students sat the GCE (A/L) examination (UGC, 2007), but only 19550 vacancies were available in the national university system. The future of the remaining 230450 students' was uncertain (UGC, 2007). Furthermore, 9% students, who sat the GCE (A/L), enter national universities and the remaining 91% face difficulties (MOE, 2007).

India and Thailand shows a similar educational foundation for general education. But Malaysian and Singaporean general education systems provide different pathways from the general education system. Sri Lanka, India and Thailand do not provide such other directions (e.g. Vocational, religious). Therefore, through ICT education, there is the possibility to redirect pure academic interests in other directions (e.g. Vocational).

3.4 Importance Of Implementing Ict Education Through The General Education Platform

The digital divide is one of the major issues of the development process of any country and it contains disparities within the nations (Wattegama & Wickramasinghe, 2003), and between the developing and the developed countries in the world. A hub of ICT Infrastructure and ICT solutions enhance elimination of the digital divide, sustainable socioeconomic development and accelerated poverty reduction, both nationally and globally (Transport, 2003).

With the advancement of technology in the world, ICT is experiencing a rapid pace of development in the modern world (ICTD & Education, 2007-2008), ICT is an essential tool for the development of education (Panitchpakdi, 2006). ICT is incorporated in all the

disciplines (Unwin, 2004). Throughout the world ICT is changing the face of education (Organization of Eastern Caribbean States [OECS], 2001). The “knowledge economy” has emphasized the production, distribution and use of new knowledge as contributors to economic growth and a product of economic activity (Organization for Economic Co-operation and Development [OECD], 1996). The emergence of an “information society” has been evident in the development and widespread implementation of ICT (Shahin & Finger, 2000).

The advent of ICT has changed the environment in which students develop skills for life, the basis of many occupational requirements and the way a number of social transactions take place (Prensky, 2004). Proficiency in ICT has become important for life in modern society and the assessment of ICT literacy has become an important component of monitoring the extent to which students develop “skills and knowledge for tomorrow’s world” (OECD, 2004).

More generally, every citizen in this and the next generation will need to have a high ‘comfort level’ with technology to live and contribute to a society that is increasingly part of an independent “wired world”). Hence ICT is changing the objectives of education (OECD, 1996). As a long-term vision plan, ICT has been able to create sustained, productivity-driven growth, technological literate and a critically thinking workforce to society (Belawati, 2002). On the other hand, there are constraints to delivering education to the right people at the right time (Mungamuru, et al., 2012). In developing countries, there is frequently a shortage of qualified school teachers. People may live in scattered communities in rural areas (Cairncross, 2006). Money for books and teaching materials may be scarce. All these factors have encouraged an interest in the use of ICT to deliver education and training (Belawati, 2002). Initially, educators saw the use of ICT in the classroom mainly as a way to teach computer literacy. Most now see a broader role: that of delivering many kinds of learning at a lower cost and of a higher quality than traditional methods of teaching allow (Cairncross, 2006). In addition, schools and universities increasingly use ICT (Prpad, 1999), as do other large organizations, to reduce the costs and improve the efficiency of the administration (Sitenen, 2007). The introduction of ICT usage and its integration and diffusion have initiated a new age in educational methodologies and have radically changed traditional methods of the teaching and learning patterns in the domain, as well as offering contemporary learning experiences to both teachers and students (Ololube, 2006). Further, education is a very socially oriented activity and quality education has traditionally been associated with strong teachers having high degrees of personal contact with learners (Oliver, 2002).

The use of ICT in education lends itself to more student-centered learning settings and often this creates some tensions for some teachers and students. But with the world moving rapidly into digital media and information (Oliver, 2002), the role of ICT in education is becoming more and more important and this importance will continue to grow and develop in the 21st century. ICT gives new development reinforcing ability to the general educational system (Alexandra House, 2009).

According to the above facts, to face the 21st Century, students should be equipped with new technologies, especially in ICT. Therefore, at the initial stage ICT should be implemented through the general education platform and hence the following gains can be achieved (Alexandra House, 2009):

(i)To minimize the digital divide (ii)To accelerate the poverty reduction process, both nationally and globally (iii)To introduce a knowledge society (iv)To obtain independence of the wired-world (v)To developed students' skills through a student centered approach (vi)To compatibly live in modern society and face future challenges locally and globally.

It implies that ICT education should be implemented through the general education platform to eliminate the digital divide and to face the national and global challenges in education, as well as in society. Further, by introducing ICT education through the general education system, students will be able to face challenges in society as well as in the modern world (Banerjee, 2008). For any country or nation introducing ICT education through general education, it is essential to maintain quality standards of an acceptable manner to obtain the benefits specified above (Becta, 2002).Therefore, exploration of how to introduce and implement quality ICT education in schools is mostly appropriate in any country.

Quality ICT Education

The quality of education depends on three major attributes as: input, process and output. Further, UNESCO (2005) has stated that the quality standards for education are applicable and can be used to measure the quality of any subject in the general education platform through these three factors. Hence, the literature review demonstrates how to obtain quality standards in ICT education through the application of the standards drive for quality education in the above section. This section elaborates how these three attributes contribute to the maintenance of ICT education at quality level in the secondary school education system.

Inputs to quality ICT Education

As discussed, quality education is based on the following major factors (UNESCO, 2005): (i) Required Goals (skills standards and expected outcomes) (ii) Quality of students and teachers (iii) Quality of curricula (iv) Quality of infrastructural facilities and (v) Support from the administration and funding sources. ICT education is also a subset of education (Aqsha & Awang, 2011). Hence the quality of ICT education will directly relate to the quality of education in schools (Adam, & Estes, 2011).Therefore, quality standards for education are directly related to the quality of ICT education (UNESCO, 2005).This chapter further investigates how these standards of education are applicable to quality ICT education.

Required Goals (skills standards and expected outcomes)

The following skills are identified as expected levels of goals for ICT education in primary and secondary ICT education in the 21st century (UNESCO, 2002;Isaacs, 2007; Novento, 2007):

(i)Digital-Age literacies (ii) Inventive thinking (iii) Effective communication and interpersonal skills (iv) High productivity. It is shown that developed countries maintain

these standards at an acceptable level, while other countries are working on them to achieve these goals through a long term framework by giving high priority to meeting emergency based needs for ICT education (Arvind, 2007). The education department of Australia (MOE-Australia, 2009; Novento, 2007) stated that, their vision for ICT education contents to be achieved are : the teaching and learning practices to be supported through ICT, the administrative practices to be supported through ICT, the ways that ICT supports the use of learning spaces throughout the school and areas of change in the school in which ICT will have an important enabling role.

The following 10 strategic elements are identified as the ICT education planning framework to achieve the expected levels of skills (MOE-Australia, 2009). The elements include:(i) personalizing and extending student learning (ii) enabling leadership (iii) supporting professional learning (iv) connecting learning beyond the school (v) improving student assessment and reporting (vi) developing measuring and monitoring student ICT capabilities (vii) accessing and utilizing student information (viii) providing, accessing and managing teaching and learning processes (ix) automating business processes (x) providing reliable infrastructure.

ICT education enables leadership, team work, critical thinking and more capabilities than other subjects in the school curriculum (Gulati, 2008; McMahan, 2009). ICT also facilitates the learning process as an education enhancement tool (Abby, 2008). The education department of Australia (Novento, 2007; MOE-Australia, 2009) also stated that the 10 strategic elements stated above are highly appropriate to any country. According to the above exploration, the following skills are expected to be developed through ICT education in schools: digital age literacy, creative thinking, team work, effective communication, high productivity, teaching and learning capabilities including personalized and extended capabilities in the school and beyond the school, administrative activities in the school, as well as in the job environment.

To achieve the expected skills, standards and expected outcomes, the quality of teachers and students are highly contributive (Abby, 2008). Therefore, investigating the quality of teachers and students is appropriate for this study.

Quality of Students and Teachers

According to UNESCO (2005) teacher education and planning helps to effectively harness the power of the new Information and Communication Technologies (ICTs). In order to maintain the quality and improve learning, the following essential requirements must be met (Khvilan, 2002): (i) Students and teachers must have sufficient access to digital technologies and the Internet in their classrooms, schools, and teacher education institutions (IBE-UNESCO, 2002) (ii) High quality, meaningful, and culturally responsive digital content must be available for teachers and learners (Chapman & Adams, 2002) (iii) Teachers must have the knowledge and skills to use new digital tools and resources to help all students achieve high academic standards (Mulford, 2006) (iv) Teachers need training not only in computers, but also in the pedagogical application of those skills to improve teaching and learning (Abby, 2008) (v) Proper pre-service training for teachers as well as contiguous in-service

training to fulfill the teaching learning requirements (UNESCO,2005) (vi) Students have positive attitudes towards ICT, and are willing to use ICT to support their own learning process(Vanderlinde, et al., 2010) (vii)Teachers' subject knowledge and verbal abilities (Abby, 2008).

It was shown that, to maintain quality ICT education and to create an ICT culture among the students, teachers should have greater access to digital contents; therefore, Internet usage in classroom and teacher training institutes has to be increased. Further, ICT school communities need to be motivated to adopt student centered environments with new advanced technology as their knowledge and skills are not limited to the classroom or any teacher training institute.

ICT is a newly introduced subject in the secondary schools curriculum (Alexandra House, 2009). Hence students and teachers should have positive attitudes to integrate ICT into the teaching and learning environment and teachers should also have pedagogical skills in ICT through pre and in- service education (Smith, 2000). Further, it is shown that a quality curriculum will contribute to the development of ICT education goals; therefore, the quality of teachers and students will be enhanced further. This literature review is highly related to the quality of ICT education and is more appropriate that one discusses the quality of ICT curricula.

Quality of Curricula

The Curriculum can be considered as a framework or guideline (Smith, 2000; Mansfield, 2007) to obtain expected skills through the curriculum using theory along with practice. To achieve the expected goals of ICT education, the curriculum can be considered as a four way approach as follows (Simith, 2000): (i) Curriculum as a body of knowledge to be transmitted (ii) Curriculum as an attempt to achieve certain end products of students (iii)Curriculum as a process (iv) Curriculum as praxis. It is helpful to consider these ways of approaching curriculum theory and practice in the light of Aristotle's influential categorization of knowledge into three disciplines: the theoretical, the productive and the practical that can be represented graphically shown as in Figure 2.1 in Chapter 2

The guidelines given by UNESCO (2006) for the development of ICT education in developing countries shows the ICT curriculum development framework as a continuum of approaches to ICT development model containing the following four stages:(i) ICT Literacy (where ICT skills are taught and learned as a separate subject) (ii) Application of ICT in Subject Areas (where ICT skills are developed within separate subjects) (iii) Infusing ICT across the Curriculum (where ICT is integrated or embedded across all subjects of the curriculum) (iv) ICT Specialization (where ICT is taught and learned as an applied subject or to prepare one for a profession).

According to the above, there are several guidelines available in a theoretical framework for the development of the ICT curriculum. Further, based on the quality of curricula, expected goals can be achieved (Mansfied, 2007).

One other major essential component for successful ICT is infrastructure (Abby, 2008). Developed countries like Australia, UK and USA have considered computer students ratio as 1:5, computer teacher ratio as 1:1 or 1:2 and the age of the computer is 3 years to 3.5 years (Alexandra House, 2009). Furthermore, investigation into the availability of adequate infrastructural facilities is immensely applicable in this study. Further, the following resources contribute greatly to the development process of ICT education in any country (Abby, 2008) : ICT hardware especially Personal Computers (PCs), Software and Connectivity.

UNESCO has recommended that the infrastructure needed for ICT education as: (UNESCO, 2006): Electricity or alternative power requirements, Computers, Related accessories and Equipment, Internet and Connectivity, Classrooms and laboratories, Software and Netware. Further, infrastructure is one of the main quality factors of ICT education (Carizo, 2011). In this regard, the ongoing drive changes in hardware is continually demonstrated in Moore's law (Bee & Chia, 2008), which imagines the doubling of computing processing power in an eighteen month time horizon. This law is helpful when implementing ICT education in connection with sustainability mechanisms (Katz, 2002). Further, there is the high availability of Free and Open Source Software (FOSS) for ICT school education (Walke, 2009) and it is most appropriate for developing countries (Shaheen, & Kavita, 2008), as well as developed countries in order to face financial constraints in education, as well as the enhancement of student development (Liyanage, 2004). Connectivity and Internet is another important activity in ICT education (UNESCO, 2006). Two major network phenomena are likely to shape the practices and the future of education. First, Metcalf's law, which imagines a doubling of available bandwidth at constant prices every eighteen months (or less) (Katz, 2002), suggests that network-based information and services will be available anywhere, anytime in the near future. Second, wireless networking will lower both the cost and the complexity of managing "last mile" connectivity on schools and campuses (Katz, 2002). More important, wireless and other low-cost forms of networking will make it possible for people to stay seamlessly and continuously connected to in-situational (and other) networks. According to the above discussion, the following are highlighted as essential infrastructure requirements for ICT education: (i) Computers and other physical devices with optimal processing power, (ii) Software, (iii) Electricity or alternative power requirements, (iv) Internet Connectivity and network with suitable bandwidth (v) Classrooms and Laboratories. For example, In Sri Lanka 76% of schools has electricity, and 26.2% have land phones. Internet and E-mail facilities are available in a very small proportion of schools; and the rates are at 6.4% and 4.1% respectively (MOE, 2006). In 2006, the student computer ratio was 138:1. Most developing countries face the lack of resource issues in the implementation of ICT education (Katz, 2002). Further, in developing countries, the major issues of ICT education are infrastructure facilities (electricity and connectivity), computers, and software (Wattegama & Wickramasinghe, 2003). The developing countries still do not have minimum requirements for ICT education (Liyanage, 2004). Considering the above facts, a developing country like Sri Lanka initially acquires the minimum requirement for ICT education, while application of Metcalf's law, Moore's law and wireless network concepts are mostly applicable to schools if minimum requirements are fulfilled.

Therefore, these facts are important after acquiring the basic requirements in schools and in subsequent stages these factors can be taken into account to compete with other developed countries (Wattegama & Wickramasinghe, 2003). The Findings of the survey reveals that there aren't adequate facilities for ICT education in Sri Lanka (MOE, 2006). In subsequent years up to now, several foreign funded projects and other organization (government and local governments) have implemented several programs for the development of ICT education in Sri Lanka (Dissanayake, 2007). No evidence is recorded on the investigation of the present status of ICT education in this regard.

ICT education goals, quality of teachers and students and infrastructural facilities do not fulfill the complete development process of ICT education in schools (Dissanayake, 2007). Still, one of the most important and essential aspects, especially in developing countries, is the lack of support from the administrative staff (Mulford, 2003) and limitations of funding facilities (Liyanage, 2004). Therefore, investigation into the facts is required for the implementation of ICT education in schools because most ICT educational projects have failed (Afshari, et al., 2010) due to the lack of support from the administrative staff and funding issues.

Support from the Administration and Funding Sources

Leadership is one of the major attributes related to quality ICT education (Afshari, et al., 2010). Principals, parents, universities and other research institutes, academics, ministry and zonal educational authorities are the leaders in education as well as in ICT education (UNESCO, 2006). School leaders, particularly the principal, have a major responsibility for initiating and implementing school change through the use of ICT and facilitate complex decisions about integration of ICT to the teaching and learning paradigm (Schiller, 2003; Afshari, et al., 2010). Principals need to be cognizant of the benefits of the new technologies. Many researchers have shared these benefits (Afshari, et al., 2010). Hence, the principals need to have proficiency in their use, and are able to promote a school culture which encourages explorations of new techniques in teaching, learning and management (Schiller, 2003).

Principals who are creative and inspirational can develop the same qualities in others (Gurra, et al., 2006). The principal's vision of the possibilities of ICT in teaching and learning are realized through supporting and developing the skills of others (Bishop, 2002). To perform the duties of a principal effectively, the principal's own role is very much involved in infusing ICT. To realize their vision, principals need to be competent users of ICT, but as a learner of ICT, the principal's personal ICT competencies and understanding may not be as sophisticated as their vision (Gurra, et al., 2006). Bishop (2002) has identified that some principals are the least informed of ICT on the school staff, but Gurra (2006) says that the modern principal will have basic understanding of ICT use in their position competently. The principal as a learner and user of ICT is a role model to the school community demonstrating the importance of ICT. An ICT role model for staff is essential in developing an ICT learning culture within a school (Cusack, et al., 1999; Day, et al., 2001; Otto & Albion, 2002; Gurra, et al., 2006).

Effective leaders are role models for other staff (Hooijberg & Dension, 2002). Hooijberg & Dension (2002) has stated that the best leaders modeled their expectations of others by demonstrating high standards of professionalism (Hooijberg & Dension, 2002). Further, encouragement, leadership, knowledge in ICT education is essential for officers in the Ministry of Education, provincial, zonal and others who are involved in the ICT education development process. According to the above facts, the majority of ICT development work is performed by principals and related officers in the Ministry of Education and provincial educational offices (Khvilon & Patru, 2002). Furthermore, there is no clear evidence to show the actual role of school leaders as principals and other responsible officers related to ICT education in Sri Lankan schools (Liyanage, 2004). If principals and related officers make a greater attempt to develop ICT education in schools, it purely depends on the available funding facilities because ICT equipment maintenance cost is higher than other subjects in the schools system (Afshari, et al., 2010). Therefore, exploration and investigation of funding is highly related to this study.

Funding

Technology enhanced education is generally perceived as a way to relieve poverty, social division and improve living standards due to the fact that technologies can deliver educational programs at a lower cost than traditional education systems (Gulati, 2008). This technology-supported education system is cost-effective, which is especially meaningful in countries with poor infrastructure (Oliver, 2002). However, compared with developed countries, the use of ICT in education programs in developing nations is relatively limited, because underdeveloped countries face shortages of financial resources, limited Internet access, a lack of trained teachers and the lack of proper policies (Gulati, 2008). Therefore, to introduce ICT education successfully, one of the affective critical factors is financial barriers (Khalid, 2009). It was proved that input for quality ICT education are, skills standards, expected outcomes, quality of teachers and students, quality of curriculum, pedagogical techniques, quality of infrastructure, and support from the administration and funding. Even if these factors contributed in a well-accepted manner, ICT quality education cannot be implemented without a proper processing methodology. Hence to maintain the quality, investigation of processing activities have provided great quality concepts in ICT education.

Process

According to the above explorations, Design and implementation procedures of Curricula, Pedagogical techniques, Training and updating procedure of teachers and education leaders, Evaluation procedure of students and teachers, Monitoring, Supervision and Maintenance of educational activities are the main key aspects to the quality of ICT education development process (Cairncross, 2006; Bee & Chia, 2008). Detailed exploration and study of how these components contribute to the maintenance of sustainable ICT education in schools is very appropriate. First, consider how the design and implementation procedures of curricula contribute to the maintenance of the quality of ICT education.

Design and Implementation Procedures of Curricula

UNESCO has proposed two models (IBE-UNESCO, 2002, UNESCO, 2006) for developing curricula for ICT education. It is a useful model for ICT development. ICT development

should provide a framework, where such a framework shows the interrelationship between various components within a system and aid understanding by educational administrators and policymakers. They have proposed two models for ICT development.

The first model considers ICT development as a continuum along which an educational system or an individual school can pinpoint the approach that relates to the growth of ICT in their particular context. This model is referred to as a continuum of approaches to ICT development (IBE-UNESCO, 2002). The second model shows different stages in the way that those who are most involved in the use of ICT in schools – teachers and students – discover, learn about, understand, and specialize in the use of ICT tools. This second model is referred to as stages of teaching and learning with and through ICT (IBE-UNESCO, 2002).

The two models, a continuum of approaches to ICT development and stages of teaching and learning with and through ICT, together provide the framework for an ICT curriculum and for the professional development of teachers.

A Continuum of Approaches

The model consists of four broad approaches termed: emerging, applying, infusing, and transforming, as shown in Figure 3.1



Figure 3.1 Model depicts a continuum of approaches to ICT development in schools (UNESCO, 2002)

Stages of Teaching and Learning

Teaching and learning are best thought of, not as separate and independent activities, but rather as two sides of the same coin, interconnected and interrelated. Studies of teaching and learning in schools around the world identify four broad stages in the way that teachers and students learn about and gain confidence in the use of ICT. These four stages give rise to the model depicted in Figure 3.2 that shows the stages in terms of discovering, learning how, understanding how and when, and specializing in the use of ICT tools.

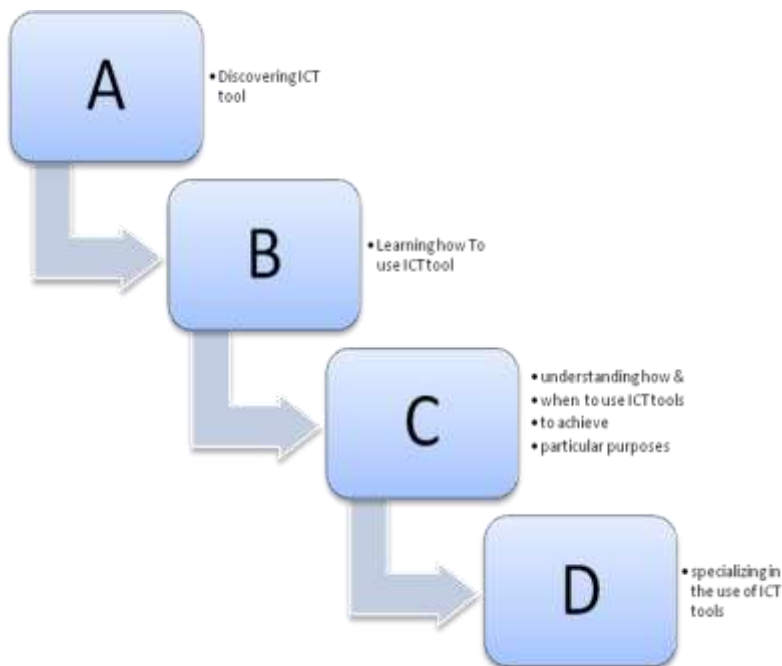


Figure 3.2 Model of stages of teaching and learning with and through ICT, Source (UNESCO, 2002)

A Curriculum Structure for Secondary Schools

The model illustrated in Figure 3.2 is useful in developing the structure of a curriculum designed for both teachers and students to improve their knowledge and skills in ICT. The design supplies four curriculum areas tied to the four stages of teaching and learning, allowing schools to progress from: (i) ICT Literacy to (ii) Application of ICT in Subject Areas (to (iii) Infusing ICT across the Curriculum to (iv) ICT Specialization .

The two models discussed above show the basic guidelines on how to develop and implement the ICT curricula for secondary schools in developing countries. But, in the continuum of approach state that began with the purchase of computing equipment and software to be performed at this stage and adding ICT to the curriculum is also performed at this stage. The latter stage of this model discusses how to expand ICT literacy and ICT specialization subject in the school curriculum through the professional development of teachers. But the weaknesses of these models are parallel deployment techniques, the real situation of developing countries and practical issues that are not considered in an appropriate manner.

A few examples are initially, purchasing computers, software and other equipment without exploring the real requirements, objectives and future expansion of ICT education. If it is realized that the purchased equipment and software are not fully compatible with the curriculum, it will be a financially unproductive expenditure for developing countries (Kashrado, et al., 2006).

In developing countries, teachers are fully engaged in day-to-day routine work (MOE, 2009). Therefore, there is a lack of human resources as teachers do not have sufficient time to invest in ICT education as school leaders do not release them for ICT leaning activities (Kamal, et al., 2009). This may be a barrier to successful ICT education. To utilize the resources to the

maximum, curriculum development and professional development should be performed at the initial stage and in order to maintain the continuity of the process computers, software and other related equipment need to be purchased accordingly (Cairncross, 2006).

In most countries where ICT is offered as a subject (Patti, 2008), the focus is on activities that deal with the solution of problems through logical thinking, information management and communication. As such, the subject will enable learners to understand the principles of computing through the use of current programming language, hardware and software, and how these apply to their daily lives, to the world of work and to their communities (Mansell, 2010).

The following learning areas are normally covered by high school ICT syllabuses (Smith, 2000; IBE-UNESCO, 2002; Patti, 2008): Hardware and system software, developing understanding of electronic communications. This includes the legal, ethical, social, political and moral aspects of access to information and data protection Social and ethical issues , the reasons for using computers and the effects of their use across a range of application areas, Programming and software development , the design, implementation, test and delivery of efficient and effective solutions to problem situations is studied (Patti, 2008). Thus, object-orientated programming language, databases, spreadsheets, word processing, websites and their interconnectivity will be used in the design and implementation of solutions to specific real life problems (Leary, 1999).

ICT Curriculum for Secondary Schools

According to the IBE-UNESCO (2002), the ICT curriculum consists of four curriculum modules as ICT literacy, Application of ICT in Subject Areas, Infusing ICT across the Curriculum, and ICT Specialization. UNESCO (2002) has proposed the following curriculum model for ICT literacy for developed and developing countries. The module, ICT Literacy, is the first stage of the curriculum. This first module is designed for students to discover ICT tools and their general functions and uses. The module comprises nine units: Basic Concepts of ICT, Using the Computer and Managing Files, Word Processing; Working with a Spreadsheet; Working with a Database; Composing Documents and Presentations; Information and Communication; Social and Ethical Issues; Jobs and/with ICT(UNESCO, 2002).

ICT Specialization

UNESCO (2002) has proposed the following curriculum model for ICT specialization.

(i) Specialization Preparation Module: Introduction to Programming and Top-Down Program Design (ii) General Specialization Module: Foundations of Programming and Software Development and Advanced Elements of Program (iii) Vocational Specialization Module: Business Information Systems, Process Control Systems and Project Management.

These units are designed for students who plan to go into professions that use ICT such as engineering, business, and computer science, or others who plan to advance to higher education (IBE UNESCO, 2002; UNESCO, 2004). These units cover the use of advanced

tools and techniques for ICT specialists. These include basic and advanced programming, planning information systems, designing process control systems, and project management. The above explorations (Patti, 2008; IBE-UNESCO, 2002; Smith, 2000) clearly identify the major components to be included in the ICT education curriculum at different stages in the education system as international benchmarks. One of the most common models functioning in most of the countries is the ICT literacy model for secondary schools. Nevertheless, the status and quality of ICT education in Sri Lanka lags behind the other developed countries (Liyanage, 2004).

3.5 Comparison Of Ict Education In Selected Countries

ICT Education in Singapore Schools

The government of Singapore spends 3.1% of its GDP on education and they have developed the ICT education system through three master plans (MOE-Singapore, 2005). The master plan 1 for ICT education in Singapore provides a blueprint for the use of ICT in schools, and access to an ICT enriched school environment for teaching and learning of every student (MOE-Singapore, 2005). ICT is harnessed to enhance learning skills, creative thinking skills and communication skills (Chapman & Adams, 2002). The aim of ICT education is to prepare students for the workplace of the future.

The first ICT master plan of Singapore (1997-2002) laid the foundation for integrating ICT into education. It focused on the setting up of the essential infrastructure for schools and the basic training of teachers on the integration of ICT into the curriculum.

The mission of the first ICT master plan was to harness ICT for institutional purposes, and to provide directions to schools for the integration of up-to-date technologies into the educational process. To achieve the objectives of master plan 1, the following were carried out: (i) Training of school teachers in the use of technology for classroom teaching that could enhance learning (ii) Provisions of hardware and software to schools (iii) Support for schools in ICT implementation (iv) Initiation of special projects to engage teachers and pupils in the continuous and active exploration of ICT use (v) Collaboration with the ICT industry.

Master plan 1 (MOE-Singapore, 2005) was implemented in three phases.

Phase 1: (from 1997) involved 22 pilot schools which were selected to spearhead the project; Phase 2: (from 1988) 108 schools and Phase 3: (from 1989) 238 schools.

At that time, their expectation was to reach the national standards of ICT provision eventually. The MOE, Singapore extended full grant financing to all schools. Their initial plan was to set up a school wide network and to maintain a pupil-computer ratio of 5:1 in every school by the end of 1999. Schools were given the flexibility to decide on the pace of implementation to achieve national standards. Under the master plan concept, they achieved the following: MOE-Singapore (2005) acquired a starter set of suitable commercially available educational software for schools, and set up a central clearinghouse to source, evaluate and recommend suitable ICT based learning resources, such as CD-based software titles and internet sites to schools, via the MOE learning websites, and edu.MAIL. They maintained a student computer ratio of 6:1 for primary schools, with a ratio of 5.1 for

secondary schools. Further, they provided access to ICT facilities in all learning areas in the school, including classrooms, libraries and special rooms, besides computer laboratories. They arranged 30-50 hours of school based training on the integration of ICT into the curriculum for every teacher. ICT was integrated into 30% of the curriculum time at all levels and into all subjects. An educational software procurement scheme was also implemented to help schools obtain software easily and at discounted prices. The MOE collaborated with industries and research institutes to undertake research and development on the use of ICT in learning.

To create a culture for ICT use among teachers, MOE-Singapore introduced the computer purchase scheme for teachers to motivate them to purchase their own computers by providing generous subsidies (MOE-Singapore, 2005). MOE also introduced recognition schemes to recognize teachers' creative use of ICT and to motivate them to move on to higher levels of ICT use.

The MOE of Singapore added a new dimension as collaboration and networking activities among the teachers and specialists to encourage the teacher to be innovative in applying ICT to enhanced learning and motivate students to move to higher levels of ICT use. The new dimension provides teachers with a platform to reflect on their own learning experiences through the innovative use of ICT, backed by strong pedagogical considerations (MOE-Singapore, 2005).

NIE-Singapore has introduced the Advanced Diploma and Advanced Postgraduate Diploma in education programmes to enable teachers to upgrade and update their content knowledge of school subjects (MOE-Singapore, 2005) or state-of-the-art educational methodologies or technologies, guidance and counseling methods and educational administration courses (MOE-Singapore, 2005). The Advanced Diploma in Information Technologies in Education has already taken in three cohorts of teachers. Advanced diplomas provide an alternative route for admission into the Institute's bachelor's and Master's degree programmes. However, the teachers can opt to sign up for individual modules in the programme and hence have a wider choice of continuous in-service professional development. The advanced diplomas and their accreditation framework also ensure better articulated linkages between in-service training and the career paths of teachers by providing greater opportunities for teachers to upgrade to degree and postgraduate qualifications (MOE-Singapore, 2005).

Further, the authorities introduced on-line course modules for pre-service teachers on the pedagogies of using ICT in the classrooms. Tutors employ a fully dynamic online learning environment to complement onsite activities as anywhere/anytime lecture, onsite laboratory tutorial, online independent hands-on session, and online asynchronous discussion (OECD, 2004).

Lesson learnt from the Singapore master plans

There is a need to first, resolve fundamental issues in education such as the relevant curricula, adequate number of qualified trained teachers, a good basic infrastructure, and strong school leadership, before introducing a system-wide use of ICT into education. If one compares with the two models proposed by UNESCO (2004) in ICT education and master plans

implemented in Singapore (MOE-Singapore, 2005), it is evident that the Singapore model provides the appropriate milestone, while UNESCO (2004) curriculum implementation methodology as the proper form. But the UNESCO (2004) model has more important aspects. So, a combination of both (Singapore master plans and UNESCO Two Models) might give a more acceptable model. If educationists introduced hybrid features (Singapore master plans and UNESCO proposed models), they can accrue more successful ICT education than earlier. Further, the ICT education devolvement process in Singapore uses highly reflective learning practices and pedagogical techniques to enhance their quality of ICT education. But, in the Sri Lankan educational system such reflective practice and the usage of pedagogical techniques is minimal.

Meanwhile, India has more technology embedded education and is one of the major successful countries in south Asia. Therefore, exploration of ICT education in India is more applicable for the study.

ICT Education in India

The government of India is spending 4.0% of GDP for education activities (Nation-India, 2011). At the initial stage, the government of India initiated the ICT education policy formulation process in 2007 (ICTD, 2007). The Department of School Education & Literacy (D/SE&L), Ministry of Human Resource Development (MHRD), of the Government of India, along with Global e-Schools and Communities Initiative (GeSCI), has initiated challenges for teaching and learning in the 21st century using technology tools. To facilitate the policy formulation process, GeSCI had partnered with the Centre for Science, Development and Media Studies (CSDMS). They identified the need for a National Policy on ICT in Education to be developed through a consultative and multi-stakeholder process (ICTD, 2007). This was a good lesson to learn because a solid policy creates a well-established implementation procedure (National Education Commission [NEC], 2007) rather than taking ad-hoc decisions.

India has some 1.2 million schools with 290 million students attending school every day, under 35 state boards, two central boards and a host of educational agencies responsible for the administration and health of the schools (ICTD, 2007; ICTD & Education, 2007-2008). Given the size and enormity of needs, aims and issues to be addressed, India has an abundance of stakeholders representing them and assisting the state governments to integrate ICT in schools (ICTD, 2007).

The model of engagement for the policy building process is based on Multi-Stakeholder Partnerships creating a lasting and meaningful impact at all levels of policy action and implementation across India to promote a more holistic approach to a National ICT in the school Education policy development and implementation process.

The model of engagement includes: Knowledge Sharing, Policy Dialogue, Partnerships, Knowledge Integration, Capacity Building, Research and Innovation, and other key thematic areas; enriched policy document, ready for implementation in the states. The Ministry of Human Resources Development, with its strategic partners, has engaged approximately 400

members of the stakeholder community including education experts, ICT specialists, businesses, schools, teachers, students and others to collate their views, suggestions and recommendations on a national policy on ICT in school education (ICTD & Education, 2007-2008). The aim has been to engage at one end, in an open and intense discussion with pedagogues and practitioners of technology in education, and also increase the outreach of the process to a geographically spread pool of experts, communities of practitioners and stakeholders.

To reach out to the wide spectrum of stakeholders, an e-Discussion series was hosted on UN Solution Exchange (<http://www.solutionexchange-un.net.in/en/>), to engage and solicit suggestions and insights from the online communities of Education and ICT for Development on seven thematic areas, viz., Infrastructure, Capacity Building, e-Content, Quality in School Education, Innovation and Research, Public-Private Partnerships and Monitoring and Evaluation (ICTD & Education, 2007-2008). Valuable inputs received through these consultations have led to the development of a draft policy document on ICT in school education (ICTD & Education, 2007-2008). The draft document will go through further reiterations with each state and with different groups of experts and stakeholders to evolve as a truly representative and informed policy document as Compendium.

The Indian state of Kerala has adopted open source software to make students IT literate for the freedom it provides in terms of modifying the source code, making improvements and its cost effectiveness (Ananthakrishnan, 2007). Governments across the world now use open source software to modernize their education systems. In India, it has been found that the education system indirectly discourages open source because the syllabus sometimes mandates the use of proprietary software. In light of the benefits of open source software, they recommended the following guidelines (Venkatesh, 2007): (i) the syllabus/curriculum should emphasize principles and not products. (ii) Whenever possible, the education system must use open source software. (iii) Software developed with tax payers' money should be placed under a suitable open source license. (iv) The e-discussion series (Dixit, 2007) of the ICT policy formulation process of India proposed key ideas as follows:

One is to provide one Laptop per child. However, the reality is that in most countries such a scenario does not exist. There are several examples from UK, US and now Africa where even with limited access in School, the "real access" is granted over the Web. Other responses (Rajen, 2008) involving the key challenges to infrastructure with reference to computers in schools are: power, maintenance and software (operating system and other application software).

Another response, (Anindya, 2007) notices that one of the most important aspects of infrastructure is missing from the thematic pillars in India; (i.e. software). The review highlighted the importance of software for ICT school education. Software to be used in the infrastructure for ICT at schools.

Other responses (Ananthakrishnan, 2007) in connection with the key capacity gaps facing ICT education in India are addressed as high student-teacher ratio, Poor infrastructure,

Limited number of computers, Refurbished computers, Computer education, Maintenance issues and Resistance to change.

The most important idea from some position paper (Hawk & Shah , 2007) reads as follows. The national policy must be for the majority. This implies: (i) First and foremost, make development of software in the local language a precondition (ii) Provide incentives to state governments for the creation of the content in the local language for free distribution (iii) Free the contents from commercial clutches by making all educational content (curricula, text book material, and multimedia contents, in hard and soft copies) in schools under Creative Commons license, independent of whether paid for by State or otherwise. (iv) All educational software to be mandatorily FOSS (Free and Open source software), even if the software is on a proprietary platform and (v) Restrict use of ICT in formal education only to secondary/middle-school/high onward and not at primary level.

Create awareness of ICT education

Before providing knowledge through computer related technologies, there should be knowledge sharing on ICT education and its usage to the rural school students (Ananthakrishnan, 2007). Due to their lack of awareness of the field of ICT, rural students are not interested in computer based education; some of them initially showed interest but did not continue due to the failure of a majority of rural ICT related programs even at the initial period. Dissemination of awareness and motivation are needed not only for students, but also for the instructors of ICT programs in rural areas. At the same time, students and teachers should be encouraged to learn English language. The Ministry of Education or other relevant authorities should develop mother tongue operating systems interfaces and educational programmes to motivate rural students for ICT awareness (ICTD, 2007). The MOE-India considered the above issues when implementing ICT education.

Infrastructural facilities

The MOE-India considered infrastructural facilities as some of the important factors for the implementation of ICT programmes in rural areas (Hawk & Shah, 2007). They considered ICT education with regard to proper infrastructural facilities like power, location of the center, connectivity and computer related materials and human support since there is need for the program to ensure the availability of all these facilities (Hawk & Shah, 2007).

Community participation

Involvement / interest of rural students is one of the significant aspects of the ICT education programme (Hawk & Shah, 2007). The attitudes and behavior of rural students with regard to the accessibility of ICTs is different from those of urban students. The urban students might have some basic knowledge of the usage of the computer and its usage through their mode of education and living conditions, whereas the rural students may not know much about the benefits of ICT leading to their improvement in education (ICTD & Education, 2007-2008)

Challenges to ICT education in rural areas

Infrastructural facilities is one of the major challenges for the rural school ICT programmes (Ananthakrishnan, 2007), specially Internet connectivity. But at the initial stages training and

information can be provided through the computer in the absence of Internet connectivity in rural areas (Ananthkrishnan, 2007).

The second objective is the linkage of government training institutions to ICT programmes. The same CD method can be followed in this program (Nagarjuna, 2008). Finally, the important aspect is the involvement and interest of teachers, the education department and the end users of the student community in rural areas. These two things can be achieved through continuous motivation and the provision of better awareness about the importance of the ICT programmes. Also, another challenge is the monitoring and evaluation of the, overall programme. This has to be done by the school education department concerned. The government can appoint suitable individuals to monitor the ICT programme in schools (Ananthkrishnan, 2007). But the individual assigned should have good overall knowledge of programme like skills, technical knowledge of various fields, and knowledge of local resources and their management.

CD based teaching and learning is a low cost ICT solution and a more appropriate solution for ICT education in rural areas in developing countries (Anindya, 2008). CD based learning activities were implemented in rural areas of Sri Lanka (MOE, 2007), but there is no evidence to show the success of CD based learning activities in Sri Lanka (De Silva, 2009). The survey investigated the success of CD based learning and issues related to CD based learning.

ICT Education in Indian schools

The National Institute of Information Technology (NIIT) has provided facilities to cater to ICT and ICT enabled learning requirements of school children in India. NIIT is an Independent Business Unit, named School Learning Solutions (SLS), to focus on the implementation of projects for Government and Private schools in India and abroad (The National Institute of Information Technology [NIIT], 2007).

This authority provides turnkey solutions on **Build, Own, Operate and Transfer Model (BOOT)** to create state of the art computer infrastructure at each school and impart computer literacy and computer-based education to the students of selected classes. The Turnkey educational projects provide the following components as infrastructure, curriculum and education delivery.

Further, ICT education in India uses time sharing possibilities of computer laboratory facilities based on the size of the school (Ministry of Human Resources, 2011). Each computer laboratory in school is equipped with at least 10 computers and a maximum of 20 computers. Not more than two students will work at a computer at a given time while a maximum of 40 students are accommodated in a 20 computer laboratory. In addition to this they provide optimum ICT infrastructure in each school as: at least one printer, scanner, projector, digital camera, audio recorders and other such devices as part of the infrastructure. They maintain a student computer ratio of a minimum of 10:1 achieved in all schools in the India. Exclusive laboratories with appropriate hardware and software are provided for the Higher secondary classes. In addition, at least one classroom is equipped with appropriate audio visual facilities to support ICT enabled teaching-learning. The student computer ratio of minimum 10:1 is achieved in all schools in India (Ministry of Human Resources, 2011).

The government of India encourages the use of free software for the following reasons (Nagarjuna, 2008): (i). to use it for any purpose, (ii) to know how it works, (iii) to improve it by modifying, and (iv) to share or propagate or distribute the modified code to others.

In India, all pre-service teacher education programmes include a compulsory ICT component. All teacher training programmes also require adequate levels of competency in ICT and ICT enabled education. Based on proficiency, pre-service teachers are recruited to the academic cadre (Nagarjuna, 2008). Further, Training on ICT in-services is integrated with general training programmes organized for teachers and school leaders at all levels in order to popularize its use and to demonstrate effective practices in ICT(MOE-India, 2009).

Each school in India developed an ICT plan, based on locale specific requirements, to optimally utilize the infrastructure established in a cost effective manner. This should be based on the learning needs of the students and training requirements of all staff, including teachers. The school level plans are reviewed at the district/ State to make available adequate resources for raising the quality of the education imparted. The states will adapt appropriate models of infrastructure, procurement, maintenance to keep the total cost of operation low and optimizing investments. The states will also ensure optimum utilization, minimize renewal and upgrading of ICT education (MOE-India, 2009). In this regard, ICT education in Malaysia has made considerable advances and merits study. Further, Malaysia is also a selected country and the implementation aspect of ICT education is considered crucial in this study.

ICT Education in Malaysia

The government of Malaysia has implemented the smart school approach to the development of ICT education in Malaysia (Terima, 2010). The aim of these Smart Schools is to help the country achieve the aims of the National Philosophy of Education, as well as to foster the development of a workforce prepared to meet the challenges of the 21st century. Transforming the educational system entails changing the culture and practices of Malaysia's primary and secondary schools, moving away from memory-based learning designed for the average to an education that stimulates thinking, creativity, and caring for all students, and catering to individual differences and learning styles based on more equitable access (Bee & Chia, 2008). Further, the government of Malaysia has allocated 4.8% from their GDP in 2008 for education in Malaysia (Master, 2011). This is a considerable amount when compared with other countries in Asia (MOE-Malaysia, 2007).

A Pilot Project trial-testing the Smart School Integrated Solution, involves the following main components: (i) Browser-based Teaching-Learning Materials (and related print materials) for Bahasa Melayu, English Language, Science and Mathematics (ii) A computerized Smart School Management System (iii) A Smart School Technology Infrastructure involving the use of IT and non-IT equipment, Local Area Networks for the pilot schools, and a virtual private network that connects the pilot schools, the Ministry's Data Centre and the Ministry's Help Desk (iv) Support services in the form of a centralized Help Desk, and service centers throughout the country to provide maintenance and support (v) Specialized services such as systems integration, project management, business process

reengineering, and change management(Master, 2011).

ICT Training In Schools

The Ministry of Education in Malaysia recognizes that training is a vital aspect in the implementation of any project (Master, 2011). The model that the Ministry uses to disseminate training is the cascade model(Terima, 2010).Selected master trainers undergo training, and they pass on this training to selected trainers, who in turn, train their colleagues at school, district, or state level (MOE-Malaysia, 2007). It is a requirement that all teacher trainees at the Teacher Training Colleges be exposed to ICT literacy, and the use of ICT in pedagogy. Activities under the smart school approach in Malaysia, conduct the following activities: The Computerization Programme in Schools, The Electronic Book Project and Penang E-Learning Community Project.

Under the smart school development program the MOE-Malaysia conducts computer awareness courses (UNESCO, 2004) to the pre-services teachers. Furthermore, the skills tested through the “International Computer Driving License” offers competency certification at the end of the course. Due to this certification teachers were motivated and it was an indicator of successful training; subsequently they used it for ICT educational teaching activities with confidence. The government of Malaysia encourages the use of Open Source Software (OSS) based on the following facts (Lewis, 2010) (i) All Government procurements had a strong preference for OSS under the Malaysian Public Sector Open Source Software Master plan (ii) Government created a \$36 million fund for start-ups developing OSS developing a national OS based on Linux(iii) The Government of Malaysia has decided to encourage the use of Open Source Software (OSS) in the Malaysian Public Sector. The government implemented a rewarding and motivation scheme for civil servants in connection with the use and software development activities, using opens source software (Master, 2011).

National ICT Education Policy of Malaysia

The **first policy** (Chan, 2001) is that of ICT for all students, meaning that ICT is used as an enabler to reduce the digital gap between the schools. The **second policy** emphasises the role and function of ICT in education as a teaching / learning tool, as part of a subject, and as a subject by itself. Apart from radio and television as a teaching / learning tool, this policy stresses the use of the computer for accessing information, communication, and as a productivity tool. ICT as part of a subject refers to the use of software (e.g. AutoCAD and SCAD) in subjects such as “Invention” and “Engineering Drawing.” ICT as a subject refers to the introduction of subjects such as “Information Technology” and “Computerisation”. The **third policy** emphasises the use of ICT to increase productivity (Chan, 2001), efficiency and effectiveness of the management system.

Further, Malaysia spends 10.7% of GDP/capita for education, while the student computer ratio for primary and secondary school is 1:43 and 1:26 respectively. Further, computer, Internet and Broadband penetration percentage of Malaysia is 11.3%, 24.4 and 0.09% respectively. The government of Malaysia included the following contents in their school curriculum as processing and productivity tools. (Word processors, databases, spreadsheets, presentation programs, multimedia authoring tools, e-mail, video production equipment, digital reference materials, electronic indices and network search engines).

The previous sections describe the ICT curriculum implementations procedures of Singapore, India and Malaysia. Further, Thailand is also another important country to be considered for ICT education exploration.

ICT Education in Thailand

The Ministry of Education in Thailand initiated the following targets and strategies as a way of implementing ICT education in Thailand schools (MOE- Thailand, 2011). The plan was to provide the following: (i) students at all levels with learning and teaching activities using ICT, (ii) create educational service centers to provide opportunities for distance learning activities to all the areas of the county (Nwachuwu, 2007), (iii) provide facilities to manage 80% of educational organization through use of ICT in schools (MOE- Thailand, 2011), (iv) provide sound knowledge for teachers and educational personal in the field of ICT, (v) provide appropriate ICT knowledge for 80% of ICT graduates and provide 50% ICT knowledge to meet international standards, (vi) provide 90% of the population in remote areas to receive ICT enabled information (vii) provide enhanced ICT skill development programs to ICT teachers in Malaysia. (viii) Provide opportunities to enhance access to, and improve the standards of e-learning media through collaborative initiatives to develop information (e-contents) through different learning media (ix) provide sufficient infrastructure facilities for ICT education.

Further, MOE of Thailand initiated one laptop per Child (OLPC) program in their schools (Kshankhow, 2007). This program focused on increasing the number of computers available throughout the education system in order to bridge the learning gap for students in rural areas. The ministry has further plans to distribute one million laptop computers to students around the country. Further, MOE of Thailand (Laohajaratsang, 2011) acquired the following achievements in ICT education.

Their computer school ratio is 6:1; The MOE has established a computer/school ratio of 1:20 for secondary schools and 1:40. 58.4% has teachers who had obtained professional training in ICT education and among the household in Thailand 1% lack electricity. Even if MOE – Thailand implements ICT education in an acceptable manner (Kshankhow, 2007), it would still face the following challenges: Lack of qualified ICT personnel, Low incentives for ICT personnel, inadequate financial support for ICT development, Unfavorable attitudes of people to ICT, Virus attacks from the Internet and elsewhere, high price of ICT equipment. Further, Thailand has recommended open source software (OSS) for the school and university education and the following supportive activities were implemented (Laohajaratsang, 2011). They distributed one million Linux based computers to stimulate OSS development and they

promoted 50% OSS in the schools system and universities. They have highlighted achievement and challenges for ICT while there was a lack of information about the ICT curriculums in schools available for public access (Laohajaratsang, 2011).

The government of Thailand provided in-service teacher training courses at three levels (UNESCO, 2004) as foundation, intermediate, and advanced. However, none of these courses are specific to any subject specialization. Many teachers are not able to apply what they have learned to their classroom teaching and learning. They are also constrained by their heavy workload and rigid class schedule. In addition, some schools do not have the budget to provide supportive environments for the integrated use of technology. There have been developments in the past three years to make the courses more subject-specific.

The above section describes ICT education procedures, models used and master plans of countries like Singapore, India, Malaysia and Thailand. According to the above guidelines and standards, it is useful to determine the quality of ICT education in Sri Lanka as well.

3.6 ICT Curricula In Sri Lankan Schools

The ICT sector is acknowledged worldwide as a tool that could be used to increase productivity, efficiency and effectiveness of work (NIE, 2006). In Sri Lanka, the level of ICT skills of the majority of the students is not adequate for the requirements of business and industry (Gunawardene, 2008). This is mainly due to the lack of opportunities for students to study ICT related subjects in the school curriculum.

According to the NIE (2009) sources, they have accepted that the most successful functioning curriculum was the ICT specialization subject for GCE (O/L) curriculum. The main objective of this syllabus is to develop the competences to use ICT tools and to build a basic theoretical base for students to pursue studies in ICT.

Course objectives of the GCE (O/L) curriculum are: (i) Impart basic computer literacy and develop a base for further studies in ICT (ii) Develop understanding of the use of different types of ICT applications and the effects of their use (iii) Develop the concepts and principles related to ICT (iv) Improve the skills necessary for the development of ICT based solutions for real world problems (v) Create an awareness of the benefits and problems of ICT use (NIE, 2006; NIE, 2007, NIE, 2008).

However, only a limited number of students will be admitted to the ICT course units due to the limitation of ICT resources in schools. Its student selection criteria were, marks in the Grade 9 mathematics paper or evaluation criteria defined by the respective school (NIE, 2006). Unlike other subjects, ICT is also taught in three languages (Sinhala, Tamil and English) and technical terms are in English (NIE, 2007). Before the process of admission, students can choose their medium of instruction for their O/L examination. In Sri Lankan schools, the module for Grade 10 & 11, the ICT literacy module, comprises eight (08) units and 14 units in the Information and communication technology (GIT) (A/L) curriculum. In addition to this, there is an elective ICT subject for GCE (A/L). Even though the government of Sri Lanka implemented these ICT course units, there is no evidence about the evaluation of

success or failure in these course units (Department of Examinations [DOE], 2008). Therefore, determination of the present status and its success is highly relevant to this study. As a specific field, ICT education has its own requirements. Among these: equipment, computer labs, other services like air conditioning, Internet connectivity, power supplies etc. are prominent. Their running cost may be high. School and other administrative settings should understand that the needs of such concerns are quite different from other sections in the same school.

In addition to the above, the literature review will cover the following aspects :(i) Implemented Projects for the enhancement of ICT education in Sri Lanka. (ii)The ICT syllabi implemented in Sri Lanka (iii) Internationally accepted technologies/methodologies used for ICT education in Sri Lanka and (iv) The flexibility of adopting new technologies/methodologies for the Sri Lankan schools system.

ICT Education in Schools

During the past few decades ICT education had undergone much transformation (Dissanayake, 2007). To understand the change in the quality of ICT education during this time span, it is necessary to study the evolution of ICT education in Sri Lanka. This review includes ICT teaching methodologies and content comparison of Sri Lanka with other internationally accepted models. Further, the review also discusses improvements and weaknesses. To discuss the success and failure of the system, it is important to include attempts and the progress of ICT education of the system. Initially, the review includes the history of ICT education.

History of ICT Education in Sri Lankan Schools

In Sri Lanka, computer education at school level started in 1982. Some schools were provided primitive type computers (less than 10 numbers) (Liyanage, 2004) and Internet connection was not available. GCE (A/L) science students who were interested in computing were the target group of this initiative. The curriculum was mainly based on what the instructor was trained in and capable of. Therefore, the curriculum was not standard and varied from centre to centre. This was more so since the curriculum was focused on computer programming, how computers function and computer architecture. Thus the curriculum was not very meaningful to students or was not related to their real life applications (De Mel, 2005).

As this initiative did not provide a direction that would create a significant impact, Computer Resource Centers (CRCs) were introduced with the assistance of the Asian Development Bank (ADB). This network of CRCs has now grown to 100 on an island-wide basis. These CRCs provide computer literacy (Introduction to programming and Application packages like Micro Soft (MS) Office) to students after their G.C.E (O/L) & G.C.E (A/L) (MOE, 2007). Hence, a part of the experience provided by CRCs was related to the real life context. However, there was no direct link between CRC and the school system or the curriculum of CRCs and the curriculum of general education (MOE, 2011). According to the setup CRCs should be self-financed. Therefore, these courses were offered at low cost.

On several occasions, the government initiated programs on ICT in education. According to the initial investigation which was held in collaboration with the MOE, NIE and students, there was no established curriculum for ICT in education and there were no proper sustainable plans for ICT in education even though high investments were made. An investigation was carried out through a survey.

General Information Technology (GIT) was implemented as a pilot program in 2004 (MOE, 2004) and was introduced as a subject to the schools system in 2004. GIT is taught only at Grade 12. GIT will not be considered as a subject for university admission. In Sri Lanka (MOE, 1999), ICT has been included under the technical subject area for Grade 10 and Grade 11 in 2006 (MOE, 2005). This subject, provided through three (03) periods per week, was provided in the same manner as a technical subject in the secondary school curriculum. The first national examination with an ICT subject was conducted in December 2007 (MOE, 2005). Even though the government has introduced such programmes, still there has been no proper investigation carried out regarding its success. There is a gap in the literature in terms of objective versus outcomes. Further, there is need to compare ICT programs in Sri Lanka with global standards and competency levels.

The current Sri Lankan education system has been substantially exposed to ICT through various programmes including CAL, ICT for GCE (O/L) and GIT at grade 12. Consequently, students have shown a growing interest in ICT education and some have, in fact, performed excellently at international competitions in ICT proving their high level of competence. Therefore, GCE (O/L) qualified students interested in developing their career path in ICT are deprived of the opportunity of learning it at the GCE (A/L). Introducing ICT as a subject for A/L would set a national standard in ICT education (NIE, 2009) at school level and provide the path for higher education at tertiary level. ICT was introduced as a main subject for GCE (A/L) students who appeared for their GCE (A/L) in 2011. According to the MOE (2009), the ICT syllabus was released by the NIE and some schools initiated ICT as a subject for GCE (A/L) in the Academic year 2009

The quality of any ICT programme depends on infrastructural facilities, computers and related equipment, qualified, pedagogical inputs, experience and the skill of teachers, well developed and continuously updatable curricula, attitudes of teachers, administrative authorities and students, good maintenance and monitoring (Lai, 2011). This study determines how the above mentioned factors contribute to the achievement of a quality ICT education. As a preliminary initiative, the investigation of facilities provided through different projects is important and are explored as follows.

3.7 Facilities Provided To Improve ICT Education In Sri Lankan Schools The General Education Project (GEP) -2)

In 2003-2004, the MOE initiated a project called GEP-2 (MOE, 2009). The main objective of this project was to improve the quality of general and ICT education in Sri Lankan schools. For this project the following resource and services were supplied. Four hundred (400) computer labs were distributed among eight (8) provinces. The computer quota for one province was fifty (50) labs so that each lab contained ten (10) computers.

Teacher training workshops were conducted by the NIE for a period of Fourteen (14) days for eight (8) teachers selected from a school. The main aim of this workshop was how to teach seven general subjects, (Mathematics, Science English etc.) using ICT. The appropriate software and tools were developed and distributed by the NIE with steps also being taken to maintain and sustain the teaching of other subjects using ICT. For this program, schools and teacher selection was done by the authorities from Provincial Education Departments and was restricted to 1AB and 1C schools (Dissanayake, 2007).

The Secondary Education Modernization Project 1 (SEMP 1)

This project commenced in 2000 and ended in 2006. The objective of the project was to improve the quality of secondary schools by modernizing secondary education and also to increase up to one million the secondary students who will benefit from this programme (MOE, 2011). Modern teaching facilities such as multimedia rooms were to be provided to all the secondary schools to enable the use of television, VCRs and audio cassettes as learning materials for key subjects such as mathematics and science etc. It is necessary to investigate the successes and failures of the above investment for the continuation of the methodology (MOE, 2011).

Secondary Education Modernization Project 2 (SEMP 2)

This project was started in 2004 and was proposed to end in 2009 (MOE, 2011). The Project expected to establish a secondary education system that is equitable and responsive to labor market requirements. It was to support the government's strategy to modernize the secondary school curriculum and teaching-learning methodologies by equipping some schools with science laboratories, computer facilities, and multimedia units. School personnel were trained to manage and sustain these facilities and improve teaching - learning activities by means of zonal trainers/facilitators. Schools were required to submit a comprehensive school development plan (SDP) before receiving any support. School-Based Management (SBM) was enhanced through the provision of small-scale school development grants (MOE, 2011).

Present Networking Facilities in Sri Lankan Schools

As a way of introducing networking facilities, the Ministry of Education established the SchoolNet of Sri Lanka.

The School Net of Sri Lanka

SEMP has taken the initiative to establish a Wide-Area Network (WAN) connecting most of the Senior Secondary Schools and other related organizations via SchoolNet, which is the platform for the stakeholders in the school education sector for: Schools, Computer Resource Centers (CRC), Provincial ICT Centers, National Colleges of Education (NCOE), Ministry of Education (MOE), National Institute of Education (NIE), Project Management Offices of SEMP etc. (MOE, 2011).

The Ministry of Education has empowered SchoolNet to host a web site called **schoolNet.lk** to improve the quality and accessibility of online Mathematics, Science and etc. (Sri Lanka Telecom [SLT], 2007; MOE, 2011). It has an interactive educational content for Sri Lankan students and teachers, thereby promoting SchoolNet (SLT, 2007), a venture by the Ministry

of Education which is an on line educational system that seeks to promote efficiency and academic achievement in public schools. It is beginning to revolutionize the way students learn, teachers teach and school administrators, operators and parents get involved in the whole education process.

Under this project, Island-wide Schools are connected to SchoolNet virtual private network (VPN), using different access speeds based on current requirements. The target is to link 5000 schools by year 2010. To date (August, 2011) 1200 schools are connected to SchoolNet. The project allows access to SchoolNet communities, promotes on-line access to educational software and enhances teaching and learning (DEMP, 2010). They improvise development in audio, video and computer assisted programs, along with computer mediated communications; thereby offering many possibilities for teachers to convert activities around interactive learning, watching videos, marking on-line assignments and communicating through real time.

At present the following tables show ICT infrastructural facilities and professional development activities in the government schools in Sri Lanka (as of 15th September 2010).

Table 3.1 Infrastructure facilities of the government schools

No	Category	No of Schools with Computer Labs
1	World Bank Assisted	400
2	SEMP 1 with ADB Assisted	1006
3	SEMP II with ADB Assisted	359
4	Education for Knowledge Society Project (EKSP) with ADB assisted Schools	2128
5	EKSP North Emergency Program	500
6	Indian assistance with solar power	100
7	Consolidated funds under ESDG	200
8	From other Sources (Donors/OBA's/Well-wishers +etc.)	200
	Total	4888

Table 3.2 ICT professional Development

No	Teacher Empowerment Program	No. Of Teachers trained
1	Principal's and Educational officers with e-citizens program	3319
2	Teachers with ICDL/CAL	69000
3	Teachers with Intel Teach	19480
4	Teachers IPICT	110000
5	Teachers with short ICT courses	1992
6	Teachers on ICT lesson planning through Oracle Education Foundation	87
7	ICT basic Literacy through Microsoft Assistant	1934

+ 50 e-village program

Further, to improve the quality of ICT education in Sri Lanka, the Sri Lanka government has designed and implemented several programs. To maintain the quality of any program, policies and strategies may get greatly important. On several occasions, the government of Sri Lanka initiated policies and strategic plans for ICT education. Under the literature review this study investigates such policies, strategic plans and their involvement in the quality of ICT education.

Initial Policy for ICT Education in Sri Lanka

The initial national policy on ICT (Vithanage, 2004) affirms the commitment of the government to provide state of the art knowledge of ICT to Sri Lanka's younger generation to prepare them to face the challenges of the 21st Century. This policy provides a clear vision and direction in making this a reality. There was an action plan from 2000-2007 in the form of a strategic plan for policy implementation. This six year project period was divided into three stages.

Stage 1: 2002-2003, Stage 2: 2004-2005, and Stage 3: 2006-2007

During the six years mentioned above, the action plan focused on,

- Use of ICT in education (Learning and Teaching)
- Use of ICT in the management of the education system.

The policy goals are: (i) Envisage and foresee the future global challenges in ICT education and lay the foundation for appropriate human resource development to meet these challenges. (ii) Create conditions enabling the effective use of IT as a tool in learning and teaching at all levels in the general education system. (iii) Provide "information literacy" for all school leavers (iv) Create conditions for the effective involvement of the school system in the lifelong education of citizens. (v) Create an information technology population of teachers and educators.

ICT education and Teaching Methodology

In the previous sections, the following were investigated: The policies involved in ICT education in selected countries, ICT development models from selected countries, Proposed ICT policies for ICT education in Sri Lankan schools, and Projects and programs implemented to enhance ICT education in Sri Lankan schools.

In addition to this, there is a need to investigate the following activities to enhance ICT education in Sri Lankan schools: Determine the objectives of the internationally accepted curricula/models/methodologies/benchmark for ICT education.

Firstly one can consider the importance of ICT education since ICT adds value to the learning/ teaching process. The Internet is a driving force that presents much development and innovations in both developed and developing countries (Dixit, 2007). Countries must be able to benefit from technological developments. To be able to do so, a cadre of professionals has to be educated with sound ICT backgrounds, independent of specific computer platforms or software environments.

Technological developments lead to changes in work and changes in the organization of work (Adam, 2004), and the required competencies are, therefore, changing. Gaining in importance are the following competencies (Mapatuna & Premaratna, 2008): Critical thinking, General (broad) competencies, ICT competencies enabling expert work, Decision-making, Handling of dynamic situations, working as a member of a team, and communicating effectively (MOE-Australia., 2009). The above competencies are very important to any person at his/her stage of education as a child. The MOE and the NIE of Sri Lanka have implemented several programs to introduce ICT in education to the Sri Lankan school system.

As a result it was reported that IT awareness among the school teachers in Sri Lanka is less than 40% (Mapatuna & Premaratna, 2008). This figure is low. Nevertheless, as a developing country this percentage is considerable. If one compares this with other subjects, ICT education caters to the achievement of the competencies above. To achieve the above competencies, ICT, the curriculum and teacher development are very important. It is very important to investigate international models or benchmarks for ICT curriculum and teacher development. The following gives the UNESCO benchmarks (Pedro, 2004) for ICT education.

Educational Content and Applications

Content of the learning materials, relevant software for educational activities, budgetary restrictions and suitability of alternative software such as FOSS investigation, is highly appropriate in this study, since Sri Lanka still lags behind developed and some developing countries that are beyond the country as an ICT education initiated country in 1982 with respect to world standards (Liyanage, 2004).

At present, staff and students of the higher educational institutes of Sri Lanka, use open source operating systems and applications to a great extent (MOE, 2009). ICT specialists encourage the use of open source software in the school system too. As a result, the ICT paper of the GCE (O/L) examination held in December 2008 (DOE, 2008) consisted of principles of ICT rather than the use of specific software products. There are several open source operating systems and application software for ICT in education and for ICT technology areas. If one uses open source rather than closed source operating and applications software and programming language, they can download the source and customize all the software according to the user's requirements (Becta, 2005). These options offer two advantages to the Sri Lankan education system: (i) minimizing funds allocated for the purchase of software and (ii) providing critical and extensive knowledge to the students in our school system, rather than just the use of closed source and pirated software.

In India, initially the Ministry of Education arranged e-discussions with 1400 people, and subsequently called for position papers to collect different knowledge and finally presented recommendations and suggestions to the ICT education policy framework. Further, the Sri Lankan ICT policy does not clearly mention details of implementation. With respect to the other policies; the second statement of the Sri Lankan policy mentions teaching ICT as a school subject and using it as an aid to teach other subjects. It is functioning properly due to the following reasons.

The Government stated that ICT education can be improved through the introduction of an ICT culture to the Sri Lanka educational system (NEC, 2007). The following aspects are identified as a means of introducing ICT culture to the schools system of Sri Lanka in the following aspects (MOE, 2004; NEC, 2007):

- i. Introduction of ICT as a subject at G.C.E. (O/L) and GIT and ICT in the G.C.E. (A/L) curriculum,
- ii. Use of ICT in the classroom to teach other subjects, and
- iii. Use of ICT in the management of the education system

ICT (O/L), ICT (A/L) and GIT (A/L) courses are already implemented in the school curriculum and are evaluated through the national examination and testing service (MOE, 1999; MOE, 2004; MOE, 2011). Because of this evaluation process, students are compelled to learn ICT and teachers are empowered to teach ICT subjects in order to achieve the expected outcomes. The government of Sri Lanka initiated several steps with the collaboration of foreign funded agencies to improve the use of ICT in the classroom to study other subjects and for the use of ICT in the management of education systems; however these improvements are relatively low (MOE, 2004; De Mel, 2005; Department of Census and Statistics [DCS], 2009).

Considering all these facts, most people today believe that an ICT education is a major tool (Lim, & Hang, 2003; Pedro, 2004; Ropke, 2009) for the development of education and is more appropriate with the current trends. At present, the school curriculum of Sri Lanka consists of three ICT subjects: (i) ICT for GCE (O/L) (ii) GIT for GCE (A/L) (iii) ICT for GCE (A/L).

Compared to ICT education in Sri Lanka, India has initiated a well-planned ICT education system. But in Sri Lanka, ICT education is implemented without a proper master plan as in India and Singapore (MOE-Singapore, 2005; MOE-India, 2007) that is, on the trial and error basis (NEC, 2007; Lake House, 2008; MOE, 2009).

Hardware and Sustainability

To avoid hardware failures and with the aim of ensuring computer maintenance the MOE Sri Lanka has initiated the following programme. The ICT branch of the Ministry of Education has made arrangements to implement a programme for the maintenance of computers and other related equipment after the expiry of their warranty period (MOE, 2009). Therefore, the ICT branch has established a hardware trainer's pool in the education system. There are about 240 individuals selected to be trained in this process at the rate of two (02) teachers per zone, one individual for the Provincial Department of Education, one individual from the National College of Education and the staff of the ministry for the trainer's pool. Of these, 40 participants will be allocated to a university for training. In addition, the Ministry of Education and provincial level authorities established fault collecting centers. According to the complaints of faults received from different schools, authorities attempted to resolve such issues.

What are the difficulties and improvement possibilities of software?

At present 95% (MOE, 2008) Sri Lankan schools use Microsoft as an operating system. With respect to computer ethics, all schools and students use licensed software. Further, software is one of the most important aspects of ICT education in any country. The above issues are directly related to ICT education in Sri Lanka. In the ICT policy and ICT education implementers are concerned with all these facts, but still no proper concrete solutions (Gunawardene, 2008) have been put forward for all these factors. Furthermore, attention is needed for the development process of ICT education in rural areas and the usability of Free and Open Source Software (FOSS) in Sri Lanka. Therefore, this is an important aspect because one of the main aims of ICT education is to eliminate the digital-divide and face global challenges in the 21st century (Liyanage, 2004; Piet & Magriet, 2005).

The summary of the literature review can be presented as follows: The above literature exploration reveals that some countries used their own policy proposals and development procedures, while other countries used ad-hoc procedures to implement ICT education in their schools with the guidance of developed or neighboring countries. UNESCO provides some guidelines for the development of ICT education, but it is also not considered as an internationally recognized criterion for ICT education development, globally. Sri Lanka also used different ad-hoc implementation procedures and policy guidelines used by other countries and/or help from our own domain experts periodically. The summary of the literature survey is represented in Table 3.3.

Table 3.3 Summary of Indicators and methodologies used in quality ICT education on international recommendation, Selected Asian countries and Sri Lanka

Factors (Pillars)	Categories	Indicators and methodologies
(i)Infrastructure and computer facilities (Internet, bandwidth, Connectivity, Electricity and Class rooms, laboratories, computers and related accessories)	International	Developed countries like Australia, UK and USA maintain a computer student ratio of 1:5, a computer teacher ratio of 1:1 or 1:2 and the age of a computer is 3 to 3.5 years. Electricity and other necessary requirements (class rooms, multimedia labs and accessories, network and internet connection with suitable bandwidth) are adequately available in developed countries
	Asian	India: They identified that infrastructural facilities are essential to maintain the quality of ICT education. Such factors are: power, connectivity and computer related materials. The MOE-India use computer laboratories and other facilities on a time sharing basis. Further, they used BOOT methodology to acquire infrastructure, computer facilities and initiation and continuation of ICT education in schools. Each computer laboratory in a school is equipped with at least 10 computers and a maximum of 20 computers. Each school has a minimum of one computer laboratory. Not more than two students will work at a computer at a given time, while a maximum of 40 students are accommodated in a computer laboratory. They provided optimum ICT infrastructure in each school with at least one printer, scanner, projector, digital camera, audio recorders and such other devices that will be part of the infrastructure.

		<p>They maintained a computer student ratio of a minimum of 1:10 in all schools in India. Exclusive laboratories with appropriate hardware and software are provided for the Higher secondary classes.</p> <p>They have at least one classroom equipped with appropriate audio visual facilities to support an ICT enabled teaching-learning environment.</p> <p>All the computers in the school are part of a single local area network to enable optimum sharing of resources.</p> <p>Internet connections are provided to the laboratory, library, teachers' common room and the school head's office. Each school is serviced with broadband connectivity of at least 2 MBPS capacity. They provide alternative solutions (timetable for power cut situations) especially in rural areas.</p> <p>Malaysia: MySchoolNet was set up to increase ICT performance in education. Computer student ratio for primary and secondary school is 1:43 and 1:26 respectively. Computer, internet and broadband penetration percentage is 11.3%, 24%, 0.09% respectively. They have acquired the necessary computers and other infrastructure facilities through the smart projects and three master plans with suitable testing.</p> <p>Thailand: They maintain a computer school ratio of 6:1; The MOE has established a computer student ratio of 1:20 for secondary schools and 1:40 for primary schools. 1% lack electricity. They use different strategies and targets to acquire infrastructure and computer resources.</p> <p>Singapore: Through the 1st master plan, they provided essential infrastructure and computer facilities according to the international benchmark for ICT education. The 1st master plan integrates 30% of ICT to the general education curriculum. They maintain a pupil-computer ratio of 5:1 in secondary education, while 6:1 is maintained for primary education.</p> <p>They provide school-wide network to use Internet and digital media resources to teachers and learners.</p> <p>They provide multimedia rooms with necessary equipment (e.g. Digital cameras, multimedia projector, network and internet facilities etc.) to fulfill the required international standards. Further, 2nd and 3rd phases of the master plan have enhanced ICT education up to international standards in all activities.</p>
	Sri Lanka (from Literature)	Several projects (GEP2,SEMP,SEMP2,OLPC Solar Power Project, EKSP and more) were implemented as ways of acquiring computer resources and infrastructure facilities to the Sri Lankan educational system. SchoolsNet is hosted to enhance the quality of education and increase the accessibility of on-line

		<p>materials. 1765 senior secondary schools, 17 National Colleges of Education, 100 computer centers, 09 provincial centers, the National Institute of Education, and 9 provisional education centers are connected to the SchoolNet. 76% of schools have electricity; a few schools use solar power.</p> <p>The computer literacy ratio of teachers is 40%, Computer awareness of teachers is 59.5%, Teacher: Computer Ratio is 7:1, student computer ratio is 100:1, student computer literacy rate is 1:57 and computer laboratory percentage is 40%.</p>
(ii) Curricula (e.g. quality, contents and implement ation issues)	Internationa l	<p>Internationally recommended indicators for this category are: Availability of textbooks, teachers' subject knowledge, appropriate pedagogical usage, verbal abilities of teachers are essential for the implementation of quality ICT education. Students and teachers need sufficient access to digital technologies; teachers need quality training on computers and pedagogical knowledge. Proper pre-service and in-service training is needed to fulfill training requirements. The curriculum should be embedded to obtain the expected skills thorough theory with practice. ICT literacy, application of ICT in other subject areas, infusing ICT across the curriculum, and ICT specialization is required as a standard for the 21st century. International recommendations say "Curriculum can be considered as a framework or guideline to obtain expected skills through the curriculum using theory with practice several curriculum developments and teaching and learning models were provided by UNESCO and related organizations for developing countries.</p>
	Asian	<p>India: They provided adequate infrastructure and capacity building for ICT development. They provided e-content to enhance the quality of education. Public private partnerships were obtained to increase the quality of education. Incentives were provided by the state government for the creation of the contents in the local language for free distribution. Students and teachers were encouraged to learn English. Awareness, motivation, attitudes and behavior change programs were conducted to motivate students and teachers in rural areas. CD based educational contents were introduced in rural areas. A majority of the implementation issues were solved by outsourcing equipment and services from NIIT as BOOT methodology. All pre-service teacher training programs included compulsory components to introduce ICT education.</p> <p>Malaysia: A computerized school management system, a data center and the Minister's help desk were introduced. The ministry educational division handled the pre-service and in-service teacher training programs. The curriculum development center conducted some training for ICT teachers. It provided ICT diplomas and ICT degrees to ICT teachers. E-learning programs were implemented</p>

		<p>with the collaboration of universities. Pre-services teachers awareness skills were tested through the international driving license test.</p> <p>Thailand: They provided distance learning activities throughout the country. They provided facilities to manage 80% of educational organizations through ICT. They provided appropriate knowledge for 80% of ICT graduates. Facilities were provided to meet 50% of the ICT knowledge to meet international standards. 90% of the students were provided access to information and creative opportunities in rural areas through ICT. On some occasions, training was provided to many teachers and they were not able to apply what they had learned to their classroom teaching and learning due to constrain of their heavy workload and rigid class schedule.</p> <p>Singapore: They trained teachers to use technology in the classroom to enhance the teaching learning process. The teaching and learning process was improved through collaboration with the ICT industry. ICT was integrated to 30% of the curriculum. Digitized media resources were provided to be accessed in all classrooms and learning areas. A systematic and holistic approach was adopted to develop quality curricula, assessment, and professional development to improve the learning culture in schools. Web based training programs were developed. Blended learning technologies and other pedagogical techniques were implemented.</p>
	Sri Lanka	<p>The government provided teacher training facilities, physical resources, selected course units curriculum and guidelines through different foreign funded projects (GEP2, SEMP, SEMP2, etc.). Even though the government provided such resources, there are many challenges in the implementation of the ICT curriculum (skilled teachers, sufficient physical and human resources, proper guidelines). For example, SchoolNet is implemented, but the quality of resources, access flexibility, and student motivation for usage are minimal. Further, different training programs are implemented (e.g. training through NIE, Universities, ICDL certification etc.). If ICT education is implemented in the absence of the required facilities, there will be no difference in grade distribution when compared with other subjects in the same basket as ICT specialization subject for GCE (O/L). Further, this showed the ICT specialization subject for GCE (O/L) is of an acceptable level of achievement when compared with the other ICT subjects in the school curriculum (ICT in Education, GCE (A/L) ICT etc.) which are at primary level. But usage of pedagogical techniques is minimal when compared with other developed countries.</p>
(iii)Software	International	<p>Free and open source software (FOSS) is recommended by UNESCO for developing countries as well as experiences based on</p>

		European and other developed countries. Software should be selected after investigating the real requirements (e.g. curriculum compatibility, financial and productivity). Use of mother tongue software is encouraged as much as possible. A Software procurement scheme should be in place to obtain software easily and at discounted prices. Research institutes should be available for the development of customized software requirements. The 'Blended Learning Approach' and FOSS are recommended for schools.
	Asian	<p>India: FOSS products are highly recommended for school ICT education. Further, their curriculum emphasizes principles, not the products. They recommend software development using local languages and their free distribution. CD based software are recommend for rural areas.</p> <p>Malaysia: The Government of Malaysia highly recommends open source software for education, as well as for industries. They have initiated several projects and have created a fund to enhance development activities of open source software.</p> <p>Thailand: The literature review does not provide detailed information about the usage of open source software.</p> <p>Singapore: They propose commercially available software products for schools. They set up a clearing house to evaluate, and recommend suitable ICT based learning resources (CD based software, internet sites to schools, learning websites edumail etc.). Further, they have motivated interested parties to develop mother tongue software within the limitations of allocated budgets</p>
	Sri Lankan	A majority of teachers and students use closed source software. But some ICT curricula encourage open source, rather than closed source systems. Further, all curriculum requirements can be replaced with open source software. Using FOSS Sri Lanka can (i) minimize funds allocated for the purchase for software (ii) provide critical and deep knowledge for students and teachers
(iv)Hardware maintenance and sustainability plans	International	The recommended benchmark for computers and related hardware is: all computers and equipment to be upgraded or replaced with new ones every three years or three and a half years. These changes in upgrading are performed on Moor's Law and Metcalf's law. Networks and network based information and services are available anywhere in the school system. According to international standards, the maintenance scheme covers warranty and maintenance services for every three years. Low-cost wireless connectivity is recommended for schools

	Asian	<p>India: They considered power cuts and power cut schedules with respect to ICT practical sessions. They included a lump sum for maintenance activities in the BOOT model for smooth functioning. They considered the following activities as computer maintenance: preventive maintenance, troubleshooting and repair. They incorporated models of infrastructure, procurement and maintenance in budget activities.</p> <p>Malaysia: They introduced and implemented comparable hardware maintenance activities through different school projects in Malaysia. Help desk and service centers throughout the country were provided for maintenance and support.</p> <p>Thailand: There is no adequate literature available on the maintenance and sustainability activities in Thailand schools.</p> <p>Singapore: All maintenance and sustainability activities are included in the three master plans. Further, they have provided a technology assistant to give first-level on-site support in resolving hardware, software and maintenance work. Further, their warranty includes 3 years of computer maintenance.</p>
	Sri Lanka	<p>MOE gave permission to conduct ICT courses to others after school hours and to earn an income to make them self-sustainable and for maintenance activities. These methodologies have failed due to several reasons. They obtain 3 years comprehensive warranty for all purchased items. They have created 240 staff members for the hardware maintenance pool to cater to hardware requirements in all the provinces. 40 participants have obtained special hardware training at national universities.</p>
(v) Human resource development (e.g. qualified and skilled teachers, teacher trainers, appropriate advisors and professionals and appropriate methodologies)	International	<p>Quality of teachers may include their competencies (integration of knowledge), skills (practical and professional experience), and attitudes (perspectives and appreciation of the profession etc.). The number of teachers, amount of teacher training, teacher's subject knowledge are quality indicators for ICT education. In other words, teacher competence includes "the right way of conveying units of knowledge, application and skills to students"</p> <p>A professional development process was recommended as in the following four methodologies: (i) ICT literacy training (ii) Application of ICT in subject areas. (iii) Infusing ICT across the subject area (iv) ICT specialization. In addition, support from the administrators, awareness, pedagogical application skills and attitudes are the major international indicators in connection with human resource development. Further, the following are identified as the international goals that should be included in the human resource development of ICT (i) digital age literacy, (ii) inventive thinking (iii) effective communication (iv) high productivity. Face-to-face training programs and blended learning or adoptive learning</p>

		<p>programs were implemented with the international community to enhance the quality of education. International educational organizations use e-learning as one of the major activities in the human resource development process.</p>
	Asian	<p>India: They have identified that one of the major indicators for ICT education is human support and the skills development process. For human resource development in India, they mostly use training colleges and NIIT. Based on international standards, NIIT provides the required training for instructors (teachers) to implement the curriculum. Further, they train school teachers and finally hand over the entire activities to the respective schools. Through the BOOT methodology, teachers obtain the required curriculum training in an on-site environment. All pre-service training programs include a compulsory ICT component for their training programs and hence the ICT knowledge of teachers is added to the system,</p> <p>Malaysia: they identify the vital impact of training in the implementation of any project. Various agencies within the ministry of education conduct ICT training for ICT teachers both in-service and pre-service. They conduct teacher training activities on a cascade model. They recruit ICT diploma and degree holders to the school system with proper pedagogical training.</p> <p>Thailand: Basic ICT skills, intermediate ICT skills (optional) and advanced training for teachers who are performing ICT specialization subject are provided as in-service teacher training courses. For ICT training activities, they select 80% ICT graduates and the majority of distance learning activities are also used for ICT teacher training activities. They provide OLPC programs for some selected schools in rural areas.</p> <p>Singapore: They provide ICT training with up-to-date technologies for teachers through the 1st phase of the master plan. One of their main objectives was to harness ICT for instructional purposes. Teachers train on ICT to integrate 30% of the curriculum. Every teacher receives 30-50 hours of training on the integration of ICT. MOE collaborates with industries and research institutes to undertake research and development in connection with teacher training. They have introduced a computer purchasing scheme to motivate students and teachers. They conduct several workshops on Saturdays. More advanced ICT based pedagogical principles and skills are offered for professional development (e.g. constructivist learning with the internet and instructional multimedia design) an advanced diploma and advanced postgraduate diploma were introduced for professional development.</p>

	Sri Lanka	There are several training programs (from universities, teacher training colleges, National Institutes of Education, CRC centers, selected private institutes and other organization) implemented to introduce and enhance ICT education in Sri Lankan schools. This training includes training of master trainers, ICT specialization subjects, ICT in education, hardware and networking, E-citizenship programs for school Leaders, OLPC training, etc. . The period of training varies from 30 hrs. 21 days and some months and years. Cascading training programs are implemented at zonal, district and provincial levels.
(vi) Research and developme nt	Internationa l	They have recommended research and development institutes within the Ministry of Education with the collaboration of university academics, industry and authorities from the research organizations. The two main objectives of universities are research and teaching. The wider available powerful ICT tools are used in ways so as to support students' learning. Most researchers and MOE authorities have accepted that ICT education is enhanced further through the research and development process. Principals, parents, universities and other research institutes, academics, ministry and zonal educational authorities are the leaders in education, as well as in ICT education. Researchers have shared their knowledge and findings to develop ICT education in any country in order to promote a school culture which encourages exploration of new techniques in teaching, learning and management. Hosting of appropriately time-framed IT education research development conferences to enhance ICT education has been recommended. Most developed countries have identified that research and innovation are one of the key thematic areas in the ICT education development process.
	Asian	India: Research and development are identified as one of the key development concepts in ICT education. Research and innovation have extensively contributed to the ICT policy formation process of India. A FOSS solution for ICT curricula through research activities has been proposed. Research findings are used to introduce ICT based solutions (e.g. CD based education) to motivate students in rural areas. Malaysia: with the research collaboration of the University of Malaysia, E-learning activities for ICT school education were developed. Their research areas are introducing Open Source

		<p>Software (OSS) and ways of narrowing the digital divide through research and innovations.</p> <p>Thailand: ICT development activities (Creating opportunities to enhance access to, and improving the standards of e-learning media through collaborative initiatives to develop information (e-contents) through different learning media, and the promotion of the use of ICT to support personalized learning in line with different learning needs in remote areas were introduced through research and development.</p> <p>Singapore: through Master Plan 1, MOE has collaborated with industries and research institutes to undertake research and development for ICT education.</p>
	Sri Lanka	<p>Individuals and groups of people in universities and research institutes conduct research activities in the development of ICT education. Usage of such findings is minimal. Motivation from government or relevant authorities for research and development in connection with ICT education is minimal for the development of ICT education, when compared with other selected countries in this study.</p>
(vii) support from administrators(school leaders, controlling authorities of education) and supportive initiatives (internet, e-mail, School Net, web sites, computer societies)	International	<p>ICT awareness programs were provided for school leaders and relevant administrators. Computerized school management systems were recommended. Leadership programs were considered as one of the major attributes to enhance quality ICT education. Therefore, the following authorities are considered as leaders: principals, parents, universities, research institutes. It was realized that the principals were the leaders and users of ICT education as a role model to the school community, thereby demonstrating the importance of ICT. Based on the concept of “Effective leaders are role models for other staff”, ICT development proposals were provided. Further, it was recommended that leadership, encouragement, knowledge of ICT was essential for officers in the Ministry of Education, as well as provincial and zonal schools. As international indicators, supportive initiatives were greatly recommending because e-learning technologies were recommended in addition to face to face learning. Further, internationally recommended conditions for qualify ICT education and supportive initiatives such as Internet facilities, school net, school websites etc. were introduced.</p>
	Asian	<p>India: Also greatly encourages public-private sector partnership for ICT development. They collect important strategies through calling for position papers; they use school administration applications (e.g. school management, time tabling, educational management information systems). CD based educational software for rural areas</p>

		<p>are provided. Use of internet facilities, maintenance of school web sites and school net as supportive initiatives for the ICT development process of School ICT education is encouraged.</p> <p>Malaysia. Provides SchoolNet and websites for the development of ICT education, There is no other literature for supportive initiatives.</p> <p>Thailand: Some schools have implemented supportive initiatives, while some schools have not allocated budgets to initiate supportive initiatives.</p> <p>Singapore: Encourages initiation of special projects to engage teachers and pupils in the continuous and active exploration of ICT use, by promoting administrative and management excellence in education. They provide school wide network for all the schools to have access to Internet and allow digital media resources. Additionally, web based training has been introduced and close collaboration with industry partners and research institutes.</p>
	Sri Lanka	<p>The MOE provided SchoolNet facilities, encouraged establishment of ICT clubs in schools , encouraged preparation of own personal web sites and schools web sites, encouraged conduct of ICT education development research conferences, initiates and awards schemes to encourage educators to promote initiatives in ICT education</p>
(viii) Policy guidelines and monitoring and evaluation plans	International	<p>The International recommendation for ICT education is the development of ICT education through ICT policy guidelines. Further, policy covers evaluation and the testing process also. ICT education was developed through the provision of necessary facilities to meet international indicators (e.g. computer student ratio, international and new educational technologies (e-learning, blended learning etc.) skills, attitude changes and performance (test score, graduation rate etc.) and quality maintained through monitoring and evaluation processes. Various initiatives were taken to minimize rural and urban disparities such as: student computer ratios, teacher student ratio, quality of teachers and related issues, distance from school to residence and more are maintained.</p> <p>Guidelines for teaching, learning, testing, resource allocation and managing with in-depth investigation are provided. This includes quality of teachers, class room setting, curriculum standards, supervision and monitoring of teachers learning process, curriculum implementation process, and quality of support from the administration.</p>
	Asian	<p>India: India has created a national policy with partnership originations and created a policy through a conducive multi-stakeholders process. They have considered the entire country's requirements and obtained facts from all the stakeholders in the system. They have developed an ICT policy to cater to the following seven thematic areas: infrastructure, capacity building, e-contents,</p>

		<p>and quality in school education, innovation and research public-private partnership, monitoring and evaluation. Their policy includes important decisions such as “the syllabus/curriculum should empathize principles and not products”. Whenever possible, the use of FOSS is encouraged. At the initial stage ICT education was developed with BOOT methodology.</p> <p>Malaysia. Their policy follows three major steps. The first step includes narrowing of the digital gap between the schools in different areas. The second emphasizes the role and function of ICT education in teaching and learning as a tool. The third policy stage includes emphasizing the use of ICT to increase productivity. Policy guidelines were applied for the development of ICT education through the smart school concept. Web based teaching and learning, computerized school management system, local area networks and virtual private network and help desk concepts were the concepts included in the policy activities. The cascade training process was implemented with master trainers and others in the country. Policy matters on the development of: teachers training, infrastructure development, software development, web designing and web based learning and hardware maintenance were introduced. Students and teachers are motivated to use OSS.</p> <p>Thailand: Their plan was to provide all levels of students with learning and teaching activities using ICT. Their aim on ICT policy is to face the following challenges: provide facilities to acquire qualified ICT personnel, give incentives to motivate ICT personnel, provide adequate financial facilities for ICT development, and minimize virus attacks.</p> <p>Singapore: all policy matters are included in their master plan under three stages. They include training of ICT teachers, acquisition and provision of software and hardware for schools, support from administrators for ICT education implementation in schools, maintenance of a standard ratio of indicators (e.g. 30% curriculum with use of ICT, student ratio as 1:5 and 1:6, computer teacher ratio etc.), encouraging creative thinking, lifelong learning, social responsibilities and promoting administrative and management excellence in education. Policy specifies that every school should include school-wide networking, internet and digitized resources to be accessed in all classrooms and learning areas. They recommend CD based software titles, internet sites via MOE learning websites and web based learning approaches. Further, plans include curriculum assessment procedure, instructional professional development, and student leaning culture of the school.</p>
	Sri Lanka	Two draft polices were developed to enhance the quality of ICT education in Sri Lankan schools. The important strategies included in the draft policies are: curriculum development, human resource

		<p>development, physical/human resource development and support development of initiatives. Further, it includes SchoolNet for the development of ICT education. Further, the activities mentioned above are expected to be completed by 2013. But the above activities have not been implemented as expected due to various reasons.</p> <p>Although they are not implemented as a valid policy, some activities are functioning at marginal level. Further, draft polices have shown that ICT education and ICT culture can be introduced through supportive initiatives (e.g.IT Clubs, schools web sites etc.)</p>
<p>(ix) National goals and budget allocation.</p>	<p>International</p>	<p>The developed countries (within the MOE or relevant organization) established research institutes to set objectives and to achieve the expectations of the country's education system. Further, they allocate required funds from their GDP and through specialized projects. In some countries, budget allocations for ICT education and the country's expectations are set through different master plans and projects. Further, international expectations of ICT education are: (i)to minimize the digital divide, (ii) to accelerate the poverty reduction process, both nationally and globally, (iii)to introduce a knowledge society ,(iv)to obtain independence of the wired-world, (v)to developed students' skills through a student oriented approach</p>
	<p>Asian</p>	<p>India: all ICT expectations are included in the ICT policy. To achieve the objectives in the ICT policy, a majority of services and equipment are outsourced from reputed organizations through a BOOT Methodology and further they maintain a computer student ratio of 1:10 and other standards at an acceptable level as mentioned in Chapter 2. Their ICT deployment process covers the following major tasks: Infrastructure, Capacity Building, e-Content, Quality of School Education, Innovation and Research, Public-Private Partnerships and Monitoring and Evaluation</p> <p>Malaysia: they developed ICT education through smart school projects to achieve the aims of the National Philosophy of Education, as well as to foster the development of a workforce prepared to meet the challenges of the 21st century.</p> <p>Their learning process was designed to stimulate thinking, creativity, and caring for all students, cater to individual differences and learning styles, based on more equitable access. They maintain and enhance ICT education through smart school project activities using the allocated funds from GDP. Additionally, they maintain a computer student ratio of 1:26(secondary) and 1:43 (primary) and other indicators at an acceptable level as mentioned in Chapter 3.</p> <p>Thailand: Their aim is to provide facilities to all students in the country through e-learning and OLPC form in rural areas to enrich ICT education in Thai schools. There is no literature on budget</p>

		<p>allocations. And also, they maintain a computer student ratio of 1:40 and other equipment and standards to some extent. All these indicators and requirements are presented in Chapter 2</p> <p>Singapore: Through a series of master plans, they have set objectives and enhanced the learning skills (creative thinking skills and communication skills). They have achieved international standards of ICT education (e.g. computer student ratio of 1:5). The aim of ICT education is to prepare students for the workplace of the future. Their main expectation is to harness ICT for institutional purposes, and to provide directions to schools for the integration of up-to-date technologies into the educational process. Furthermore, their expectations include encouraging creative thinking, lifelong learning and social responsibility; Generating innovation in education; and Promoting administrative and management excellence in education</p>
	Sri Lanka	<p>At present, ICT education is implemented with GDP allocations, and through foreign funded projects. But funding does not fulfill requirements. The aim of ICT education is to give a well-accepted ICT education to students all over the country to face international standards to face the 21st century.</p>

According to the literature survey, it is revealed that there is no universally accepted international standard for ICT education. The literature review also identified the main more appropriate quality factors, indicators and methodologies used for the development of ICT education in a comparative manner.

Although the Sri Lankan education system applies guidelines, indicators and methodologies, the suitability of guidelines and implementation procedures in the Sri Lankan context have not been determined in a pragmatic manner.

Chapter 4: Research Methodology

4.1 Introduction

This chapter presents information regarding how the study was planned and the action taken to achieve the research objectives. Further, this chapter illustrates the designing philosophy of achieving the specific objectives of the study. The three tier architecture was used. The detailed design of the first two tiers is provided in this chapter. Obtaining the outcomes of the first two tiers, the third tier was designed and implemented and the implementation procedure is presented in Chapter 6.

All the objectives of the study are mapped on to the three-tier architecture. The design performed to achieve the objectives was as follows: objective one was achieved from the literature review while objective two was achieved through the literature review and the survey. The third and fourth objectives were designed with the aid of gap analysis, and other theoretical aspects (Aristotle's influential categorization of knowledge, UNESCO proposed models, etc.) were used to obtain feedback from observation and evaluation techniques. The sample survey was designed to obtain information from 5 districts, 35 schools, 35 principals, 1295 students and 48 ICT teachers. In addition to this, a variety of stakeholders (MOE, NIE, NCOE, NEC, CRC, Universities and ICT experts in industry) in ICT education and different methodologies (classroom observation and workshops) was used in the survey. As fact gathering instruments, questionnaires, unstructured interview schedules, classroom observation sheets and workshop monitoring sheets were designed and used. Methodologies to analyze the data using analysis techniques (descriptive statistics) were provided. The overall percentages, averages, modes and ranges (where applicable) were used and presented in table and/or chart form. Further, the inferential statistical analysis as hypotheses testing were used. The hypotheses were tested with Kruskal-Wallis test, Paired-T test and correlations coefficient with suitable confidence intervals. As the main techniques of data presentation and visualization; data reduction, data organization and data interpretation were done using the CS-Pro, SPSS, MINITAB Packages because all these features are incorporated in the above mentioned packages.

Finally, the design provides the mechanism to achieve all four objectives and obtain the status expected and the achievable level of ICT specialization subject for the GCE (O/L) curriculum in Sri Lankan schools. This outcome of the first-four objectives was used as an input to achieve the 5th objective of the study. Achievement of objective 5 via the 3rd tier of the proposed model is included in Chapter 6.

As discussed in Chapter 3, the basic requirements needed to maintain quality ICT education is summarized in Figure 4.1 as the overall design framework.

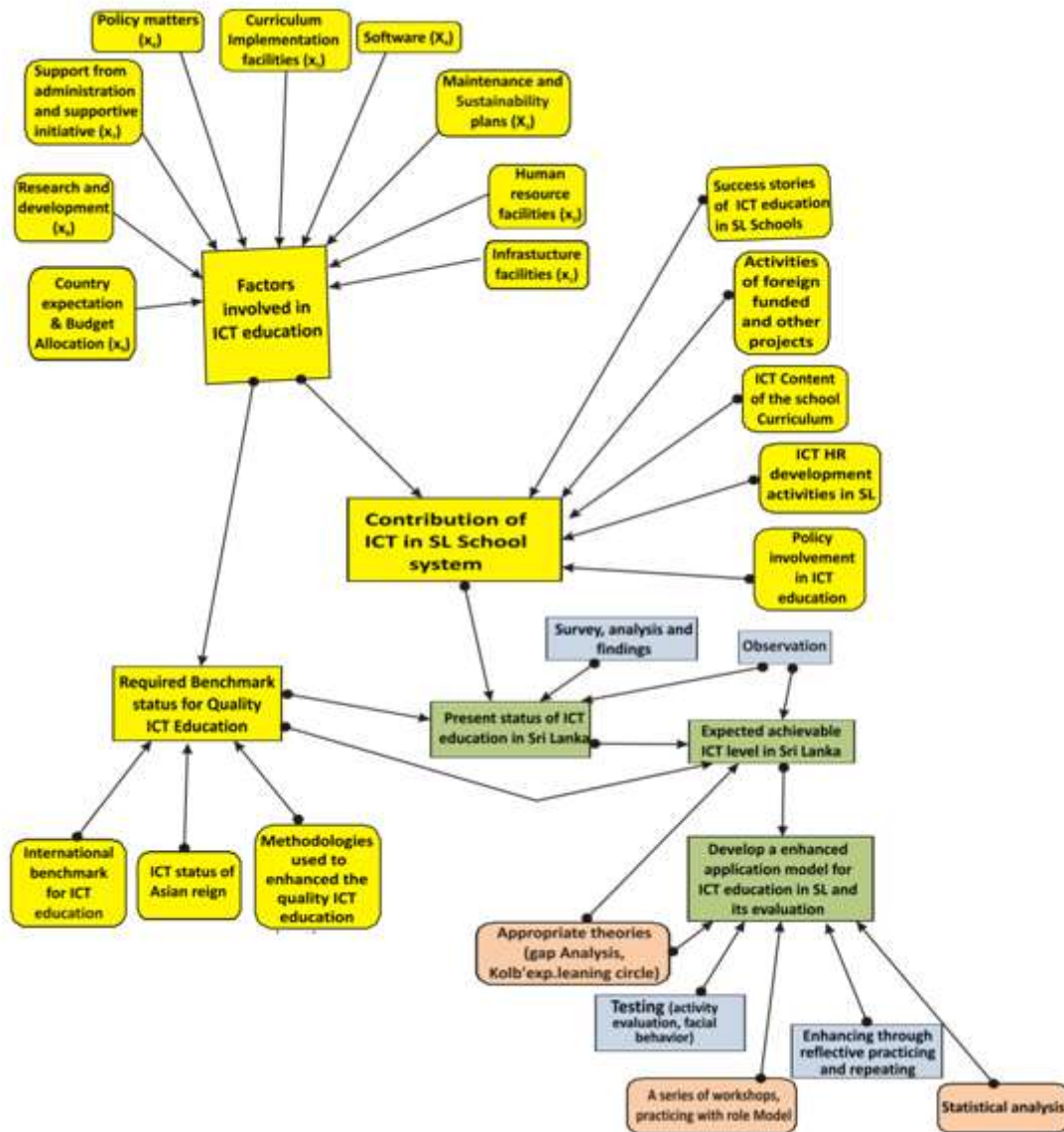


Figure 4.1 Complete design frameworks for the study

In the above diagram, the yellow coloured section represents the tasks achieved through the literature review. However, requirements shown in the major task as in other colours have not been properly evaluated in the Sri Lankan context. Therefore, this study intends to collect empirical data relations to achieve the requirements shown in green in Figure 4.1 as a way of achieving the objectives of the study.

The related literature review has provided vital information to design the study in order to achieve the objectives to a great extent. In this regard national goals, country expectations, budget allocation, international benchmarks and standards related to quality ICT education such as infrastructure facilities (X_1), human resource facilities (X_2), maintenance and sustainability plans(X_3), software (X_4), curriculum implementation facilities(X_5), policy matters (X_6), support from the administration and supportive initiative(X_7), research and

development(X_8) and budget allocation and country expectations (X_9) are essential factors in the investigation of the quality of ICT education in Sri Lanka. In the design stage, the conceptual model is expanded up to a complete design framework which includes how the investigation was carried out, the quality indicators for ICT education in Sri Lanka and the development framework for ICT education in Sri Lanka. This application model will give a better understanding of various factors such as external conditions, economic values and the real world setting which affects the quality of ICT education. Further, Chapter 2 provides knowledge towards a comprehensive approach for a qualitative and quantitative research. This research includes a complete design framework with the aim of understanding the external world entities and to give a high level of a qualitative and quantitative approach. This study includes a complete design framework that elaborates the entire design approach as shown in Figure 4.2

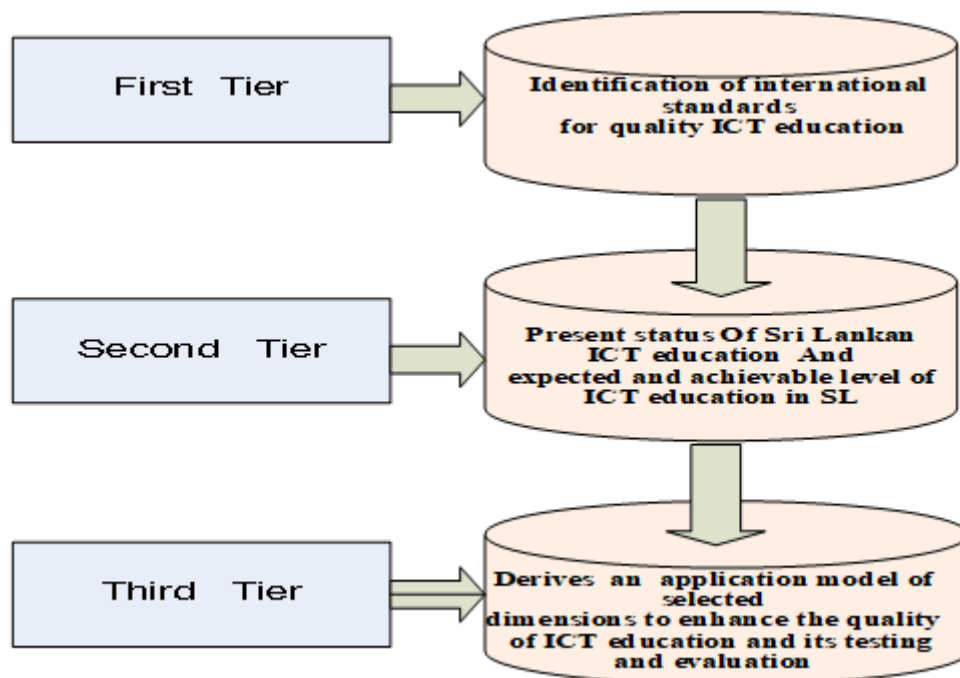


Figure 4.2 Three tier architecture of the proposed research design model

According to the overall research design provided in Figure 4.2, the research study was implemented in two phases as follows:

Phase 1: Provides detailed design approaches to achieve the first two tiers of the proposed design. Further, the first-two tiers of the design cover the achievement of the first four objectives as: The first objective achieved according to the design approach specified in Figure 4.3 using the literature review. Second objective: Based on the outcomes of objective 1, a survey was conducted to identify the present status of the quality of ICT specialization subject for GCE (O/L) in Sri Lankan schools. From the survey analysis and gap analysis and other methodologies, the third and fourth objectives were achieved. Achievement of objectives 1 to 4 are presented as follows: (i) literature review presented in chapter 3, (ii)

presentation of the survey results is included in Chapter 5, (iii) Chapter 6 includes findings, discussions, conclusions related to the first two objectives while chapter 6 also includes the achievement of objective 3 and 4 via gap analysis, descriptive and inferential statistical techniques and other theoretical aspects. At the end of phase I, the necessary information, guidelines and relevant criteria for the design and implementation of activities of Phase II are provided.

Phase II: According to the design approach provided in Figure 4.2, with the detailed design and implementations of deriving an application model of selected dimensions to enhance the quality of ICT specialization subject for GCE(O/L) curriculum in Sri Lankan schools the outcomes of Objective 1 to 4 were implemented and the testing and evaluation of the suitability of the proposed application model to the Sri Lankan school environment with a small group is presented in the same chapter, as the means of achieving objective 5 of the study.

According to the complete design framework, a survey (e.g. regarding the present facilities, classroom observation, workshops etc., a series of interviews and other related activities (e.g. activities implementation and testing)) was used to achieve the objectives of the study. The development of suitable instruments was greatly applicable to the achievement of the expected goals of this study. As a way of reducing the design complexity and to introduce modular engineering as discussed in Chapter 2, the study design process is performed based on the three tier architecture. The entire methodology will be presented as follows.

4.2 Research Design

Overview

Considering the research objectives and facts explored through the literature survey, the design process can be divided into three major phases: (i) Explore the factors (or indicators) that contribute to the maintenance of the quality of ICT education (ii) Determine the present status of ICT specialization subject for GCE (O/L) in Sri Lankan schools compared to international standards and according to the status existing in the Asian region. Subsequently identify the gaps in ICT education of the Sri Lankan school system as an acceptable and achievable level. (iii) Propose a criterion for maintenance of the quality ICT specialization subject for GCE (O/L) in Sri Lankan schools, develop an application model to enhance the quality of ICT education in Sri Lankan schools and implement testing and evaluation on a suitable testing platform.

The complete design framework of the study is shown in Figure 4.1 which includes the achievement of the objectives of the study. Further, the three-tier architecture (Gray, 2000) was modified and applied to achieve the objectives of the study. The activities are divided into three categories and are mapped on to the three tier architecture described in Figure 2.2, Chapter 2. All activities in the study are laid in a well-organized and solvable manner in the proposed three-tier model. Further, the three major activities of the of the study can be represented using the proposed three tier architecture model as shown in Figure 4.2 In addition , the above high level design approach can be further refined and shown in a detailed manner as follows.

Detailed Design

With the aim of achieving the specific research objectives of this study and providing a framework for a sustainable quality model for ICT education in Sri Lanka, the research was designed as three tiers. An overall study approach is presented in Figure 4.1, the basic three tier architecture design model is represented in Figure 4.2 and all three tiers in detail are represented in Figure 4.3, 4.4 and 6.5 in Chapter 6 to represent the entire design approach of the study.

The detailed design of the first tier is as follows:

First Tier: This will identify the necessary factors needed for quality ICT education in schools and will investigate the specified international benchmarks recommended by the international educational agencies and status of the Asian region. In addition to the above, ICT education and its development procedure in the Sri Lankan system were explored. Chapter 3 was designed to identify indicators/factors that represent the quality of ICT education and explores the existing criteria and methodologies used for the development of ICT education in international organizations, relevant authorities in the Asian region, government and other (e.g. NGO) organizations in Sri Lanka. The first tier of the research design approach has achieved the following specific objectives; First objective and a part of the second objective which is the investigation of the past contribution and development of ICT education in the Sri Lankan educational system.

Further, the graphical representation of Tier 1 is represented in Figure 4.3

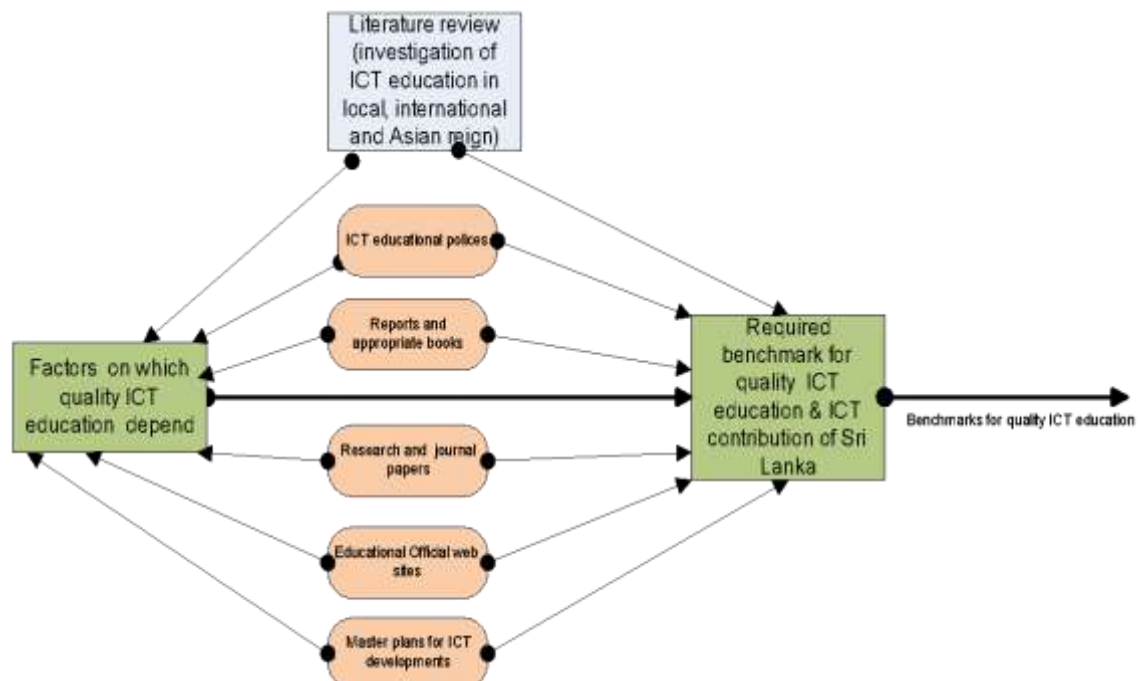


Figure 4.3 First Tier of the research design

Second Tier: Based on the outcomes found in Tier 1, a mechanism to fill the gaps specified in the literature review was found and finally an expectable and achievable ICT education system for the Sri Lankan education system was designed as shown in Figure 4.4

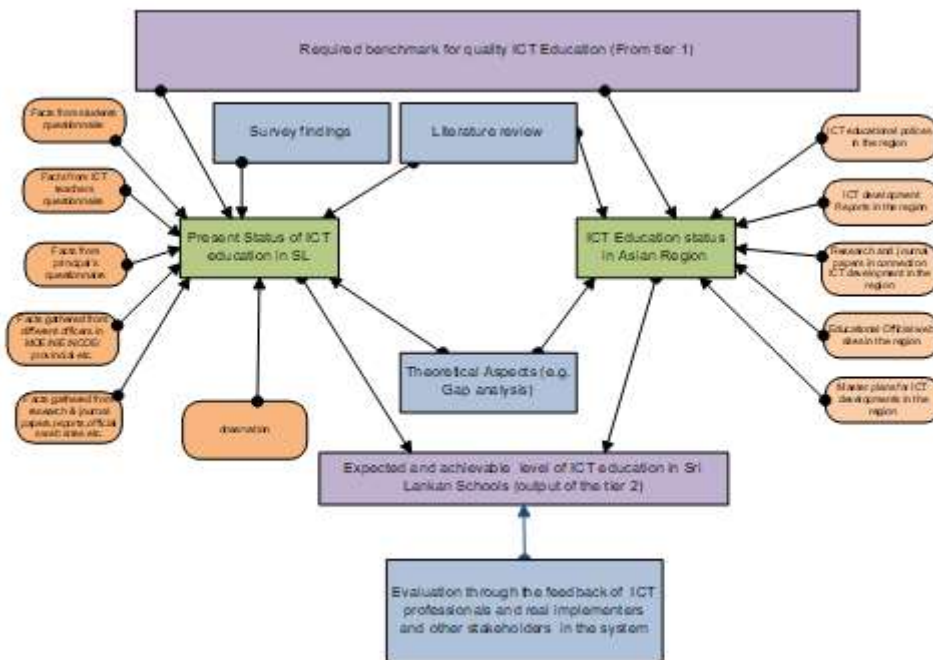


Figure 4.4 Second Tier of the research design

As the initial task of tier 2, a survey was conducted to determine the present status of ICT specialization subject for the GCE (O/L) curriculum. The status of ICT education in the Asian region was also investigated as a part of the literature review. As the final task of the 2nd tier, the 3rd and 4th objectives were achieved as follows:

As a means of achieving the above objectives, the following stakeholders and authorities were selected for the survey. The logical structure diagram of the survey is represented in Figure 4.5 and survey findings were utilized to achieve the second objective.

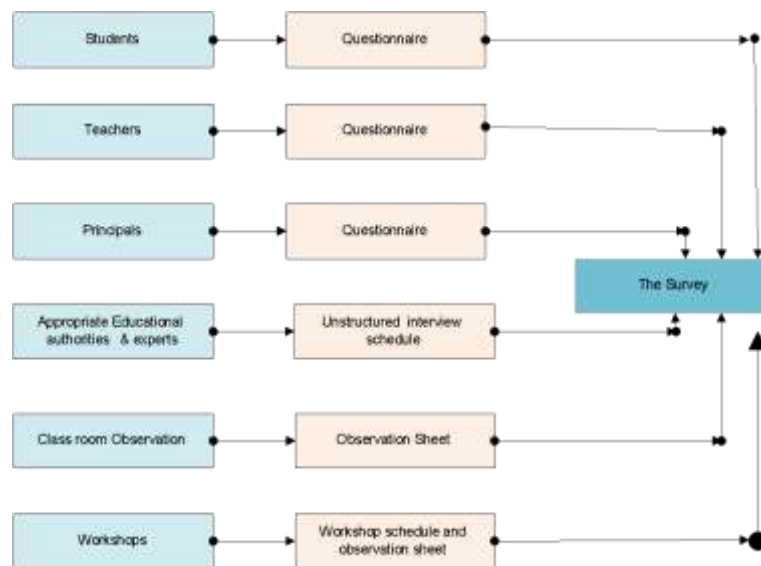


Figure 4.5 Basic Structure of the preliminary survey

Using the theoretical aspects (descriptive and inferential statistics and other educational theories, etc.), the gaps in ICT education in the Sri Lankan school system were determined and finally an expected and an achievable level of ICT specialization subject for GCE (O/L) in Sri Lanka with evaluation was proposed based on the feedback from professionals and stakeholders shown in Figure 4.4.

This tier, designed on the observations obtained through the survey findings, has been used in theoretical aspects, proposed models for ICT education developments and gap analysis. In addition to the above, Tier 2 of the research design model includes Gap analysis which determines how to develop an application model for ICT education in Sri Lanka to the expected level. The expected standard of ICT education in Sri Lankan schools does not match the present situation (Ministry of Higher Education [MoHE], 2009). There is a gap in the present situation and expectations. Therefore, it is essential to identify the gaps and hence a framework to eliminate such gaps is greatly important in this study. The design approach for the gap analysis is presented as follows.

Gap Analysis is a strategic planning tool to help one understand where one is, where one wants to be and how one is going to get there. The following model (Figure 4.6) shows the proposed model to determine the gap in an existing ICT education system in a developing country. It was customized on the model proposed by Charles (2004) to determine the current gap in an educational system.

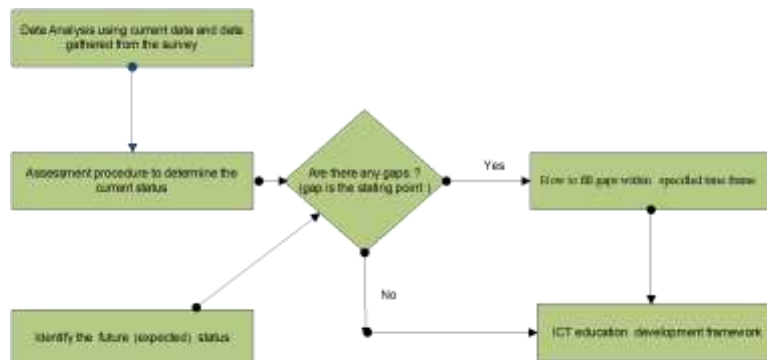


Figure 4.6: Gap eliminating process

According to the Figure 4.6, gap eliminating guidelines, the gap analysis instrument was designed (according to the Table 4.1) and was used to eliminate the gap.

Table 4.1, Table of the gap elimination guidelines

Factors	Attributes (if any)	Gap identification Process			How to fill gaps within a specified time frame
		Current	Expectation	Gap	
National Goals					
Infrastructure facilities					
Curriculum implementation					
Software					
Hardware and maintenance					
HR development					
Research and development					
Supportive initiative and support from the administration					
Policy Guidelines					

The selected participants and other procedures for the survey are given as below.

4.3 Sources Of Data

Overview

Under the literature review, three important categories of people were identified for the survey. They were students, principals and ICT teachers. From the student population, a more suitable sample of students had to be selected to achieve the expected goals. Therefore, the most suitable student sample was a group of students who were doing ICT as a subject in the GCE (O/L) curriculum. Further, these students were appearing for their National GCE (O/L) examination and the national evaluation was applicable to these students. Moreover, ICT teachers and principals who conduct ICT as a subject in the GCE (O/L) curriculum and provide facilities in their schools are the most suitable participant for the survey. In addition to the three categories above, there are other people and organizations involved in the ICT education development process. As other important key stakeholders, the following persons

or organizations were selected for the survey as they are identified as the most suitable people from the literature review.

Relevant authorities from NIE and MOE: these authorities are responsible for providing facilities for successful ICT education (e.g. providing infrastructure, computers, human resource allocation, administration, monitoring and evaluation, curriculum design and teacher training and further activities).

Selected officers from CRC centers and Provincial ICT center coordinators: CRCs provide computer facilities and ICT instructions for the students and teachers while provincial ICT center coordinators are responsible for enhancement activities of ICT education at the province.

Selected NCOE officers: these officers are responsible for in-service and pre-service teacher training activities and some involvement in the curriculum design and development process)

Selected NEC officers: this authority is responsible to provide education policy and make recommendations ensuring continuity in all segments of the education system in the context of the changing needs of Sri Lanka.

Selected Provincial and zonal ICT officers: they facilitate ICT education activities and help enhance ICT education through different activities.

Selected ICT experts from Universities and Industrial experts: they provide expert knowledge for the creation of the education policy framework, curriculum development, teacher training as well as for the evaluation procedure and requirements of industry to set the educational and learning objectives)

Class room observation sessions with ICT students and teachers: provide real feedback about the current situation in ICT education)

Two workshop sessions for ICT teachers (provide facilities to determine the real status and environment of the teaching and learning activities and to identify the modifications needed for the enhancement of ICT education development possibilities through observation)

For the data collection, Multi-Stage sampling theory was used and most of the applicable three (03) sampling techniques for the study : the Random Judgment Sampling, Stratified Random Sampling and Cluster Sampling were used and appropriated theoretical background was represented in the section 2.3 of the Chapter 2

Selection of schools

Considering the above facts and the aim of achieving the expected goals, the following students, teachers and principals were selected from different schools in different districts based on the following selection criteria with the foundation of the above mentioned sampling theories.

Selection of Sample

(a) Selection of District

In terms of education (UGC, 2007), there are 25 educational districts in Sri Lanka. Out of these, 16 districts are categorized as educationally disadvantaged. The following five districts (as a 20% district sample) were selected for the survey with the following justifications. (i) Colombo (ii) Gampaha (iii) Puttalam (iv) Nuwar-eliya (v) Hambantota. The first two districts (Colombo and Gampaha) are categorized as educationally privileged/advantaged districts (UGC, 2007) while the remaining three districts are categorized as educationally disadvantaged (underprivileged) districts and are physically at a great distance from the capital. The Puttalam and Nuwara-eliya districts are modest in development. The Hambantota district is underprivileged but is a rapidly developing district. Therefore, district samples were selected to represent the entire school population as being on par and as suitable as this study is mainly qualitative while a different environment will give a higher value for the study.

Selection of Students from different schools

Thirty five (35) schools were selected for the survey from the 5 above mentioned districts as follows:

The Sample includes National and Provincial schools from school Types 1AB, 1C, and Type 2. Considering the student population of Sri Lankan schools (MOE, 2011), the following numbers of schools were selected for the sample survey as given in Table 4.2. These 35 schools conduct ICT as a subject for grade 10 and/or grade 11 and such schools were selected because it was more relevant to the achievement of the goals of the research study.

Table 4.2 Selected schools for the sample survey

District	1 AB (national)	1 AB (Provincial)	1 C	Type 2	Total
Colombo	3	2	4	3	12
Gampaha	1	2	2	2	7
Puttalam	1	1	1	1	4
Nuwara-Eliya	1	1	3	1	6
Hambanthota	2	2	1	1	6
Total	8	8	11	8	35

From each school, two classes (Grade 10 & Grade 11, one of each) were selected.

Note: Schools of Type 3 were not considered as they do not have grade 10 and grade 11 students.

Students: A maximum of 40 students from each school were selected from Grade 10 and Grade 11 respectively doing ICT as a subject for their ICT (O/L) examination

Principals

35 Principals from different schools (one from each school) were selected for this survey

ICT Teachers

The sample includes at least one ICT teacher from each school in the school sample. In schools which had more than one ICT teacher, information was collected from all the ICT teachers in the school

Selection of other organizations

In addition to the three categories mentioned above, the study selected officers and organizations as mentioned below because the following categories were mostly engaged and were responsible for the development of ICT education in Sri Lanka.

National Institute of Education (NIE) - NIE is responsible for the curriculum development and curriculum implementation procedure. The following ICT development personnel are involved in the development process and are the key personnel in the development process of ICT education in the NIE context. Therefore, to obtain more accurate and meaningful data, the following officers were interviewed. Officer in Charge of ICT (O/L), officer in charge of ICT in education, curriculum development staff, teacher training staff (at least one from each category)

Ministry of Education (MOE) - (relevant officers of the MOE, e.g. Director/IT, Deputy/Director/IT, and other relevant officers (e.g. Cadre, Procurement etc.)

ICT Policy Makers of the NEC (at least two officers)

Two CRC Centre Co-coordinators & Provincial ICT Center Coordinators

National Colleges of Education (NCOE) – (ICT training providers, and their residential trainers, at least two individuals from each category)

ICT expert (from the Universities and from ICT industry) – (They are aware of the future requirements of ICT in higher studies and the expectations of industry in the field of ICT from the school environment)

To achieve the specific objective “**To identify the status of the quality of ICT education in the Sri Lankan school system compared to the indicators identified**”, the following instruments were designed and surveying methodologies used as explored in the literature survey from the selected authorities above.

With the aim of gathering information from the above mentioned authorities, the following instruments were designed.

4.4 Data Collection

Overview of the Materials

The following materials were used to collect data and facts through the survey (i) Students’ Questionnaire (See Appendix 1) (ii) Principals’ Questionnaire (See Appendix 2) (iii) ICT teachers’ Questionnaire (See Appendix 3) (iv) Interview schedule for NIE officers (See Appendix 4) (v) Interview schedule for MOE officers (See Appendix 5) (vi) Interview

schedule for CRC center officers and provincial ICT center coordinators (See Appendix 6) (vi) Interview schedule for NCOE officers (See Appendix 7) (vii) Interview schedule for NEC officers (See Appendix 8) (viii) Interview schedule for provincial and zonal ICT officers (See Appendix 9) (ix) Classroom observation sheet (See Appendix 10) (x) Workshop monitoring schedule (See Appendix 11).

Detailed Description of Materials

As data gathering instruments, three main questionnaires were designed and used in this study. They included alternative and projective method questions to collect clear-cut answers from students, teachers and principals. Based on accepted guidelines for questionnaire design described in Chapter 4, the three questionnaires were as follows.

Students Questionnaire

This general information is important in cross analysis and as well as to get a clear picture about the student background. The student questionnaire consisted of 54 items from 9 major categories (Appendix 1). The first category was on general and demographical information such as grade, gender, distance between the school and home and time taken for journey to school.

To determine the present status of ICT education, computer infrastructure facilities, computer laboratory facilities and other information are needed. Therefore, the second category was on infrastructural facilities available in the school for ICT education. These items include the availability of computer lab facilities, availability of ICT teachers for ICT education, availability of network facilities and availability of internet facilities. These items would help collect information related to the infrastructure of ICT education that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown as in Tier 1, benchmarks and standards. Moreover, these facts were useful to determine the present status of ICT education in the Sri Lankan school system as shown in Tier 2 of the research design diagram labeled in Figure 4.4

The internet and schoolNet is a highly applicable tool in ICT education in modern education. Therefore, chapter 3 highlights that internet and SchoolNet are essential requirements in ICT education and that its availability index is higher in developed countries. Although some countries have such facilities, the usage is minimal. Therefore, the encouragement of teachers and relevant authorities is important for better utilization. Furthermore, the third category was based on the usage of internet related activities in schools. These items include the usage of internet to enhance the other subjects, encouragement by teachers for the use of SchoolNet by students and the possibility and ability of getting subject matter through SchoolNet by students on their own. These items would help to collect information related to curriculum and implementation issues that were derived as an indicator of the quality of ICT education in Chapter 3. This is a criterion shown in Tier 1, benchmark and standard. Further, these facts are useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2 of the research design diagram.

The fourth category was based on other activities which are supporting and affecting factors, which involve enhancement of the quality of ICT education. These items include ability to

use internet facilities in their homes or any other location, ability to learn ICT theory and practical components from the school according to the time table, usage of e-mail facilities, encouragement of teachers to use e-mail for their problem solving activities in connection with their studies and usability of the Sinhala e-mail messages using English characters by students to convey their messages. Further, factors that affect practical sessions of ICT education such as non-availability of computers, non-availability of teachers, non-availability of a defined task at ICT practical sessions, non-availability of a time slot in the time table for practical sessions, non-availability of suitable software and guidelines for the implementation of the curriculum would be included in the fourth category. These facts would be used to collect information related to the curriculum and development issues that were derived as indicators of quality ICT education in Chapter 4 which is a criterion shown in Tier 1. Moreover, these facts will be useful to determine the status of ICT education in Sri Lanka as shown in Tier 2.

The fifth and six categories were based on the skill levels of students regarding the grade 10 and grade 11 ICT curricula. These items include skill levels in the fundamentals of ICT, word processing, spreadsheet, presentation, database management, network and internet, information systems, programming concepts, web designing, ICT and society and the individual project. Further, investigation also includes the skill level of students in both theory and practical and status of the coverage of the syllabus. These facts would help collect information related to the skill level of ICT students related to the curriculum implementation that was derived as an indicator of the quality of ICT education in Chapter 3. It is a prime criterion shown in Tier 1, benchmarks and standards. Moreover, these facts will be useful to determine the status of ICT education in Sri Lanka shown in Tier 2.

The seventh category was based on the difficulties faced by students during the study of ICT as a subject in Sri Lankan Schools. As difficulties, this category includes investigation of the lack of knowledge of English of students, curriculum implementation issues with the lack of teachers, lack of a properly designed set of ICT practical sessions, lack of text books and lack of helpful tuition classes. These items would help to collect information related to the curriculum and implementation issues derived as an indicator of quality ICT education in Chapter 3. It is a criterion shown in Tier 1, benchmark and standard. Further, these facts are useful to determine the present status of ICT education in Sri Lanka shown in Tier 2.

The eighth category was based on how students use ICT as a tool to learn other subjects. This includes investigation of student's usage of educational software to enhance other subjects introduced by the NIE and other educational institutes, accession of the NIE web site to download subject materials, syllabuses, and teachers' guides and the usability of ICT for projects on other subjects. These facts would be used to collect information related to supportive initiatives and curriculum and implementation issues that were derived as an indicator of quality ICT education in Chapter 3. These facts would be useful to determine the present status of ICT education in Sri Lanka shown in Tier 2.

The ninth category was based on the usage of operating systems, application software and some useful support initiatives which help to enhance the quality of ICT education. This

includes usage of open source, Microsoft products and frequency of students enhancing quality ICT education through group and individual projects. Further, this category includes investigation of the quality of tuition classes, availability of a computer society and its membership, availability of a home computer with internet facilities and usage of e-mail facilities through home computer. The latter part of the above facts indirectly involves the improvement of the quality of ICT education. These activities would be used to collect information related to supportive initiatives and software and sustainability issues that were derived as an indicator of quality ICT education in Chapter 3. These facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Principals' Questionnaire

The principals' questionnaire consists of 83 items under 46 different categories labeled Appendix 2. The first two categories were on general factors such as the nature of the school and gender category of schools. This kind of information is important in cross analysis as well as to determine the general status of schools and principals.

The third, fourth, fifth and sixth categories include the number of students in the school and the number of students in different class categories (e.g. Grade 1-5, Grade 6, grade 10, grade11 etc., to determine the ICT requirements). These items were used to collect information to determine the requirement of ICT infrastructure for ICT education derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. These facts were useful to determine the present status of ICT education in Sri Lanka shown in Tier 2.

The seventh category includes availability of computer labs in schools. This information also was collected from students and it would be useful to crosscheck the validity of information. Further, the eighth and the ninth categories include the availability of GIT and ICT for the A/L course in schools. These items would be used to collect information to determine the curriculum and implementation issues to ICT education that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. These facts would also be useful to determine the present status of ICT education in Sri Lanka shown in Tier 2.

The tenth to fourteenth categories include information about the working computers in the school; the number of malfunctioning computers in the school, repair mechanism from MOE or relevant authority regarding the breakdown of computers, self-ability to repair broken computers in the school and proposed mechanism to repair computers from the school administrator's point of view. These items would be used to collect information to determine the hardware and sustainability issue to ICT education that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. These facts would also be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The fifteenth category includes information about the problems and issues in the implementation of Grade 10 and Grade 11 ICT specialization subject. This covers the effects

caused due to the lack of teachers, disinterest of students, lack of text books and lack of proper guidelines. These items would help to collect information needed to determine the curriculum and implementation issue to ICT education that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1- benchmarks and standards. These facts would also be useful to determine the present status of ICT education in Sri Lanka shown in Tire 2.

The sixteenth to nineteenth categories include the main infrastructure of ICT education and its maintenance issues. These items include determination of power sources for ICT education, availability of networking facilities, ability to maintain networks and the availability of multimedia facilities. These items were collected to determine the curriculum and implementation issues and hardware and sustainability that were derived as an indicator of quality ICT education in chapter 3. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The twentieth category includes facts about the involvement of Human resources in ICT education. Moreover, it includes availability of an ICT teacher for ICT education, investigation of their main subjects, and the available number of ICT teachers in the school. These facts would help to determine the availability of human resources for the development of ICT education. This was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The twenty-first to twenty-fourth categories include the availability of web sites in schools, maintenance activities of school web sites, usage of computers to teach other subjects, problems and issues in connection with implementation of ICT education due to the lack of trained ICT teachers, lack of well-planned guidelines, lack of resources, disinterest of students and unavailability of access to computer labs. This information would help to determine the involvement of supportive initiatives for ICT education and the problems and issues prevailing in connection with ICT education. These facts would help determine the availability of supportive initiatives and infrastructural facilities for the development of ICT education that was derived as an indicator of quality ICT education in Chapter 2. This is a prime criterion as shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The twenty-fifth to twenty-seventh categories include the investigation of computer usage in schools for different activities and the difficulties and issues that affect ICT in education. Further, this includes investigation of computer usage for administrative work in schools, students' assignment and assessment work, for teacher training purposes and students' knowledge enhancement purposes. In addition to the above, this category includes investigation of the importance of computers as a tool to teach other subjects, difficulties in ICT education due to the lack of computers, lack of infrastructural facilities, lack of text books, lack of well-planned curriculum for ICT in education, importance of ICT in education, computer maintenance issues and lack of trained teachers for ICT in education. These facts would help determine the status of the curriculum and implementation issues which were

derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Categories twenty-eight to twenty-nine include determination of ICT teaching vacancies in schools and the real requirements of ICT teachers to handle ICT education in schools. These facts would help to determine the status of human resource development of Sri Lanka derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards.

Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The thirtieth to thirty-ninth categories cover the research and development of ICT education in Sri Lankan schools. Further, it includes how ICT will contribute to enhance the good attitudes of students, proposals for enhancing the presentation skills of students to improve the quality education, knowledge sharing through peer education with internet facilities and schoolNet, training aspects on new technologies as e-learning-conference and blended learning technologies. Further, this category includes how one could implement the new technologies mentioned above to enhance the quality of education. The need was to investigate the difficulties of ICT education due to the lack of knowledge of English, lack of technical skills and guidelines, present heavy workload, reliability of similar existing methodologies and lack of change of behavior. This also includes investigations to obtain e-citizenship programs and similar programmes by the principals for the development of ICT education in schools, possibility of enhancing ICT education through blended learning technologies, and how the conduct of students is affected by the introduction of internet and schoolNet to education. These facts would help determine the status of research and development of the curriculum and implementation issues of ICT education of Sri Lanka derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The fortieth category includes investigation of the selection procedure of students to pursue ICT education in Sri Lankan schools. These facts would help determine the status of curriculum and implementation issues in ICT education of Sri Lanka derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The forty-first to forty-second categories include a collection of facts based on present experiences of principals, regarding the enhancement of ICT education in Sri Lankan schools. These include investigation of the strengths and weaknesses of the physical resource distribution procedure among the schools, allocation and distribution of human resources, teacher evaluation mechanisms, teacher updating programmes etc. These facts would help to determine the status of curriculum and implementation issues and human resource

development in ICT education of Sri Lanka that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Categories forty-three to forty-six cover the performance displayed by students at national examinations. Further this includes whether students have not displayed good performance, reasons such as the lack of ICT teachers, lack of computers, lack of knowledge of English, lack of motivation and guidelines from authorized organizations and disinterest of students. If students have performed well in ICT national evaluation, then it would add facts on the commitment of students and teachers, availability of sufficient facilities for ICT education, motivation of parents etc. Moreover, this category would represent aspects of ICT in education. These facts would help to determine the status of curriculum and implementation issues in ICT education of Sri Lanka that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Use of students as stakeholders to collect facts based on the nine above mentioned categories.

ICT teacher's questionnaire

The ICT teacher's questionnaire consists of 73 items from 10 major categories as labeled in Appendix 3. The first category was on general and demographical information such as gender, highest qualification obtained by teachers and their main subject of teaching. This kind of information is important in the cross-analysis as well as to determine the general status of ICT teachers.

Item three to item five in the 2nd category represent facts on human resource development of ICT teachers. This includes statistics about the institutes that train ICT teachers, duration of training, whether appointment is as ICT or as Non_ICT, whether teachers expect methodical training and whether ICT teachers expect English education. These facts would help to plan human resource development of Sri Lanka derived as an indicator of quality ICT education in Chapter 3. It is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Item nine and item ten of the second category include the availability of a computer and internet access at home. These facts would help to plan infrastructure development, curriculum and implementation issue of ICT education in Sri Lanka that was derived as an indicator of quality ICT education in Chapter 3. It is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Category three includes investigation of training requirements for ICT teachers involved in teaching. GCE (O/L) ICT subject. Further, training details of training requirements include

principles/fundamentals of ICT, number representation, internal structure of a computer and its functions, word processing, spreadsheet, presentation, database management, network and internet, information systems, algorithms and programming, web design, ICT and society, group projects and individual projects. These facts would help to plan human resource development of ICT education in Sri Lanka that was derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Category four includes the investigation of services and their ability of such services to maintain the computer systems in schools. Further, the availability of guidelines and support from MOE, provincial educational officers and other relevant organizations (e.g. NIE, NEC, etc.), training leading to the maintenance of hardware and software will be investigated. These items would help to collect information related to curriculum and implementation issues, software and hardware issues that were derived as an indicator of quality ICT education in Chapter 3. This is a criterion shown in Tier 1, benchmark and standard. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Category five includes the investigation of difficulties and problems in ICT education faced by ICT teachers. Further, this category includes the effect of the lack of knowledge of English, non-availability of text books, non-availability of computer laboratory facilities, support from other teachers and administrative staff of schools, non-availability of a planned teaching methodology, virus effects, non-availability of internet facilities, non-availability of hardware upgrading facilities and effects of electricity interruptions when implementing ICT education. These items would help to collect information related to curriculum, implementation, hardware and sustainability issues derived as an indicator of quality ICT education in Chapter 3. It is a criterion shown in Tier 1, benchmark and standard. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Category six was based on investigation of teacher training proposals from ICT teachers. Further, this category includes investigation of suitability in connection with face-to-face training, LMS, E-learning, distance education through video conferencing and virtual class room technologies etc. These items would help to collect information related to human resource development that was derived as an indicator of quality ICT education in Chapter 3. It is a criterion shown in Tier 1, benchmark and standard. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

The seventh category was based on ICT development initiative possibilities and possibilities of different software usage. Further, this includes investigation of the implementation of ICT group and individual projects for the ICT subject, educational benefits from the ICT subject compared to other subjects, possibilities of introducing new blended technologies for ICT education, importance of internet facilities, the necessity of eliminating accessibility restrictions or introducing filtering techniques to students for ICT education in schools

according to the view of ICT teachers, investigation of usage of different software platforms, usage, benefits and availability of important programs on SchoolNet. These items would help to collect information related to research and development, software and curriculum and implementation issues that were derived as an indicator of quality ICT education in Chapter 3. It is a criterion shown in Tier 1, benchmark and standard. Further, these facts would be useful to determine the present status of ICT education in Sri Lanka shown in Tier 2.

The eighth category includes investigation of the usage of ICT as a tool to develop other subjects and the implementation of projects on other subjects. These items would help to collect information related to curriculum and implementation issues as well as supportive initiatives that were derived as an indicator of quality ICT education in Chapter 3.

The ninth and tenth categories include investigation of the usage of pedagogical applications in teacher training activities and classroom activities in their teaching and learning domain. This is a criterion shown in Tier 1, benchmark and standard. Further, these facts are useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2.

Selected officers from the National Institute of Education (NIE)

Chapter 3 reveals that the vision of the NIE is to provide quality education for all, by developing curricula, enhancing professionalism and engaging in research to empower learners in order to realize their potential to build a humane society. Therefore, the informal interview schedule consisted of the following facts on the investigation of the present status of ICT education, facilities, difficulties, improvement possibilities and enhancement suggestion for ICT for O/L, ICT for A/L, GIT and ICT in education, their curriculum development, and availability of training and updating facilities for ICT teachers, Curriculum development process and its guidelines. The entire informal interview process schedule is shown in Appendix 4.

These items would help collect information related to curriculum, implementation issues, human resource development and research & development that were derived as an indicator of quality ICT education in Chapter 3. This is a criterion shown in Tier 1, benchmark and standard. Further, these facts were useful to determine the present status of ICT education in Sri Lanka shown in Tier 2 in the research design architecture diagram. Further, the NIE is the leading and authorized developer of curriculum, implementation and human resource development of general education in Sri Lanka. Therefore, their observations are quite essential for the success of this research.

Informal interview schedule for MOE officers

Chapter three reveals that the MOE is mandated to develop competent citizens keeping in line with global trends through innovative and modern approaches in education leading to efficiency, equity and high quality in performance ensuring stakeholder satisfaction. Further, the MOE provides infrastructure, human resources and is the controlling body of the entirety educational activities including funding. The informal interview schedule (See Appendix 5) for the MOE officers includes the following key facts.

Steps taken to enhance the quality of ICT education in the Sri Lankan school system are: facilities provided, provision of schoolNet facilities, infrastructure, HR development, software and hardware facilities etc. to enhance ICT education, procedure of cadre requirements, creations and recruitment, cadre positions for ICT education, purchase and distribution of computers, related equipment and services and supportive initiative development plan for the enhancement of ICT education.

These items would help to collect information related to infrastructure, policy guidelines, human resources, software and hardware of ICT education that was derived as an indicator of quality ICT education in Chapter 3. It is a prime criterion shown in Tier 1, benchmarks and standards. Moreover, these facts are useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2 of the conceptual design architecture diagram.

Informal interview schedule for CRC officers and Provincial ICT center coordinators

According to chapter 3, CRC provides training to students (especially for school leavers) and some teachers while provincial ICT centre coordinators conduct subject update programs and provide ICT facilities to students as well as teachers in the province or the zone. To collect more information the following facts were included in the informal interview schedule as labeled in Appendix 6.

Present status of the CRC centres involve , role expected by the MOE from CRCs, courses conducted by the CRC centres, demand and enrolment in their regards , course demand of selected CRC centres, possibility of conducting teacher training programmes in CRCs, investigation of the possibility of using ICT resources for students who lack ICT facilities in their schools.

These items would help collect information related to infrastructure, policy guidelines and human resources that were derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Moreover, these facts are useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2 of the research design architecture diagram.

Informal Interview Schedule for NCOE officers

The NCOE plays a prominent role in pre-service teacher education in Sri Lanka. These institutes provide pre-service teacher education based on what is accomplished through a three-year course in teacher education. Further, NCOEs upgrade the professionalism of teacher education by providing continuous education through updating of programmes (National Collage of Education [NCOE] , 2004). Some NOCEs conduct ICT education programs for a period of three years. The informal interview schedule for NCOE officers containing the following facts is labeled, Appendix 7.

ICT courses available in NOCE's, course contents of ICT courses, compatibility with ongoing ICT courses in the schools system and NOCE's, students capacity of NCOE for ICT training, ICT infrastructure facilities and human resources in NCOE's for ICT education, issues and problems in ICT program implementation.

These facts would help to collect information related to human resources that were derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Moreover, these facts are useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2 in the research design diagram.

Informal Interview Schedule for NEC Officers

The vision of the NEC is to provide a comprehensive national policy framework for a sound education for all, ensuring fairness and adaptability, to face all challenges and for the maintenance of the Sri Lankan identity. Chapter 3 reveals that a draft policy was released on two occasions. However it was not released as an acceptable policy. To collect more information about the ICT policy, an informal interview was scheduled with the following inquiries and is labeled, Appendix 7.

The importance of an ICT policy, status of the draft ICT policy and delays in its implementations, problems and issues due to lack of an ICT policy, how ICT education could be enhanced with a proper policy, etc. These facts would help to collect information related to the policy guidelines that were derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Moreover, these facts are useful to determine the present status of ICT education in Sri Lanka as shown in Tier 2 in the research design diagram shown in Figure 4.4.

Informal Interview Schedule for ICT Experts in Universities

Some subject experts in Universities are deeply involved in curriculum design and examination activities in the secondary education system. Based on their expert knowledge and experiences, they are better suited to find more information. The appropriate facts gathering questions were included in their informal interview schedule and are represented in Appendix 8.

Informal Interview Schedule for ICT experts in the ICT Industry

Experts in the ICT industry have wide knowledge of the requirements of the industry and have sound knowledge of the output expectations from secondary education. Opinions regarding software, HR development, supportive initiatives and research development are very important from experts in the industry for the future development of ICT education in Sri Lanka. The following facts were included in the informal interview with experts in industry labeled as Appendix 9.

What are the foundation requirements of industry in ICT studies that should be included in the ICT school curriculum? What kind of software and hardware skills should be incorporated in the school curriculum, what kinds of supportive initiatives can be included in school ICT education? What kind of help can be obtained from industry?

These facts would help to collect information related to software, HR development, supportive initiative and research development that were derived as an indicator of quality ICT education in Chapter 3. This is a prime criterion shown in Tier 1, benchmarks and standards. Moreover, these facts are useful to determine the present status of ICT education to

help in the future development of ICT education in Sri Lanka as specified in Tier 3 in the research design diagram as shown in Figure 7.3

Class room Observation schedule

To investigate the real situation of ICT education in Sri Lankan schools, a class room observation form was prepared as a means of collecting necessary observations and processes. The schedule is annexed in Appendix 10. The following fact gathering techniques were included in the class room observation sheet.

Development of learning objectives, selection and use of instructional materials, educational climate conducive to learning (are students and teachers interested and enthusiastic), preparation for class session, instructional methods, opportunity for student participation, responsiveness to student feedback, learning difficulties.

Workshop observation schedule

To determine the ICT skill levels of ICT teachers and the methodology, this research study included two workshop sessions. During the workshops, the following facts were collected: The initial skill level of ICT teachers on particular areas and the level of understanding of teachers on some requested sessions of the O/L curriculum were requested from the zonal ICT director, at end of each session, the skill level of problem solving and the ability at teaching was assessed. The schedule of workshop observation criteria is annexed in Appendix 11.

According to the survey methodologies explored in chapter 3, the following hybrid survey techniques were used to gather useful data with the aim of achieving the research objectives successfully.

A survey was conducted with students, ICT teachers, principals and other officials as well as through class room observation and workshops to access the present status of ICT education in the Sri Lankan educational system and to determine the future requirements and expectation from the school ICT education.

Implementation procedure of Students' Questionnaire

With the aim of achieving the research objectives, the most suitable methodology for fact finding from students was the questionnaire. It enabled the student to provide average qualitative properties for ICT education because their age is below 18 years (not adults). Students are usually in sets or groups in a particular school and class. Respondents need more help and instruction when filling the questionnaires. Moreover, the sample consisted of more than one thousand students and a regular form of fact finding mechanism was needed. Therefore, based on theory background described in section 2.3 of Chapter 2, the group administered questionnaire methodology was used because the researcher or supportive educational officers had to provide guidelines in filling the questionnaire. Because of this, the researcher could obtain a high percentage of accurate completed questionnaires. When compared with other surveying technologies the group administered questionnaire methodology was more suitable than other methodologies for this research study.

Implementation procedure of ICT teachers' and Principals' Questionnaire

With the aim of achieving the research objectives, facts were gathered from ICT teachers and principals using the proposed questionnaires. During the survey period, ICT teachers and principals were busy with their school's end of year, academic and administrative matters. Based on their willingness, the survey was done on Group administrated questionnaire or Household **drop-off** survey questionnaire methodology because this alternative option gave a high value response percentage.

Implementation procedure in conducting Personal interviews with different stakeholders

More information was collected from different selected organizations in this research study.. The researcher personally interviewed different ranks of officers despite their busy schedules and a few telephone interviews were conducted with few officers who lived far from Colombo. Further, the interviewer had the opportunity to probe or ask open ended questions to achieve the research objectives. For the above reasons, the personal and telephone interview methodology was the most appropriate methodology to gather relevant information in this situation for this study.

Workshop sessions for ICT teachers

To identify the productivity of workshops and as a fact finding method, this study included two workshop sessions in the Western Province for ICT education. The workshops included some selected areas of ICT O/L syllabus. Further, this provided an environment for teachers to learn and share ICT skills and problems solving activities. During the session, observations were made about the ability and skills through problem solving activities, body language and through peer to peer learning activities. In addition to this, workshop observations included the following: interest in participating in the workshop, willingness to understand the theory session, feedback and questioning habits, ability or the skills of problem solving and interest in problem solving activities, behavior of teachers which is indicative of interest in learning new trends in ICT, study of the ability of teachers to teach through peer education, motivation of teachers to learn peer education and blended learning. These facts were very useful to determine the current status of the curriculum and its implementation. Further, observation was a useful method to determine the present status and future development of ICT education in Sri Lankan schools.

Implementation of class room observation procedure

The purpose of the class room observation for this research was to observe the real time situation of the teaching learning process in ICT education and to crosscheck the validity of responses of students, teachers and principals to the questionnaire and informal interviews from relevant officers. Further, four observation sessions were carried out in different categories of schools (IAB National and provincial, 1C and type 2) and they were limited to one period (approximately forty minutes). The observation further focused on the determination of the following features:

Method of delivery, availability of infrastructure and other facilities for a successful lesson, achievement of lesson objectives, lesson preparation of teacher and skill of the teacher,

academic relation between teacher and students, motivation of students for problem solving activities. Quality of teachers as they present topics in a logical sequence, summarization of major points of the lesson, and response to problems raised during the lesson were included in the observation schedule. Further, the class room observation schedule incorporated the following techniques to determine the quality of teaching and learning process: instructional methodology, opportunity for students' preparation, responsiveness of student's feedback and learning difficulties (Minnesota, 2009). The survey, interviews procedure with the different authorities and individuals are as follows.

4.5 Mixed Methods Used To Develop The Study Including The Survey

Overview

This chapter includes how surveys and fact finding methodologies were carried out to achieve the expected goals. Further, this includes how moderate the research materials were, the environment where the pilot survey was conducted, how the information was collected, and who the respondents to the survey were. Also, this section includes the number of responses obtained from students, teachers and principals for the survey. Finally this contains information on who the other respondents in the survey were and how information was collected from them.

Detailed Procedure

The research investigates possible survey methodologies to fill the gaps in the literature review and to achieve the research objectives in the research study. After studying the standard survey methods explored in Chapter 3, three types of questionnaires were designed with the guidance and feedback of ICT and education experts. Subsequently, all the materials were proof-read by a Sinhala language expert and the pilot project was implemented in one IAB School in the Gampaha district. After eliminating the problems and issues in the questionnaires, a sample survey was conducted with the help of the provincial ICT directors and assistant directors of planning. The researcher personally visited all the school in the sample selected from Colombo, Gampaha and Puttalam districts. With the help of ICT teachers and principals, all the questionnaires were distributed to students which they filled in the presence of the researcher. Two assistant directors of planning arranged the distribution and collection of the completed questionnaires from the selected students, teachers and principals in remote districts of Nuwara-eliya and Hambantota. The relevant questionnaires, and instructions were sent via postal service and the completed questionnaires were obtained by post. Through this methodology, approximately 100% of completed students' questionnaires were collected because the data collection mechanism was performed in three districts (Colombo, Gampaha and Puttalam) by the researcher using the group administrated methodology in the presence of students and the other two districts (Nuwara-eliya and Hambantota) were done by two assistant directors of planning in the corresponding provinces. Table 4.3 reveals the numbers of completed questionnaires collected in the survey.

Table 4.3 Questionnaire sample completed by Students

	Total
Total	1295
Colombo	510
Gampaha	257
Puttalam	217
Hambantota	193
Nuwara Eliya	118

32 completed questionnaires were collected from principals. Some principals were unable to handover the questionnaires due to the busy end of the year school administration work. However, the completed questionnaires indicated a high percentage of 91.43% out of the total distributed questionnaires. Some schools had more than one ICT teacher and with the aim of collecting a set of meaningful responses it was possible to collect forty eight (48) completed questionnaires from ICT teachers from thirty five (35) selected schools. This number was more than the initially expected value.

NIE officers selected for the survey

According to the informal interview schedule in Appendix 4, three project officers from the NIE were interviewed in view of their major involvement as they were in-charges of ICT (O/L), ICT (A/L) and GIT programs.. They were essentially involved in curriculum development activities, teacher training activities and research and development in the area of ICT education.

MOE officers selected for the survey

According to the informal interview schedule designed in Appendix 5, the required information was gathered from three MOE officers such as Director/IT, Deputy Director/IT, Deputy Director/ Procurement and one officer from the tender processing and supplies department.

CRC centre officers and Provincial ICT centre coordinators selected

Personal interviews were conducted with one CRC centre co-coordinator in the Colombo zone and one ICT CLC coordinator from the Jayewardenepura Zone in the Western Province. Further, telephone interviews were conducted with two CRC and two CLC coordinators according to the interview schedule in Appendix 6.

NCOE officers selected

Telephone interviews were conducted with two NCOE officers including one officer from Ruwanpura National College of Education, based on the informal interview schedule in Appendix 7.

NEC Officers selected

Telephone interviews were conducted with a senior project officer at the NEC to gather the required information requested by the informal interview schedule in Appendix 8. Further, to

get more information in connection with ICT policy and ICT plans, several electronic documents were obtained through e-mail.

ICT experts in Universities selected

Certain subject experts in universities are essentially involved in curriculum design and examination activities in the secondary education system. Based on their expert knowledge and experiences, they were the most appropriate to obtain more information from. The required facts were obtained from them according to the interview schedule as described in Appendix 8. The interview experts were as follows; One ICT / Computer science senior lecturer who is involved in the ICT education development program and evaluation process and one education specialist engaged in the educational development process as well as ICT development process.

ICT Experts in Industry selected

Two experts in industry were personally interviewed according to the informal interview schedule in Appendix 10. As they are the ICT human resources consumers and their feedback, guidelines and explanations were very useful when implementing school ICT education.

Based on the survey instruments and procedures described in the above sections, the relevant data was gathered, entered, validated and analyzed as follows.

As discussed in the literature review, the qualitative analysis techniques including data reduction, data organization and data interpretation including hypothesis testing are important and all these features are incorporated in CS-pro, MINITAB and SPSS packages. Therefore, CS-pro, MINITAB and SPSS packages were used as a data analysis tool in this study. Further, SPSS version 20.0 and Minitab Version 14 were specially used to develop the statistical approach in the study.

4.6 Data Analysis And Interpretation

The gathered data was entered through the CSpro package for data analysis. Further, double entry was performed and validity was tested through range consistency editing. After the validation process, cross tabulation and descriptive statistics were generated. The data were analyzed using both descriptive and inferential statistics using SPSS version 20.0 and Minitab Version 14.

Frequencies were made to run for the generation of descriptive statistics. Important variable in the survey, overall percentages, averages, modes ranges, (where applicable) were presented in Table and/or chart form. Appendices 1 to 3 contain the fixed alternative questions and multiple-choice type answers. The questions in the three appendices are grouped and overall percentages, averages, and ranges (where applicable) are presented in Table and/or graphical summary with the median and significant levels chart form in Chapter 5 and Appendix 12. Further, hypothesis testing was used to derive the application model. Mainly Kruskal-Wallis test and correlation testing were used in phase I. For the comparison of the ranks of sum of the five districts and different school categories, Kruskal-Wallis Test

has been used instead of Analysis of Variance (ANOVA) because ANOVA is a parametric test. Data of the study is categorical. Therefore, ANOVA counterpart in non-parametric test. Therefore, Kruskal-Wallis Test was used.

Further, based on the three structured questionnaires, the following questions were grouped for the nine variables (quality factors) which represent the attributes in each variable and are presented in the Table 4.4

Table 4.4 Attributes in Quality factors

Variable	Appendix	Question Numbers
Infrastructure (X ₁)	Appendix 1 – Student’s Questionnaire	Question 3.1, Question 3.3, Question 3.4, Question 4.4, Question 4.7.1, Question 8.2
	Appendix 2–Principal’s questionnaire	Question 7.0, Question 10.0 , Question 16.0, Question 17.0, Question 19.0, Question 20.0
	Appendix 3- ICT Teacher’s Questionnaire	Question 2.8, Question 2.9, Question 5.3, Question 5.7
Human Resource Facilities (X ₂)	Appendix 1 – Student’s Questionnaire	Question 3.2, Question 4.2, Question 4.3, Question 4.7.2, Question 7.2
	Appendix 2–Principal’s Questionnaire	Question 15.1, Question 27.1 , Question 28.0, Question 29.0 ,
	Appendix 3- ICT Teacher’s Questionnaire	Question 2.1, Question 2.2, Question 2.3, Question 2.4, Question 2.5, Question 4.1, Question 4.2, Question 5.1
Maintenance and Sustainability Plans(X ₃)	Appendix 1 – Student’s Questionnaire	
	Appendix 2–Principal’s Questionnaire	Question 4.3, Question 4.4, Question 4.5, Question 5.8, Question 5.9, Question 5.10
	Appendix 3- ICT Teacher’s Questionnaire	Question 15.1, Question 27.1 , Question 28.0, Question 29.0 ,
Software (X ₄)	Appendix 1 – Student’s Questionnaire	Question 4.7.5, Question 9.1, Question 9.2
	Appendix 2–Principal’s Questionnaire	Question 7.6
	Appendix 3- ICT Teacher’s Questionnaire	
Curriculum implementation facilities(X ₅)	Appendix 1 – Student’s Questionnaire	Question 5.0(Question 5.1- Question 5.7), Question 6.0 (Questions 6.1 to Questions 6.5), Question 7.1, Question 7.3, Question 7.4, Question 8.3, Question 9.3
	Appendix 2–Principal’s Questionnaire	Question 8.0, Question 9.0, Question 15.4, Question 25.2, Question 25.3, Question 27.3, Question 27.4, Question 38.0, Question 40.0
	Appendix 3- ICT Teacher’s	Question 2.6, Question 2.7 , Question 3.0(Questions 3.1 – Questions 3.13), Question

	Questionnaire	5.2 , Question 5.5, Question 9.0 (Questions 9.1 to Question 9.7), Question 10.0 (Questions 10.1 to 10.7)
Pedagogical techniques (X _{5.1})	Appendix 1 – Student’s Questionnaire	
	Appendix 2–Principal’s Questionnaire	
	Appendix 3- ICT Teacher’s Questionnaire	Question 9.0 (Questions 9.1 to Question 9.7), Question 10.0 (Questions 10.1 to 10.7)
Support form Administration and Supportive Initiatives (X ₇)	Appendix 1 – Student’s Questionnaire	Question 4.5, Question 7.1, Question 8.1, Question 8.4, Question 9.6, Question 9.7, Question 9.8, Question 9.9, Question 9.10, Question 9.11
	Appendix 2–Principal’s Questionnaire	Question 15.5, Question 21.0, Question 23.0, Question 25.1, Question 36.0
	Appendix 3- ICT Teacher’s Questionnaire	Question 5.4, Question 7.7, Question 7.8, Question 7.9, Question 8.1, Questions 8.2
Research and Development (X ₈)	Appendix 1 – Student’s Questionnaire	
	Appendix 2–Principal’s Questionnaire	Question 26.0, Question 30.0, Question 31.0, Question 32.0, Question 33.0, Question 34.0, Question 35.0 (Questions 35.1 to Questions 35.7), Question 37.0, Question 42.0, Question 46.0
	Appendix 3- ICT Teacher’s Questionnaire	Question 6.1, Question 6.2, Question 6.3, Question 7.1, Question 7.2, Question 7.3, Question 7.4, Question 7.5) 6.3

Further, the Policy matters (X₆) and Budget Allocation and Country Expectation (X₉) are not covered in the structured questionnaires.

Also, possible minimum rank sum and possible maximum rank sum per variable (for each questionnaires) are calculated according to the variables specified in the Table 4.4 as follows:

Possible minimum rank sum per variable = $\sum_{i=1}^n$ minimum weighted value of i^{th} attribute.

Possible maximum rank sum per variable = $\sum_{i=1}^n$ maximum weighted value of i^{th} attribute.

According to the two formulas above, the possible minimum rank sum per person and possible maximum rank sum per person are calculated and shown in Table 4.5.

Table 4.5 Possible Minimum and Maximum Rank Sum of Variables

Instrument and Variable	Question Number	Rank weight	Possible Minimal Rank	Possible Maximum Rank
Infrastructure (X ₁)- (Student's questionnaire Source: Appendix 1)	3.1	1=Not-Known 2=No 3=Yes	6	15
	3.3,	1=Not-Known 2=No 3=Yes		
	3.4,	1=Not-Known 2=No 3=Yes		
	4.4	1=No 2=Yes		
	4.7.1	1=Yes 2=No		
	8.2	1=No 2=Yes		
Infrastructure (X ₁)- (Principal's questionnaire Source: Appendix 2)	7.0	1=No 2=Yes	6	16
	10.0	1=1-5 2=6-10 3=11-20 4=21-50 5=21-100 6=>100		
	16.0	1=Solar Power 2= Electricity		
	17.0	1=No 2=Yes		
	19.0	1=No 2=Yes		
	20.0	1=No 2=Yes		
Infrastructure (X ₁)- (Teacher's questionnaire Source: Appendix 3)	2.8	1=No 2=Yes	4	10
	2.9	1=No 2=Yes		
	5.3	1=Deep Training is Required 2=Quick Surface Training is Required 3= No Need Training		
	5.7	1= Strictly Affected 2=Slightly Affected 3=Not Affected		

According to Table 4.5, minimum possible rank sum of a person is 6 and the possible maximum rank sum for a person is 15 in connection with the infrastructure (X₁) which was obtained from the student's questionnaire (Appendix 1). Further, possible minimum rank sum and possible maximum rank sum per person in connection with the Principals' and ICT teachers questionnaires related to the infrastructure facilities are also shown in the Table 4.6. Similarly, the possible minimum rank sum per person and possible maximum rank sum per person for other relevant variables are calculated and presented in the Table 4.6.

Table 4.6 Possible Minimum and Maximum Rank Sum for a person.

Variable	Rank Sum		
		Possible minimum sum	Possible maximum sum
Infrastructure (X ₁)	Student	6	15
	Principal	6	16
	Teacher	4	10
Human resource facilities and its strength (X ₁)	Student	5	11
	Principal	4	11
	Teacher	7	24
Maintenance and sustainability facilities (X ₃)	Student	-	-
	Principal	6	16
	Teacher	6	17
software (X ₄)	Student	12	45
	Principal	-	-
	Teacher	1	3
Curriculum implementation facilities (X ₅)	Student	-	-
	Principal	-	-
	Teacher	31	80
Pedagogical techniques (X _{5.1})	Student	-	-
	Principal	9	18
	Teacher	14	42
Support from administration & supportive initiative (X ₇)	Student	10	20
	Principal	5	10
	Teacher	4	14
Research and development (X ₈)	Student	-	-
	Principal	21	47
	Teacher	8	16

Similarly, Rank Sum was calculated for all other variables according to the variables in Table 4.4

Further, total rank sum was calculated as follows:

Total rank sum = $\sum_{i=1}^n$ Rank sum of i^{th} person

Further, descriptive statistics and graphical summary were generated considering the median value, value of minimum, maximum, 1st quartile and 3rd quartile values of total rank sum.

Further, the 95% confidence interval for median was also used to derive the appropriate variable in connection with the application model.

Further, rank sum ratio was also calculated as follows:

Rank sum ratio of i^{th} person = Rank sum of i^{th} person/ total maximum rank sum of the variable

Finally, total rank sum ratio was calculated as follows:

Total rank sum ratio = $\sum_{i=1}^n$ Rank sum ratio of i^{th} person

Further, descriptive statistics and graphical summary were generated, including the median value and values of minimum, maximum, 1st quartile and 3rd quartile values of total rank sum ratio. Further, 95% confidence interval for median was also used to find the quality factors for ICT education.

In addition to the above, Kruskal- Wallis Test was used to test the following hypothesis in connection with the nine (09) variables as follows:

Infrastructure Facilities (X₁)

To determine the fairness of the distribution of infrastructure facilities in all five districts, the following hypothesis testing was used from the point of view of ICT teachers.

Hypothesis I

H₀: Teachers' attitude towards the infrastructure facilities for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the infrastructure facilities of ICT education for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from that of the others.

Based on the ICT teacher's point of view, the above hypothesis was tested using the Kruskal-Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, to determine the fairness of infrastructure facilities in all five districts, the following hypothesis was tested using the attitudes of principals.

Hypothesis II

H₀: Principals' attitude towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Principals' attitude towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others.

Further, the above hypotheses were tested using the Kruskal - Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, the following hypotheses were used to determine the differences in schools category wise in connection with human resource facilities and its strength when performing the ICT specialization subject for the GCE (O/L) curriculum.

Hypothesis III

H₀: Principals' attitude towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all schools types conducting ICT specialization subject for grade 10 and 11.

H₁: Principals' attitude towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one school type is different from the others.

Further, the above hypotheses were tested using the Kruskal - Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Human Resource Issues (X₂)

The following hypothesis test was used from the point of view of ICT teachers to determine the human resource facilities and its strength for the implementation of ICT specialization subject for GCE (O/L) in all five districts.

Hypothesis IV

H₀: Teachers' attitude towards the human resource facilities and its strength for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the human resource facilities and its strength for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from that of the others.

Further, the above hypotheses were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, the following hypotheses were used to determine the differences in schools - category wise and in connection with human resource facilities and its strength.

Hypothesis V

H₀: Principals' attitude towards the human resource facilities and its strength for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Principals' attitude towards the human resource facilities and its strength for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others.

Further, the above hypotheses were used tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Hypothesis VI

H₀: Principals' attitude towards the human resource facilities and its strength for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all schools types.

H₁: Principals' attitude towards the human resource facilities and its strength for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one school type is different from the others.

Further, the above hypotheses were tested using the Kruskal-Wallis Test and based on the P value it was decided to accept or reject the null hypothesis. According to the theory of statistics, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Maintenance And Sustainability Plans (X₃)

Further, the following hypothesis test was used from the point of view of ICT teachers to determine the maintenance and sustainability plans for the implementation of ICT specialization subject for GCE (O/L) is the same in all five districts.

Hypothesis VII

H₀: Teachers' attitude towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others

Further, the above hypotheses were used tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Hypothesis VIII

H₀: Principals' attitude towards the maintenance and sustainability mechanism for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Principals' attitude towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others

Further, the above hypotheses were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, the following hypothesis were used to determine the differences in schools category-wise in connection with maintenance and sustainability plans.

Hypothesis IX

H₀: Principals' attitude towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all schools types.

H₁: Principals' attitude towards the maintenance and sustainability mechanism for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one school type is different from the others.

Further, the above hypothesis was tested using the Kruskal- Wallis Test and, based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Software (X₄)

The following hypothesis was used to determine whether the ICT teachers' preferences regarding the software solutions are the same district-wise.

Hypothesis X

H₀: Teachers' attitude towards the usage of software for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the usage of software for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in, at least one district, is different from the others.

Further, the above hypotheses were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

The above hypothesis outcome can be verified using the students' opinion. Therefore, the following hypotheses are used.

Hypothesis XI

H₀: Students' attitude about the usage of Microsoft product for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Students' attitude about the usage of Microsoft products for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others

Further, the above hypotheses were tested using the Kruskal - Wallis Test and, based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Curriculum Implementation Facilities And Issues (X₅)

The following hypothesis was used to determine that the curriculum implementation facilities and its strength is the same district-wise when implementing the ICT specialization subject in Sri Lankan schools from the teachers' point of view.

Hypothesis XII

H₀: Teachers' attitude towards the curriculum implementation facilities/techniques of ICT education for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the curriculum implementation facilities/techniques of ICT education for ICT specialization subject for GCE (O/L) in Sri Lankan schools in, at least, one district is different from the others

Further, the above hypotheses were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, based on the principal's opinion, the following hypothesis was used.

Hypothesis XIII

H₀: Principals' attitude towards the implementation facilities for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Principals' attitude towards the implementation facilities for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others. Further, the above hypotheses were tested using the Kruskal - Wallis Test and, based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected. Further, the following hypothesis was used to determine the differences in schools category wise in connection with curriculum implementation facilities and issues.

Hypothesis XIV

H₀: Principals' attitude towards the curriculum implementation facilities for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all schools types who are conducting ICT specialization subject for grade 10 and 11.

H₁: Principals' attitude towards the curriculum implementation facilities for ICT specialization subject for GCE (O/L) in Sri Lankan schools in, at least one school type is, different from the others.

Further, the above hypothesis were tested using the Kruskal- Wallis Test and, based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

According to the literature review, it was shown that the usage of pedagogical techniques is minimal in ICT education in Sri Lankan schools. Further, the following hypothesis was used to determine district-wise differences in the usage of pedagogical techniques when implementing the ICT specialization subject in Sri Lankan schools from the ICT teachers' point of view.

Hypothesis XV

H₀: Teachers' attitude towards the usage of pedagogical techniques for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the usage of pedagogical techniques for ICT specialization subject for GCE (O/L) in Sri Lankan schools in, at least one district, is different from the others

The above hypothesis was tested by Kruskal- Wallis test. Based on the P-value, the acceptance or rejection of the null hypothesis can be decided.

Further, literature review reveals that the programming and problem solving unit was a major creative thinking unit of the ICT specialization subject. To determine the correlation with other course units, the following hypothesis was tested using correlation.

Hypothesis XVI

H₀: There is no association between Q6.2 (programming and problem solving techniques) and Q6.1 (information systems)

H₁: There is an association between Q6.2 (programming and problem solving techniques) and Q6.1 (information systems)

Hypothesis XVII

H₀: There is no association between Q6.2 (programming and problem solving techniques) and Q6.3 (web design)

H₁: There is an association between Q6.2 (programming and problem solving techniques) and Q6.3 (web design)

Hypothesis XVIII

H₀: There is no association between Q6.2 (programming and problem solving techniques) and Q6.4 (ICT and society)

H₀: There is an association between Q6.2 (programming and problem solving techniques) and Q6.4 (ICT and Society)

Hypothesis XIX

H₀: There is no association between Q6.2 (programming and problem solving techniques) and Q6.5 (individual project)

H₁: There is an association between Q6.2 (programming and problem solving techniques) and Q6.5 (individual project)

According to the p values, it can be decided whether the null hypothesis can be rejected or not.

Support From The Administration And Supportive Initiative (X₇)

The following hypothesis was used to determine that the support from the administration and supportive initiative is the same, district-wise, when implementing the ICT specialization subject in Sri Lankan schools from the ICT teachers' point of view.

Hypothesis XX

H₀: Teachers' attitude towards the support from administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the support from administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others

Further, the above hypotheses were tested using the Kruskal - Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, based on the principals' opinions, the following hypothesis was tested.

Hypothesis XXI

H₀: Principals' attitude towards the support from administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Principals' attitude towards the support from administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others.

Further, the above hypotheses were tested using the Kruskal- Wallis Test and, based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, the following hypothesis was used to determine the differences in schools category-wise in connection with support from the administration and supportive initiative for ICT specialization subject for GCE (O/L).

Hypothesis XXII

H₀: Principals' attitude towards support from administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all school types conducting ICT specialization subject for grade 10 and 11.

H₁: Principals' attitude towards the support from administration and supportive initiative for the ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one school type is different from the others.

Further, the above hypotheses were tested using the Kruskal - Wallis Test and, based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

The following hypothesis was used to determine that the research and development activities are the same district-wise when implementing the ICT specialization subject in Sri Lankan schools from ICT teachers' point of view.

Hypothesis XXIII

H₀: Teachers' attitude towards the importance of adopting research and development activities to enhance for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Teachers' attitude towards the importance of adopting research and development activities to enhance for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district, is different from the others.

Further, the above hypothesis were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, based on the principals' opinions, the following hypothesis was tested.

Hypothesis XXIV

H₀: Principals' attitude towards the importance of adopting the research and development activities to enhance the ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H₁: Principals' attitude towards the importance of adopting research and development activities to enhance the ICT specialization subject for GCE (O/L) in Sri Lankan schools, in at least one district, is different from the others.

Further, the above hypotheses were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H₀ can be rejected.

Further, the following hypothesis was used to determine the differences in schools category-wise in connection with the importance to adopt research and development activities to enhance ICT specialization subject for GCE (O/L) in Sri Lankan school.

Hypothesis XXV

H₀: Principals' attitude towards the importance of adopting research and development activities to enhance for ICT specialization subject for GCE (O/L) in Sri Lankan schools, is the same in all school types who are conducting ICT specialization subject for grades 10 and 11.

H₁: Principals' attitude towards the importance of adopting research and development activities to enhance for ICT specialization subject for GCE (O/L) in Sri Lankan schools, in at least one school type, is different from the others.

Further, the above hypotheses were tested using the Kruskal- Wallis Test and based on the P value, if the p value is less than the significant level ($\alpha=0.05$), then H_0 can be rejected

Further, appendices 4-9 contain outputs of open ended informal interviews, class room observations, and participation at workshops. All information gathered is presented in summarized manner using data reduction techniques.

After obtaining the present status of ICT education in Sri Lanka as mentioned in the specific objective 2 in the research study and based on the status of ICT education in the Asian region (as explored in the literature review),the entire tier 2 was designed as follows.

The Table 4.1 in section 4.2 used to cover the achievement of the specific objects 3 and 4.

The above design methodology illustrates the achievement of specific objectives 1-4 in the research study.

4.7 Justification Of Methodology

All the objectives of the study are mapped on to the three-tier architecture. The research study comprises two phases. Phase I includes Tier 1 and Tier 2 of the design approach which achieve the first four objectives of the research study. Finally, the design provides a mechanism to achieve all four objectives and to obtain the status expected and the achievable level of ICT education in Sri Lankan schools. This outcome of the first-four objectives were used as input to achieve the 5th objective of the study and achievement of objective 5 via the 3rd tier of the proposed application model design. The implementation and evaluation of objective 5 is described in Chapter 6.

Chapter 5: Analysis And Results Presentation Of Phase I

5.1 Introduction

As presented, the purpose of the study was to determine the present status of ICT education in Sri Lankan schools and identify how factors such as strategies, standards indicators and methodologies affect quality ICT education and finally propose necessary suggestions for the improvement of ICT education under the quality framework in the Sri Lankan Context.

This Chapter includes the results related to the survey according to the proposed complete design framework for the study in Figure 4.1 in Chapter 4, where information was grouped and presented according to the indicators mentioned in the first two tiers of the proposed three tier architecture model shown in Figure 4.2 in Chapter 4 based on the following 9 pillars: (i) Infrastructure facilities (X₁) (ii) Human resource facilities (X₂) (iii) Maintenance and sustainability plans(X₃) (iv) Software (X₄) (v) Curriculum implementation facilities(X₅) (vi) Policy matters (X₆) (vii) Support from the administration and supportive initiative (X₇) (viii) Research and development(X₈) (ix) Budget allocation and country expectations (X₉).

With the aim of achieving the research objectives successfully, data collecting instruments were designed to meet the broad objectives of the study. Further, applying theoretical aspects, the achieved outcomes of the first four objectives and results were presented in Chapter 5. To avoid data duplication and redundancy, presentation of results have been included in the first four objectives together as the first phase of the study.

5.2 Results Related To The Survey Analysis

Results presentation includes two major parts, such as the nature of sample and outcome of the survey.

5.3 Nature Of The Sample

This section presents information on how well the sample represents the population. This includes the composition of the sample by district, school type, gender, school grade, distance from school to home, time taken to travel to school (i.e. home to school and school to home) from students. Further, information was collected from teachers, principals and selected officers from different organizations related to ICT education.

The details of the selected sample of schools for the survey is shown in Table 5.1.1

Table 5.1.1 Composition of the sample by district

District	Sample	
	Total	Percent %
Total	35	100
Colombo	12	34.3
Gampaha	7	20
Puttalam	4	11.4
Hambantota	8	22.9
Nuwara Eliya	4	11.4

This study used multi-stage sampling methods and for the selection of districts, schools and students, the random judgment sampling technique was used. The number of schools from

each district for the survey was selected considering the number of available schools in each district. For example, Table 5.1.1 above shows, that Colombo district has a large number of schools while Puttalam and Nuwara-Eliya show low values. Further, the sample represents more than 10% of the population. Moreover, the school sample is representative of the whole population as much as possible.

Sri Lankan schools are traditionally classified into several categories and one of the major categories is according to school type. The sample consists of a fair distribution according to traditional classification.

Table 5.1.2 Composition of the sample by school type

	sample Total	Percent %
Total	35	100
1 AB National	8	22.9
1 AB Provincial	8	22.9
1 C	11	31.4
Type 2	8	22.9

Table 5.1.2 shows sample distribution according to school type. The sample composition includes more than 20% of each category and represents a fair number of schools from each category. Further, type 3 is not considered for the survey because it has classes only up to grade 9 and ICT specialization commences from grade 10. Women and men play identical roles in society. They have equal access to education, work, career opportunities and economic resources. Therefore, fair distribution of gender is important for any kind of survey.

Table 5.1.3 Composition of the sample by Gender

	Sample Total	Percent %
Total	1295	100
Male	764	59
Female	531	41

Table 5.1.4 Nature of students

	Total	Percentage %
Total	32	100
Boys	3	9
Girls	4	13
Both	25	78

Table 5.1.3 shows gender distribution of the sample. The sample consists of a fairly equal distribution of the male and female percentages for analysis. Out of 32 schools in the sample on which information was provided by principals, 9% were boys' schools, 13% girls' schools and 78% were mixed schools (fairly distributed male and female according to the country's population) Table 5.1.3 and Table 5.1.4 reveal that equally balanced ratios of male and female students were selected for the analysis. The survey is mostly focused on grade 10 and grade 11 students pursuing ICT specialization subject. Therefore, an equal distribution is very important for fair analysis.

Table 5.1.5 The Total number of students who follow ICT specialization subject at Grade 10 and Grade 11 in selected schools

	ICT 10		ICT-11		Total
	ICT-10	%	ICT-11	ICT-11 %	
Colombo	303	53%	270	47%	573
Gampaha	177	54%	148	46%	325
Puttlum	32	20%	126	80%	158
Hambanthota	259	56%	207	44%	466
Nuwara-Eliya	65	51%	63	49%	128
Total	836	51%	814	49%	1650

Table 5.1.5 shows a fair distribution of students following ICT specialization subject at grade 10 and grade 11 in the schools.

Table 5.1.6 Composition of the sample by School Grade

	Sample Total	Percent %
Total	1295	100
Grade 10	697	53.8
Grade 11	598	46.2

Table 5.1.6 shows the sample distribution by grades 10 and 11. The survey was conducted in the month of December; the end of the academic year. Therefore, one can get effective information on the status and coverage of the curriculum. Further this sample shows a fair distribution of percentages of Grade 10 and Grade 11, as 53.8% and 46.2% respectively. There is a slight difference in grade percentage and this is due to the fact that in some schools ICT education commenced in the current years; there aren't many ICT students in grade 11 compared to grade 10.

According to the literature, the physical and human resources related to ICT education in Sri Lankan schools are limited and their facilities depend purely on the number of students in a particular school. Therefore, the number of students in the selected sample is quite important.

Table 5.1.7 Total number of students in school

Category	No of Students	Total	Percentage %
		32	100%
1	1-100	0	0%
2	101-500	6	19%
3	501-1000	7	22%
4	1001-2000	11	34%
5	2001-3000	6	19%
6	>30000	2	6%

The selected sample was fairly distributed with different schools having different student densities. Students' density in the selected schools is shown in Table 5.1.7

As background information, the available resources are very useful for different courses of studies in the schools system. Different ICT courses are offered in different grade ranges. For

example, ICT (O/L) is only applicable for grades 10 and 11 while GIT is only applicable for grade 12 students. Therefore, grade-wise sample distribution is important for the study.

Table 5.1.8 Total Student population in selected sch

	1-5year	6-9 year	Grade 10	Grade 11	Grade 12	Total
Colombo	6806	5091	1163	1223	613	14896
Gampaha	2265	2614	676	721	693	6969
Puttlum	1332	2762	697	671	930	6392
Hambanthota	3259	2716	703	720	490	7888
Nuwara-Eliya	638	835	222	240	256	2191
Total	14300	14018	3461	3575	2982	38336

Table 5.1.8 reveals that the selected sample has a different number of students in different grade categories. When implementing ICT specialization and ICT education, the actual values above were very useful.

The government has initiated ICT education for students from grade 6 to grade 9. As a base year, grade 6 is important in order to commence the project. Therefore, grade 6 is very important apart from the other grades up to grade 9.

Table 5.1.9 The total number of students following ICT literacy subject in Grade 6 in the selected schools

	ICT-6
Colombo	335
Gampaha	59
Puttlum	40
Hambanthota	284
Nuwara-Eliya	30
Total	748

Table 5.1.9 shows, that though the above is reported, there are very few students who learn ICT literacy subject. According to the facts related to the study, it was revealed that still there is no approved curricular or documented guidelines for grades 6 to 9.

The distance from school to home and time taken for the school journey is greatly related in maintaining quality education as well as ICT education.

Table 5.1.10 Distance from school to home

	Sample Total	Percent %
Total	1295	100
1- 5 Km	910	70.3
6- 10 Km	209	16.1
11- 20 Km	112	8.6
20- 50 Km	61	4.7
51 Km more	3	0.2

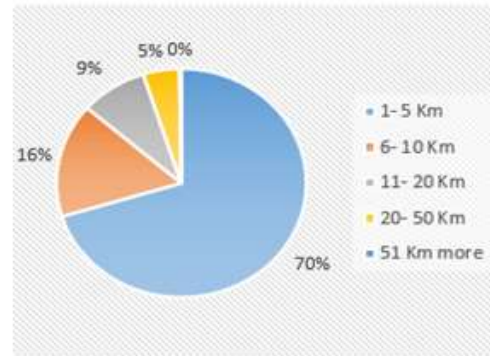


Fig 5.1.1 pie chart of distance from school to home

Table 5.1.10 and Figure 5.1 shows the frequency distribution of distance from home to school. It shows that 70.3% students are around a 1-5km radius and 16.1% are within a 6-10km radius.

Table 5.1.11 Composition of the sample in terms of the time taken to travel from school to home and vice versa

	Sample Total	% Percent
Total	1295	100
Upto 1 Hour	1073	82.9
1 Hour to 2 Hours	182	14.1
2 Hour to 3 Hours	37	2.9
3 Hour to 4 Hours	2	0.2
More than 4 Hours	1	0.1

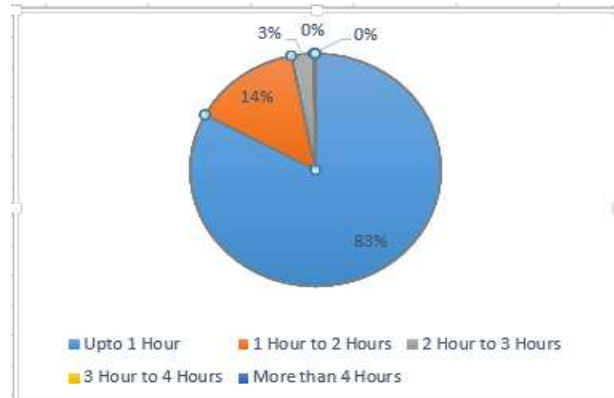


Figure 5.1.2: Time spend on the journey

According to the table, 82.9% of students spent up to 1 hour and 14.15% students spent 1 to 2 hours on their school journey while 3.2% students spent more than two hours on their school journey. One of the major roles in ICT education is played by the ICT teachers. Therefore, general information on ICT teachers who are conducting ICT specialization subject for grade 10 and 11 is greatly relevant to the background analysis.

Table 5.1.12 ICT teachers' information; gender-wise and district-wise

	Total	Male	%	Female	%
Total	48	7	15%	41	85%
Colombo	19	1	5%	18	95%
Gampaha	9	2	22%	7	78%
Puttalam	6	0	0%	6	100%
Hambantota	10	2	20%	8	80%
Nuwara Eliya	4	2	50%	2	50%

Table 5.1.12 shows gender distribution of ICT teachers. According to the table, it is seen that the percentage of female teachers is higher with respect to the male percentage.

Table 5.1.13 The Number of ICT teachers in schools

	Total	1	%	2	%	3	%	4	%
Total	32	19	59%	7	22%	4	13%	2	6%
Colombo	11	5	45%	5	45%	0	0%	1	9%
Gampaha	7	6	86%	0	0%	1	14%	0	0%
Puttalam	4	3	75%	0	0%	0	0%	1	25%
Hambantota	7	3	43%	1	14%	3	43%	0	0%
Nuwara Eliya	3	2	67%	1	33%	0	0%	0	0%

Table 5.1.13 reveals that as much as 59% of the sample has one ICT teacher in their school while 6% of schools have 4 ICT teachers in their schools. According to the objectives of the study, the survey has collected the required data and it shows the results of achieving the objectives.

5.4 Results Pertaining To Phase I (Objectives 1 To 4)

Overview

Based on the outcome of the survey, the following results elaborated the present quality status of Sri Lankan schools in connection with the ICT specialization subject for GCE (O/L). The order of the present results, nine variables (X_1 - X_9) which were derived from the literature review were used as follows. Further, all the outliers in connection with the variables X_1 to X_9 are eliminated using the methodology described in Boxplot theoretical foundation in the outlier analysis in Section 2.2 and Figure 2.2 of Chapter 2.

5.5 Infrastructure Facilities (X_1)

Computer accessibility and other related infrastructural facilities (e.g. power supply, networks, internet connectivity etc.) are the most vital factors for the implementation of quality ICT education. Therefore, investigation of accessibility to computers for the students and teachers is an essential ingredient in this regard.

Based on the survey outcomes, descriptive statistics in connection with the infrastructure facilities (X_1) are shown in Appendix 12.

The Tables 1.1 and 1.2 of Appendix 12 indicate that 98% of students following ICT specialization subject for GCE (O/L) in Sri Lankan schools have the opportunity to use computer facilities and 100% students use electricity as a power source. Network infrastructure is provided to connect a large number of schools and other related organizations. The main objective of the network is to improve the quality of education (including ICT in education) and resource sharing within a school and also to connect all the schools into a single network. The Internet is one of the important tools a person has, to be successful in their future. It provides jobs, resources and communication all over the world. It is essential that children learn to use and learn from Internet. Investigation of usage of

internet is one of the major aspects of this study. Therefore, investigation of the availability of a network and internet connectivity in schools and other related organizations is a very necessary aspect of this study because of the achievement of objective 5 that uses blended learning approaches. Table 1.3 in Appendix 12 shows that, on average, 75% and 83% of the schools that conduct ICT specialization subject for GCE (O/L) have networking facilities and internet facilities in their schools, respectively.

Computer Facilities Student Computer Ratio

Computer resources are one of the main ingredients of ICT education. Availability of computer facilities greatly affects ICT education. Therefore, investigation of computer facilities is essential for the success of this study.

According to Table 1.4 in Appendix 12, it was revealed that, on average, 23 computers are available in the school's computer laboratory. Further, Table 1.5 in Appendix 12 shows that on average, computer student ratio is 1:12 among the students who are following ICT specialization subject for GCE (O/L) in Sri Lankan schools. Further, the following descriptive statistics was derived using the facts collected from the MOE and NIE authorities based on Appendix 4 and 5 especially in connection with ICT specialization subject for GCE (O/L) curriculum.

Based on the outcome of Appendices 4-7 and Tables 1.4, 1.5 and 1.7 in Appendix 12, the estimated real requirement of computer student ratio for the implementation of the ICT specialization subject for GCE (O/L) in Sri Lankan schools is 1:24. But based on Table 1.6 in Appendix 12 shows that, the available computer student ratio is 1:12.

According to the above descriptive statistics and based on the outcome of the feedback of other stakeholders in the survey, it was concluded that the existing infrastructure facilities are sufficient to implement the ICT specialization subject for GCE (O/L) in the Sri Lankan education system. The following Inferential Statistics were used with the aim of further strengthening the above conclusion.

According to the methodology described in the Chapter 4, the total rank sum and total rank sum ratio of related dimensions in connection with the infrastructure facilities were determined and also nonparametric hypothesis testing were applied to achieve the outcome of the survey. The following inferential statistics elaborated the quality of infrastructure facilities for the implementation of ICT specialization subject for GCE (O/L) in the Sri Lankan education system.

The variable X_1 (Infrastructure facilities) was derived from the dimensions related to the infrastructure as shown in Table 4.4 in chapter 4.

Figure 5.2.1 shows the summary statistics regarding the availability of infrastructure facilities from ICT teachers' point of view for the implementation of ICT specialization subject for the Grade 10 and 11 students.

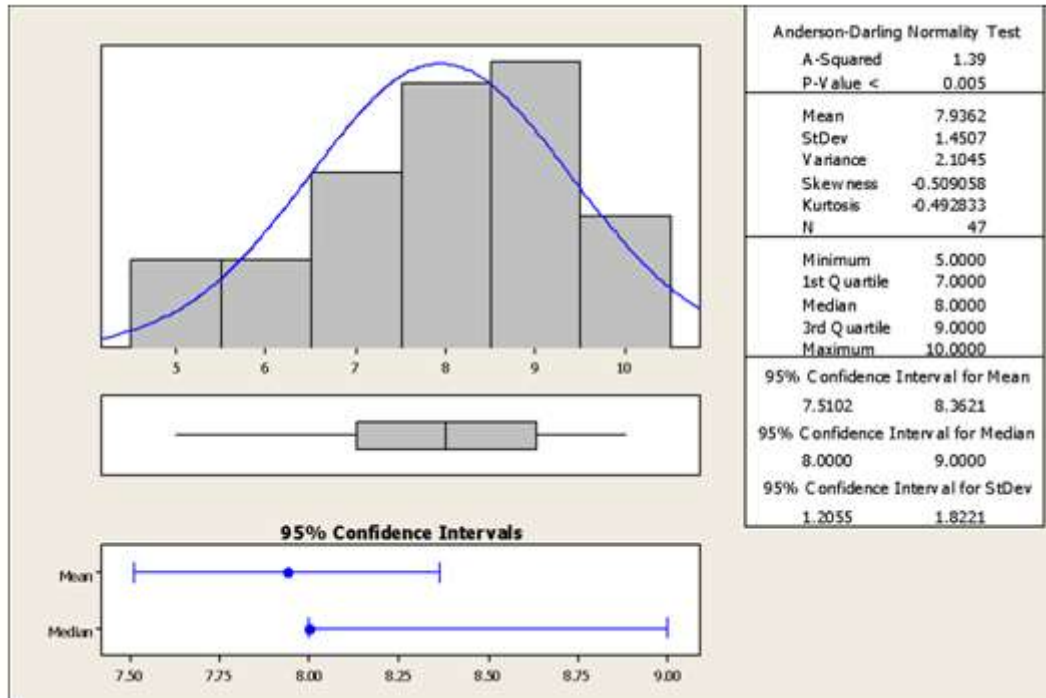


Figure 5.2.1 Summary statistics for total rank sum on infrastructure (X₁) – ICT teachers' point of view

According to Figure 5.2.1, the minimum rank sum is 5.0 and the maximum rank sum is 10.0. Median 8.0 indicates that 50% of the respondents are given a rank greater than or equal to 8.0. 1st quartile is 7.0. This means that the rank sum of 75% of the respondents is greater than or equal to 7.0. Further, 3rd quartile is 9.0. It claims that the rank sum of 25% of the respondents is greater than or equal to 9.0.

Accordingly, attitudes towards the infrastructure for the implementation of ICT specialization subject for Grade 10 and 11 is up to satisfactory level from the point of view of ICT teachers. The confidence interval for mean and median also support the same.

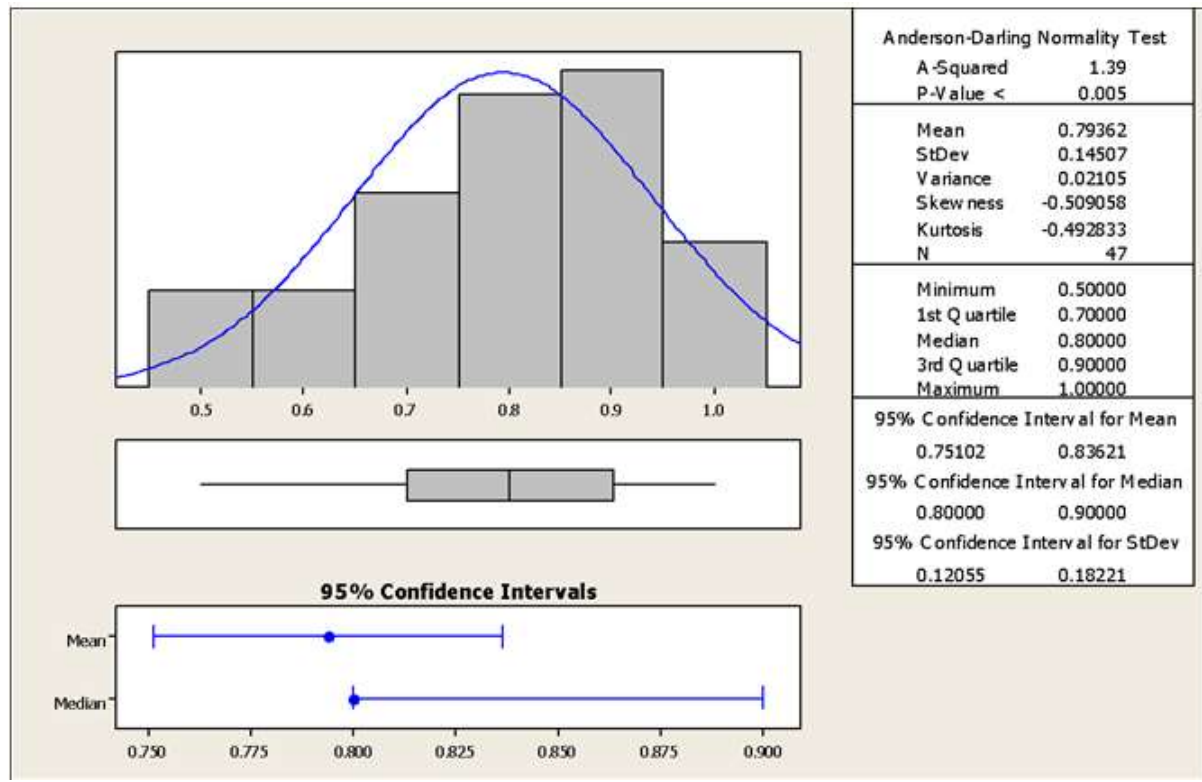


Figure 5.2.2 Summary statistics for rank sum ratio on infrastructure. (X_1)– ICT teachers' point of view

Summary statistics for rank sum ratio was also obtained and is shown in the Figure 5.2.2. 95% confidence interval for median is (0.800, 0.900) in Figure 5.2.2 and (8.00, 9.00) in Figure 5.2.1. This means that, there is 95% of a chance that the rank sum lies in the interval (8.00, 9.00) and total rank ratio lies between (0.800, 0.900). Further, these statistics also confirm that the existing infrastructure is sufficient to implement the ICT specialization subject for GCE (O/L) curriculum.

The following hypothesis I was tested using the Kruskal- Wallis test which was described in section 4.6 of Chapter 4.

H_0 : Teachers attitude towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

H_1 : Teachers attitude towards the infrastructure of ICT education for ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one district is different from the others.

The following results were obtained.

Table 5.2.1 Kruskal-Wallis test for total rank sum versus district on infrastructure – ICT teachers’ point of view

District	N	Median	Average Rank	Z
Colombo	19	9.000	27.7	1.54
Gampaha	9	8.000	19.4	-1.11
Puttalam	6	7.500	17.5	-1.24
Hambanthota	9	9.000	26.1	0.5
Nuwara-Eliya	4	8.000	21.6	-0.36
Overall	47		24	

H = 4.08 DF = 4 P = 0.396

H = 4.27 DF = 4 P = 0.371 (adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.371 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that “Teachers’ attitudes towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.”

According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all the ICT teachers who are teaching ICT specialization subject for grades 10 and 11 are satisfied with the existing infrastructure.

Principals are the chief administrative officers in schools and they are quite aware of the availability of infrastructure facilities for ICT education. Questions related to the infrastructure in principals questionnaires were taken, rank summed and summary statistics was represented in Figure 5.2.3

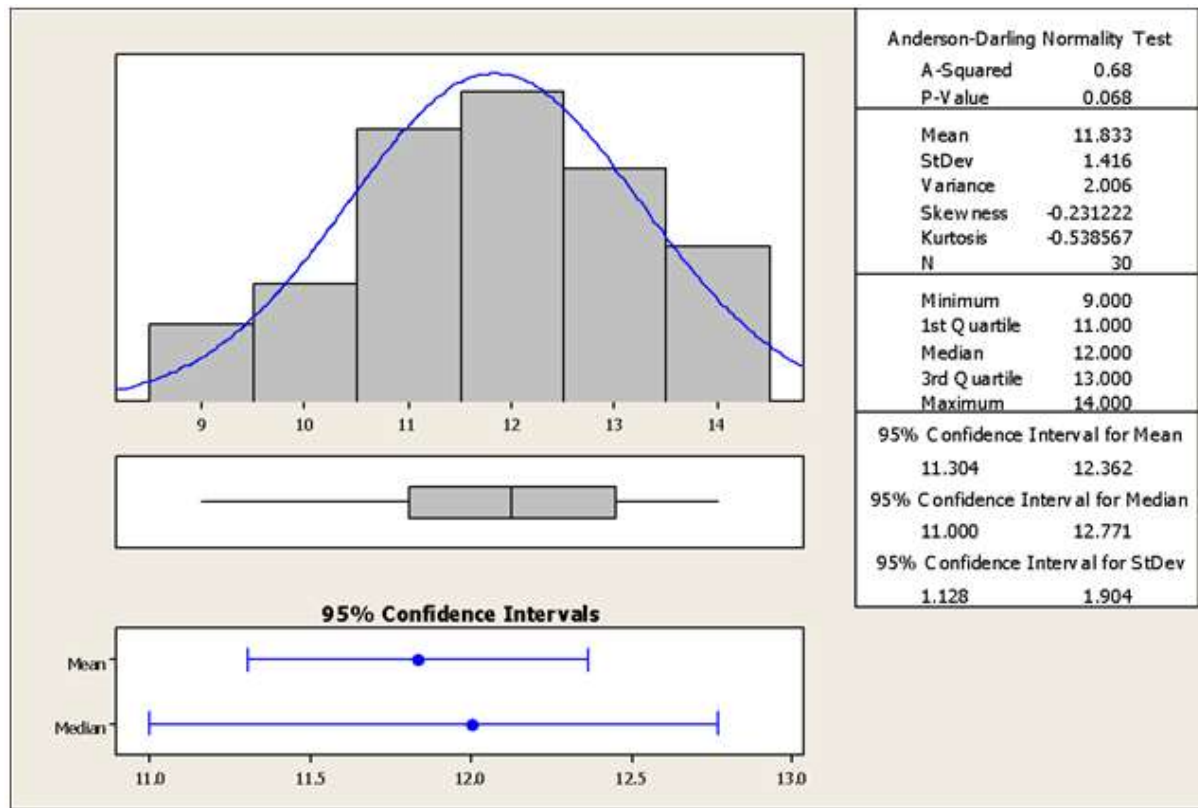


Figure 5.2.3 Summary statistics for rank of sum on infrastructure (X_1) on– Principals' point of view

According to Figure 5.2.3, the minimum rank sum is 9.0 and the maximum rank sum is 14.0. Median 12.0 indicates that 50% of the respondents are given the rank sum greater than or equal to 12.0. 1st quartile is 11.0. It means that the rank sum of 75% of the respondents is greater than or equal to 11.0. Further, the 3rd quartile is 13.0. It claims that 25% of the respondents rank sum is greater than 13.

Accordingly, attitudes towards the infrastructure for the implementation of ICT specialization subject for grades 10 and 11 is up to a satisfactory level from the point of view of principals'. 95% of the confidence interval for mean and median are (11.30, 12.36) and (11.00, 12.77) respectively and also support the same.

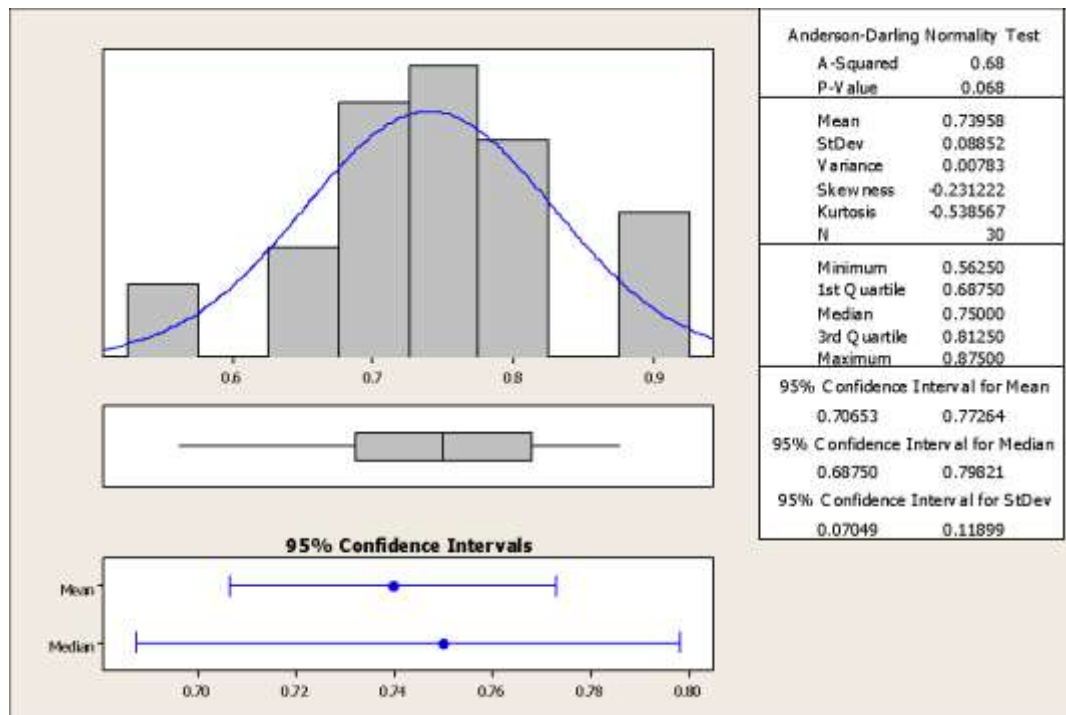


Figure 5.2.4 Summary statistics for rank sum ratio on infrastructure(X_1) – principal's point of view

The ratio of ranks sum obtained and also shown as in summary statistics in the Figure 5.2.4. 95% confidence interval for rank sum ratio median is (0.686, 0.798) in Figure 5.2.4 and rank sum median is (11.00, 12.77) in Figure 5.3. This means that, there is a 95% chance that the rank sum interval is (11.00, 12.77) and the rank sum ratio (0.686, 0.798) contains the median. The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis II which is described in section 4.6 of Chapter 4.

Table 5.2.2 *Kruskal-Wallis Test for rank sum versus district on infrastructure – Principal's point of view*

District	N	Median	Average Rank	Z
Colombo	11	12.000	15	-0.24
Gampaha	6	11.000	11.8	-1.17
Puttalam	3	13.000	22.8	1.52
Hambanthota	7	12.000	18.1	0.88
Nuwara-Eliya	3	11.000	11.5	-0.83
Overall	30		15.5	

H = 4.42 DF = 4 P = 0.352

H = 4.62 DF = 4 P = 0.329 (adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.329 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that “Principals’ attitude towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.”

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis III which was described in section 4.6 of Chapter 4.

Table 5.2.3 Kruskal-Wallis Test for rank sum versus School Type on infrastructure – Principals’ point of view

School Type	N	Median	Average Rank	Z
National	3	14.000	26.8	2.35
1 AB	12	12.000	16.7	0.61
1 C	11	12.000	15.3	-0.11
Type 2	4	9.500	4	-2.81
Overall	30		15.5	

H = 12.03 DF = 3 P = 0.007

H = 12.56 DF = 3 P = 0.006 (adjusted for ties)

The P value of the Kruskal-Wallis Test on total rank is 0.006 (adjusted for ties). As the P value is less than the significant level ($\alpha = 0.05$), H_0 can be rejected. It can be concluded that “Principals’ attitudes towards the infrastructure for ICT specialization subject for GCE (O/L) in Sri Lankan schools is that at least one school type is different from the others”.

According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all the Principals conducting ICT specialization subject for grades 10 and 11 are satisfied with the existing infrastructure. Furthermore, the above results show that, there are no disparities district-wise but there are some disparities in school types (school categories). Availability of infrastructure directly affect the students. Therefore, to confirm the validity of the above outcomes, other stakeholders’ attitudes are greatly important.

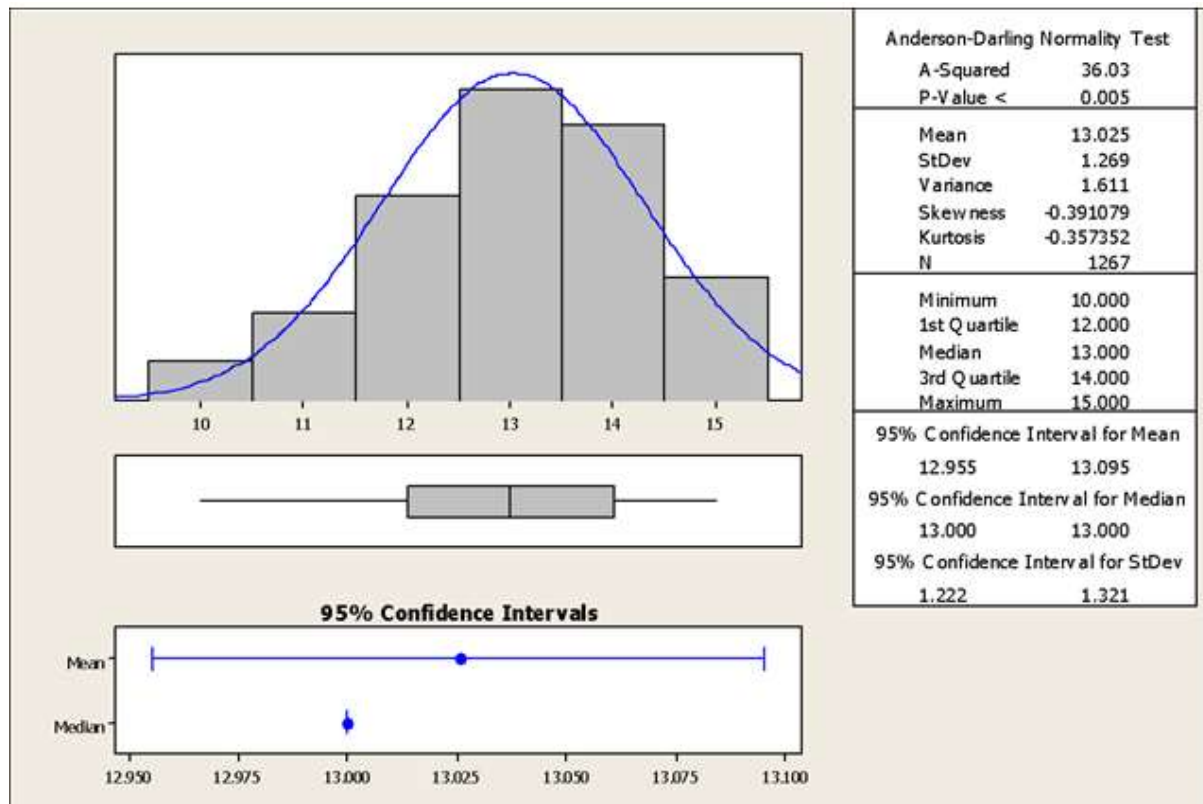


Figure 5.2.5 Summary statistics for rank sum on infrastructure (X1) – Students' point of view.

According to the Figure 5.2.5, minimum rank sum is 10.0 and maximum rank sum is 15.00. The median 13.0 indicates that 50% of the respondents are given a rank greater than or equal to 13.0. 1st quartile is 12.0. This means that the rank sum of 75% of the respondents is greater than or equal to 12.0. Further, the 3rd quartile is 13.0. It claims that above 25% of the respondents rank sum is greater than or equal to 13.

According to the above statistics, attitudes towards the infrastructure for implementation of ICT specialization subject for Grade 10 and 11 is up to a satisfactory level from the point of view of students. The lower and upper levels confidence interval values for median also coincide.

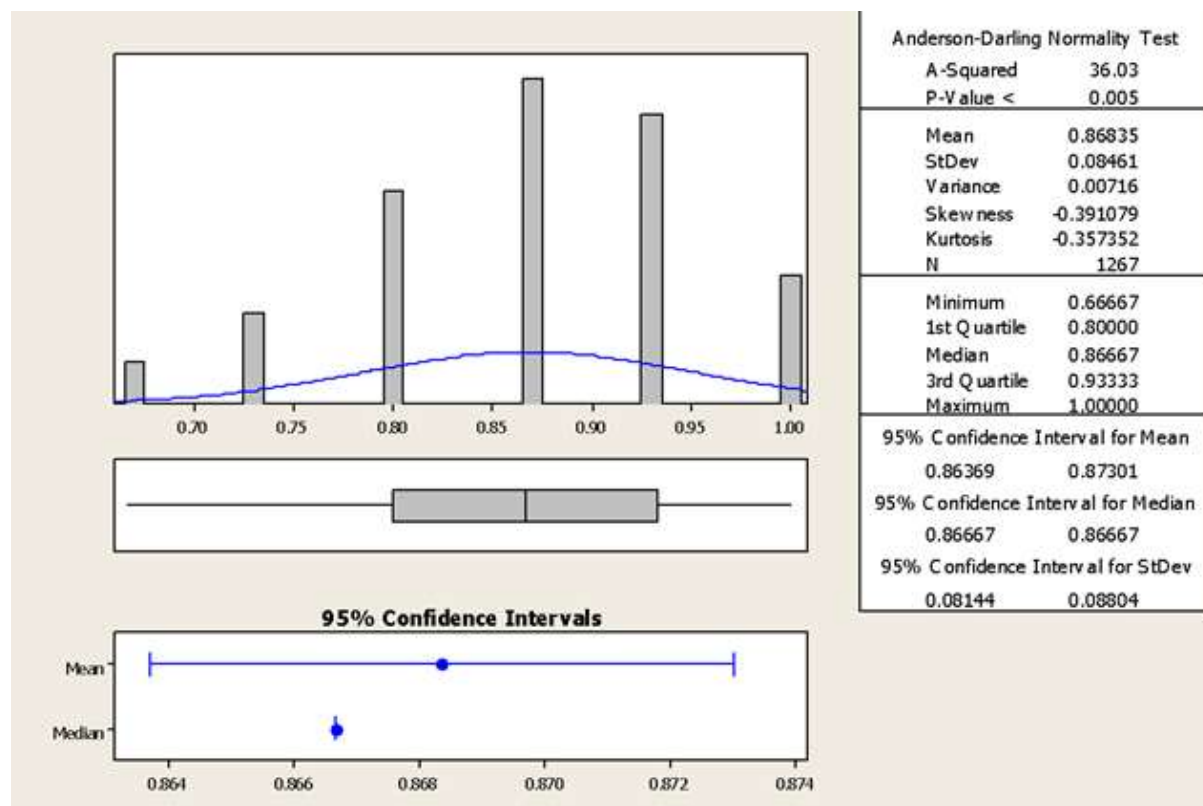


Figure 5.2.6 Summary statistics for rank sum ratio for infrastructure (X1) – ICT Students' point of view.

Summary statistics for ratio of ranks is also obtained and shown in the Figure 5.2.6. 95% confidence interval for median is (0.866, 0.866) in Figure 5.6 and (13.00, 13.00) in Figure 5.2.5. This means that, there is 95% of a chance that rank sum is point value (13.00, 13.00) and total rank ratio is point value (0.866, 0.866) contains the median. These statistics also confirm the same conclusion above.

The overall conclusion is that teachers, principals, students are satisfied with the existing infrastructure for ICT specialization subject for grades 10 and 11 in Sri Lankan schools.

5.6 Human Resource Issues (X₂)

Lack of Teachers

One of the major issues in human resources is the lack of ICT teachers and their skill levels. The skilled teachers play a prominent role in connection with the development of ICT education. Further, human resource facilities and strength are the most important factors in ICT education. According to Table 1.8 in Appendix 12, the following outcomes are revealed. 22% of Principals' mentioned that they are faced with difficulties due to lack of ICT teachers when implementing the ICT specialization subject. Further, 38% principals mentioned that they had un-filled ICT vacancies. When filling vacancies according to the approved cadre, it takes a long time due to administrative implications. For example, the only specialized ICT training college is at Ratnapura and its student intake is 240 students per academic year. Further, Table 1.8 illustrates that 52% teachers with non-ICT appointments are performing

the ICT specialization subject. The following Figure 5.2.7 shows the ICT teachers educational status.

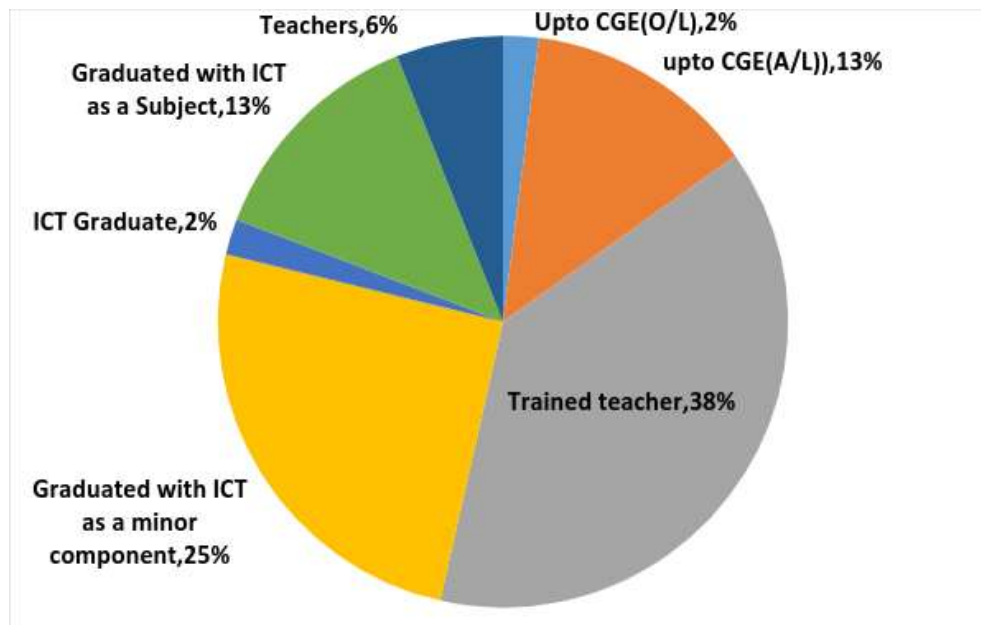


Figure 5.2.7. The ICT Teachers' qualification

Figure 5.2.7 reveals that 2% and 13% teachers have only GCE (O/L) and GCE (A/L) qualifications respectively. Table 1.9 in Appendix 12 also reveals that 29% ICT teachers have received less than 3 months training to teach ICT specialization for grades 10 and 11. Table 1.10 in Appendix 12 shows that all the teachers in the sample expect well-planned teacher training programs to enhance their knowledge as well as to educate their children in a quality manner. According to the results of Appendix 6 and 7, in connection with teacher training programs, the following information was gathered and is presented in summarized form.

A few CRC officers have reported that they trained ICT teachers at the early stage of ICT introduction but now they do not have the chance to train ICT teachers. Further, according to informal interviews conducted with selected officers in CRC's based on Annexure 6, the results are presented as follows. The vision of the Computer resource centers (CRC's) was to enrich the students, teachers as well as the nation in the zone with knowledge of ICT. The mission is defined as to train the nation using modern information communication knowledge in their day to day life so that people can move with modern society (CRC Kekirawa, 2009). The zonal computer resource centers (CRC), are governed by the Ministry of Education. Some of their activities, are as follows. (i) Computer course for after GCE (O/L) and GCE (A/L) students (ii) Teacher training programmes (the syllabus contents were broadened from GCE (O/L) and GCE (A/L) syllabus) (iii) Graduate teacher training programmes (iv) Vocational computer training programmes (v) Computer courses for government officers (vi) CAL teacher training (vii) Teacher training programmes for international computer driving license (ICDL) (viii) Advanced computer courses. Initially, CRC center facilities were provided by the MOE and a few (2 to 4) teachers were attached to these centers. After that

the MOE expected self-sustainability of CRC centers. The staff of the CRC centers should conduct courses to run the center. The course fees for all the courses are according to the MOE, Circular No. HRD/PPR/2002/9, Ministry of Education 2004. In the case study the following were observed in the CRC centers.

Several courses were conducted at the CRC centers with the approval of the zonal educational committee. (Composition of the committee is as follows. Chairperson –zonal educational secretary, secretary- CRC center co-coordinator, member, principal and other members).Some of CRC centers function successfully and some function with less quality. According to the case study, two successful CRC centers are the Horana Taxila computer resource center and Lumbini Vidyalaya identified from the Colombo district. Success depends on the performance of the center co-coordinator and the staff.

At the beginning large numbers of students enrolled on the ICT course at the CRC centers but these gradually decreased. For example, Table 1.11 in Appnedix12 shows student enrolment at the Lumbini Vidyalaya, CRC center (with 15 Computers).

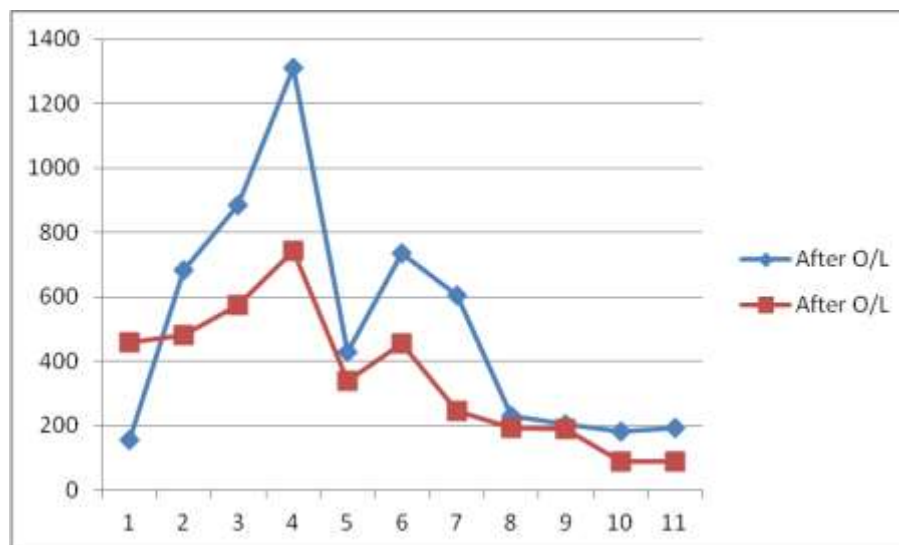


Figure 5.2.8 student intake at Lumbini Computer Resource Center

Source: (Computer Resource Center [CRC], 2009)

This information shows the present status of the CRC centers (No of Years versus number of students enrolled) and how it can contribute to ICT educations in schools (Teacher training, ICT education for schools and benefits to the schools communities). Further, number of years in the above Figure 5.2.8 is recorded as follows: 1=2001, 2=2002, 3=2003, 4=2004, 5=2005, 6=2006, 7=2007, 8=2008, 9=2009, 10=2010 and 11=2011.

According to Figure 5.2.8, it is seen that after 2004, the enrolment of students has decreased. To overcome this problem, some Centers started Web design, Graphic design, and 3D animation video editing, and advanced programming courses while others were failures due to traditional courses. During the case study, the staffs of the CRC's mentioned that the

failure of CRC centers will occurred due to the following reasons. Progress/activities of CRC center depends on the ability and performance of their staff. Improper co-ordination and monitoring by the relevant authorities and lack of modern training facilities to the staff of CRC centers.

Further, one of the zonal ICT directors has reported that they conduct ICT teacher updating programs selecting the title of the updating program at a zonal level but with the resource person conducting his/her own selection of sub-titles. According to Annexure 7, some trainee students in ICT training colleges have mentioned that they get proper training in all the areas in a satisfactory manner excepting in ICT subjects. They reported that there were several issues and problems with the ICT subjects.

Some students who studied at CRC centers are engaged in teaching in private sector ICT institutions. Some students conduct ICT literacy courses for teachers (CRC, 2009) which were conducted by private ICT institutes by request of the MOE.

Further, a survey was conducted to collect information related to the status of the present ICT cadre positions, recruitment and teachers assigned for ICT course units conducted at schools by MOE authorities and provincial council educational officers' views were presented as follows.

According to the Ministry of Education and provincial council educational officers', Cadre creation and recruitment procedure take a long time. According to specified dates in a particular year, respective school principals should forward their ICT teacher requirements to the provincial educational office, after the recommendation of provincial state educational commission, through the ministry of education; they should get approval from the management service committee at the Treasury. Based on their approval, provincial educational officers can advertise and recruit suitable persons from the graduates in the province. Further, in the case of national schools, the Ministry of Education will recruit teachers in the same manner. On some occasions, the output of the National Colleges of Education will be allocated to national schools as well as provincial schools for their recruitment and the MOE should follow the above mentioned procedure. When filling vacancies according to the approved cadre, it takes a long time due to administrative overheads. Further, especially in the ICT Teacher Training College at Ruwanpura the student intake is 240 students per academic year. Due to the above reason, Sri Lankan school system doesn't have sufficient people for ICT education in Sri Lankan Schools. According to the MOE and provincial educational officers' statements, some ICT teachers teach other subjects in the school curriculum on a full time basis. Considering the above descriptive statistics, it was concluded that the human resource facilities and its strength is not of a satisfactory level to implement the ICT specialization subject for GCE (O/L) in Sri Lankan schools. With the aim of strengthening the above conclusion made on human resource facilities, the following inferential statistics were used.

Inferential Statistics used to illustrate the Human Resource strength

The literature review and the above descriptive facts reveal that the Human resource contribution is one of the most important pillars and it can be used to enhance the quality of ICT education. The following analysis illustrate the status of human resource facilities and its strength used to implement the ICT specialization subject for grade 10 and 11 in Sri Lankan schools. Figure 5.2.9 shows the summary statistics regarding the availability of human resource facilities and its strength from ICT teachers' point of view for the implementation of ICT specialization subject for GCE (O/L) students

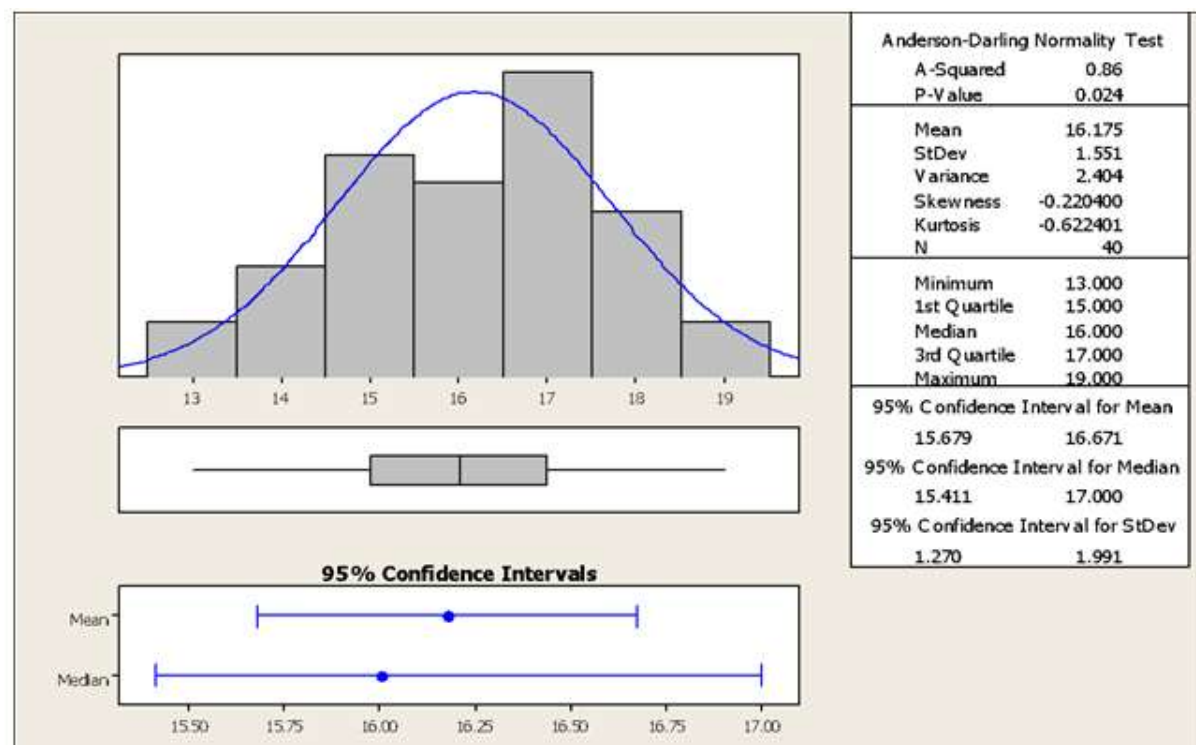


Figure 5.2.9 Summary statistics for Human resource (X_2) on rank of sum – ICT teachers' point of view.

According to Figure 5.2.9, minimum rank sum is 13.0 and maximum rank sum is 19.0. Median 16.0 indicates that nearly 50% of the respondents are given a rank sum greater than or equal to 16.00. The 1st quartile is 15.0. This means that 75% of the respondents' rank sum is greater than or equal 15.0. Further, the 3rd quartile is 17.0. It claims that above 25% of the respondents' rank sum is greater than or equal to 17.0.

Accordingly, attitudes towards the human resource facilities and its strength for the implementation of ICT specialization subject for Grade 10 and 11 is up to a satisfactory level from the point of view of ICT teachers. The confidence interval for the mean and median also support the same and this is close to the upper bound of the range.

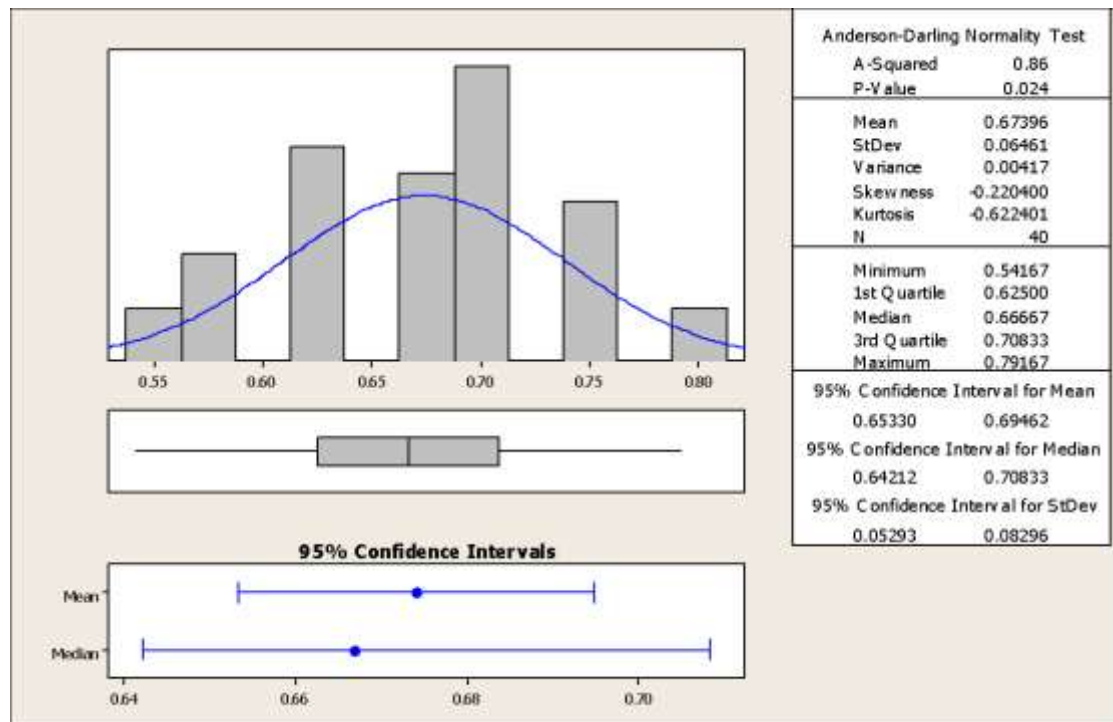


Figure 5.2.10: Summary statistics for human resource facilities and its strength (X_2) –on rank sum ratio- ICT teachers' point of view

Summary statistics for rank sum ratio was also obtained and is shown in Figure 5.2.10. 95% of the confidence interval for median is (0.642, 0.708) in Figure 5.2.10 and (15.41, 16.67) in Figure 5.2.9. This means that, there is a 95% chance that the rank sum lies in the interval (15.41, 16.67) and rank sum ratio lies between (0.642, 0.708) contains the median.

According to Figure 5.2.9, 95% of the confidence interval for median is (15.41, 17.00) and it seems close to the upper bound of the rank sum. According to Figure 5.2.10, the above statistic shows that the rank ratio is also close to the median.

Accordingly, attitudes towards the human resource facilities and its strength for the implementation of ICT specialization subject for Grade 10 and 11 is up to a satisfactory level from the point of view of ICT teachers. The confidence interval for the mean and median also support the same.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis IV described in section 4.6 of Chapter 4.

Table 5.2.4 Kruskal-Wallis Test on total ranks for Human resource facilities and its strength – ICT teachers' point of view

District	N	Median	Average Rank	Z
Colombo	17	16.000	18.4	-1.00
Gampaha	7	16.000	21.9	0.34
Puttalam	5	15.000	15.9	-0.94

Hambanthota	8	17.000	25.4	1.34
Nuwara-Eliya	3	17.000	24.0	0.54
Overall	40		20.5	

H = 3.14 DF = 4 P = 0.535
H = 3.26 DF = 4 P = 0.515 (adjusted for ties)

P value of the Kruskal-Wallis test on total rank is 0.515 (adjusted for ties). As the P value is greater than the significant level ($\alpha= 0.05$). H_0 cannot be rejected. It can be concluded that “Teachers’ attitude towards the Human resource facilities and its strength for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.”

As the main administrative officer of the respective schools, principals are directly aware of the availability of human resource facilities in the school for implementation of ICT specialization subject for grade 10 and 11. Figure 5.2.11, illustrates the status of human resource facilities and its strength in the Sri Lankan school system according to the principals’ point of view.

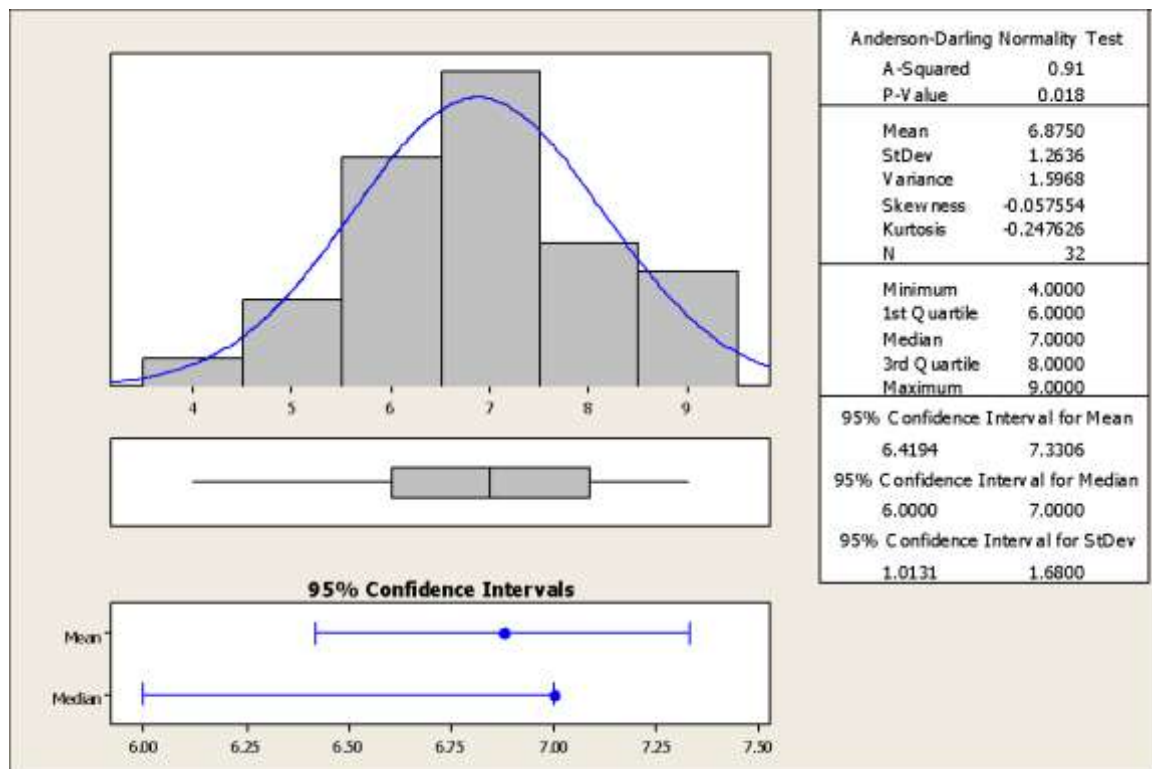


Figure 5.2.11 Summary statistics for Human resource facilities and its strength (X_2) on rank sum – ICT principals’ point of view.

According to Figure 5.2.11, minimum rank sum is 4.0 and maximum rank sum is 9.0. Median 7.0 indicates that near 50% of the respondents are given the rank sum which is greater than or

equal to 9.0. 1st quartile is 6.0. This means that the rank sum of 25% of the respondents is less than or equal to 6.0. Further, the 3rd quartile is 8.0. It claims that above 25% of the respondents' rank sum is greater than or equal to 8.0.

Accordingly, attitudes towards the human resource facilities and its strength for implementation of ICT specialization subject for Grade 10 and 11 is of a fairly low level from the principals' point of view. Confidence interval for the mean and median also support same.

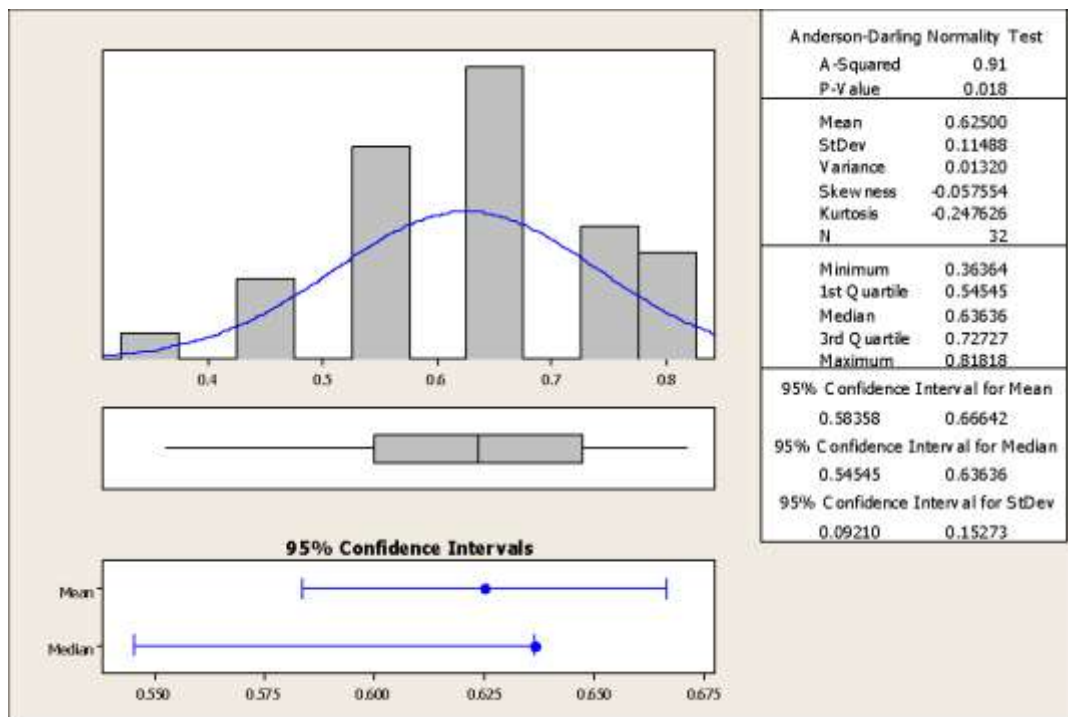


Figure 5.2.12 Summary statistics for rank sum ratio on Human resource facilities and its strength (X_2) – ICT Principals' point of view

Summary statistics for sum ratio is also obtained and shown in Figure 5.2.12. 95% confidence interval for the median is (0.54, 0.63) in Figure 5.10 and (6.00, 7.00) in Figure 5.2.11. This means that, there is a 95% chance that the rank sum lies in the interval (6.00, 7.00) and that the total rank ratio lies between (0.54, 0.63) contains the median.

According to values of rank-ratio, attitudes towards the human resource facilities and its strength for implementation of ICT specialization subject for Grade 10 and 11 is up to a marginally low level from the point of view of ICT principals.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis V which was described in the section 4.6 of Chapter 4.

Table 5.2.5 Kruskal-Wallis Test on total ranks for human resource facilities/strength – Principals’ point of view

District	N	Median	Average Rank	Z
Colombo	11	7.000	16.2	-0.14
Gampaha	7	7.000	17.6	0.34
Puttalam	4	5.500	11.3	-1.20
Hambanthota	7	7.000	20	1.12
Nuwara-Eliya	3	6.000	14.0	-0.48
Overall	32		16.5	

H = 2.54 DF = 4 P = 0.637

H = 2.71 DF = 4 P = 0.607 (adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.607 (adjusted for ties). As the P value is greater than the significant level ($\alpha= 0.05$), H_0 cannot be rejected. It can be concluded that “Principals attitude towards the human resource facilities and its strength for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is same in all five districts.”

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis VI described in section 4.6 of Chapter 4.

H_0 : Principals attitude towards the Human resource facilities and its strength for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is same in all schools types.

H_1 : Principals attitude towards the human resource facilities and its strength for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools in at least one school type is different from the others.

Table 5.2.6 Kruskal-Wallis Test on total ranks versus School Type for human resource facilities and its strength – Principals’ point of view

School Type	N	Median	Average Rank	Z
National	3	7.000	19	0.48
1 AB	12	6.500	15.5	-0.45
1 C	12	7.000	18.3	0.82
Type 2	5	7.000	13.1	-0.88
Overall	32		16.5	

H = 1.41 DF = 3 P = 0.703

H = 1.51 DF = 3 P = 0.681 (adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.681 (adjusted for ties). As the P value is greater than the significant level ($\alpha= 0.05$), H_0 cannot be rejected. It can be concluded that “Principals attitude towards the Human resource facilities and strength for

implementation of ICT specialization subject for GCE(O/L) in Sri Lankan schools is same in all schools types conducting ICT specialization subject for grades 10 and 11”.

According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all the Principals who are conducting ICT specialization subject in their schools for grades 10 and 11 are fairly low about the human resource facilities/strength of ICT education in Sri Lankan schools. Furthermore, the above results show that, there are no disparities in district-wise as well as in school types (school categories) regarding the human resource facilities and its strength for implementation of ICT specialization subject for GCE (O/L).

Availability of human resources and their strength directly affect students’ education. Therefore, investigation of students’ attitudes towards human resource facilities and its strength in performing academic activities might be important in this study.

Figure 5.2.13 shows the summary statistics in connection to the human resources facilities and its strength availability to implement the ICT specialized subject for grades 10 and 11 from the point of view of students.

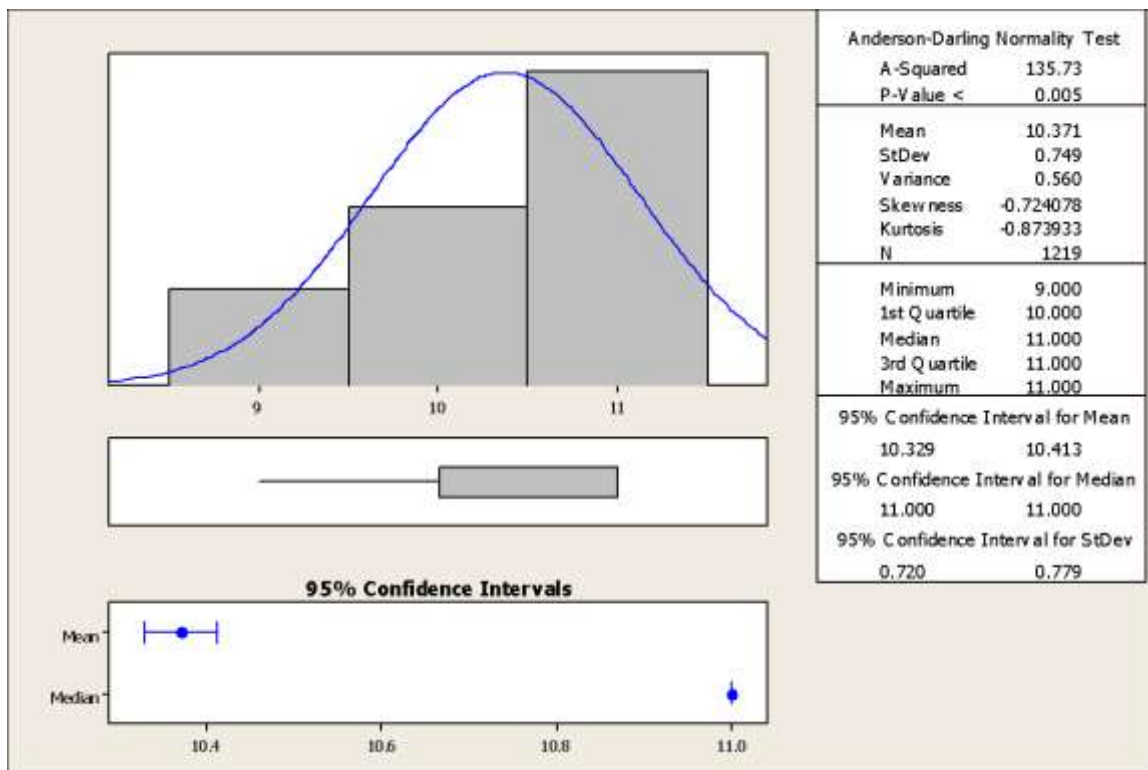


Figure 5.2.13 Summary statistics for Human resource facilities and its strength b(X₂) on rank sum—students’ point of view

According to Figure 5.2.13, the minimum rank sum is 9.0 and the maximum rank sum is 11.00. The first quartile is 10. This means that the rank sum of 75% of the respondents is greater than or equal to 10. Further, the median, third quartile and maximum value is the same and is 11. It claims that above 50% of the respondents rank sum is greater than or equal

to 11.00. 95% confidence interval for mean and medians are (10.32, 10.41) and (11.00, 11.00) respectively. 95% confidence interval for standard deviation is (0.720, 0.779). According to the above statistics, it seems that students in the sample have given very close responses. Accordingly attitudes towards human resource facilities and its strength for the implementation of ICT specialization subject for grades 10 and 11 is up to satisfactory level from the point of view of students . The confidence interval for the mean and median also support the same and is close to the upper bound of the range.

But completion of the questionnaires in the presence of the teachers and in the school environment, students may not be able give genuine responses. Therefore, it was assumed that human resource facilities and its strength are greatly related to current ICT teachers' future. According to the analysis, teachers were satisfied about the human resources and its strength.

In contrast, the principals' were not satisfied with the same. As principals are the administrators, it can be assumed that they are more knowledgeable and their assessments are more reliable regarding administrative matters. Therefore, it was concluded that, Human resources and its strength are not up to a satisfactory level. Furthermore, the above result shows that, there are no disparities, district-wise, and also school type-wise (school categories) regarding the human resource facilities and its strength for the implementation of the ICT specialization subject for GCE (O/L).

5.7 Maintenance And Sustainability Plans (X₃)

Among the quality factors, Maintenance and sustainability mechanism makes a high contribution to quality education. Further, sustainability of future quality CT education also depends purely on the maintenance and sustainability mechanism. The following analysis shows the status of the involvement of maintenance and sustainability plans used to implement ICT Specialization subject for grade 10 and Grade 11 curriculum in Sri Lankan schools.

For successful ICT education, computer hardware maintenance and its sustainability has a high impact. Further, Chapter 3 reveals that there are no proper concrete solutions for hardware maintenance. This section explores the present status of computer breakdown ratio, computer maintenance procedure from MOE or relevant organizations, principal's expectations about computer maintenance and how to introduce a sustainable mechanism for computer maintenance activities. Further, hardware and sustainability are also included in computer maintenance activities, software installation and troubleshooting and network maintenance.

Table 1.12 in Appendix 10 reveal that, on average, approximately 3 computers out of 23 or 13%, computers are not in working condition. Further, Table 1.13 in Appendix 12 reveals that 60% of ICT teachers have reported that there is no concrete solution provided by MOE or relevant provincial authorities for the computer maintenance process. Table 1.14 in Appendix 12 reveals that on average 66% principals have reported that there is no proper computer maintenance agreement from the MOE or any other authority. Network

maintenance is another important aspect of a computer maintenance activity phase. Resource sharing, internet, e-mail, school Net and other e-learning activities depend on the stability of network capabilities. Therefore, network connectivity is highly important for quality ICT education. Table 1.15 of Appendix 12 reveals that on average 56% of schools do not have the ability to maintain their computer networks. Further, Chapter 3 also highlighted that several attempts were initiated by the authorities in connection with hardware maintenance and a majority of them were of great success. Based on the experience, on average 71% of principals' expectation about computer maintenance was to have it done by a school teacher. According to descriptive statistics of the above, it was concluded that, there are no satisfactory levels of computer maintenance and sustainability plan in Sri Lankan schools. With the aim of strengthen the above conclusion made on maintenance and sustainability, the following inferential statistics were used.

Inferential Statistics used to illustrate the maintenance and sustainability mechanisms

The Figure 5.2.14 shows the summary statistics regarding the maintenance and sustainability status from ICT teachers' point of view for the implementation of ICT specialization subject for the Grade 10 and 11 students.

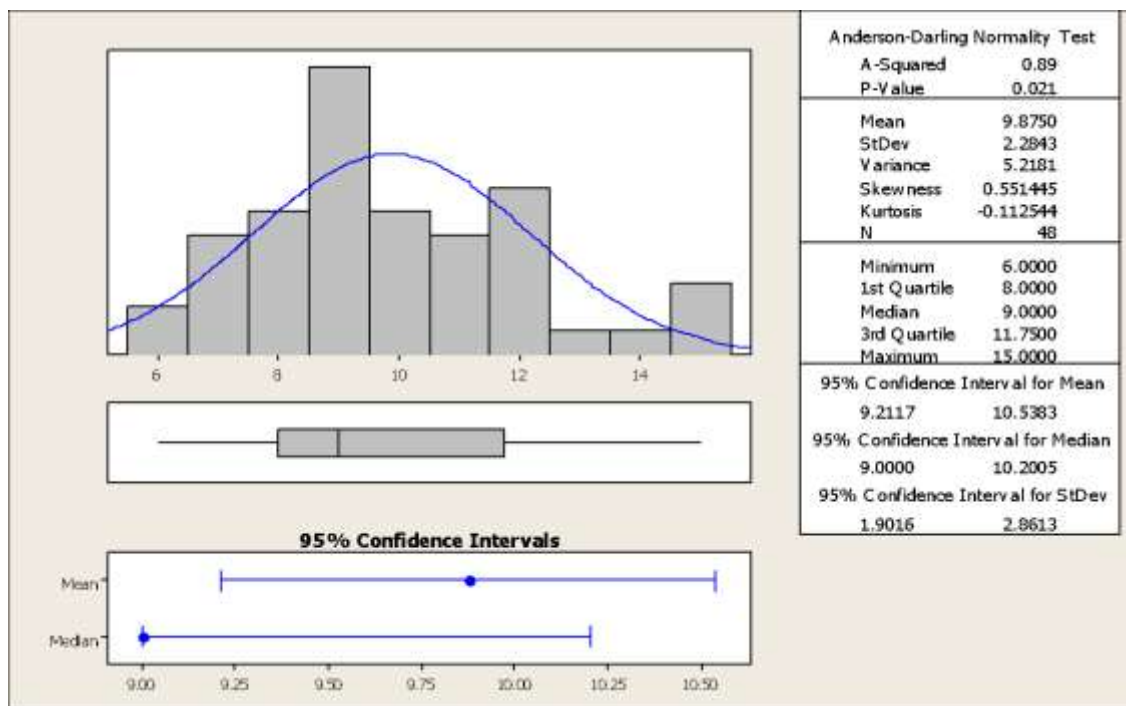


Figure 5.2.14 Summary statistics of rank sum for maintenance and sustainability mechanism (X₃) – ICT teachers' point of view

According to Figure 5.2.14, the minimum rank sum is 6.0 and the maximum rank sum is 15.0. Median 9.00 indicates that 50% of the respondents are given a rank that is greater than or equal to 9.00. The 1st quartile is 8.0. This means that 75% of the respondents rank sum is greater than or equal to 8.0. Further, the 3rd quartile is 11.75. It claims that above 25% of the respondents rank sum is greater than or equal to 11.75.

According to the above statistics, it was concluded that, attitudes towards maintenance and sustainability plans for the implementation of ICT specialization subject for Grade 10 and 11 is not of satisfactory level from the point of view of ICT teachers. Confidence interval for mean and median also support the same and it was close to the median of the range.

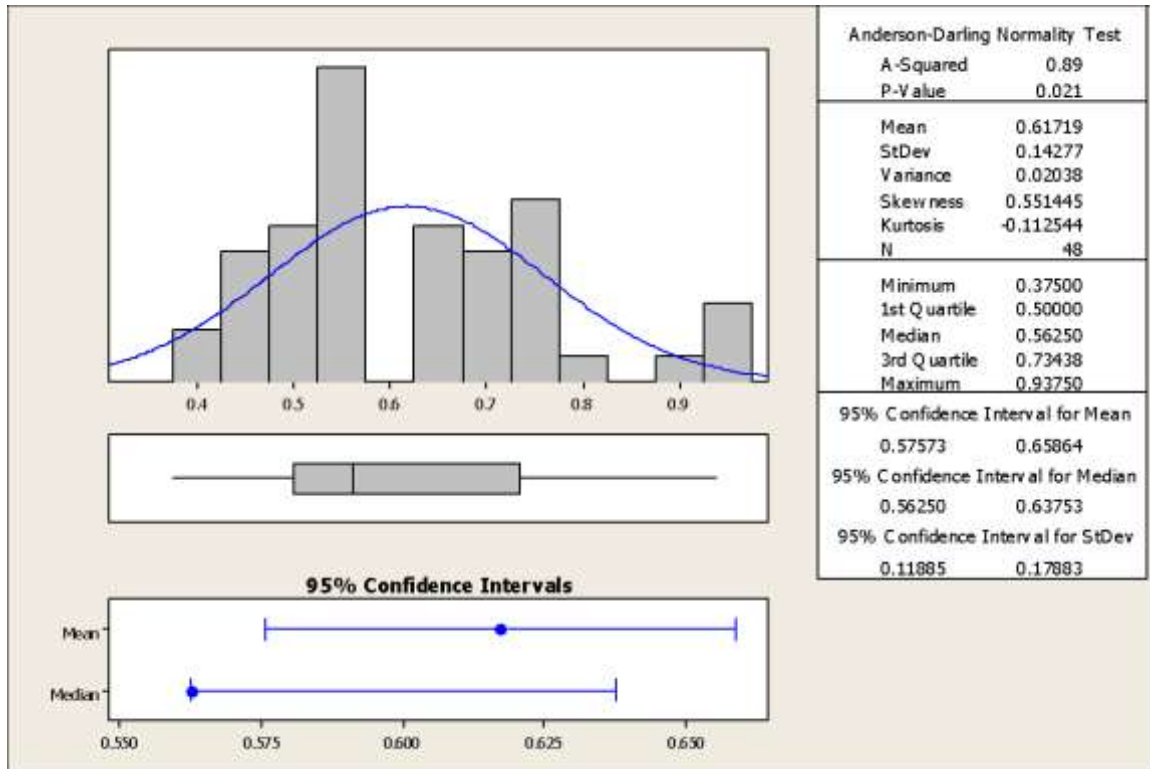


Figure 5.2.15 Summary statistics for rank sum ratio for maintenance and sustainability mechanism (X_3) – ICT teachers' point of view

Summary statistics for rank ratio was also obtained and shown in Figure 5.2.15. 95% confidence interval for median is (0.562, 0.658) in Figure 5.2.15 and (9.00, 10.20) in Figure 5.2.14. This means that, there is a 95% of chance that rank sum lies in the interval (9.00,10.20) and the rank sum ratio lies between (0.562, 0.637).

Accordingly, attitudes towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for Grade 10 and 11 is of a low level from the point of view of ICT teachers. Confidence interval for mean and median also support the same. According to literature review, to achieve international standards, maintenance and sustainability mechanism become tangible factors and have to be improved in the implementation of ICT specialization subject for grades 10 and 11 in Sri Lankan schools to achieve quality yield.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis VII which was described in the section 4.6 of Chapter 4.

Table 5.2.7 Kruskal-Wallis Test on total ranks for Human resource facilities and its strength – ICT teachers' point of view

District	N	Median	Average Rank	Z
Colombo	19	10.000	22.3	-0.90
Gampaha	9	9.000	17.2	-1.73
Puttalam	6	9.500	27.8	0.61
Hambanthota	10	10.500	31.7	1.82
Nuwara- Eliya	4	10.500	28.8	0.63
Overall	48		24.5	

$$H = 6.22 \quad DF = 4 \quad P = 0.183$$

$$H = 6.38 \quad DF = 4 \quad P = 0.173 \text{ (adjusted for ties)}$$

The P value of the Kruskal-Wallis test on total rank is 0.173 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that “Teachers attitude towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.”

As the main administrative officer of the respective schools, principals are directly aware of the availability of maintenance and sustainability mechanism for the implementation of the ICT specialization subject for GCE (O/L). Figure 5.2.16 shows the summary statistics regarding the availability of maintenance and sustainability mechanism from principals' point of view for the implementation of ICT specialization subject for Grade 10 and 11 students.

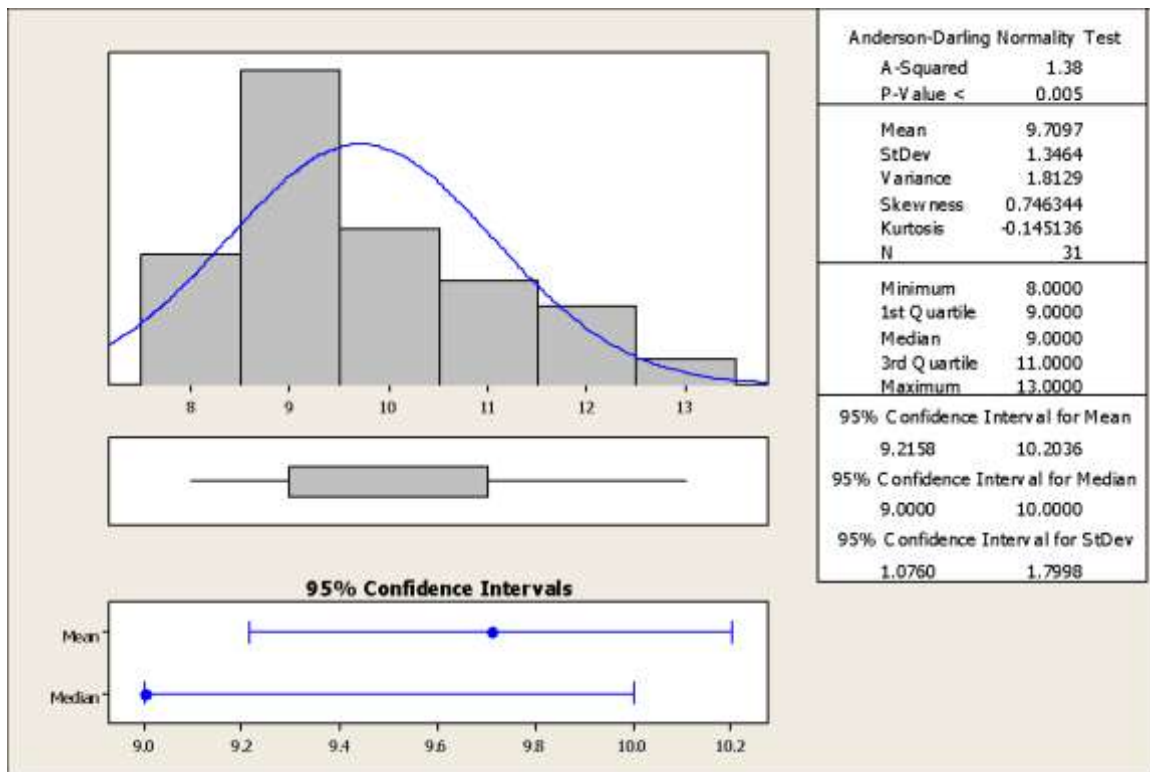


Figure 5.2.16 Summary statistics for maintenance and sustainability mechanism (X₃) on rank of sum – principals' point of view

According to Figure 5.2.16, the minimum rank sum is 8.0 and the maximum rank sum is 13.0. 1st quartile and Median 9.0 indicates that 75% of the respondents are given the rank which is greater than or equal to 9.0. Further, 3rd quartile is 11.0. It claims that above 75% of the respondents' rank sum is less than or equal to 11.0.

Accordingly, attitudes towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for grades 10 and 11 is of a marginally low satisfactory level from the point of view of principals'. The confidence interval for the mean and the median also support same.

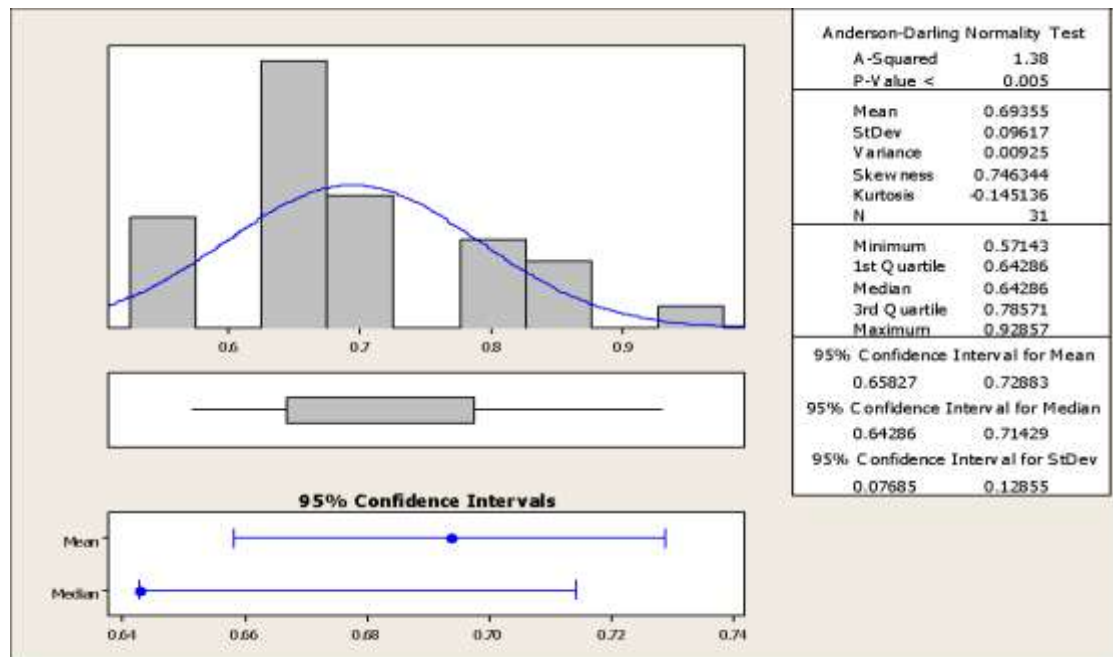


Figure 5.2.17 Summary statistics for maintenance and sustainability mechanism (X_3) on rank sum ratio-principals' point of view

Summary statistics for rank ratio is also obtained and shown in Figure 5.2.17. 95% confidence interval for median is (0.642, 0.714) in Figure 5.2.17 and (9.00, 10.00) in Figure 5.2.16. This means that, there is a 95% chance that the rank sum lies in the intervals ((9.00, 10.00) and the rank sum ratio lies between (0.642, 0.714).

These confirm that the existing maintenance and sustainability mechanism for the implementation of ICT specialization subject for grades 10 and 11 was not of a satisfactory level from the point of view of principals'. The confidence interval for mean and median also support the same.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis VIII which was described in the section 4.6 of Chapter 4.

Table 5.2.8 Kruskal-Wallis Test on total ranks for maintenance and sustainability mechanism – Principals' point of view

District	N	Median	Average Rank	Z
Colombo	10	9.000	14.9	-0.46
Gampaha	7	9.000	15.4	-0.21
Puttalam	4	9.500	15.1	-0.21
Hambanthota	7	10.000	17.4	0.45
Nuwara-Eliya	3	10.000	19.2	0.63
Overall	31		16.0	

$H = 0.74$ DF = 4 P = 0.947

$H = 0.80$ DF = 4 P = 0.939(adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.939 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$). H_0 cannot be rejected. It can be concluded that “Principals’ attitude towards the maintenance and sustainability mechanism for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.”

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis IX which was described in the section 4.6 of Chapter 4.

Table 5.2.9 *Kruskal-Wallis Test on total ranks versus School Type for maintenance and sustainability mechanism – Principal’s point of view*

School Type	N	Median	Average Rank	Z
National	3	10.000	20.3	0.87
1 AB	12	9.000	12.3	-1.78
1 C	11	10.000	16.7	0.33
Type 2	5	11.000	20.6	1.24
Overall	31		16.000	

$$H = 3.98 \quad DF = 3 \quad P = 0.263$$

$$H = 4.29 \quad DF = 3 \quad P = 0.232 \text{ (adjusted for ties)}$$

The P value of the Kruskal-Wallis test on total rank is 0.232 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$). H_0 cannot be rejected. It can be concluded that “Principals attitude towards the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE(O/L) in Sri Lankan schools is same in all schools types that are conducting ICT specialization subject for grades 10 and 11” .

According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all the Principals and ICT teachers conducting ICT specialization subject in their schools for grade 10 and 11 are not satisfied with the maintenance and sustainability mechanism of ICT education in Sri Lankan schools. Further, the above results show that, there were no disparities district-wise as well as in school types (school categories) regarding the maintenance and sustainability mechanism for the implementation of ICT specialization subject for GCE (O/L).

5.8 Software (X₄) To Implement Ict Education For Gce (O/L Curriculum

Literature reviews reveals that, Software is one of the main ingredients of quality ICT education. Some developed countries and our neighboring countries also use Free and Open Source Software (FOSS) for ICT education. Further, some ICT specialization subject for GCE (A/L) and university education also use FOSS solution. Therefore, investigation of software usage, application ability and alternative mechanism to avoid financial constraints when implementing quality education is highly applicable to this research study.

Figure 5.2.18 shows that, on average, 67% of teachers recommend both open source and Microsoft products and 8% only open source software to implement ICT specialization

subject for grade 10 and 11 classes. It was concluded that teachers may find an alternative solution other than the Microsoft product to implement the ICT specialization subject for GCE (O/L) classes.

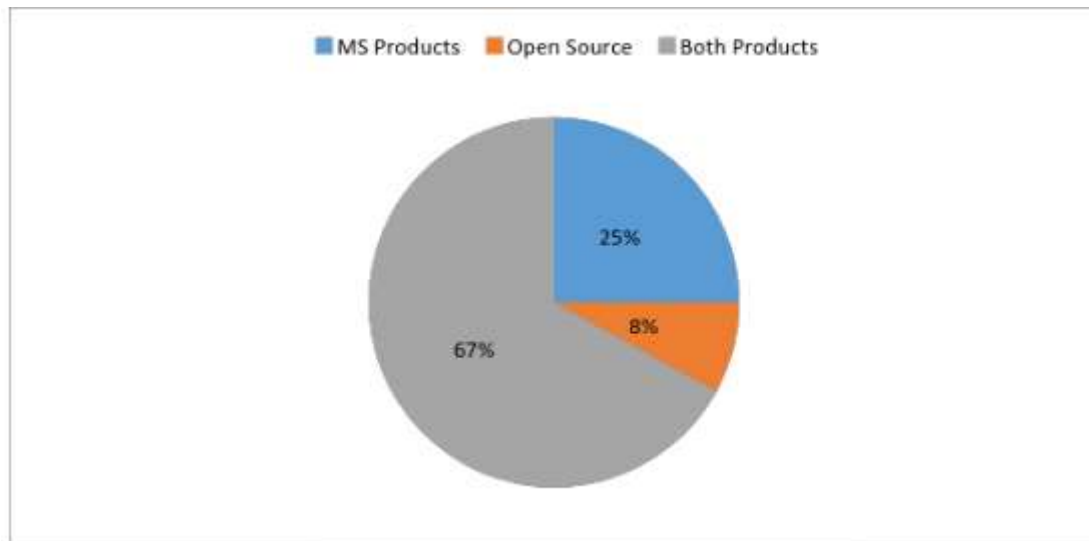


Figure 5.2.18 Recommendation of the teachers about willingness in software usage

Table 1.16 in Appendix 12 shows that, on average 66% of teachers do not have the ability to install operating system(S), application software and related day-to-day software troubleshooting activities. Further, Appendix 13 proves that free and open source software provided several benefits when implementing the ICT speciation subject in Grade 10 and curriculums. According to the above, it was concluded that teachers are willing to use alternative software products for the implementation of ICT specialization subject for grade 10 and 11. With the aim of strengthening the above conclusion drawn on software usage, the following inferential statistics were used.

Inferential Statistics used to illustrate the software usage

The Figure 15.2.19 shows the summary statistics regarding the expectation of software usage from ICT teacher's point of view for the implementation of ICT specialization subject for GCE (O/L) students.

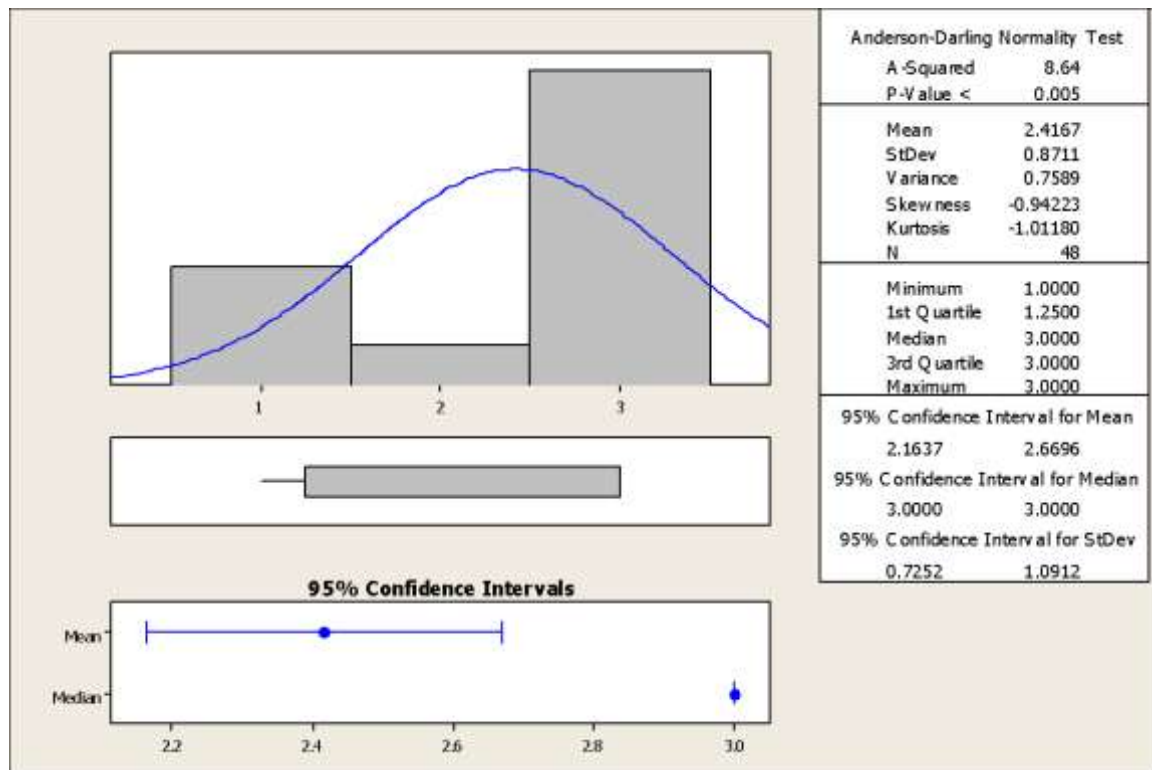


Figure 15.2.19 Summary statistics for rank of sum for expectation of software usage (X₅) – ICT teachers' point of view.

According to Figure 15.2.19, the minimum total rank sum is 1.0 and the maximum total rank sum is 3.0. Median 3.0 indicates that 50% of the respondents were given the rank greater than or equal to 3.0. The 1st quartile is 1.25. This means that 75% of the respondents' expectation was to use open source or both open source and Microsoft software for the implementation of ICT specialization subject for Grade 10 and 11. Further, the median and the 3rd quartile is 3.0. It claims that above 50% of the respondents value is greater than or equal to 3.0.

According to attitudes towards the software usage for the implementation of ICT specialization subject for grades 10 and 11, it was recommended to use both Microsoft and open source software from the ICT teachers' point of view. Confidence interval for mean and median also support same.

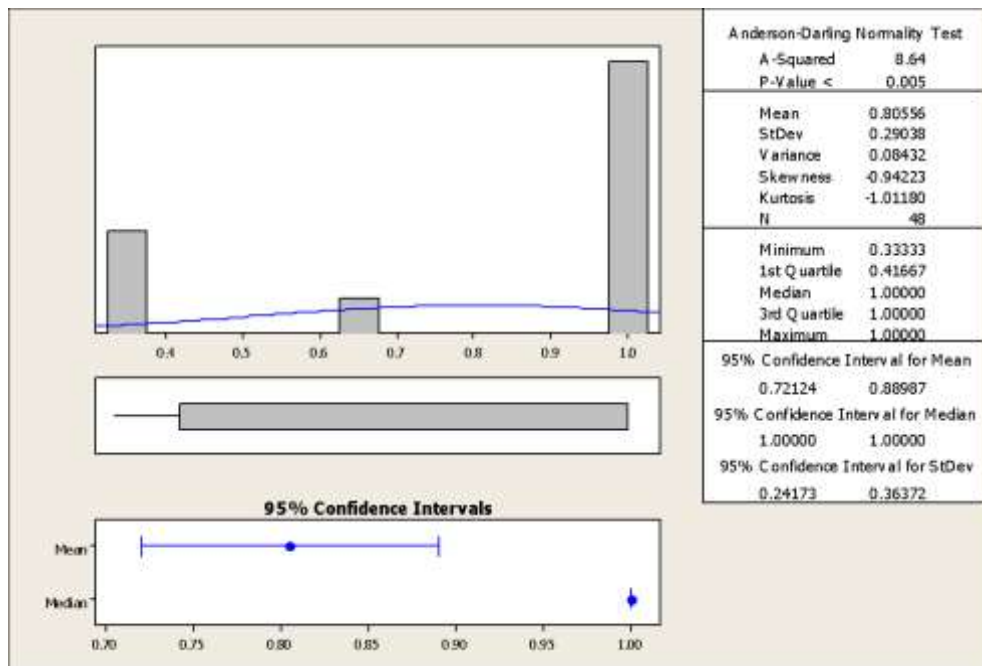


Figure 5.2.20 Summary statistics for software (X₄) on rank ratio– ICT teachers’ point of view

Summary statistics for ratio of ranks was also obtained and shown in Figure 5.2.20. 95% confidence interval for the median is (1.00, 1.00) in Figure 5.2.19 and (3.00, 3.00) in Figure 5.2.19. This means that, there is 95% of chance that the rank sum lies in the interval (3.00, 3.00) and total rank ratio lies between (1.00, 1.00). According to the above statistics, it was concluded that ICT teachers’ preferred not only Microsoft products but they also preferred other products such as Linux, Ubuntu. Open office, Python etc.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis X which was described in section 4.6 of Chapter 4.

Table 5.2.10 Kruskal-Wallis Test on expectation on usage of software – ICT teachers’ point of view

District	N	Median	Average Rank	Z
Colombo	19	3.000	21.9	-1.05
Gampaha	9	3.000	20.9	-0.85
Puttalam	6	3.000	28.2	0.69
Hambanthota	10	3.000	27.3	0.71
Nuwara-Eliya	4	3.000	32.5	1.19
Overall	48		24.5	

$H = 3.37$ DF = 4 P = 0.489

$H = 4.90$ DF = 4 P = 0.298 (adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.298 (adjusted for ties). As the P is value greater than the significant level ($\alpha = 0.05$). H_0 cannot be rejected. It can be concluded

that “Teachers attitude towards the usage of software for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.” According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all the ICT teachers who are teaching ICT specialization subject for grade 10 and 11 will use software other than Microsoft products for the implementation of grade 10 and 11 ICT specialization subject in Sri Lankan schools.

Usage of software directly affects to students’ education. Therefore, to confirm the validity of the above outcomes real stakeholder’s usage is quite important. The following Figure 5.2.20 shows the usage of different operating systems towards the attitudes of students.

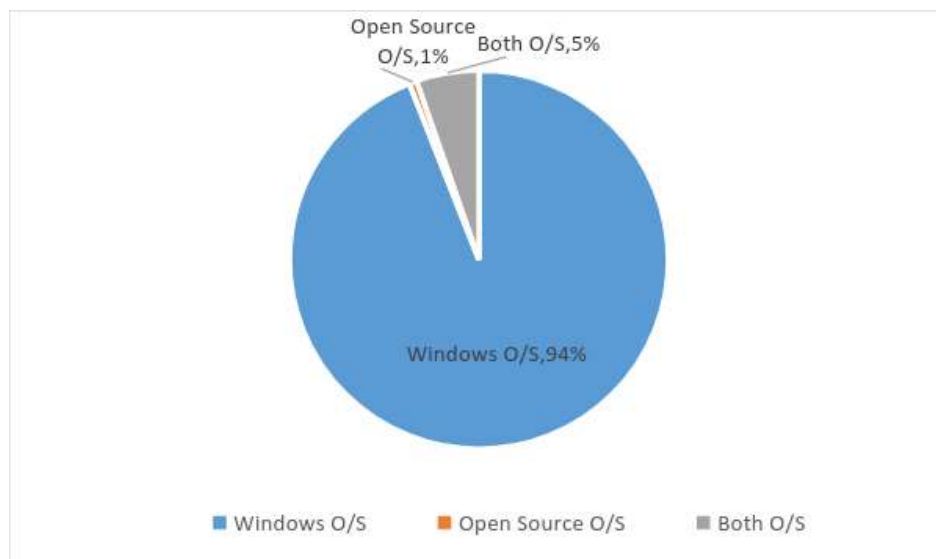
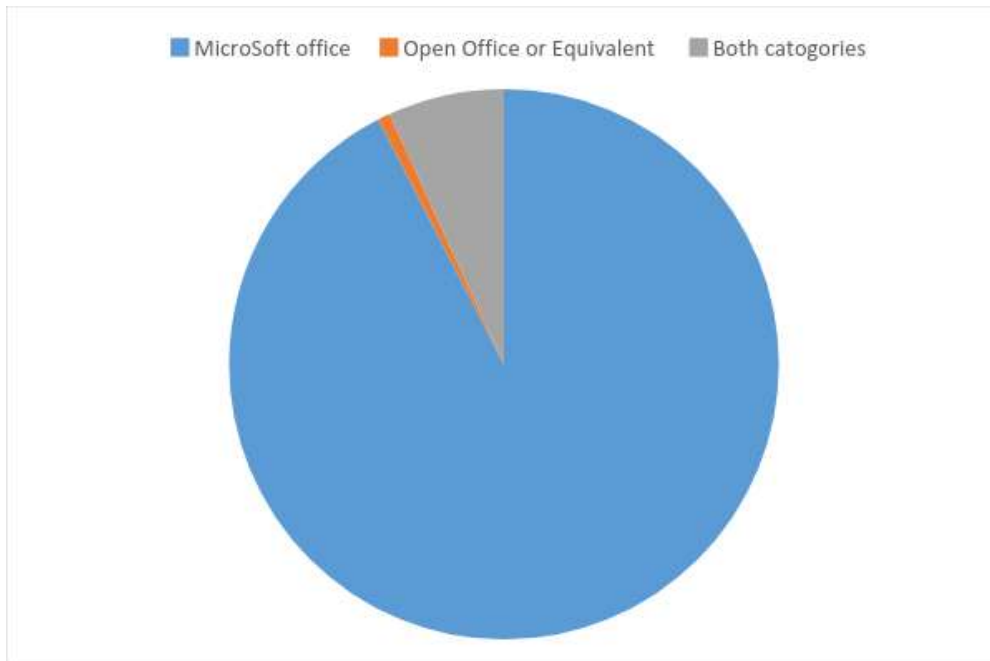


Figure 5.2.21 Usage of different Operating system in Sri Lankan Schools

The above Figure 5.2.21 shows that on average 94% of students use windows operating system for the implementation of ICT specialization subject for grade 10 and 11. Further, on average 1% of students use only open source operating systems and 5% students use both operating systems.



5.2.22 Usage of different basic software categories in Sri Lankan schools

According to the two pie-charts above, it reveals that the majority of students use Microsoft products.

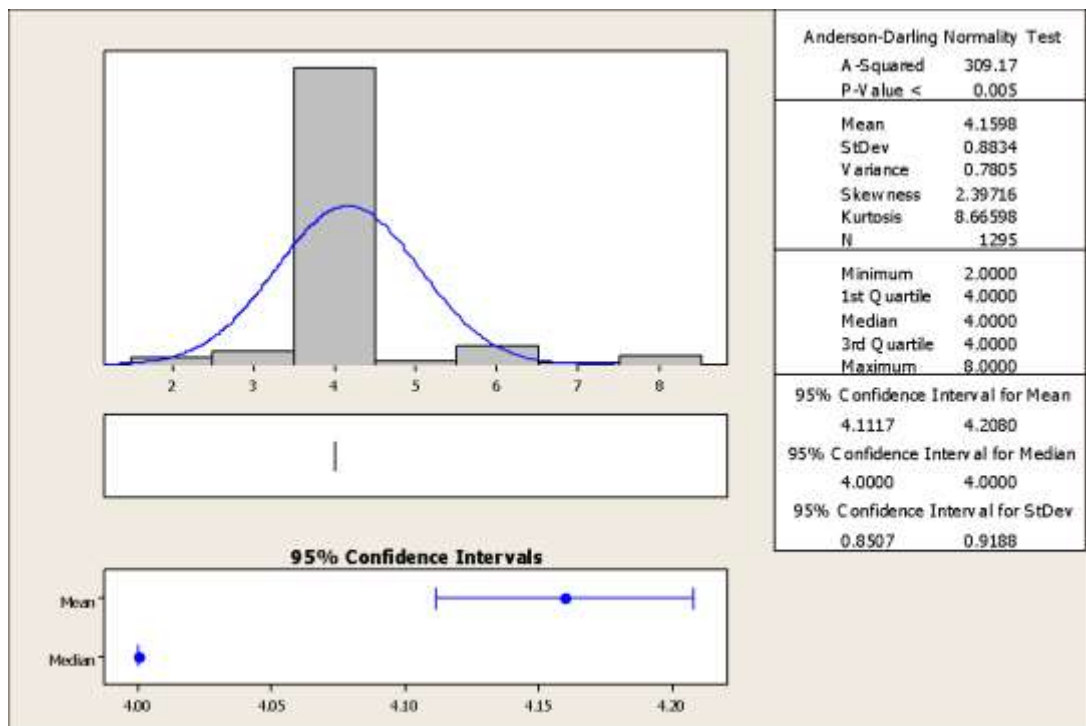


Figure 5.2.23 Summary statistics for the usage of software (X_1) on rank of sum – Students' point of view.

According to Figure 5.2.23, the minimum rank sum is 2.0 and the maximum rank sum is 8.00. First quartile, median, and 3rd quartile value is 4.00. This indicates that 75% of the respondents are given a rank greater than or equal to 4.0. Further 25% of the responses are less than or equal to the median value 4. Accordingly, the usage of software for the implementation of ICT specialization subject for grades 10 and 11 is limited to the Microsoft products. Lower and upper levels confidence interval for medians coincide and support same.

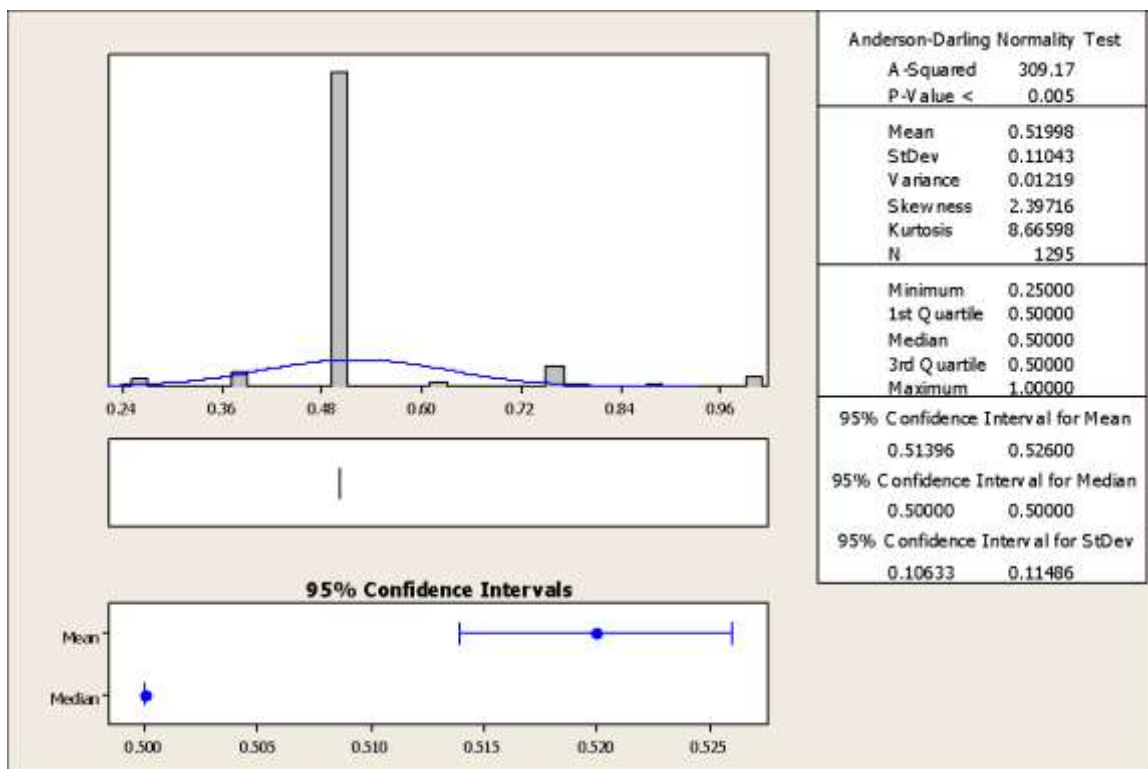


Figure 5.2.24 Summary statistics for rank sum ratio for usage of software (X_4) ratio- ICT Students' point of view.

Summary statistics for ratio of ranks is also obtained and shown in Figure 5.2.24. 95% confidence interval for the median is (0.50, 0.50) in Figure 5.2.24 and (4.0, 4.0) in Figure 5.2.23. This means that, there is a 95% chance that the rank sum lies in the point value (4.0, 4.0) and rank sum ratio is a point value (0.50, 0.50)

The overall conclusion about the software was as follows: Teachers do not hesitate to use only Microsoft products but they also preferred to use other products. Further, students' responses reveal that still a majority of schools use Microsoft products to implement the ICT specialization subject for GCE (O/L) in Sri Lankan schools.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XI which was described in the section 4.6 of Chapter 4.

Table 5.2.11 Kruskal-Wallis Test on expectation on usage of software – ICT students’ point of view

District	N	Median	Average Rank	Z
Colombo	510	4.000	645.9	-0.16
Gampaha	257	4.000	613.4	-1.65
Puttalam	217	4.000	679	1.34
Hambanthota	193	4.000	596.7	-2.06
Nuwara- Eliya	118	3.000	759.2	3.39
Overall	1295		648.0	

H = 17.77 DF = 4 P = 0.001

H = 44.22 DF = 4 P = 0.000(adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.000 (adjusted for ties). As the P value is less than the significant level ($\alpha = 0.05$), H_0 can be rejected. It can be concluded that “Students’ attitude to the usage of Microsoft products for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is that at least one district is different from the others”.

It was concluded that ICT teachers’ attitude was not only to use Microsoft product for implementation of ICT specialization subject for grade 10 and 11 in Sri Lankan schools. According to the analysis of the study, a majority of schools use Microsoft product for the implementation ICT specialization subject for GCE (O/L). In contrast, the ICT teachers were not satisfied with the usage of only Microsoft products. They recommended both Microsoft products and open source products. As ICT teachers are the real implementers of the ICT curriculums, it can be assumed that they were knowledgeable stakeholders in the implementation domain. Further, it may assumed they have identified the difficulties with Microsoft products, flexibility of usage of open source products and that there are more reliable software products. Considering all the above statistics and facts, it was concluded that as an alternative solution, open source software products can be used to enhance the quality of ICT specialization subject for grades 10 and 11. Further, it was concluded that the usage of Microsoft products for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

5.9 Curriculum Implementation Facilities And Issues (X₅)

Chapter 3 reveals that, the development of ICT education should be initiated from the school educational system and hence minimum infrastructure should be provided to fulfill the requirements. Electricity and related issues, computers and related accessories, other infrastructure facilities, lack of ICT teachers for ICT education, non-availability of internet-e-mail, virus threats and attacks, indifference of students, non-availability of text books, lack of knowledge of English, lack of proper guidelines from relevant authorities, lack of required skill levels of teachers, skills level of students, inability to conduct ICT education with the existing facilities, are the main issues of curriculum implementation. Furthermore, with facts obtained by using an unstructured interview schedule (Annexure 4), authorities have reported

that infrastructure, financial difficulties and the most important factor, right curriculum implementation techniques and methodologies might be a problem in the implementation of ICT training programs and ICT education. According to the global standards, pure face-to-face Teaching is not sufficient for the success of ICT education. Further, blended learning, additional reading, library facilities and knowledge of English are highly related to the success of ICT education. Therefore, this section explores the availability of text books and the knowledge of English of students.

According to Table 1.16 in Appendix 12, it was reported that 41% lack text books, 52% lack library facilities, 51% lack English knowledge of students and teachers, 75% lack proper guidance from relevant authorities, 57% lack of enhanced methodologies and 51% lack clearly defined practical sessions in the time table, which affect the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools. When maintaining the quality of ICT education, usage and application of pedagogical techniques is highly important. According to Table 1.17 in Appendix 12, it was reported that the usage and application of pedagogical techniques are of very low percentages as 2.04%. Such pedagogical techniques are: Kolb's Reflective learning circle, Bloom's Taxonomy, Blended Learning Technologies, class room observation, Role model, activity based teaching and learning and stakeholders' feedback (81.6%). Further, it was reported that all the above techniques used by respective teachers in their class rooms is a very low percentage as 2.04%.

According to the above descriptive statistics, it was concluded that general facts (e.g. English knowledge, proper guidelines from authorities, etc.) are not of a satisfactory level in the implementation of ICT specialization subject in grades 10 and 11 in Sri Lankan schools. Further, it was concluded that usage and application of pedagogical techniques in teacher training programs and application and usage of such techniques in their respective schools are also at a minimum level. With the aim of strengthening the above conclusion made on curriculum implementation issues, the following inferential statistics were used.

Inferential Statistics used to illustrate the curriculum implementation issues

The Figure 5.2.25 shows the summary statistics regarding the curriculum implementation issues from ICT teacher's point of view for the implementation of ICT specialization subject for the Grade 10 and 11 students in Sri Lankan schools.

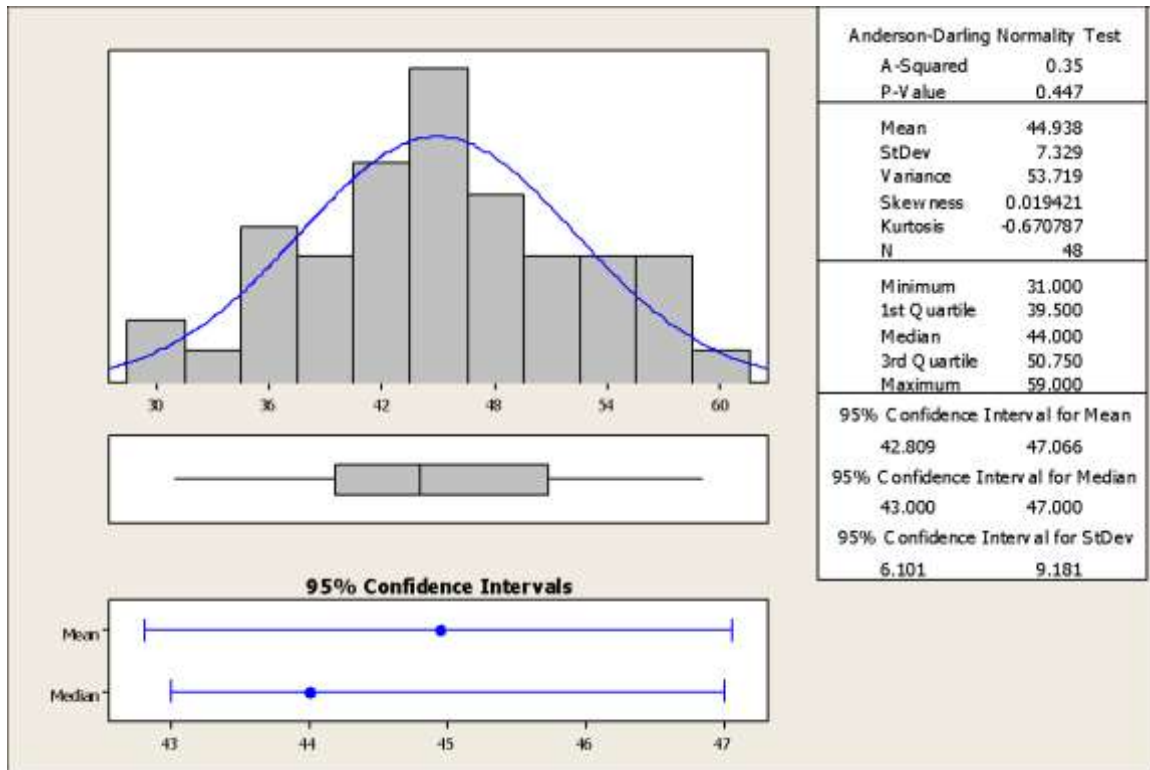


Figure 5.2.25 Summary statistics for curriculum implementation facilities (X₅) on rank of sum – ICT teachers' point of view

According to Figure 5.2.25, minimum rank sum is 31.00 and maximum rank sum is 59.00. The median 44.00 indicates that about 50% of the respondents are given the rank less than or equal to 44.00. The 1st quartile is 39.5. This means that 25% of the respondents are less than or equal to 39.5. Further, the 3rd quartile is 50.75. It claims that above 25% of the respondents' rank sum is greater than or equal to 50.75. Accordingly attitudes towards the curriculum implementation facilities are not of a satisfactory level for the implementation of ICT specialization subject for Grade 10 and 11 from the point of view of ICT teachers. Confidence interval for the mean and median also support same.

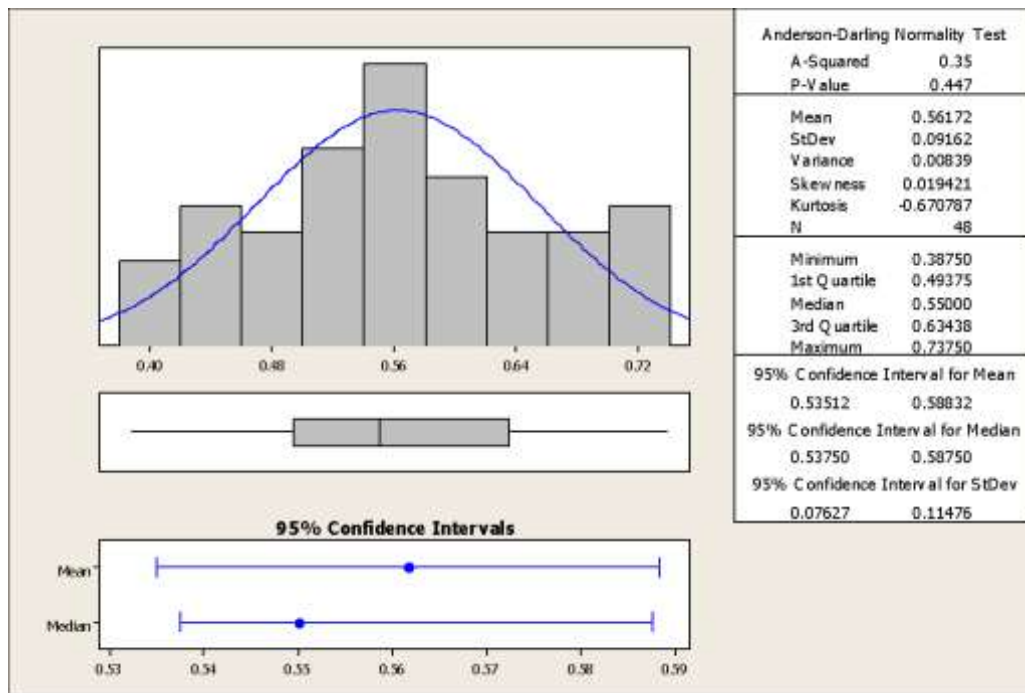


Figure 5.2.26 Summary statistics for curriculum implementation facilities/techniques (X_5) on rank sum ratio – ICT teachers' point of view

Summary statistics for ratio of ranks were also obtained and shown in the Figure 5.2.26. 95% confidence interval for median is (0.537, 587) in Figure 5.26 and (43.00, 47.00) in Figure 5.25. This means that, there is a 95% chance that rank sum lies in the interval (43.00, 47.00) and the total rank ratio lies between (0.535, 0.587). Further, it was concluded that the attitude towards the curriculum implantation facilities/ techniques are not satisfactory from the ICT teachers' point of view.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XII which was described in the section 4.6 of Chapter 4.

Table 5.2.12 Kruskal-Wallis Test on total ranks for curriculum implementation facilities/techniques – ICT teachers' point of view

District	N	Median	Average Rank	Z
Colombo	19	46.000	27.2	1.09
Gampaha	9	45.000	24.5	0
Puttalam	6	43.000	16.8	-1.45
Hambanthota	10	44.000	29	1.13
Nuwara-Eliya	4	36.500	12.1	-1.85
Overall	48		24.5	

H = 6.69 DF = 4 P = 0.153

H = 6.72 DF = 4 P = 0.151(adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.151 (adjusted for ties). As the P value is greater than the significant level ($\alpha= 0.05$). H_0 cannot be rejected. It can be concluded that the teachers' attitude towards the curriculum implementation facilities/techniques of ICT education for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts.

According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that the attitude towards the curriculum implementation facilities and techniques in Sri Lankan schools are not of a satisfactory level from the point of view of ICT teachers who are teaching ICT specialization subject for grades 10 and 11.

Further, the literature review reveals that pedagogical techniques greatly contribute to the maintenance of the quality of ICT education. Therefore, to determine the pedagogical usage in Sri Lankan schools, X_5 variable is divided into two categories as follows:

$X_{5.1}$ – Pedagogical techniques usage to implement ICT specialization curriculum in Sri Lankan schools

$X_{5.2}$ – General techniques used to implement ICT specialization curriculum in Sri Lankan schools

Further, all statistical techniques applied to the X_5 were applied to the variable $x_{5.1}$ and the following outcomes were obtained.

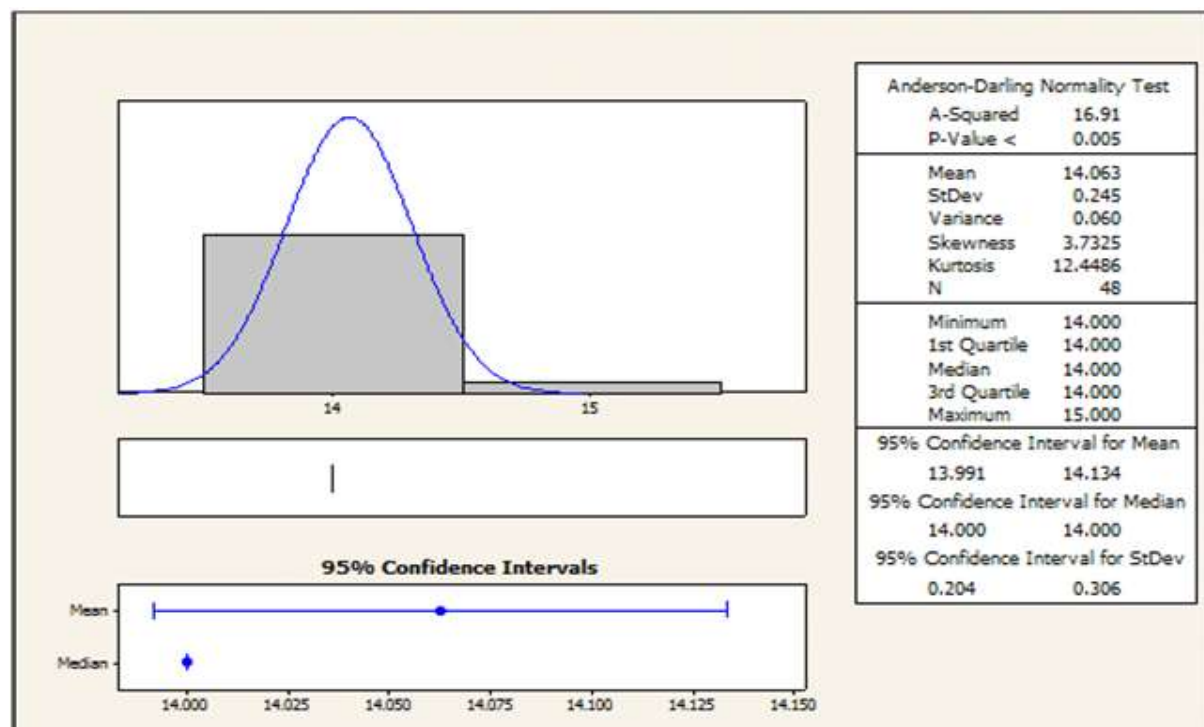


Figure 5.2.27 Summary statistics for rank sum on curriculum implementation facilities as pedagogical techniques usage ($X_{5.1}$) – ICT teachers' point of view

According to Figure 5.2.27, the minimum rank sum is 14.00 and the maximum rank sum is 15.00. and the median is 14.00. The 1st quartile, median, 3rd quartile and maximum is less than or equal to 14. Accordingly curriculum implementation facilities/techniques in connection with pedagogical techniques were completely missing in the implementation of ICT specialization subject for grades 10 and 11 in Sri Lankan schools. Confidence interval for mean and median also support the same.

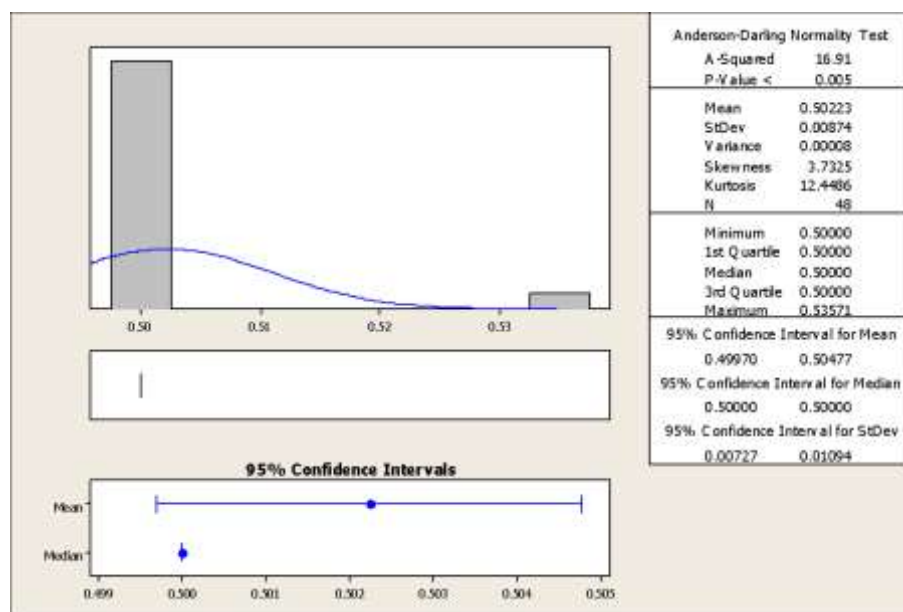


Figure 5.2.28 Summary statistics for curriculum implementation facilities/techniques as pedagogical techniques usage ($X_{5.1}$) on rank ratio – ICT teachers' point of view

According to Figure 5.2.28, the minimum rank ratio is 0.50 and the maximum rank ratio is 0.53. The 1st quartile, median, and 3rd quartile is 0.50. Further, 75% of respondents' rank ratio is 0.50. Accordingly, attitudes towards the usage of pedagogical techniques for the implementation of ICT specialization subject for Grade 10 and 11 is very poor and missing in Sri Lankan ICT specialization subject for GCE(O/L). This also confirms that the confidence interval for the mean and median also support the same.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XV which was described in the section 4.6 of Chapter 4.

Table 5.2.13 Kruskal-Wallis Test on total ranks for usage of pedagogical techniques under the curriculum implementation facilities/techniques – ICT teachers’ point of view

District	N	Median	Average Rank	Z
Colombo	19	14.000	25.5	0.41
Gampaha	9	14.000	23	-0.36
Puttalam	6	14.000	23	-0.28
Hambanthota	10	14.000	25.4	0.23
Nuwara-Eliya	4	14.000	23.0	-0.22
Overall	48		24.5	

H = 0.36 DF = 4 P = 0.986
H = 2.06 DF = 4 P = 0.725 (adjusted for ties)

According to the above Table 5.2.13, the P value is 0.725 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that “Teachers’ attitude towards the usage of pedagogical techniques for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts”.

Based on the questions related to the curriculum implementation facilities by Principals’ questionnaire were taken, rank summed and summary statistics were represented as in Figure 5.2.29.

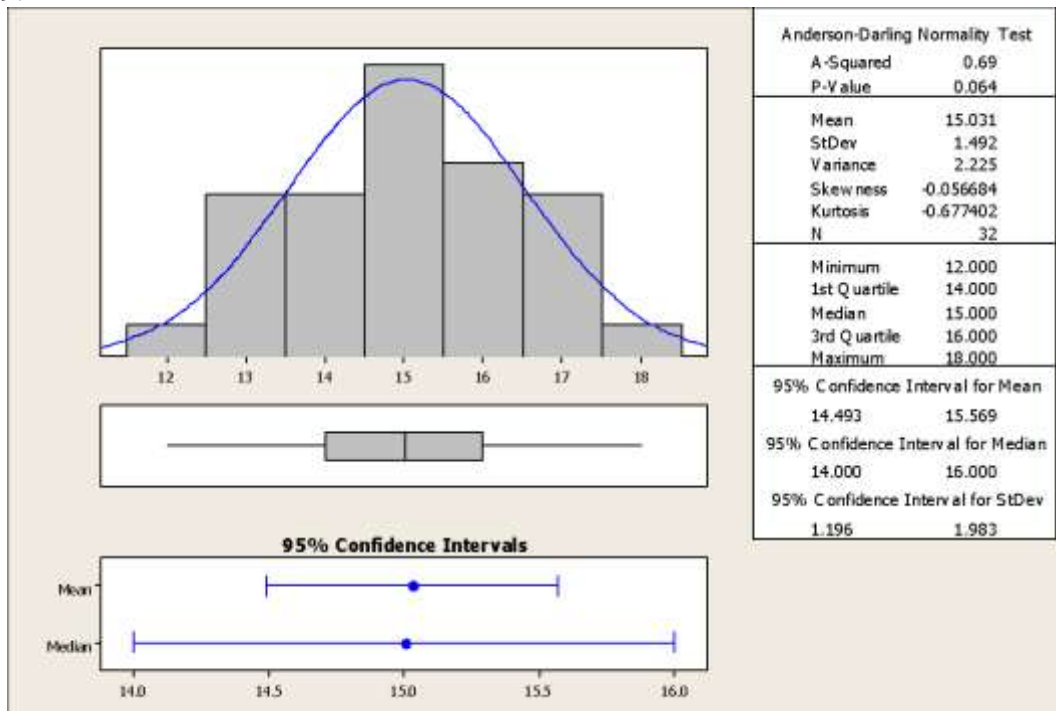


Figure 5.2.29 Summary statistics for curriculum implementation facilities (X₅) on rank of sum – principals’ point of view

According to the Figure 5.2.29, minimum rank sum is 12.00 and maximum rank sum is 18.00. Median 15.00 indicates that 50% of the respondents are given the rank less than or equal to 15.00. The 1st quartile is 14.00. This means that the rank sum of 25% of the respondents is less than or equal to 14.00. Further, the 3rd quartile is 16.00. It claims that above 75% of the respondents rank sum is less than or equal to 16.00. Accordingly attitudes towards the curriculum implementation facilities for the implementation of the ICT specialization subject for grades 10 and 11 is of a marginally satisfactory level from the point of view of principals. The confidence interval for mean and median also support same. Summary statistics for sum of rank ratio is also obtained and shown in the Figure 5.2.30

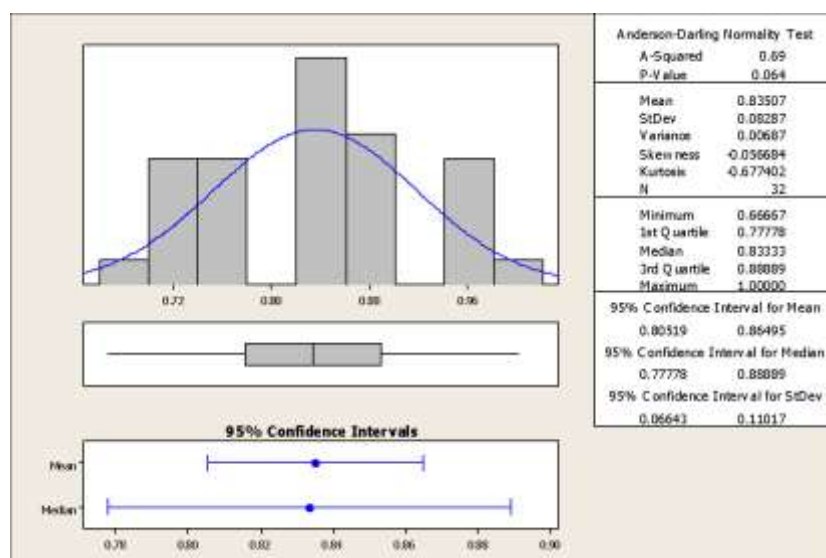


Figure 5.2.30 Summary statistics for curriculum implementation facilities (X_5) on rank sum ratio – principals' point of view

95% confidence interval for median is (0.77, 0.88) in Figure 5.2.30 and (14.00, 16.00) in Figure 5.2.28. This means that, there is 95% chance that rank sum lies in the interval (14.00, 16.00) and total rank ratio lies between (0.77, 0.88). Further, these confirm that existing curriculum implementation facilities are marginally satisfied from the principals' point of view.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XIII which was described in the section 4.6 of Chapter 4.

Table 5.2.14 Kruskal-Wallis Test on total ranks versus district for curriculum implementation issues – Principal's point of view

District	N	Median	Average Rank	Z
Colombo	11	15.000	16.1	-0.18
Gampaha	7	14.000	13.1	-1.07
Puttalam	4	16.000	21.6	1.17
Hambanthota	7	15.000	19.1	0.82
Nuwara-Eliya	3	14.000	13.0	-0.68
Overall	32		16.5	

$$H = 3.05 \text{ DF} = 4 \text{ P} = 0.549$$

$$H = 3.18 \text{ DF} = 4 \text{ P} = 0.528(\text{adjusted for ties})$$

The P value of the Kruskal-Wallis test on total rank is 0.528(adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that “Principals attitude towards the curriculum implementation facilities for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts”.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XIV which was described in the section 4.6 of Chapter 4.

Table 5.2.15 Kruskal-Wallis Test on total ranks versus School Type for infrastructure – Principal's point of view

School Type	N	Median	Average Rank	Z
National	3	16.000	22.8	1.23
1 AB	12	15.000	18.5	0.91
1 C	12	15.000	16.3	-0.08
Type 2	5	14.000	8.4	-2.1
Overall	32		16.500	

$$H = 5.62 \text{ DF} = 3 \text{ P} = 0.132$$

$$H = 5.85 \text{ DF} = 3 \text{ P} = 0.119 (\text{adjusted for ties})$$

The P value of the Kruskal-Wallis test on total rank is 0.119 (adjusted for ties). As the P value is less than the significant level ($\alpha = 0.05$), H_0 can be rejected. It can be concluded that “Principals attitude towards the curriculum implementation facilities for ICT specialization subject for GCE(O/L) in Sri Lankan schools is the same in all schools types conducting ICT specialization subject for grades 10 and 11.”

Students' responses towards the curriculum implementation facilities and techniques are presented in the Figure 5.2.31

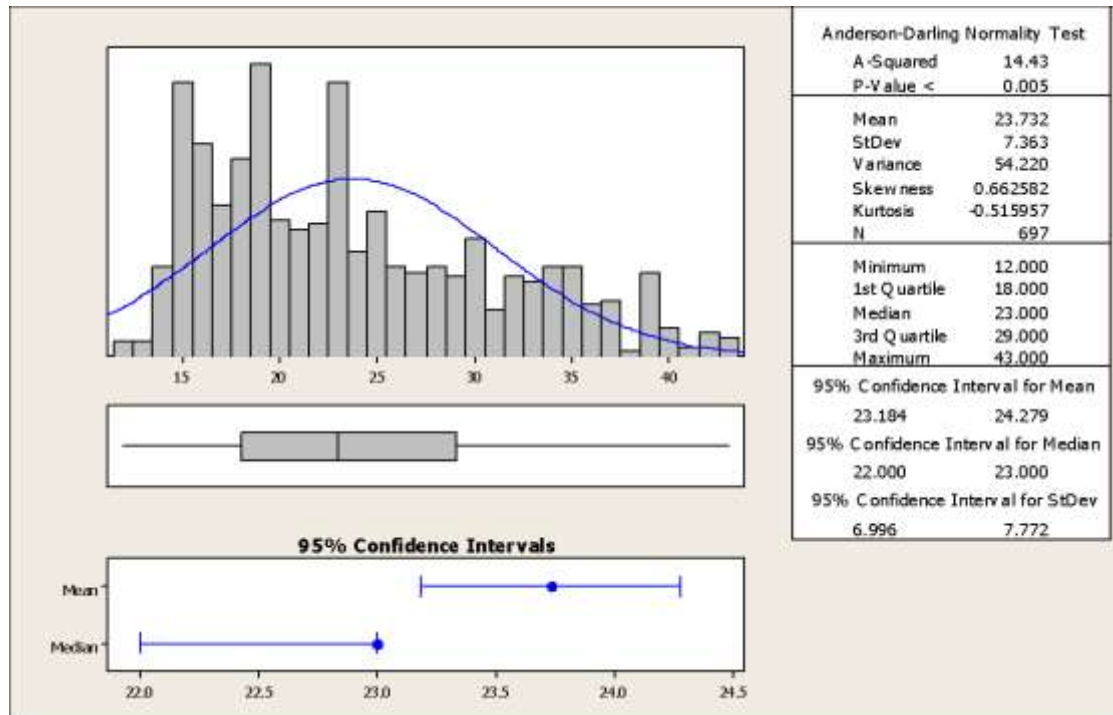


Figure 5.2.31 Summary statistics for rank sum for curriculum implementation facilities and its strength (X_5) – students' point of view

According to the Figure 5.2.31, the 1st quartile, median is less than 18.00. Median 23% indicates that nearly 50% of respondents are given a rank less than or equal to 23.00. Further, the 3rd quartile is also of very low value and it is equal to 29.00. 75% of respondents stated that the rank sum is less than 29. It is concluded that there are major issues in curriculum implementation from the students' point of view.

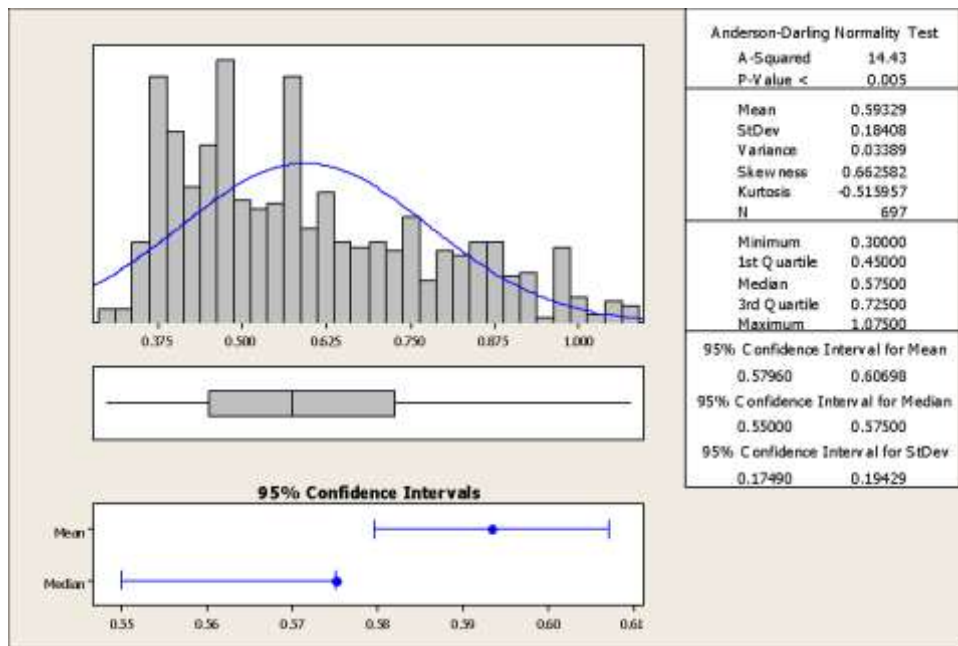


Figure 5.2.32 Summary statistics for curriculum implementation facilities (X5) on rank sum ratio – students' point of view

Summary statistics for rank sum ratio is also obtained and shown in Figure 5.2.32. 95% confidence interval for median is (0.55, 0.57) in Figure 5.2.32 and (22.00, 23.00) in Figure 5.2.31. This means that, there is 95% of chance that rank sum lies in the interval (22.00, 23.00) and total rank ratio lies between (0.55, 0.57).

Further, the above facts confirm that the existing curriculum implementation facilities and their strengths are not of a satisfactory level to implement the ICT specialization subject for grade 10 and 11.

Considering the outcomes and facts related to the ICT teachers' responses which is greatly reliable because curriculum implementation facilities and their strengths directly contribute to quality ICT education than the principals' and students' responses. Therefore, it was assumed that teachers' responses may dominate the entire variable. Further, from the administrative point of view, principals are not so familiar with usage of pedagogical techniques and facilities in curriculum implementation and practical issues in connection with the ICT specialization subject.

Further, literature reveals that programming and problems solving aspects create students' creative thinking abilities. Programming techniques and problem solving capability information were obtained from the students' survey and the outcome were presented as in Figure 5.2.33.

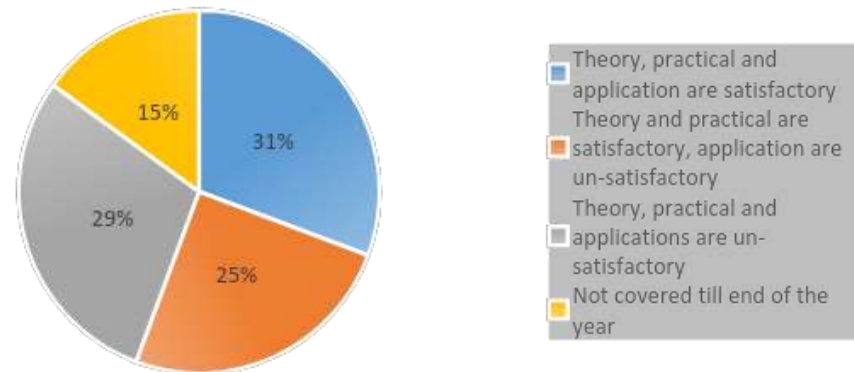


Figure 5.2.33 Students' attitudes towards the status of programming and problem solving techniques

According to Figure 5.2.33, on average 31% students' skill development in connection with the programming and problems solving techniques is satisfactory. Further, 25% applicability of theory and practical are satisfactory but application is un-satisfactory. 29% applicability of theory, practical and application is un-satisfactory. Further, till the end of the year, 15% of students stated that their schools did not cover the programming and problems solving unit of the ICT specialization subject in grades 11 curriculum. In addition to that, the programming and problem solving unit is highly related with the individual project (for programming projects) unit.

Further, attitudes towards the curriculum implementation issues and facilities for implementation of ICT specialization subject for grades 10 and 11 is not of a satisfactory level from the point of view of ICT teachers and usage of pedagogical techniques is completely missing. A majority of students have curriculum implementation issues. For example, Programming and problem solving capability is one of the major assets of the ICT specialization subject. Further, it was highly related with other course units in the grade 11 curriculum. The following correlation confirms the same.

The following hypothesis were tested using correlation.

Hypothesis XVI

The following results were obtained by applying the correlation techniques for the Hypothesis XVI which was described in section 4.6 of Chapter 4. According to Table 5.2.16, below it reveals the following outcome in connection with Hypothesis XVI. At 1% significant level P value is 0.000 ($p=0.000$). It is less than 0.01 (correlation is significant at the 0.01 (2-tailed), therefore, H_0 can be rejected. It was concluded that there is an association between the Q6.2 and Q6.1. In other words, there is an association between the programming and problem solving unit and the information systems.

Hypothesis XVII

The following results were obtained by applying the correlation techniques for the Hypothesis XVII which was described in section 4.6 of Chapter 4. According to Table 5.2.16 below, the following outcomes in connection with Hypothesis XVII is shown. At 1%

significant level P value is 0.000 ($p=0.000$) it is less than 0.01 (correlation is significant at the 0.01 (2-tailed), accordingly H_0 can be rejected. It was concluded that there is an association between the Q6.2 and Q6.3. In other words, there is an association between the programming and problem solving unit and the web design.

Hypothesis XVIII

The following results were obtained by applying the correlation techniques for the Hypothesis XVIII which was described in section 4.6 of Chapter 4. According to Table 5.2.16 below, the followings outcomes in connection with Hypothesis XVIII is revealed. At 1% significant level P value is 0.000 ($p=0.000$). It is less than 0.01 (correlation is significant at the 0.01 (2-tailed). Accordingly H_0 can be rejected. It was concluded that there is an association between the Q6.2 and Q6.4. In other words, there is a relationship between the programming and problem solving unit and ICT and society.

Hypothesis XIV

The following results were obtained by applying correlation techniques for the Hypothesis XIV which was described in the section 4.6 of Chapter 4. According to Table 5.2.16, below the following outcomes in connection with Hypothesis XIX is revealed.

At 1% significant level P value is 0.000 ($p=0.000$) it is less than 0.01 (correlation is significant at the 0.01 (2-tailed)), accordingly H_0 can be rejected. It was concluded that there is an association between the Q6.2 and Q6.5. In other words, there is a relationship between the programming and problem solving unit and the individual project.

Table 5.2.16 correlation between the programming and problem solving unit (Q6.2) with other course units in Grade 11 curriculum (Q6.1, Q6.3, Q6.4, and Q6.5).

			Information systems	Programming and Problem solving	Web Designing
Spearman's rank order	Information systems	Correlation Coefficient	1.000	.370**	.201**
		Sig. (2-tailed)	.	.000	.000
		N	578	578	578
	Programming and Problem solving	Correlation Coefficient	.370**	1.000	.531**
		Sig. (2-tailed)	.000	.	.000
		N	578	578	578
	Web Designing	Correlation Coefficient	.201**	.531**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	578	578	578
	ICT and Society	Correlation Coefficient	.292**	.501**	.619**
		Sig. (2-tailed)	.000	.000	.000

	N	578	578	578
Individual Project	Correlation Coefficient	.328**	.404**	.517**
	Sig. (2-tailed)	.000	.000	.000
	N	578	578	578

Correlations

			ICT Society and	Individual Project
Spearman's rank order	Information systems	Correlation Coefficient	.292	.328**
		Sig. (2-tailed)	.000	.000
		N	578	578
	Programming and Problem solving	Correlation Coefficient	.501**	.404
		Sig. (2-tailed)	.000	.000
		N	578	578
	Web Designing	Correlation Coefficient	.619**	.517**
		Sig. (2-tailed)	.000	.000
		N	578	578
	ICT Society and	Correlation Coefficient	1.000**	.435**
		Sig. (2-tailed)	.	.000
		N	578	578
Individual Project	Correlation Coefficient	.435**	1.000**	
	Sig. (2-tailed)	.000	.	
	N	578	578	

** . Correlation is significant at the 0.01 level (2-tailed). **Nonparametric Correlations**

According to the above statistics, it was confirmed that the programming and problem solving unit is an essential unit for the ICT specialization subject. Further, it showed that there are some implementation issues and the outcome is not of a satisfactory level. Further, programming and problem solving unit is more important and it is highly correlated with other course units in the curriculum. It was concluded that programming and problem solving

unit may improve students' ICT skill development in an acceptable manner than the other course units in the ICT specialization subject.

5.10 Policy Matters (X₆)

Chapter 3 (Literature review) provided and discussed accessible draft policy proposals for the development of ICT education in Sri Lankan schools. Further, questions related to policy matters were not included in the survey due to the following reasons: the three main stakeholders of the survey are students, teachers and principals. They are not much aware about national plans and policy matters. Further, other stakeholders (NIE, MOE, NEC officers etc.) are unable to provide their unpublished draft policy matters for the study. Therefore, considering ethical issues and in-accessibility of the facts, policy matters (X₆) was not considered for the survey analysis.

5.11 Support From The Administration And Supportive Initiative (X₇)

Support from the administration is greatly important for the implementation of ICT education in Sri Lankan schools. Administrators are the respective principals, zonal officers, provincial officers, MOE, NIE and other related officers. According to Chapter 3, it is revealed that supportive initiatives contribute greatly to the enhancement of ICT culture in the school system and it also affects ICT specializations subject for GCE (O/L). Further, the chapter highlights usage of web sites, e-mail usage, IT quizzes etc. as parameters to the introduction of an ICT culture among the schools.

Table 1.18 in Appendix 12 reveals that 66% schools have a web site, 73% of schools have connected to the SchoolNet, 53% of students use e-mail to solve day-to-day problems and exchange messages. Further, Table 1.8 in Appendix 12 shows that 52% schools have a computer society and 65% of out of them are members of the computer society. Finally it is reported that 39% of teachers have computer facilities in their residences and 84% of schools use computer facilities for their administrative work. Table 1.19 of Appendix 12 shows that 59% of principals have obtained basic training on the importance of the usage of computer applications and e-citizenship program. Because of these types of training, principals may support the school's computer ICT education as well as motivate students and ICT teachers to do ICT activities. These facts may indirectly affect enhance the quality of ICT education in schools.

According to the above descriptive statistics and the facts explored in Chapter 3, it was concluded that, there is significant support from the administration and supportive initiative that exists in the Sri Lankan school system to perform the ICT specialization subject for GCE (O/L) in a satisfactory level. With the aim of strengthening the above conclusion drawn regarding support from the administration and supportive initiative, the following inferential statistics were used.

Inferential Statistics used to illustrate the support from the administration and supportive initiative.

Figure 5.2.34 shows the summary statistics regarding support from administration and Supportive initiative from ICT teacher’s point of view for the implementation of ICT specialization subject for the grades 10 and 11 students.

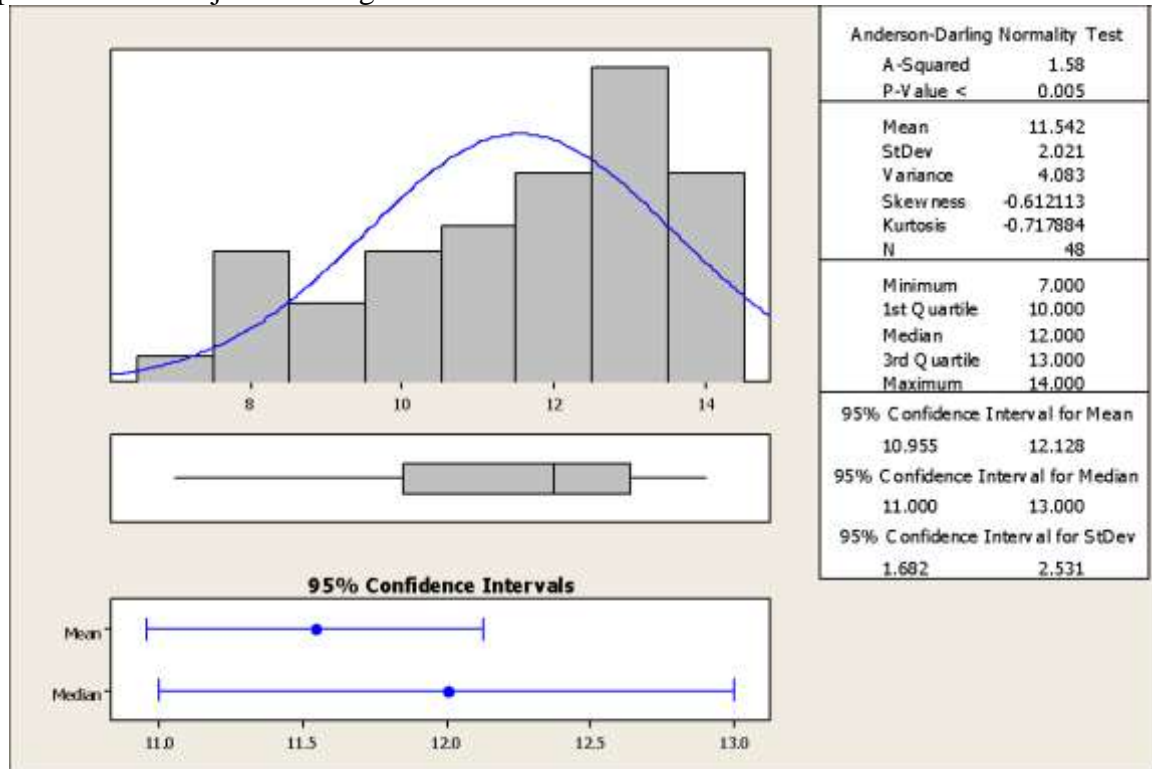


Figure 5.2.34 Summary statistics for support from administration and supportive initiative (X_7) on rank of sum – ICT teachers' point of view.

According to the Figure 5.2.34, the minimum rank sum is 7.0 and the maximum rank sum is 14.00. The median 12.0 indicates that nearly 50% of the respondents are given the rank greater than and equal to 12.0. 1st quartile is 10.0. It means that rank sum of 75% of the respondents is greater than or equal to 10. Further, 3rd quartile is 13.00. It claims that 25% of the respondents' rank sum is above 13.00. Accordingly, attitudes towards support from the administration and supportive initiative for the implementation of ICT specialization subject for Grade 10 and 11 is up to a satisfactory level from the point of view of ICT teachers. The confidence interval for mean and median also support the same.

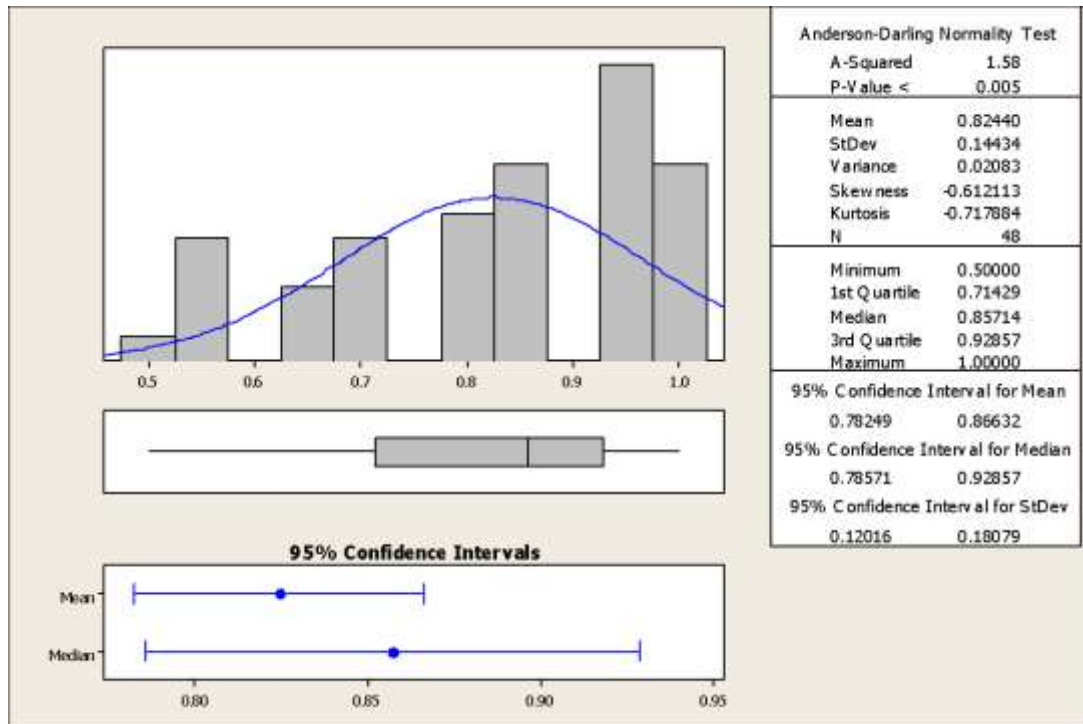


Figure 5.2.35 Summary statistics for support from administration and supportive initiative (X_7) on rank sum ratio – ICT teachers' point of view

Summary statistics for ratio of ranks are also obtained and shown in the Figure 5.2.35. 95% confidence interval for median is (0.785, 0.928) in Figure 5.2.34 and (11.00, 13.00) in Figure 5.2.34. It means that, there is a 95% chance that the rank sum lies in the interval (11.00, 13.00) and the total rank ratio lies between (0.785, 0.928).

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XX which was described in the section 4.6 of Chapter 4.

Table 5.2.17 Kruskal-Wallis Test on total ranks for Support from administration and supportive initiative – ICT teachers' point of view

District	N	Median	Average Rank	Z
Colombo	19	12.000	26.6	0.83
Gampaha	9	11.000	21.2	-0.78
Puttalam	6	11.500	20.5	0.75
Hambanthota	10	13.000	26.9	0.61
Nuwara-Eliya	4	11.000	22.0	-0.37
Overall	48		24.5	

H = 1.82 DF = 4 P = 0.768

H = 1.88 DF = 4 P = 0.758(adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.758 (adjusted for ties). As the P value is greater than the significant level ($\alpha= 0.05$). H_0 cannot be rejected. According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all ICT teachers teaching ICT specialization subject for grades 10 and 11 are satisfied the Support from the administration and supportive initiative in the ICT education in Sri Lankan schools for grade 10 and 11 ICT specialization subject. Further, it can concluded that “Teachers’ attitude towards the Support from the administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan school is the same in all five districts”. Principals are the chief administrative officers in the school and they are greatly aware of the Support from the administration and supportive initiative for ICT education. Based on the questions related to the infrastructure in the principals’ questionnaire was taken, rank summed and summary statistics were represented as in Figure 5.2.36.

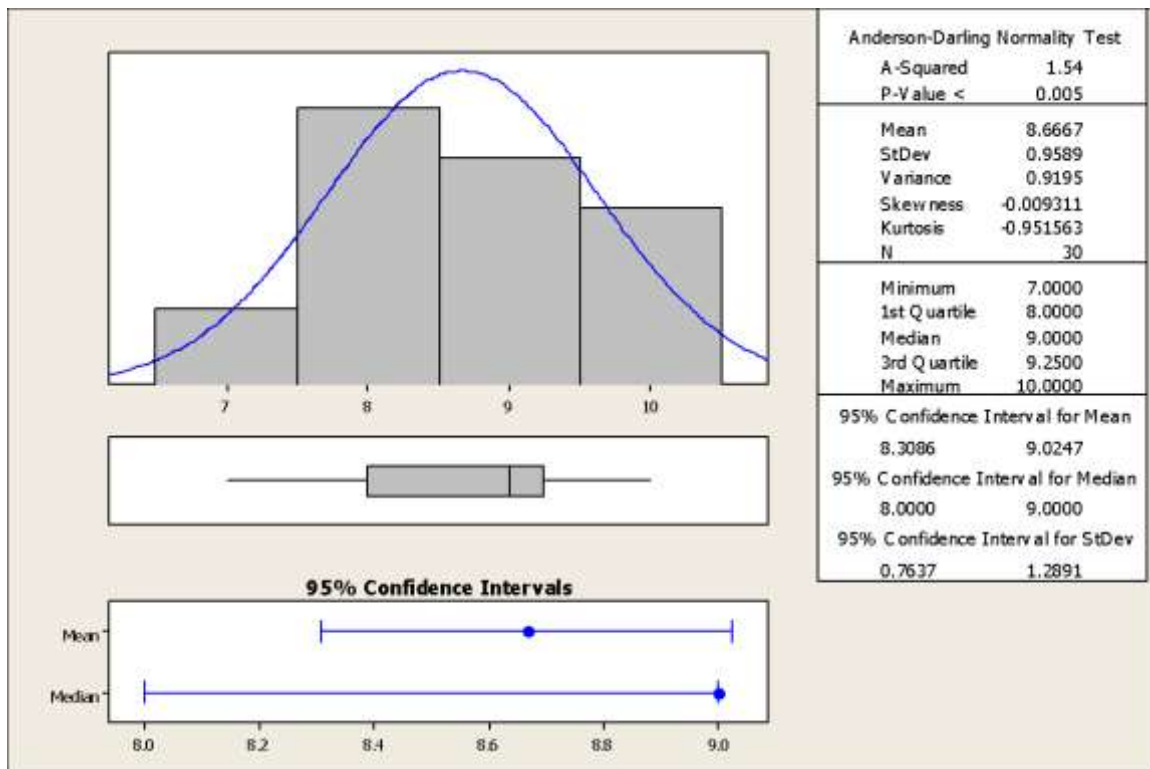


Figure 5.2.36 Summary statistics for Support from the administration and supportive initiative on rank of sum – Principals’ point of view

According to Figure 5.2.36, the minimum rank sum is 7.0 and the maximum rank sum is 10.0 Median 9.00 indicates that nearly 50% of the respondents are given the rank 9.00. The 1st quartile is 8.0. This means that the rank sum of 75% of the respondents is greater than or equal to 9.0. Further, 3rd quartile is 9.250. It claims that above 25% of the respondents’ rank sum is greater than or equal to 9.25. 95% Confidence interval for mean and median are (8.30, 9.02) and (8.00, 9.00) respectively and also support the same. Accordingly, attitudes towards the Support from the administration and supportive initiative for implementation of ICT specialization subject for Grade 10 and 11 is up to satisfactory level from the point of view of principals.

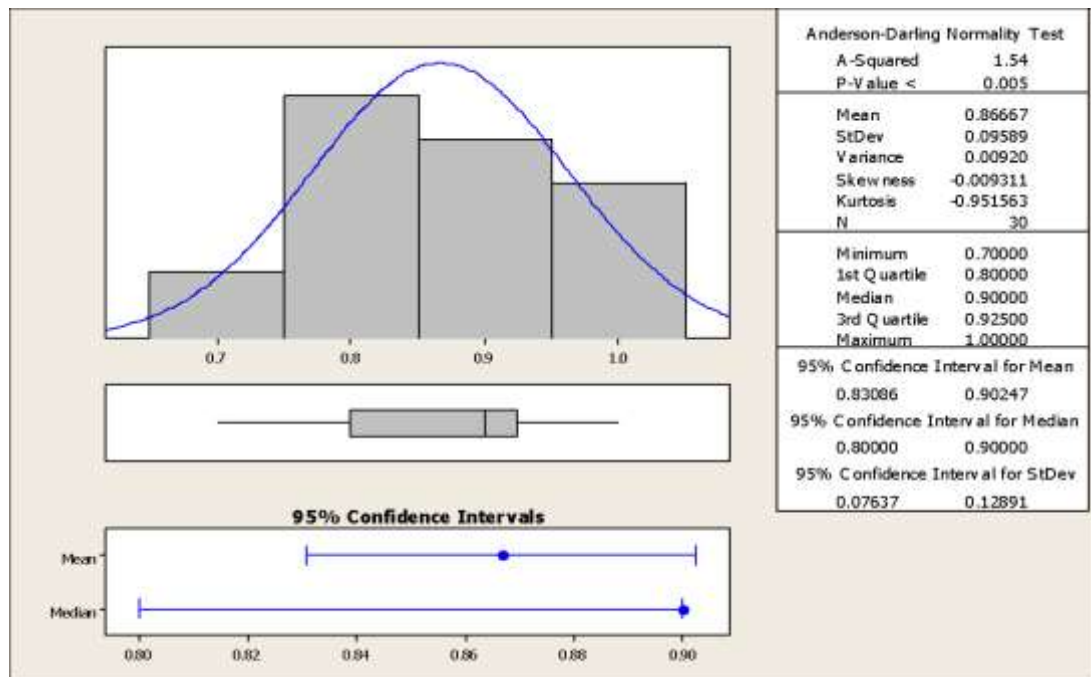


Figure 5.2.37 Summary statistics for Support from administration and supportive initiative on rank sum ratio – principals' point of view

The ratio of ranks obtained shown in summary statistics in the Figure 5.2.37. 95% confidence interval for rank ratio median is (0.80, 0.90) in Figure 5.2.37 and rank sum median is (8.00, 9.00) in Figure 5.2.36. This means that, there is a 95% chance that the rank sum lies in the interval (8.00, 9.00) and the rank sum ratio lies between (0.80, 0.90). These values confirm that Support from the administration and supportive initiative for implementation of ICT specialization subject for Grade 10 and 11 is up to a satisfactory level from the point of view of principals’.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XXI which was described in the section 4.6 of Chapter 4.

Table 5.2.18 Kruskal-Wallis Test on total ranks versus district for Support from the administration and supportive initiative – Principals' point of view

District	N	Median	Average Rank	Z
Colombo	10	9.000	17.4	0.84
Gampaha	6	8.500	11.7	-1.19
Puttalam	4	9.500	20.5	1.22
Hambanthota	7	8.000	10.9	-1.59
Nuwara-Eliya	3	10.000	21.0	1.14
Overall	30		15.5	

$H = 6.01$ DF = 4 P = 0.198

$H = 6.60$ DF = 4 P = 0.159(adjusted for ties)

The P value of the Kruskal-Wallis test on total rank is 0.159 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that "Principals' attitude towards the support from the administration and supportive initiative for ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts."

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XXII which was described in the section 4.6 of Chapter 4.

Table 5.2.19 Kruskal-Wallis Test on total ranks versus School Type for Support from the administration and supportive initiative – Principals' point of view

School Type	N	Median	Average Rank	Z
National	3	8.000	15	-0.1
1 AB	11	9.000	16.9	0.67
1 C	11	9.000	18.5	1.4
Type 2	5	8.000	6.2	-2.59
Overall	30		15.500	

$$H = 7.11 \quad DF = 3 \quad P = 0.068$$

$$H = 7.81 \quad DF = 3 \quad P = 0.050 \text{ (adjusted for ties)}$$

The P value of the Kruskal-Wallis test on total rank is 0.006 (adjusted for ties). As the P value is equal to the significant level ($\alpha = 0.05$), H_0 can be rejected. It can be concluded that "Principals' attitude towards the support from the administration and supportive initiative for ICT specialization subject for GCE(O/L) in Sri Lankan schools is at least in one school type different from the others".

According to the summary statistics and the results of the Kruskal-Wallis test, it was concluded that all the Principals conducting ICT specialization subject for grades 10 and 11 are satisfied with the support from the administration and supportive initiative at the ICT education in Sri Lankan schools for grade 10 and 11 ICT specialization subject. Furthermore, the above results show that, there are no disparities district-wise but there are some disparities in school types (school categories) regarding the support from the administration and supportive initiative for implementation of ICT specialization subject for GCE (O/L).

Availability of support from the administration and supportive initiative directly affect students. Therefore, to confirm the validity of the above outcomes, stakeholder's attitudes are most important.

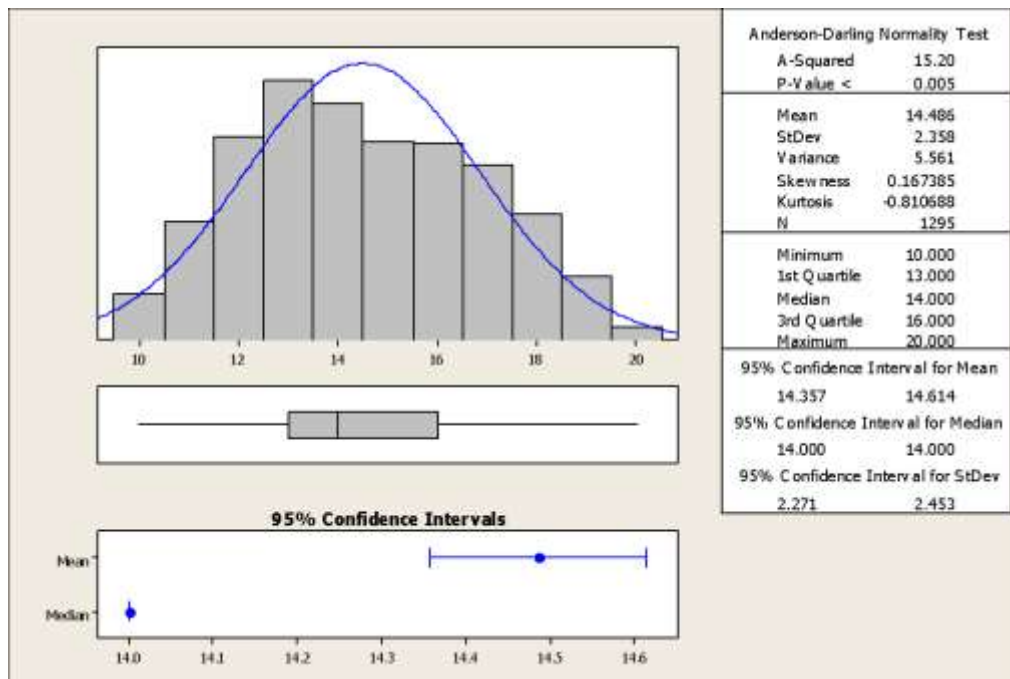


Figure 5.2.38 Summary statistics for support from the administration and supportive initiative on rank of sum – Students' point of view

According to the Figure 5.2.38, the minimum rank sum is 10.0 and the maximum rank sum is 20.00. Median 14.0 indicates that nearly 50% of the respondents are given the rank 14.0. The 1st quartile is 13.0. This means that the rank sum of 25% of the respondents is less than or equal to 13.0. Further, the 3rd quartile is 16.0. It claims that a rank sum of 25% of the respondents is greater than or equal to 16. Accordingly, attitudes towards the support from the administration and supportive initiative for implementation of ICT specialization subject for grades 10 and 11 is of marginally satisfactory level from the point of view of students. The lower and upper levels of confidence for median coincide.

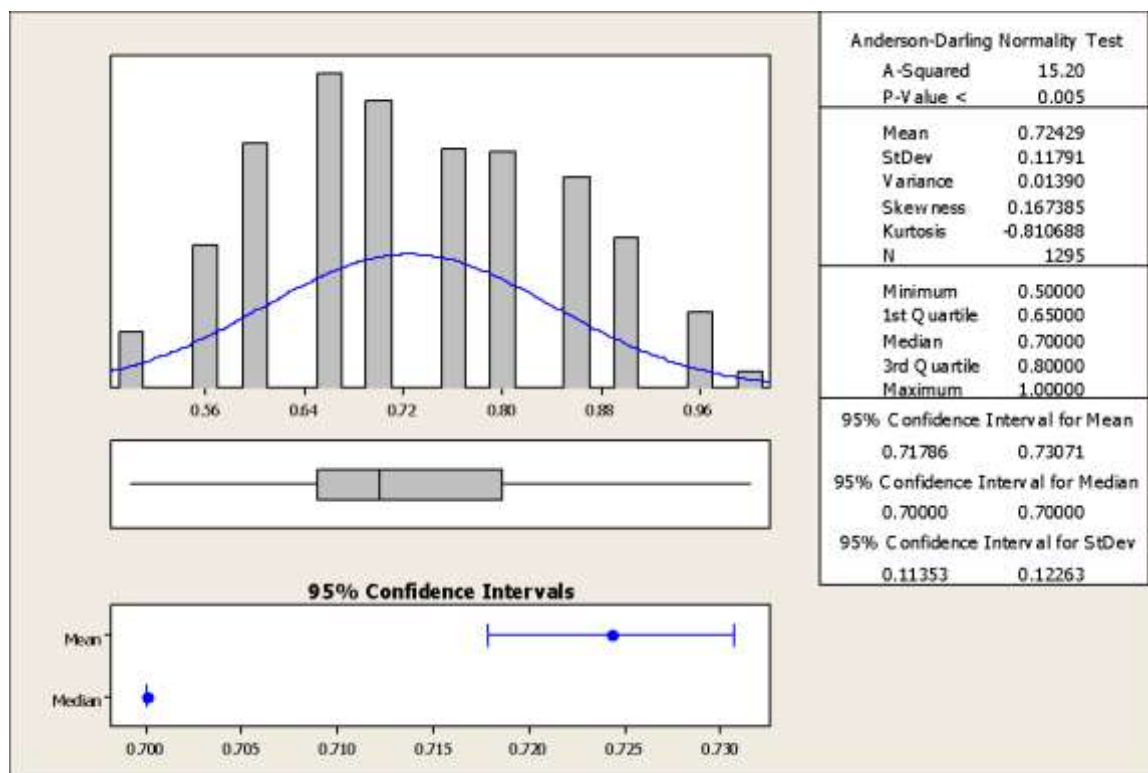


Figure 5.2.39 Summary statistics for support from the administration and supportive initiative on rank sum ratio – ICT Students' point of view

Summary statistics for ratio of ranks are also obtained and shown in the Figure 5.2.38. 95% confidence interval for median is (0.700, 0.700) in Figure 5.2.38 and (14.00, 14.00) in Figure 5.2.37. This means that, there is a 95% of chance that the rank sum lies in a point value (14.00, 14.00) and total rank ratio also lies in a point value (0.866, 0.866). It was concluded that support from the administration and supportive initiative for implementation of ICT specialization subject for grades 10 and 11 is of a marginally satisfactory level from the point of view of students.

Principals and subsequently teachers are greatly aware of the support of the administration and supportive initiatives. Students may not be adequately mature to judge the status of support from the administration. Therefore, their responses may not be reliable as those of the teachers and principals but they are also satisfied at marginal level. Considering the above facts, it was concluded that support from the administration and supportive initiatives are of a satisfactory level for the implementation of ICT specialization subject in grades 10 and Grade 11.

5.12 Research And Development (X_s)

Research and development are immensely useful for ICT education because there is a rapid development of the ICT industry when compared with other disciplines. Therefore, to maintain international standards in ICT education, the Sri Lankan educational system should implement research and development activities in connection with ICT education. A few

activities in connection with research and development investigation are included in this study.

Table 1.9 in Appendix 12 shows 63% of principals' attitudes towards the ICT specialization subject will improve students' knowledge, usage of hi-tech instruments, self-problem solving and self-thinking abilities with respect to other subjects in the GCE(O/L) curriculum . Further, 34% of principals have accepted the above at a satisfactory level. Further, Table 1.20 in Appendix 12 reveals the principals' recommendations regarding the following alternative enhancement possibilities to the ICT specialization subject for GCE (O/L) in addition to the existing face-to-face traditional teaching and learning process. 98% of principals are recommended to use Knowledge sharing methodologies through group projects and presentations, 97% of principals recommended Knowledge sharing using internet facilities, 88% principals recommended use of knowledge sharing mechanisms through e-learning, e-conference and virtual classroom concepts, 61% of principals recommended knowledge sharing methodologies through blended learning technologies and 0% of principals recommended use of only the existing traditional technologies rather than using the blended learning approaches.

Further, Figure 5.2.40. Shows difficulties in the implementation of blended learning techniques.

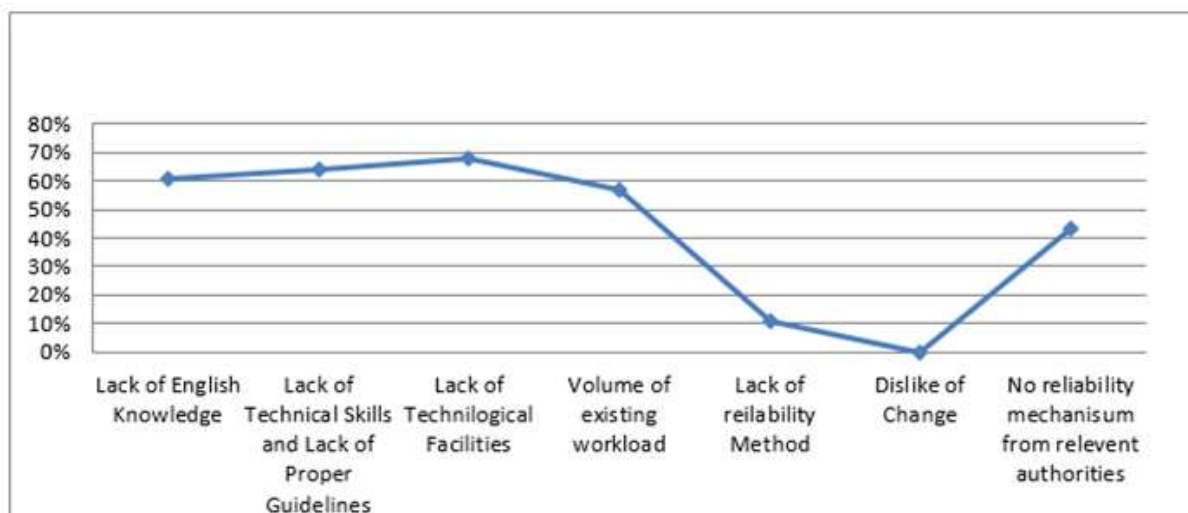


Figure 5. 2.40 Difficulties in the implementation of Blended Learning

The above descriptive statistics show the problem faced by the principals in connection with blended learning difficulties. If authorities take action to minimize the above difficulties , principals and ICT teachers will be positively willing to absorb the blended learning technologies into the ICT specilization subject in grades 10 and 11. Based on the above facts, it was concluded that principals, teachers and others need to carry out research and development activities in connection with the ICT specilization subject. With the aim of strengthening the above conclusion, the following inferential statistical techniques were also used.

Necessity of research and development activities in ICT specialization subject for GCE (O/L)

It was identified that research and development activities (X_8) are very important to enhance the quality of ICT specialization subject. Figure 5.2.40 shows the summary statistics regarding importance of implementing research and development activities to enhance ICT specialization subject for the Grade 10 and 11 students from ICT teachers’ point of view.

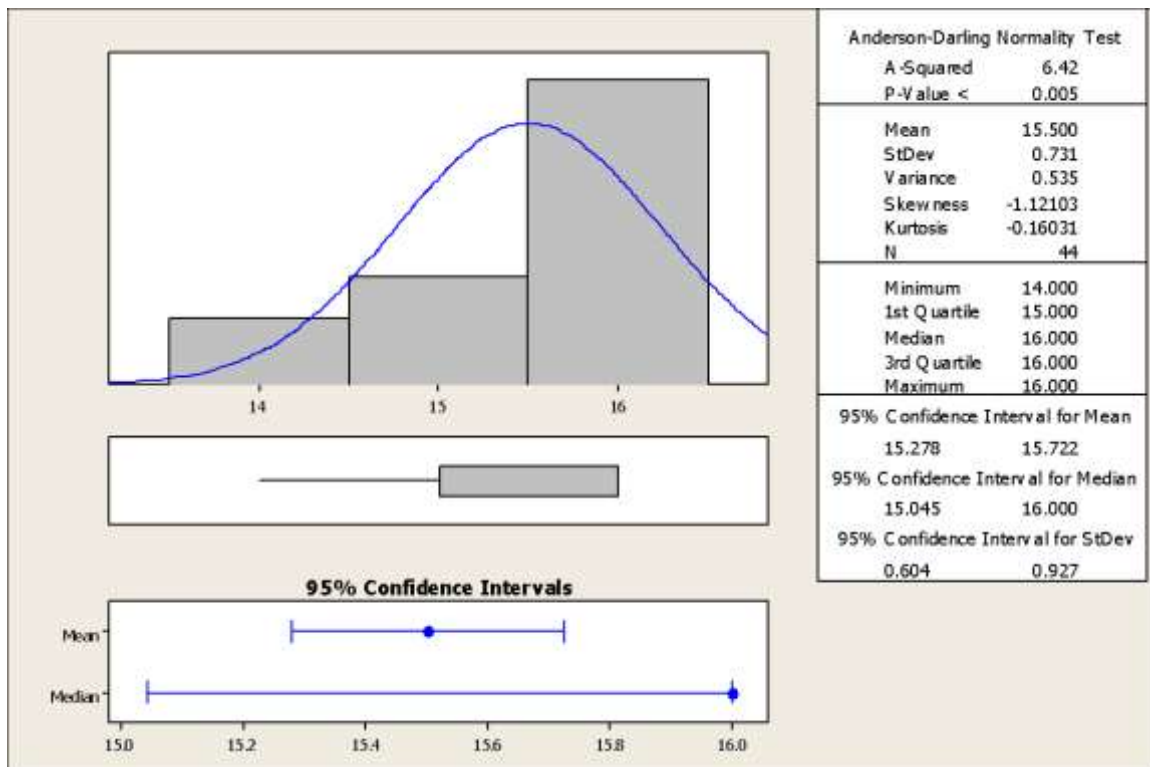


Figure 5.2.41 Summary statistics of the importance of adopting research and development activities -on rank of sum – ICT teachers’ point of view

According to the Figure 5.2.41, the minimum rank sum is 14.00 and the maximum rank sum is 16.00. The median, 16.0 indicates that nearly 50% of the respondents have given the rank greater than or equal to 16.00. The 1st quartile is 15.00. This means that rank sum of 75% of the respondents is greater than or equal to 15.00. Further, the median and the 3rd quartile is 16. It claims that 50% of the respondents rank sum is greater than or equal to 16.00. Confidence interval for mean and median also support same. Further, response values and other outcomes are very close to the upper bound of the total rank sum. Accordingly, the importance of implementing research and development activities to enhance ICT specialization for the implementation of ICT specialization subject for grades 10 and 11 is of a great satisfactory level from the point of view of ICT teachers’.

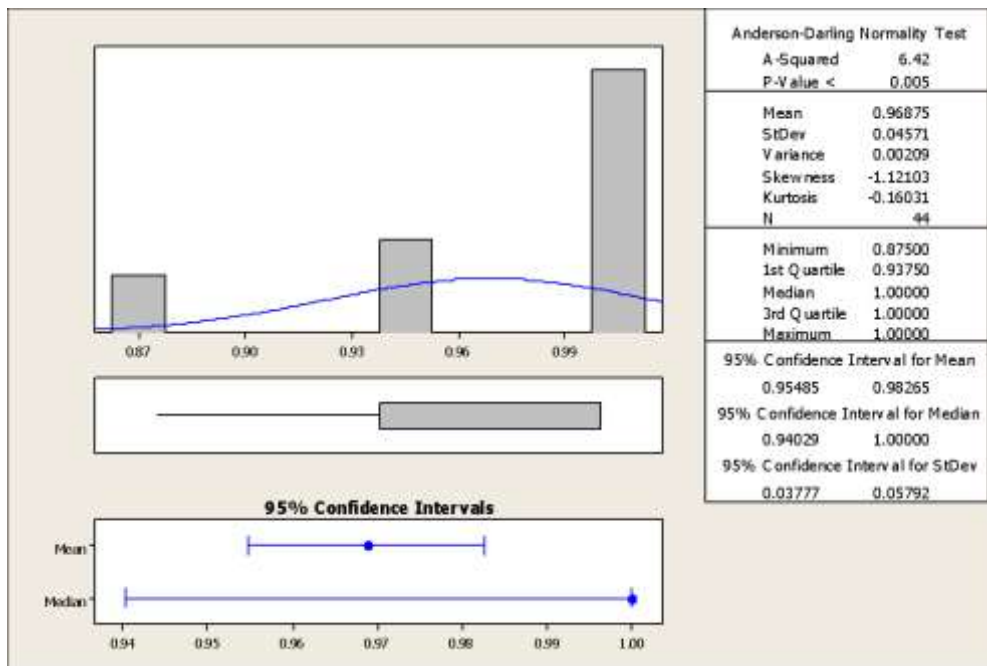


Figure 5.2.42 Summary statistics on the importance of adopting research and development activities on rank sum ratio – ICT teachers' point of view

Summary statistics for ratio of ranks also obtained and shown in the Figure 5.2.42. 95% confidence interval for median is (0.95, 0.98) in Figure 5.2.42 and (15.00, 16.00) in Figure 5.2.41. This means that, there is 95% of chance that the rank sum lies in the interval (15.00, 16.00) and total rank ratio lies between (0.95, 0.98). These facts also confirm the above conclusion.

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XXIII which was described in the section 4.6 of Chapter 4.

Table 5.2.20 Kruskal-Wallis Test on total ranks for infrastructure – ICT teachers' point of view.

District	N	Median	Average Rank	Z
Colombo	17	16.000	23	0.22
Gampaha	8	15.500	19	-0.85
Puttalam	6	16.000	30.5	1.64
Hambanthota	9	15.000	17.8	-1.22
Nuwara-Eliya	4	16.000	25.8	0.53
Overall	44		22.5	

$$H = 4.39 \text{ DF} = 4 \text{ P} = 0.355$$

$$H = 6.03 \text{ DF} = 4 \text{ P} = 0.197(\text{adjusted for ties})$$

The P value of the Kruskal-Wallis test on total rank is 0.197 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded

that “Teachers attitude towards the importance of adopting research and development activities to enhance ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts”.

According to the summary statistics and the results of the Kruskal-Wallis test, it was concluded that all the ICT teachers teaching ICT specialization subject for grade 10 and 11 are willing to adopt research and development activities to enhance the ICT specialization subject for grade 10 and 11 in Sri Lankan schools.

Principals are the chief administrative officers and they should identify the importance of adopting research and development activities to enhance the ICT specialization subject for grades 10 and 11 in Sri Lankan schools.

The principals’ attitudes in connection with the importance of adopting of research and development activities to enhance ICT specialization subject for grade 10 and 11 in Sri Lankan schools were analyzed and presented in Figure 5.2.43.

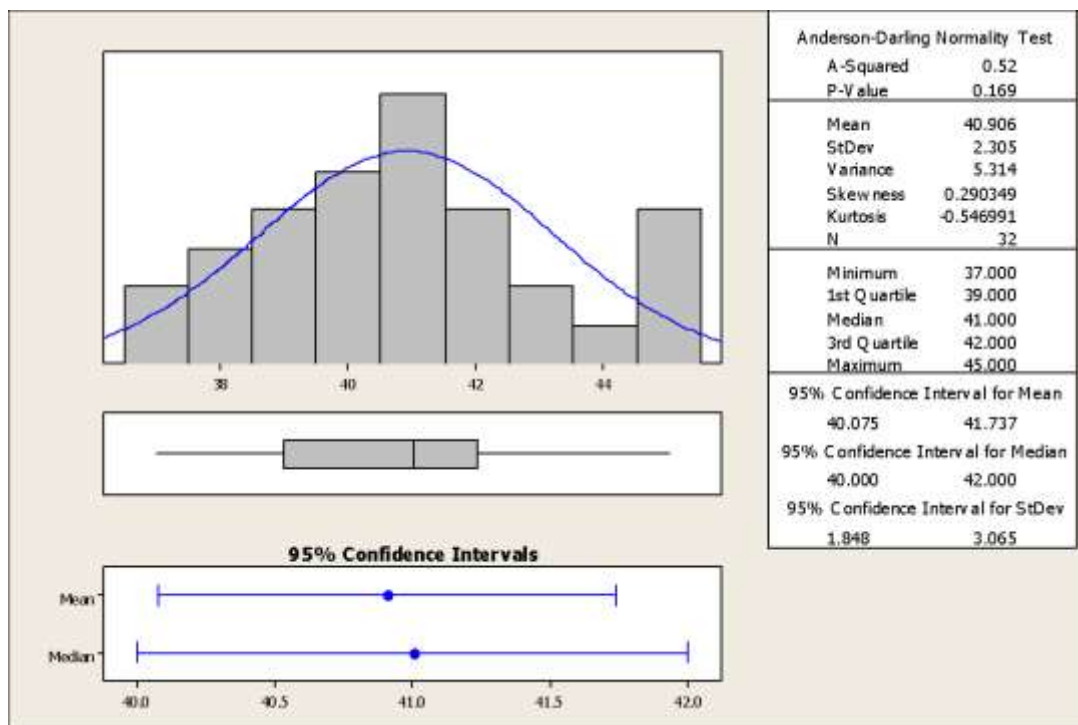


Figure 5.2.43 Summary statistics for the importance to adopt research and development activities to enhance the ICT Specialization subject (X_s) on rank of sum – Principals’ point of view

According to the Figure 5.2.43, the minimum rank sum is 37.00 and the maximum rank sum is 45.00. Median 41.00 indicates that nearly 50% of the respondents are given the rank greater than or equal to 41.00. The 1st quartile is 39.000. This means that a rank sum of 75% of the respondents is greater than or equal to 39.000. Further, the 3rd quartile is 42.00. It claims that nearly 25% of the respondents’ rank sum is greater than or equal to 42.00. The 95% confidence interval for the mean and median are (40.07, 41.73) and (40.00, 42.00)

respectively and also support the same. Further, respondents' outcomes are very close to the upper bound of the range. Accordingly, attitudes towards the adoption of research and development activities to enhance the ICT specialization subject of grades 10 and 11 students were of highly satisfactory levels from the point of view of principals.

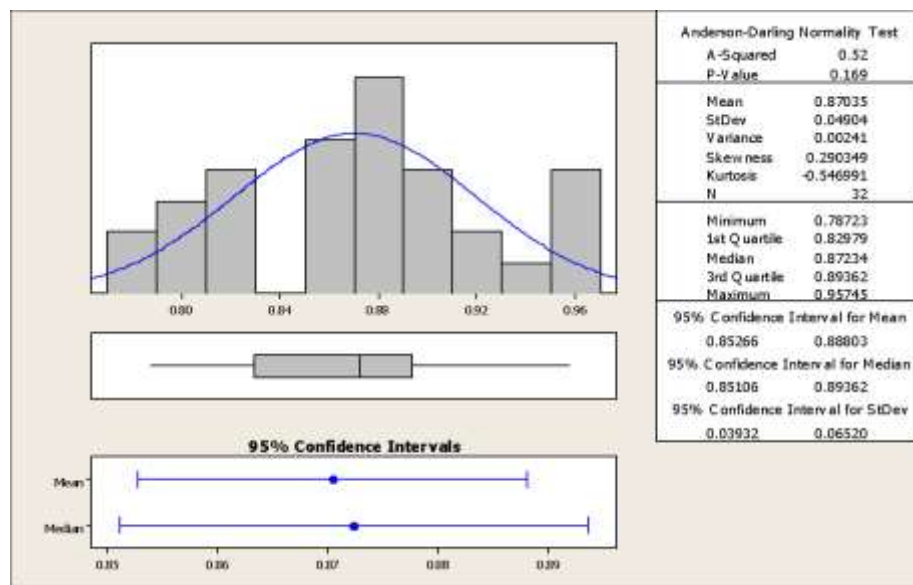


Figure 5.2.44 Summary statistics on the importance of adopting research and development activities to enhance the ICT Specialization subject to grade 10 and 11 students (X_s) on rank sum ratio – Principals point of view.

The ratio of ranks are obtained and are also shown as in summary statistics in the Figure 5.2.44. 95% confidence interval for rank sum ratio median is (0.85, 0.89) in Figure 5.2.44 and rank sum median is (40.00, 42.00) in Figure 5.2.43. This means that, there is a 95% of chance that the rank sum lies in the interval (40.00, 42.00) and rank sum ratio lies between (0.85, 0.89).

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XXIV which was described in the section 4.6 of Chapter 4.

Table 5.2.21 Kruskal-Wallis Test on total ranks versus districts on the importance of adopting research and development activities to enhance ICT specialization subject – principals' point of view

District	N	Median	Average Rank	Z
Colombo	11	41.000	19.3	1.21
Gampaha	7	41.000	16.3	-0.07
Puttalam	4	41.000	15.9	-0.14
Hambanthota	7	39.000	12.3	-1.34
Nuwara-Eliya	3	41.000	17.5	0.19
Overall	32		16.5	

$$H = 2.43 \text{ DF} = 4 \text{ P} = 0.657$$

$$H = 2.48 \quad DF = 4 \quad P = 0.648(\text{adjusted for ties})$$

The P value of the Kruskal-Wallis test on total rank is 0.648 (adjusted for ties). As the P value is greater than the significant level ($\alpha = 0.05$), H_0 cannot be rejected. It can be concluded that “Principals’ attitude towards the importance of adopting research and development activities to enhance ICT specialization subject for GCE (O/L) in Sri Lankan schools is the same in all five districts”.

The following hypothesis was tested by Kruskal- Wallis test:

The following results were obtained by applying the Kruskal-Wallis test for the Hypothesis XXV which was described in the section 4.6 of Chapter 4.

Table 5.2.22 Kruskal-Wallis Test on total ranks on the importance of adopting research and development activities to enhance for ICT specialization versus School Type for infrastructure – Principal’s point of view

School Type	N	Median	Average Rank	Z
National	3	40.000	16.7	0.03
1 AB	12	40.000	13.6	-1.34
1 C	12	41.500	19.6	1.46
Type 2	5	41.000	15.8	-0.18
Overall	32		16.500	

$$H = 2.49 \quad DF = 3 \quad P = 0.478$$

$$H = 2.54 \quad DF = 3 \quad P = 0.468 (\text{adjusted for ties})$$

The P value of the Kruskal-Wallis test on total rank is 0.478 (adjusted for ties). As the P value is less than the significant level ($\alpha = 0.05$), H_0 can be rejected. It can be concluded that “Principals’ attitude towards the importance of adopting research and development activities to enhance ICT specialization subject for GCE (O/L) in Sri Lankan schools is same in all schools-types”.

According to the summary statistics and the results of the Kruskal-Wallis test, it can be concluded that all the principals conducting ICT specialization subject for grade 10 and 11 are willing adopt research and development activities to enhance ICT specialization subject for GCE (O/L) in Sri Lankan schools. Furthermore, the above results show that, there are no disparities, district as well as in school types (school categories).

Finally, it was concluded that ICT teachers and principals are quite willing to adopt research and development activities to enhance ICT specialization subject for GCE (O/L) in Sri Lankan schools. Further, literature review also reveals that there is a lack of research and development activities in Sri Lankan ICT education and that there is a great need for such involvement according to international quality standards.

5.13 Budget Allocation And Country Expectations (X₉)

Chapter 3 provides and discusses the accessible budget allocations and country expectations for the development of ICT education in Sri Lankan schools. Further, questions related to the budget allocation and country expectations were not included in the survey due to the following reasons: the three main stakeholders of the survey are students, teachers and principals. It was assumed that they are not aware of the budget allocations and country expectations. Further, other stakeholders (NIE, MOE, NEC officers etc.) are unable to provide financial allocations and proposals for the study. Therefore, considering ethical issues and in-accessibility, budget allocations and country expectation were not considered for the survey analysis.

5.14 Enhancement Possibilities To Fill Gaps In Ict Specialization Subject

The presentation of the above results has shown the present status of ICT education in Sri Lankan schools and gaps and limitations that might affect the quality of ICT specialization subject for the GCE (O/L) in Sri Lankan schools. Based on the literature review and descriptive statistics derived from the survey related to ICT education in Sri Lanka, it was summarized and presented in Table 5.2.23. Further, Table 5.2.24 shows the summary of indicators and methodologies that are used in quality factors for ICT education on international recommendations of selected Asian countries and Sri Lanka according to the research design proposed in Figure 4.2 and Figure 4.4 in Chapter 4. It also recognizes the gaps and limitations that might affect the quality of ICT specialization subject in grade 10 and in Sri Lankan schools. The gaps and limitations that might affect the ICT specialization subject for GCE (O/L) in Sri Lankan schools as achievement of the 3rd objective of the research study is summarized and shown in Table 5.2.23 as follows.

Table 5.2.23 Recognition of the gaps and limitations that might affect the quality of ICT specialization subject in grade 10 and in Sri Lankan schools

Quality Factor /pillars	Variable Notation	Gap in the quality factors (variables) and its limitations in connection with the implementation of ICT Specialization subject for GCE(O/L)
(i) Infrastructure facilities	X ₁	Infrastructure facilities for the implementation of ICT specialization for GCE (O/L) are of a satisfactory level. District-wise, there are no infrastructure disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka. Schools category-wise, there are infrastructure disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka.
(ii) Human resource facilities and their strengths	X ₂	Human resource facilities and their strength for the ICT specialization subject are not up to a satisfactory level. There are no disparities district-wise and also school type- wise (among the school categories)

		regarding human resource facilities and its strength for implementation of ICT specialization subject.
(iii) Maintenance and sustainability plans	X ₃	Computer maintenance and sustainability plan for the ICT specialization subject is not of a satisfactory level. There were no disparities, district-wise, as well as in school types (school categories) regarding the maintenance and sustainability mechanism for implementation of ICT specialization subject
(iv) Software	X ₄	The majority of schools use Microsoft products for the implementation ICT specialization subject. In contrast, the ICT stakeholders were not satisfied with the usage of only Microsoft products. They recommended the use of both Microsoft and open source products. Further, it was identified that the usage of only Microsoft products creates difficulties in the implementation of ICT specialization subject in Sri Lankan schools. Open source products are more flexible and reliable. As an alternative solution, open source software products can be used to enhance the quality of ICT specialization subject. Further, it was identified that the usage of software for the ICT specialization subject in Sri Lankan schools is the same in all five districts.
(v) Curriculum implementation facilities	X ₅	The curriculum implementation facilities/ techniques are not of a satisfactory level in the ICT specialization subject in Sri Lankan schools. Curriculum implementation facilities/techniques for the ICT specialization subject in Sri Lankan schools is the same in all districts. The programming and problem solving unit is an essential unit for the ICT specialization subject. Further, it was shown that there are some implementation issues and the outcome was also not of a satisfactory level. Further, the programming and problem solving unit is very important and it is highly correlated with other course units in the curriculum. The programming and problem solving unit may improve students' ICT skill development in an acceptable manner than the other course units in the ICT specialization subject.
Usage of Pedagogical	X _{5.1}	The curriculum implementation facilities and techniques in connection with pedagogical

<p>techniques to implement ICT specialization curriculum in Sri Lankan schools</p>		<p>techniques were completely missing in the implementation of the ICT specialization subject for Grade 10 and 11 in Sri Lankan schools.</p> <p>Applications of pedagogical techniques for ICT specialization subject in Sri Lankan schools is the same in all districts.</p> <p>The curriculum implementation facilities and techniques for ICT specialization subject in Sri Lankan schools is the same in all schools types (categories) conducting ICT specialization subject for grades 10 and 11.</p>
<p>(vi) Policy Matters</p>	<p>X₆</p>	<p>Further, questions related to the policy matters were not included in the survey due to the following reasons: the three main stakeholders of the survey are students, teachers and principals. They are not much aware of national plans and policy matters. Further, other stakeholders (NIE, MOE, NEC officers etc.) were unable to provide their unpublished draft policy matters for the study. Therefore, considering ethical issues and in-accessibility to the facts, policy matters (X₆) was not considered for the survey analysis. Relevant authorities should attend to the variable.</p>
<p>(vii) Support from the administration and supportive initiatives</p>	<p>X₇</p>	<p>Support from the administration and supportive initiatives for the implementation of ICT specialization subject in Sri Lankan schools is up to satisfactory level.</p> <p>There are no disparities district-wise but there is some disparity in school types (school categories) regarding the support from administration and supportive initiatives for the implementation of ICT specialization subject in Sri Lankan schools.</p>
<p>(viii) Research and development</p>	<p>X₈</p>	<p>It was indicated that there was a lack of research and development activities involved in Sri Lankan ICT education and there is a need of such for enhancement according to international quality standards</p> <p>All stakeholders are greatly willing to adopt research and development activities to enhance the ICT specialization subject in Sri Lankan schools.</p> <p>The willingness of stakeholders to adopt research and development activities to enhance the ICT specialization subject in Sri Lankan schools is same in all districts and also there are no</p>

		disparities in all school- types.
(ix) Budget allocations and country expectations	X ₉	Questions related to the budget allocation and country expectations were not included in the survey due to the following reasons: the three main stakeholders of the survey are students, teachers and principals. It was assumed that they are not aware of the budget allocation and country expectations. Further, other stakeholders (NIE, MOE, NEC officers etc.) are un-willing to provide the financial information and proposals for the study. Therefore, considering ethical issues and in-accessibility, budget allocations and country expectations were considered for the survey analysis.

Gap Analysis (Charles, 2004) was used to suggest possible enhancement to fill the gap in ICT specialization subject for GCE (O/L) in Sri Lankan schools. This process covers the achievement of the 4th objective of the study.

Table 5.2.24: The recommendations of the enhancement possibilities of the study in connection with the ICT specialization subject for GCE (O/L) in Sri Lankan schools.

Variable /factor	Gap identification Process			How to fill gaps within a specified time frame
	Current	Expectation	Gap	
Infrastructure facilities (X ₁)	There are sufficient infrastructure facilities available for the implementation of ICT specialization subject for GCE(O/L) schools in Sri Lanka.	Need sufficient infrastructure facilities (e.g. computers, internet connectivity, networking facilities) for smooth implementation of ICT specialization subject.	-	No gaps appear in connection with the infrastructure facilities to implement the ICT specialization subject for GCE (O/L) in Sri Lankan schools.
Human resource facilities (X ₂)	There are no satisfactory levels of human resource facilities and	To provide skillful ICT human resource facilities to implement ICT specialization subject for GCE	Unable to achieve the expected skills development of grades 10 and 11 students	It was shown that there are several improvements needed to maintain the quality of ICT specialization subject for GCE (O/L) in connection with human resource facilities and

	strength to implement ICT specialization subject for GCE(O/L) examination	(O/L) curriculums of good quality.	doing ICT specialization subject for their GCE(O/L) examination	its strength. Some of these are recruitment of qualified staff, appropriate pre-service and in-service training, usage of standard teaching methodologies, usage of blended learning and e-learning activities etc. it was suggested that authorities should attend to the above mentioned matters. Further, the following methodologies can be tested through this study. Provide experimental teacher training mechanisms with embedded standard teaching methodologies, e-learning and blended learning approaches. Further, provide guidance to implement the enhanced activities learnt at experimental teacher training programs in connection with ICT specialization subject for grades 10 and 11 in selected respective schools.
Maintenance and sustainability plans(X ₃)	Computer maintenance and sustainability plan for ICT specialization subject for GCE (O/L) in Sri Lankan schools is not of a satisfactory level.	Provide smooth hardware maintenance and sustainable mechanisms without affecting the implementation of ICT specialization subject for GCE (O/L) curriculums.	Authorities should attend to this matter and provide a sustainable mechanism to provide smooth a hardware platform to implement the ICT specialization subject for GCE(O/L) curriculum without any interruption	Higher level authorities have more privileges to attend to this factor. Therefore, this study does not concentrate on the maintenance and sustainability.
Software (X ₄)	A majority of schools use Microsoft product to	Provide hassle free environment to study ICT specialization	With regards to maintaining the ethical practices, usage of	Recommend to introduce Free and Open source (FOSS) product to experimental teacher training programs and

	<p>implement the ICT specialization subject. Further, curriculum emphasizes principles rather than products. There are some issues in connection with the usage of Microsoft products, such as: financial constraints with licensed software, virus threats, software version incompatibility issues and Un-ethical practices.</p>	subject	<p>Microsoft products will create practical implementation issues. Further, in Microsoft product's source programs accessibility is restricted. If source programs are accessible to students and teachers, then there is the possibility of enhancing their software development/exploration knowledge</p>	<p>based on its success, try out the model with their respective students. This was highly recommended according to international standards, used by developed countries as well as countries in the Asian region. Further, at present ICT GCE (A/L) curriculum in Sri Lankan schools also use open source products.</p>
Curriculum implementation facilities(X ₅)	<p>Major activities are limited face-to-face, there is a lack of educational methodologies in the teaching and learning process (e.g. Activity based learning-learning methodology, reflecting practicing, e-Learning approaches, pedagogical techniques are missing.</p>	<p>Provide ICT skill development of students and teachers to meet the requirements of the 21st century.</p>	<p>Students are weak in achieving the learning outcomes specified in the curriculum.</p>	<p>To eliminate the above mentioned gap, the following methodologies are recommended from the study. The accepted educational methodologies like (Bloom's taxonomy, Kolb's reflective learning circle, role model, blended learning approaches, feedback, activity based learning etc.) Especially usage of pedagogical techniques is highly recommended in this study.</p>
Policy	Up to now,	Provide a solid	Due to	Higher level authorities have

matters(X ₆)	According to the investigation, the accepted policy proposal for the ICT education has not been implemented	ICT policy to perform the activities and allocate the required funds to perform the implementation activities of ICT education in a successful manner.	unavailability of a solid ICT policy, trial and error personalize methodologies may be implemented	more privilege to attend to this factor. Therefore, this study does not concentrate on policy matters in connection with ICT education
Support from the administration and supportive initiatives (X ₇)	Authorities who provide guidance from top level officers to students in an hierarchical manner, further, supportive initiatives (internet, e-mail, computer societies etc.) of acceptable level in connection with ICT specialization subject	Need positive support from administrators to implement the ICT specialization subject. Further, supportive initiatives should be provided to create an ICT culture in schools and also get indirect support for ICT specialization.	There is no considerable gap at present in connection with support from administration and supportive initiatives aspect. But further improvements recommended.	Providing more infrastructural facilities which can be used to improve the supportive initiatives and through motivation programs, and support from administration, the supportive initiative quality level can be improved. Further, it was assumed that authorities have a greater privilege to improve such facilities. Therefore, support from the administration and supportive initiatives(X ₇) factor has not been dealt with this study.
Research and development(X ₈)	There is a lack of research and development activities involved in the ICT specialization subject. Stakeholders are quite willing to incorporate research and development activities with	Provide research and development environment and introduce new innovations to the ICT teaching and learning paradigm.	Stakeholders are performing day-to-day routine activities and they are not motivated to do research and development activities.	It is highly recommended that motivation of students, teachers and immediate administrators for experimental research activities to enhance the ICT education is necessary. Further, to provide opportunities to get support from university academics and other researchers in the ICT industry

	ICT education			
Budget allocations and country expectations (X ₉)	There is no solid policy framework for the development of ICT education. Therefore, it is difficult to clearly define or focus on the country expectation. Further, budget allocation is not sufficient for the standard implementation of ICT education.	Define a country expectation to be achieved from the school education system and incorporate it in in the policy framework. Accordingly sufficient funds to be allocated for implementation.	There is no clearly defined expectation which should be achieved from the ICT educational system in phase I. There is no solid ICT framework. Sufficient funds may be not allocated to implement ICT education.	High level authorities should attend to the Budget allocation and country expectation(X ₉) factor. Therefore, this study does not concentrate on Budget allocations and country expectations (X ₉) in connection with education.

This chapter presents the results related to the current situation of ICT specialization subject for GCE (O/L) in Sri Lankan Schools and enhancement possibilities. One of the most important key findings of the study was the lack of usage of pedagogical techniques in ICT development programs. The outcomes were presented on nine fillers (factors) which was the outcome of the objective 1 and this was derived according to international standards and Asian standards which align with the Sri Lankan context. Based on the results of the survey, the outcome of the gap analysis and important findings of the literature review, the gaps and limitations that might affect quality ICT specialization subject for GCE (O/L) in Sri Lankan Schools were recognized and recommendations were provided along with enhancement possibilities of ICT specialization subject for GCE (O/L) in Sri Lankan schools are also presented in Chapter 6. These outcomes were used to achieve the research Objective 5.

CHAPTER 6: Implementation Of Proposed Application Model

6.1 Introduction

This chapter presents the findings and conclusions of the research study as related to Phase I (achievement of the objectives 1 to 4) and relevant justification through a discussion drawn from the outcomes obtained from Chapter 3 and Chapter 5 together with the final conclusions of the first four objectives of the research study. The findings and conclusions are strengthened through a discussion which includes illustration of important facts contained in the literature review and outcomes from the survey analyses as justification to validate the key findings. Finally, this chapter provides the entire research development process activities towards achievement of research objective 5.

Achievement of objective 5 includes the main activities with the presentation of the enhanced framework (application model) designed from the outcomes of Phase 1 and the results of the tryout of the implementation with a small group of stakeholders including an ICT expert, an ICT instructor, ICT teachers and selected students in the school environment. These activities will provide for a framework aimed to enhance the quality of ICT education in Sri Lankan schools using the outcomes of Objectives 1-4. Based on the recommendations in Table 5.2.35 in Chapter 5 (outcome of the gap analysis), findings and conclusion in Phase 1 were greatly helpful to derive the application model. At the end of the chapter, a series of evaluation tests were conducted to prove the validity of the proposed application model. This Chapter includes the introduction, literature review, appropriated theories, design methodology, implementation, testing and evaluation of the proposed application model.

6.2 Conclusions On Quality Factors For Ict Education (Objective 1)

Based on the outcome of the first tier of the research design through various activities, it was concluded that nine (09) factors are involved in maintaining quality ICT education (i.e. achievement of the research objective 1). These factors are (i) infrastructure facilities (including computers, related equipment and facilities (e.g. electricity, communication facilities, computer laboratories with adequate equipment against the student density)) (ii) Human resource facilities (e.g. qualified and skilled teachers, teacher trainers, appropriate advisors and professionals and appropriate methodologies) (iii) hardware maintenance and sustainability plans (iv) Software (v) Curriculum implementation facilities and issues (e.g. quality, contents, implementation techniques and implementation issues) (vi) policy guidelines and monitoring plans. (vii) Support from administrators (school leaders, controlling and managing education authorities) and supportive initiatives (Internet, e-mail, SchoolNet, web sites, computer societies) (viii) Research and development (ix) National Goals and budget allocations.

Taken together, the nine pillars are shown in relation to internationally recommended standards for quality ICT education. The present status of ICT education in selected Asian countries and the Sri Lankan context are shown in Table 3.6 in Chapter 3. This Table (3.6 in Chapter 3) also shows the factors, indicators and methodologies that could be used to maintain the quality of ICT education according to international benchmarks, the status prevailing in selected Asian countries and the literature status along with the successful

approaches in the study premises of Sri Lanka are. Further, Table 3.6 in Chapter 3 shows the outcome of objective 1 as mentioned in the design phase in Tier 1. The following findings and conclusion are presented according to the second tier of the proposed research design as a means to achieve the second, third and fourth objectives of the research study.

6.3 Conclusions Regarding Current Quality Status Related To Ict Specialization Subject For Gce (O/L) In Sri Lanka (Objectives 2 To 4)

The outcome of objective 1 shows the nine factors involved in maintaining the quality of the ICT education. Accordingly, the following findings and conclusions are related to the achievement of two to four research objectives of the study.

Infrastructure Facilities (X₁)

Almost all the schools have electricity. Over 90% schools have computer laboratories. The computer student ratio is 1:12 while the estimated number of required computers for the student ratio is 1:24. On average there are 23 computers available in a school, Over 75% of schools have networking facilities. The majority, amounting to 83% of students have internet facilities in their school. Based on the outcome of the hypothesis testing and other statistics of the study, the following observations were concluded in connection with infrastructure facilities: The existing infrastructure facilities are sufficient to implement the ICT specialization subject for the GCE (O/L) curriculum in Sri Lankan schools. Further, district-wise, there are no infrastructure disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka. However, schools' category-wise, there are infrastructure disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka.

Human resource facilities (X₂)

Human resource facilities and strengths were investigated with regard to the schools conducting ICT specialization subject for GEC (O/L). Accordingly, there is a considerable number (38%) of vacancies for ICT teachers in the Sri Lankan schools system. Of those available, 29% of ICT teachers have received less than 3 months training to teach ICT specialization for GCE (O/L) curriculum. 81% of teachers are not adequately trained to teach the ICT specialization subject for the GCE (O/L) curriculum.

The recruitment procedure for ICT teachers is very complicated with too many administrative barriers in the present system. At present the MOE and the provincial educational offices face difficulties in providing skilled ICT teachers on demand. The study shows that the majority of ICT Teacher training and student updating programs are not adequately compatible with the curriculum requirements. Based on the outcome of hypothetical testing and the descriptive statistics discussed above, it was concluded that the Human resource facilities and their strength for the implementation of ICT specialization subject for GEC (O/L) curriculum is not up to a satisfactory level. Further, district-wise, there are no human resource facilities and, therefore, strength disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka remain wide. In addition, Schools, category-wise, there are no human resource facilities and there are strength disparities in schools that teach ICT specialization subject for GCE (O/L) in Sri Lanka.

Maintenance and sustainability plans (X₃)

On average, the computer breakdown rate per school is 13%. A majority of schools do not have a proper and sustainable computer maintenance mechanism. On the whole, 44% schools are willing to do their computer maintenance activities in respective schools if authorities provided guidance and funding. In addition to this, 62% of schools strictly and 23% of schools slightly faced difficulties with the implementation of ICT specialization subject for GCE (O/L) curriculum due to non-availability of rapid provisions to upgrade computers and other equipment.

Based on the outcome of the summary of hypothesis testing and considering the above basic conclusions, it was concluded that the Computer maintenance and sustainability plan for the implementation of ICT specialization subject for GCE (O/L) curriculum is not up to a satisfactory level. Further, district-wise, there are no disparities with regard to Computer maintenance and sustainability plan in schools which are conducting ICT specialization subject for GCE (O/L) in Sri Lanka. In addition, Schools' category-wise, there are no disparities with Computer maintenance and sustainability plans in schools which are conducting ICT specialization subject for GCE (O/L) in Sri Lanka.

Software (X₄)

On average, 67% of ICT teachers recommend use of both open source and Microsoft products and only 8% open source product software to implement ICT specialization subject for GCE alternative (O/L) curriculum. As such, it was concluded that teachers may find alternative solutions as against the Microsoft product to implement the ICT specialization subject for the GCE (O/L) curriculum. A majority of ICT teachers (66%) find it difficult to install, configure and troubleshoot operating systems and other Application Software packages under the closed source software environment. Based on the outcomes of hypothesis testing and descriptive statistics of the study it was concluded that The Sri Lankan educational system can obtain financial and other benefits if they use open source products. Further, it was concluded that there are complete software solutions available in the open source environment. However, ICT stakeholders were not satisfied about the usage of only Microsoft products. Therefore, it was concluded that, the use of open source products will minimize the practical implementation and financial difficulties encountered with the implementation of ICT specialization subject for GCE (O/L) curriculum in Sri Lankan schools. It was also concluded that the usage of software for the ICT specialization subject in Sri Lankan schools remains at the same level in all five districts.

Curriculum implementation facilities(X₅)

The study shows that the curriculum implementation facilities and its strengths are one of the most important factors in the implementation of quality ICT education. Taking this fact into consideration, all the resource requirements in schools which are conducting ICT specialization subject for GCE (O/L) were investigated. Accordingly the observations made, relate to the following: 41% stakeholders have stated that the lack of a textbook is one major factors affecting the maintenance of quality ICT education. In addition, the following factors too appear to affect maintenance of quality ICT education. They are: the poor English knowledge of both students and teachers, the absence of proper guidance from the authorities and the lack of enhanced teaching and learning methodologies in the teaching and learning processes. It was also concluded that a very low percentage of teachers use

pedagogical techniques in their teaching and learning paradigm. Such pedagogical techniques found absent are Gibb's and Kolb's reflective learning circle, Bloom's taxonomy, classroom observation, stakeholder feedback, Role model and activity based learning activities.

Based on the outcome of the summary of hypothesis testing shown with the study, it was concluded that the curriculum implementation facilities/ techniques are not of a satisfactory level with the ICT specialization subject for GCE (O/L) curriculum in Sri Lankan schools. It was also concluded that district-wise, there are no curriculum implementation issues/facilities disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka. Schools category-wise, too, there are no disparities with curriculum implementation issues/facilities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka.

In addition to the above, further investigation into the outcome from pedagogical involvement with the ICT specialization subject for GCE (O/L) reveal the following:

Pedagogical techniques (X_{5.1})

It was concluded that the usage of pedagogical techniques with the implementation of ICT specialization subject for GCE (O/L) in Sri Lanka are more or less absent in the teaching and learning paradigm. It was also observed that the use of pedagogical techniques with the ICT specialization subject for GCE (O/L) in Sri Lankan school remained equal in all districts.

The study reveals that the programming and problem solving unit is an important and an essential unit with the ICT specialization subject for the GCE (O/L) curriculum. The study also concluded that, there are some implementation issues and outcome remained unsatisfactory with the implementation of the programming and problem solving unit in the Grade 11 curriculum. Accordingly, based on hypothesis testing of the study, it was concluded that the programming and problem solving unit is most important as it correlated heavily with other course units in the curriculum. Such correlated course units are Information Systems, Web designing, ICT and Society and Individual project units in the ICT specialization subject in Grade 11 curriculum. Therefore, the study concluded that all the ICT teachers be requested to be well organized and technologically competent after following teacher training programs to teach the ICT specialization subject for GCE (O/L) curriculum. In addition to the above, it was also concluded that the programming and problem solving unit may improve students' ICT skill development in more favorable ways than the other course units in the ICT specialization subject. Going by the observations made, it was recommended to incorporate pedagogical techniques to further enhance the quality of student learning while improving teachers in their teaching.

Policy Matters (X₆)

Inaccessibility to information in connection with policy matters in ICT education was not a concern with this study. Based on the literature, it is another important matter in connection with ICT education. As such, it was concluded that authorities be allowed to attend to policy matters in connection with the quality enhancement of ICT education in Sri Lankan schools.

Support from administration and supportive initiative (X₇)

The study concluded that support from administration and supportive initiative for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools remains at a satisfactory level. There are no disparities district-wise but there are some disparities with school types (school categories) regarding the support from the administration and supportive initiative for implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools. Yet, satisfaction remains at minimum levels in connection with the support from the administration and supportive initiatives. The study shows that some improvement possibilities exist but it was concluded that some enhancements are needed in connection with the support from the administration and supportive initiatives for the enhancement of ICT education. Authorities may attend in this regard.

Research and development (X₈)

There appears to be a lack of research and development activities with regard to ICT education in Sri Lanka and it is evident that there is enhancement to suit standards for international quality status. All stakeholders are anxious to engage in research and development activities to enhance the ICT specialization subject in Sri Lankan schools. Such activities could relate to use and for research activities on LMS, e-learning, video conferencing and blended learning approaches. It was heartening to note that teachers are willing to do research activities on the use of educational technologies (e.g. Bloom's taxonomy, reflective learning etc.) Therefore, it was concluded that the willingness of stakeholders to adopt research and development activities to enhance the ICT specialization subject in Sri Lankan school remains at the same levels in all districts showing no disparities among all school type categories.

National Goals and Budget Allocations (X₉)

Chapter 3 and the survey findings evidently reveal that the Sri Lankan educational system needs to accommodate ICT activities in the school curriculum meeting specifications from international standards while maintaining UNESCO standards. Two of the main national goals directly related to ICT Education in Sri Lanka are to build up a Sri Lankan nation through the promotion of national cohesion, national integrity, national unity and to develop human resources for productive work that contribute to the economic development of the country. These expectations are restricted by the budget allocation (for example, in 2012, 1.86% allocated from the GDP for general education and higher education). In addition to the budget allocation, there are several other factors contributing to the achievement of National goals through ICT education. As mentioned in the study, it was concluded that authorities should attempt to resolve problems and issues in connection with this factor (Variable X₉). The researcher has no provisions in this regard.

6.4 Recommendation Of Proposed Application Model For Quality Improvement (Phase II)

Going by the outcome for Phase I, the quality of ICT education in Sri Lanka appears to depend on nine (09) factors namely: (i) infrastructure facilities, (ii) Human resource facilities, (iii) hardware maintenance and sustainability plans, (iv) Software, (v) Curriculum implementation facilities and issues, (vi) policy guidelines and monitoring plans, (vii)

Support from administrators and supportive initiatives, (viii) Research and development, and (ix) National Goals and budget allocations. Therefore, maintaining the above factors at an appropriate level would support quality ICT education in Sri Lanka. Further, except for factors: software, curriculum implementation facilities and issues, and research and development, other factors are found currently manageable for the GCE (O/L), at school level.

Accordingly, towards a researchable framework aimed at enhancing quality of ICT education in Sri Lankan schools, three factors out of the nine referred to: software, curriculum implementation facilities and issues with pedagogical techniques, and research and development, can be considered as critical factors influencing the quality of ICT education in Sri Lanka. These three factors can easily provide for a useful research investigation platform, reasons for which are discussed hereafter on each topic.

(i) Software: Outcomes from Phase I reveal that, ICT stakeholders find alternative software solutions instead of commercial software products to implement ICT education in Sri Lankan schools due to economical, operational and technical feasibility. Further, the study also proved that open source software provide complete software solutions to satisfactorily perform tasks related to ICT education in the Sri Lankan ICT curriculum, with no barriers in between.

(ii) Curriculum implementation facilities and its strength and pedagogical techniques: Outcome from Phase I show that the curriculum implementation facilities and its strengths are one of the most important factors in the implementation of quality ICT education. On further analysis it was proved that curriculum implementation facilities and its strength, and pedagogical techniques are badly lacking in the Sri Lankan ICT educational system. In addition, outcome from Phase I revealed that the Programming and Problem Solving unit improves students' ICT skills development in more favorable ways than with the other course units in the ICT specialization subject.

(iii) Research and development: Findings from Phase I, show that there is a lack of research and development activities with regard to ICT education in Sri Lanka and it is evident that enhancement to suit standards for international quality status need attention. Further, ICT stakeholders are willing to adopt research and development activities to enhance ICT specialization in Sri Lankan schools.

Considering the facts discussed with each factor, these three variables appeared to be crucial towards maintaining the quality of ICT education in Sri Lankan schools. Therefore, these three variables were selected for further experiential purposes in Phase II of the study.

Table 6.1 Experimental activities

Variable/Factor	Name of Variable	Experiential activities
X ₄	Software	Open source software used as an alternative solution to enhance the ICT specialization subject for GCE(O/L) curriculum
X ₅	Curriculum implementation facilities and issues	Pedagogical techniques used to enhance the quality of ICT education Programming and problem solving unit selected for further enhancement of the experimental study. In-service groups of teachers used for implementation and testing with the application model
X ₈	Research and development	Blended learning activities and pedagogical techniques used to enhance the quality level of ICT specialization subject for GCE (O/L) curriculum in Sri Lankan schools in an experimental approach.

The findings of phase I explored in this study drew on the necessity of an application to enhance the quality of ICT specialization subject for the GCE (O/L) curriculum to achieve expected standards. Initially, phase II explored the relevant literature required to carry out the designed approach given in Figure 6.1. The application was implemented according to the design approach based on a three tier architecture as described in Figure 4.2 in chapter 4. The usage of pedagogical techniques, blended learning activities, activity based learning, and reflective practice and open source software are the important features embedded in this application. The developed prototype application was tested with selected teachers and selected students in an appropriate environment and were further tested using facial analysis and feedback together with suitable reflection.

6.5 Theoretical Foundation And Literature Review

The previous Chapters reveal that the system for ICT education in Sri Lanka makes minimal usage of pedagogical applications and activity based learning compared to the developed and some selected developing countries. Further, the study reveals that pedagogical usage in teacher training programs as well as in students' teaching activities in schools are minimal in the present context. In Chapter 5, authorities have also confirmed that pedagogical applications and usage are minimal with ICT education development programs in the Sri Lankan ICT educational system. The need to embed pedagogical applications to enhance the quality of ICT education in Sri Lankan schools is another concern. Therefore, consideration is given in this study towards some of the most important techniques that relate to: Kolb's experiential learning circle, Feedback and class room observation, Bloom's Taxonomy, the Seven Universal Facial Expression of the Emotional model, Role Model and evaluation techniques. They are extremely useful in the development of the process towards education with ICT. Moreover, findings from phase I of the study also reveal the importance of FOSS or OSS usage.

Furthermore, as discussed in chapter 3, blended learning approaches with peer-to-peer student groups, student-and teacher, peer-to-peer teacher groups and teacher-to-teacher trainer model showed a high impact with the development of ICT education in Sri Lankan schools. Chapter 5 reveals that the teacher's subject knowledge with the programming and problem solving unit in ICT specialization curriculum for the GCE (O/L) is an essential component for quality improvement. Further, Chapter 5 reveals that the Programming and problem solving unit correlated heavily with the other course units in the grade 11 curriculum in the ICT specialization subject for CGE (O/L) curriculum.

A majority of teachers and students are willing to use open source software due to problems of use with pirate software as well as the flexibility of open source for ICT education. Open source is widely used in the sphere of higher education in Sri Lanka (e.g. Universities) as well as in the ICT industry.

With regard to facial expression, it is considered an effective body language that provides important clues for teachers to know the learning status of students. Thus, vision-based expression analysis is invaluable and goes beyond the Human-Computer Interface in e-Learning. As discussed in Chapter 2, the seven universal expressions of emotion model may be very useful to track the level of success of learning during the learning process and to monitor it accordingly. As discussed in Chapters 2, 3 and the conclusion part of Chapter 6, they provide feedback, class room observation and monitoring procedure for teaching and learning and are extremely useful in developing ICT education through the use of pedagogical techniques and evaluation techniques. The quality of the teaching, learning and evaluation process are highly important in education. Moreover, as discussed in Chapter 2, Bloom's Taxonomy will play a major role in quality management with education.

Bloom's Taxonomy helps trainers acquire fundamental aspects to perform their tasks qualitatively (Krathwohi, 2002). These aspects refer to: (i) Cognitive: Mental skills (Knowledge) (ii) Affective: Growth of feelings or emotional areas (Attitudes) (iii) Psychomotor: Manual or physical skills (Skills)

Bloom's Taxonomy and Kolb's Experiential Learning Circle

The improvement framework for ICT education was designed to suit the theoretical foundation provided in the Revised Bloom's Taxonomy shown in Figure 2.3 of Chapter 2. Different learning levels in Bloom's Taxonomy are described in Section 2.4.1 of Chapter 2 and similar appropriate verbs shown in Table 2.1 in Chapter 2 were also used in the design and implementation of the application model. The above mentioned techniques are incorporated with the activities in the application model. It is shown in Appendix 14.

In addition to the above mentioned theoretical background, the comprehensive Kolb's (1984) experiential learning circle as shown in Figure 2.7 and Figures 2.1 to Figure 2.4 in Chapter 2 were also used within each level of Bloom's Taxonomy in the application model. The above mentioned theoretical foundation provided much guidance to the development of learning activities in ICT education in the study.

Role Model

According to the social learning theory (Bandura, 1971), human behavior is transmitted largely through exposure to role models, that is, modeling phenomena. Teachers identified by students as models in an educational context may play a particularly important role in students' learning processes (Lashley & Barron, 2006). To practice the proposed application model at the respective schools, teachers used a role model. The theoretical background of the Role model is described in Section 2.4.2 and Figure 2.4 of Chapter 2 of the study.

The Universal Facial Expression of Emotion Model

The Universal Facial Expression of Emotion Model and stakeholders' feedback play a major role in quality evaluation of the teaching and learning paradigm (Manas, et al., 1998). Developed countries use evaluation of quality through facial behavior of teachers in teacher training programs as well as in implementing such programs in their schools. Their success is evaluated through applying the model to their students (Mansfield, 2007; Hinett, 2011) too. While well developed countries and some selected countries use this model to evaluate performance (Belawati, 2002; Ainley, et al., 2006), there is no indication in any literature review to reveal that this model is implemented in the Sri Lankan schools' system to evaluate the success of the teaching- learning process. Further, utilizing the existing resources and to improve the existing quality of the ICT teaching and learning process, the following four levels of knowledge sharing methodology were used in phase II of the study. These four levels are: (i) Level 1: Peer-to-Peer Students Group Activity Model (ii) Level 2: Teacher – Student Activity Model (iii) Level 3: Peer-to-Peer Teacher Group Activity Model (iv) Master Trainer-to-Teacher Activity Model. Further, more theoretical background regarding the Universal Facial Expression of Emotion Model and its features are described in section 2.4.3 of the theoretical foundation Chapter (Chapter 2). In addition to the above, Hypothesis testing and paired T-testing and etc. described in section 2.3 of Chapter 2 were also used as the theoretical foundation of study phase II.

6.6 Design Methodology

In the achievement of objective 5, a selected number of dimensions were used according to Table 6.1 and appropriate justification given above. To achieve objective 5, the third tier of the design architecture in Figure 4.2 in Chapter 4 was used and the detailed design of the application model is as follows:

Third Tier: Based on the outcomes of the first and second tiers of the study, the study recommended the application model to enhance the quality of the ICT specialization subject for GCE (O/L) in Sri Lankan schools and was designed with appropriate testing to suit the country's expectations and accordingly, to meet global and Asian standards. The detailed design approach is shown in Figure 6.1.

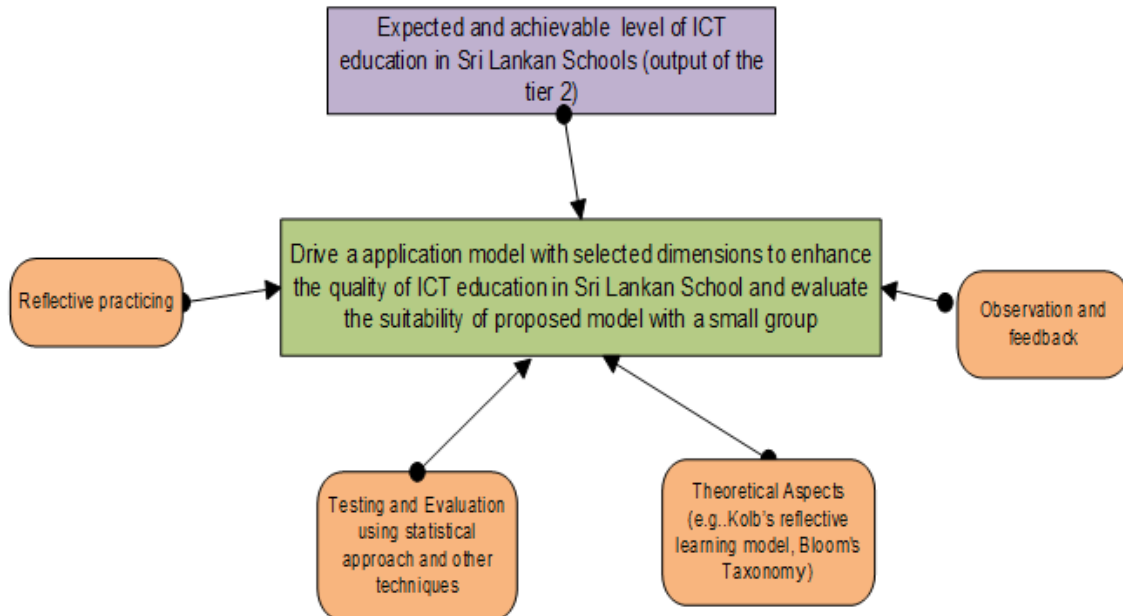


Figure 6.1 Third Tier of the research design

Proposed Model

The description, hereafter, shows the outcomes of the implementation of the proposed application model. Phase II where two major tasks are included. The results are presented in the following sections: (i) Try out model with selected ICT teachers and (ii) Try out model by appropriate teachers in their schools with respective students.

To achieve objective 5, the design application model in Figure 6.1 was used according to the activities described in Annexure 14. David Kolb's experiential learning circle as explored in Chapter 2 and section 6.5 in Chapter 6 was used as a methodology towards further enhancing the application model. In designing the application model, a blended learning approach, activity based leaning, Revised Bloom's Taxonomy, peer learning, and other theoretical and practical activities were used. The general observation and feedback obtained from the main stakeholders in implementing the proposed draft application model in the school environment in a specified time period were also used. Finally the draft application was fine-tuned using the fundamental theory embedded in Kolb's experiential learning circle, to be practiced in the school environment.

As a major activity of tier 3, Kolb's experiential learning circle was used to improve and enhance the application model. The Reflective experiential learning circle, testing and evaluation were carried out in the following manner on selected dimensions easily controlled by the researcher in the school environment with the help of the school authorities, ICT experts and educational specialists in the system for a period of two months. The enhancement of ICT specialization subject for G.C.E. (O/L) will have a great impact to create an ICT culture in the Sri Lankan educational system and to face the global challenges in ICT education and general education.

To implement and test the application model, the following approach was used. (i) conclusions and recommendations proposed by outcomes of objectives 1-4 (ii) Three schools were selected to test and implement the system (iii) two or more ICT teachers from each school were selected (iv) One ICT instructor was selected (v) One ICT expert was selected (v) 61 students from three schools were selected.

Due to practical implementation issues, two or more ICT teachers from three different schools in the Colombo district, one ICT instructor, and one ICT expert from NIE were selected as the sample for the model enhancement and testing purposes. Further, the researcher and the ICT expert from the NIE worked as facilitators for the master-teacher model as described in Chapter 4. Performing several sessions and using the principles of reflective learning, the application was developed and was fine-tuned further using the class room observation, stakeholders' feedback and outcome of the hypothesis testing. The following material designed and used to collect data recommended by the outcomes of phase I, were implemented and tested on the developed application model to achieve objective 5.

6.7 Data Collection (Phase II)

Overview of the materials

The following Appendices were developed based on the outcomes of objective 1-4 with all the learning activities explored in the previous chapters embedded and also the appendices are developed towards achieving objective 5. (i) Activity model with five stages (See Appendix 14) (ii) Sample answers for the activity model (See Appendix 15) (iii) course materials to improve programming concepts of python programming language and skills development with problem solving using a blended learning approach (See Appendix 16)

The entire process of application model implementation, testing and evaluation was performed as follows:

6.8 Try Out The Application Model

The application model was tried out with the selected teachers and subsequently trained teachers tried out the application model in their respective schools. With both tryout activities, the application model was fine-tuned to determine identification of enhancement possibilities.

6.8.1 Try Out Model With Selected Ict Teachers

Master-Trainer- Teacher Model and the Peer-to-Peer Teacher Model

Sample course material was developed (See Appendix 16) using an open source programming language (python) to satisfy the following conditions:

(i) To achieve the learning outcomes of the course of study (ii) to satisfy the contents and guidelines of teachers' guide and students' textbook available for the ICT specialization subject (especially in the Grade 10-11 ICT curriculum) in the Sri Lankan school curriculum. Further, feedback was obtained from an ICT expert in the education sector, from responsible authorities like the NIE, ICT instructors and a few ICT teachers and the developed content was re-modified in a reflective manner as described in Kolb's reflective learning circle. The

application model was implemented to minimize the gap specified in Table 5.2.35 in Chapter 5.

Based on the request made by the researcher to implement and test the application model with ICT teachers, Provincial Education Director/Western Province, granted permission and a letter was issued for the release of ICT teachers (who teach ICT specialization subject) from 3 schools (One boys' school - Thurston College and two girls' schools (Anula Vidyalaya, Nugegoda and Sumudra Devi Vidyalaya, Nugegoda) to trial the developed application within their respective schools (see Appendix 17). Based on the Principals' and the ICT teachers' requests and considering the availability of required facilities for implementation, the University of Colombo School of Computing (UCSC) was selected to conduct a series of workshops with the permission of Director/UCSC. Further, UCSC granted all facilities specified by the system requirements in the proposed application model based on the outcomes of the research objectives 1-4.

The initial series of workshops were conducted as follows: Provided one computer per teacher with all the specified requirements (e.g. Internet, as recommended in Table 5.2.35 in Chapter 5).

Initially, guidance was provided to install, configure, handle troubleshoot activities and the basic idea to use python programming language. Further sessions were conducted face-to-face as well as through blended technology and involved activities as follows:

Initially, principles and concepts of programming and problem solving were delivered in a face-to-face manner. This included principles of python programming language, principles of Bloom's Taxonomy, Kolb's reflective leaning cycle, activities of the role model, blended learning approach, how to apply the above techniques in a practical environment to enhance the ICT teaching-learning process and techniques specified by the recommended model (e.g. master- trainer guidelines, peer-education etc.). To achieve the research objective 5, as discussed in Table 5.2.35, the following three variables (software (X₅), curriculum implementation issues and its facilities(X₆) and research and development activities(X₈) were used.

Curriculum Implementation, software and research and development activities

For purposes of application implementation, python programming language was selected for the following reasons: (i) Python is a programming language that works more quickly and integrates subsystems more effectively (ii) Python has immediate gains in productivity and lower maintenance costs (iii) Python runs on Windows, Linux/Unix, Mac OS and has been ported to the Java and .NET virtual machines (iv) Python is free to use, even for commercial products, because of its OSI-approved open source license (v) At present, ICT Specialization subject for GCE(A/L) also uses python as the programming language.

The proposed curriculum was implemented as follows to test the suitability of the application model implementation through different testing instruments and techniques. Pre-service training activities of teachers, principals, other educational authorities and master trainers training program activities are to be included in the ICT policy document and are to be

implemented by the authorities. In this study, in-service sample teacher training activities were performed for the teachers conducting ICT specialization subject in GCE (O/L) curriculum in a face-to-face manner using adoptive technologies. Further, HR development activities were enhanced through the principles of Kolb's learning circle using reflective practice, implemented as a role model approach.

Teacher training was done with the designed activities to suit the existing curriculum, face-to-face and used selected adoptive learning technologies with proper testing and evaluation. Teachers conducted their classes according to the role model approach with selected students and feedback was provided for enhancement. According to the principles of Kolb's experiential learning circle, reflective practice and role (Cascade) model were used to enhance curriculum implementation procedure throughout the study. All in all, the entire application model was implemented, validated and fine-tuned using an experimented approach with the research and development techniques described in Chapters 2 and 5.

Activities, Implementation Procedure Master Trainer- Teacher Model

Based on the above justification and limited to three variables, practical implementation of the 5th objective was carried out and the suitability of the proposed application model was evaluated. This was done with a small group and was implemented as follows:

This phase was carried out through the appropriate expansion of the ICT specialization subject which was tested in the school environment. Nevertheless, other attributes/dimensions derived from objectives one to four will be available for future research and innovative activities.

The application model implementation and initial session was delivered by the former ICT/Director, NIE and Consultant/ Web pathashala jointly with the researcher. A series of workshops with the following participants were conducted

Table 6.2: Number of Participants who participated in the series of workshop

College Name	Number of Participants (ICT Teachers)
Thurston College	03
AnulaVidyalaya	03
SamudradeviVidyalaya	03
ICT Instructor /Colombo	01

The workshops were conducted on three consecutive Wednesdays from 8.30 am to 1.00 pm and were based on the principles of Bloom's Taxonomy.

According to Gibbs & Habeshaw (1997), for every 10-15 minutes of lectures an activity break was included during the entire series of workshop sessions. The series of workshops were conducted incorporating the following activity modules to cover the different levels in Bloom's Taxonomy as discussed in Table 2.1 in Chapter 2. Initially, all these activity models

(as shown in Appendix 14) were tested with the help of the former ICT Director/NIE and an ICT instructor. Based on their feedback, activity models were enhanced using the principles of Kolb's reflective circle.

Different explanations in Kolb's Reflective Experiential Learning Circle in Tables 2.2 to 2.4 in Chapter 2, are used to enhance the proposed application model and customized version according to the study, are shown in Table 6.3

Table 6.3 Proposed customized reflective experimental learning circle for implementation of the activity model

Stage	Description	Activities to help
Concrete experience	To explore the existing knowledge of teachers with problem solving activities, prepared a series of activities to suit the section on programming and problem solving unit in the ICT specialization subject for GCE (O/L) curriculum. Further, printed materials on programming and problem solving activities were distributed. Similar solved questions and answers also were provided. This process was repeated for several activities. Provisions were granted to conduct peer discussions too.	Provided facilities for (computers and other related resources) individual learning activities. Conducted problem solving sessions. Gave additional practical exercises With group discussion, peer discussion was encouraged. In an appropriate manner, activities in Appendix 14 were practiced.
Reflective observation	Based on the individual and group activities according to Appendix 14, asked for observations in connection with the previous stage (concrete experience stage). Further, conducted brainstorming sessions to gather different ideas and problem solving methodologies from the audience of teachers. Provided facilities to ask rhetorical and thought provoking questions from group members. At the end of the each activity, provided facilities to complete learning logs.	Provided facilities to present students' observation in connection with the problem solving activities given in Appendix 14. Provided facilities to conduct a brainstorming session to judge validity of their own solutions and outcomes of the collaborative activities. Provided facilities to conduct a session of rhetorical and thought provoking questions. Provided facilities to maintain individual learning reflections by maintaining a log.
Abstract conceptualization	Provided a series of lectures in connection with the following: stages of Bloom's taxonomy and its usage, how to use e-materials to enhance the quality of teaching, learning and evaluation process. Elaborated blended learning approaches to enhance ICT education. Introduced active learning facilities and usage in the field of ICT specialization subject. Provided facilities to enhance the activities through feedback, provided facilities to use and apply LMS activities in connection with	Conducted a series of lectures on the following areas using blended learning approach (face-to-face, e-learning and other technologies: Bloom's taxonomy and how to apply Bloom's Taxonomy to enhance the process of teaching, learning and evaluation process. Active Learning concepts, usage of stakeholders' feedback to enhance the teacher and learning quality, use and apply LMS activities to enhance the quality of

	programming and problem solving course unit. Provided facilities to give feedback on their work. Provided facilities for group discussion to master teacher-student and peer-to-peer-student approaches to enhance the quality of the learning process	teaching, learning and evaluation process. Provided discussion with teacher students and student-students groups.
Active experimentation	Used facilities and encouragement to realize the importance of teaching and learning activities using the techniques discussed in the Abstract conceptualization stage. Provided facilities and encouraged use of all activities described and performed in the Abstract conceptualization level to their teacher and learning domain. Further, provided guidelines to plan their teaching, learning activities using the above mentioned activities and methodologies discussed in the Abstract conceptualization level	Gave time to learners to plan. Provided facilities to use on-line materials, case studies, role play, Peer-discussion, blended learning approach (LMS, e-learning materials), and brainstorming sessions. All activities in Appendix 14 were practiced.

Incorporating the concepts in Bloom’s Taxonomy, principles of Kolb’s Experiential Learning Circle and Techniques of Blended learning activities, the proposed model was implemented according to the activities given in Appendix 14.

6.8.2 Teachers Try Out Model In School With Their Students

Teacher-Student Model and Peer-to-Peer Student Model

These trained teachers practiced the model in their respective government schools using the role model approach and tested the developed application model and fine-tuned it accordingly. The following test environment was selected to implement and test the model. Three classes were selected (Grade 11 doing ICT as a subject), recommended infrastructure facilities and HR resources (all recommended dimensions presented in Chapter 6) were provided. Based on the recommended framework, ICT educational activities were carried out within a specified defined period of time. Further evaluation was done and feedback was obtained from the appropriate stakeholders. Based on the evaluation and feedback, the activities were modified according to Kolb’s experiential learning circle and the enhancement continued with reflective practice with the process on a few (two to three) occasions to achieve success.

Director of Education / Western province gave permission and instructions to principals in the selected schools to implement and practice the model in appropriate schools as a way of testing. In addition to that, he gave permission to the researcher to monitor the implementation and to give tangible support and feedback during the session to appropriate ICT teachers who implemented the model in their schools towards fine-tuning the model. All the activities (Activity Model 1-5) in Appendix 14 were performed with teacher-student model as well as student-student peer model in the school environment to implement this

application model. The role model was applied. Further, at the end of the each activity, a common evaluation test was given to all student groups in the three selected schools to determine the success of the proposed model. The following student sample as shown in Table 6.4 was selected from three different schools to implement and test the performance of the proposed Model.

Table 6.4 selected number of students for the implementation of the application model

School Name	No of Students
Anula Vidyalaya	26
Thurston College	16
Samudradevi BalikaVidyalaya	19
Total	61

As listed in Table 6.4, the sample of students was selected from three different schools to implement and test the performance of the proposed model. Further, the same procedure was implemented for teachers as Master Trainer-Teacher Model section 6.8.1 in Chapter 6 which was used to implement the application model in a reflective manner in the school environment.

The following qualitative techniques were used to test and evaluate the above model: (i) recording and analysis of key interactions (video tape) via video analysis according to the seven universal facial expressions of emotion as described in the literature(ii) conducting interviews and obtaining feedback from the participants (ICT instructor, ICT teachers and students) (iii) obtaining the observations of the stakeholders (iv) Finally, conducted an evaluation test to determine the success of the model and its outcomes introduced to enhance the model in the next stage. (v) A further testing and evaluation process was performed using the feedback of stakeholders and the output of the seven universal facial expressions of emotion.

As discussed in Chapter 2 and section 6.5 of Chapter 6, this facial analysis was done manually and consequences were applied at the same level of the activity model or on some occasions it was applied at the next level of the activity model. This mechanism continued till the end of the specified period of time and an acceptable application model for the development of ICT specialization subject for GCE (O/L) was obtained.

6.9. Results Related To The Proposed Application Model

The results presentation is in two stages. The first stage includes the results pertaining to the implementation of the application model with ICT teachers and the second stage includes the results related to the teachers who tried out the proposed application model in their respective schools with their students.

6.9.1 Master-Trainer And Teacher Model And The Peer-To-Peer-Teacher Model

According to section 6.6, implementation of the proposed model was carried out as follows: Initially, the researcher conducted an introductory session about the importance of the proposed application model and implementation procedure of the model through a series of workshops for selected ICT teachers.

According to the methodologies described in Chapter 3 and section 6.6 of Chapter 6, the introductory session of the application model was implemented. The selected teachers participated in an implementation process of the application model in a positive and successful manner. The introduction to Bloom’s Taxonomy and how to apply Bloom’s Taxonomy to the Teaching Learning paradigm of ICT was delivered by the Former Director/ICT, NIE & Consultant/NIE. According to the methodology described in Chapter 4 in the introduction of Bloom’s Taxonomy and how it could be applied to the ICT domain were implemented. The feedback shows the success of the proposed model due to techniques of Bloom’s taxonomy being embedded.

The session output shows, that the teachers were motivated to learn Bloom’s Taxonomy and motivated teachers used Bloom’s Taxonomy in their teaching and learning paradigm of ICT. During and after the series of workshops, the success of the session was observed and analyzed using the facial behavior of teachers using “**the seven universal facial expressions of emotional methodology**” as described in section 2.4.7 of Chapter 2 and section 6.5 of chapter 6. Table 6.5 shows the results of the facial analysis in the implementation of the proposed model (each activity covers one or two levels in Bloom’s Taxonomy) in the teaching and learning domain using manual comparison.

Table 6.5 Output of the Seven Universal Facial Expressions of Emotional Methodology

	Face-to-face only	%	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Average	%
Happy	5	50%	9	8	7	7	6	7.4	74%
Surprise	2	20%	1	1	1	1	1	1	10%
Contempt	1	05%	0	1	1	2	1	1	10%
Sadness	1	05%	0	0	1	0	1	0.5	5%
Fear	0	0%	0	0	0	0	0	0	0%
Disgust	1	05%	0	0	0	0	0	0	0%
Anger	0	0%	0	0	0	0	0	0	0%

According to Table 6.5, on average 74% of teachers happily did the activities included in the application model. The application model also covers how the different stages of Bloom’s Taxonomy are embedded in the teaching and learning domain to improve ICT education in Sri Lanka.

The feedback from teachers show, how Bloom’s Taxonomy is useful to enhance the teaching and learning process of ICT education, especially in problem solving activities with the ICT specialization subject. After some motivation activities, all the teachers in the sample accepted Bloom’s Taxonomy as an acceptable methodology in the development process of ICT education in Sri Lankan Schools. Sample feedback from some teachers are as follows.

Feedback from Participant 1– ICT teacher, Samudra Devi Balika, Nugegoda

“I am “participant 1”, first of all, I would like to thank “Mr Researcher” for giving me the opportunity to participate in this workshop series. I am an ICT degree holder and ICT teacher of Samudra Devi Balika vidyalaya, Nugegoda. So far, I taught the ICT subject without knowing the teaching methodologies or using other modern techniques because we didn’t get any training in this regard. I want to say as a teacher, I realized the importance of Blooms taxonomy as a way of enhancing the teaching and learning process, we should learn this methodology, apply and practice it. Subsequently it can be applied to the teaching process at the school. Finally, I want to say that, Blooms taxonomy is a successful methodology and that we should use it to enhance the teaching and learning process. Finally, thanks to the Researcher and wish him success in this research”.

Feedback from participant 2 – ICT teacher, Anula Vidyalaya, Nugegoda.

“First of all, I would like to thank sir for selecting and inviting us to participate in this workshop. We learnt problem solving activities, Blooms Taxonomy and Blended Learning Techniques. From this workshop we learnt, how to conduct a lesson (or teaching session) using different stages of (know, understand, apply, analyze, synthesis and evaluate) Blooms

Taxonomy as follows.

To use as it is, what we learn

To create a novelty or design new innovation using what we learn from the lesson

We learnt how to teach students in an enhanced manner and well as how to learn as teachers to fulfill the teaching and learning requirements through the steps of Blooms Taxonomy.

Further, we learnt peer-to-peer learning, e-learning activities, how to perform problem solving activities with the aid of internet facilities and resources

Finally, I would like to thank sir, for arranging this series of workshops to deliver important teaching and learning methodologies to us”.

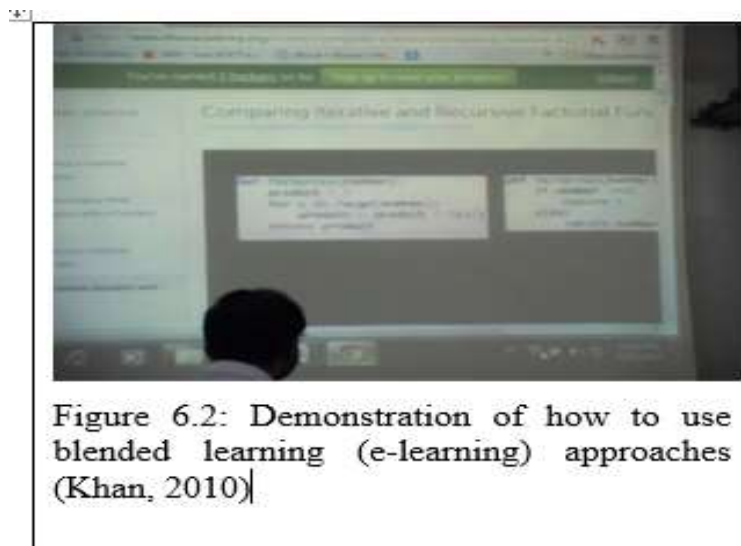
6.10 Outcomes Of The Activity Model 1

Activity Model 1-Implementation of first Stage activities in Bloom’s Taxonomy

As explored in section 6.6 of Chapter 6, the first level activities in Bloom’s Taxonomy as mentioned in Exercise 1.1 in Activity Model 1 in Appendix 14 were carried out and the following outcomes were obtained. First level activities in Bloom’s Taxonomy covered all four stages of Kolb’s experiential learning as shown in Appendix 14.

Initially, teachers wrote their answers based on prior knowledge, based on the given course materials and outcomes of the face-to-face session. A majority of the teachers’ answers were mostly similar and limited to the facts provided in the course materials.

Going beyond, the researcher demonstrated the use of e-materials, activity based learning materials, advantages of peer discussion and feedback, LMS activities to enhance the answer to the question and a sample view was illustrated in Figure 6.2 (Khan, 2010). Proceeding, the researcher provided guidelines to prepare examination questions, provided facilities to conduct a rhetorical and thought question session related to cover the learning outcomes related to the first level of Bloom's Taxonomy. Moreover, an e-discussion series to improve the answer to the question was arranged. Participants were also encouraged to develop their own learning material for their students. They also developed evaluation materials to test their students' performance according to the first level of Bloom's taxonomy which covers all four stages of Kolb's experiential learning circle. Finally, they fine-tuned the answer through a brainstorming session using the face-to-face mode. Figure 6.2 shows the demonstration to use blended learning (e-learning) approaches to enhance the quality of ICT education.



Activity Model 2 - Implementation of Second Stage activities in Bloom's Taxonomy

Activity Model 2, in Appendix 14, was implemented and tested according to the guidance given in the 2nd stage of Bloom's Taxonomy. Teachers entered these program segments and tried to get answers. A few teachers were able to get the answer immediately while others had some syntax errors. Some teachers referred to different resources to de-bug the code (on-line help, given handouts, e-materials etc.). Outcome of the second stage of Bloom's taxonomy as given in Appendix 14 were carried out and it also covered all four steps of Kolb's experiential learning circle.

A few teachers were unable to get the code error-free, and then they got help from the nearest peers. It was noticed that teachers who were capable of problem solving, helped others, hence they were motivated further through this activity while teachers who lacked problem solving skills, were able to obtain the necessary skills through peer help and trying out other activities in the model.

More problem solving questions were given in a step-by-step manner. Activities were carried out in the same way as the methodologies used in Activity Model 1. Further, by practicing the

activities, teachers were motivated as follows: (i) Gradually learned to use the first two levels of Bloom's taxonomy (ii) Learned how to use blended learning approaches to enhance the teaching and learning process (iii) Learned the applicability of peer-to-peer discussion in the enhancement of the teaching and learning process in ICT education as well as in problem solving activities using critical thinking (iv) Learned the importance of group activities (v) Learned the importance of reflective practice rather than rigid behavior.

Discussion forums, e-learning activities and reflective behavior, helped increase the utilization of available resources. The delivery of course materials was systematized and the quality of school level ICT courses got enhanced. While such advances in the delivery of school education has permitted greater flexibility for participants with the opportunity of studying almost anywhere at any time, such modes of delivery can place significant time demands on academics than with the traditional and peer-based approaches to learning.

The e-learning environment often creates an onus upon the instructor to be extensively involved in dialogue on course content through such mediums as discussion forums. Activity model 2 is an innovative approach to discussion forums that draw the students into the online learning process by encouraging them to take a more active and a central role with their learning.

Activity model 2 covers the 2nd level of Bloom's Taxonomy. It is enhanced and tested through the activities of reflective practice as described in Table 6.3 in Chapter 6 and analyzed using the "seven universal facial expressions of" as emotional methodology described in Figure 2.8 in section 2.4. 7 in Chapter 2 and in section 6.5 in Chapter 6.

The following final outcomes were obtained from activity model 2. Teachers carried out their teaching and learning activities according to the first two stages of Bloom's taxonomy and for each level of Bloom's taxonomy they created technology embedded teaching and learning materials to cover learning outcome covering all four steps in Kolb's experiential learning circle towards realizing learning objectives. They prepared the course unit mentioned above. Finally, they prepared the evaluation paper for their students to determine achievement of the learning outcomes specified in the course unit through the first two stages of Bloom's Taxonomy and Kolb's Experiential Learning Circle. The activities mentioned in the activity model 2 appear in Appendix 14.

3rd (Third) Activity Model - Implementation of Third Stage Activities in Bloom's Taxonomy

The 3rd stage of Bloom's Taxonomy was practiced according to the steps given in the Activity Model 3 in Appendix 14. It was further improved through the steps mentioned in Kolb's experiential learning circle based on the feedback from the teachers. The quality of expected outcomes from the exercises in activity Model 3 increased and finally analyzing the facial behavior of teachers as a methodology is given in Chapter 2 and section 6.5 in Chapter 6. Moreover, issues, difficulties and problems were minimized with the application of the steps given in Kolb's experiential learning circle as described in Table 6.3. The application was further strengthened through practice in the classroom and through homework sessions.

The final outcome obtained from activity model 3 is as follows. Teachers carried out their teaching and learning activities according to the first three stages of Bloom's taxonomy and each level of Bloom's taxonomy covered all four steps in Kolb's experiential learning circle. Teachers prepared the above mentioned technology embedded teaching and learning materials to achieve the learning outcome from the course unit. Finally, they prepared the evaluation paper to determine student achievement of the learning outcomes specified in the course unit adhering to the first three stages of Bloom's taxonomy and Kolb's experiential learning circle using the activities mentioned in activity model 3 in appendix 14.

4th (Fourth) Activity model – Implementation of Fourth and Fifth Stage activities in Bloom's Taxonomy

In the 4th activity model, the fourth and fifth stage activities of Bloom's Taxonomy as described in section 6.6 were implemented with the selected group of teachers. To test the success of the model, the researcher obtained feedback from teachers, an ICT instructor and a NIE consultant. The facial behavior during the session was observed as described in Section 6.6 in chapter 6

Feedback from ICT instructor

“As an ICT instructor, I knew the importance of the model for the enhancement process of ICT education in Sri Lankan schools. Further, I also learned how to use and the importance of blended learning and other approaches appropriate for the enhancement process of ICT education from this workshop series. As a result of this series of workshops, I realized that the blended learning process is a very helpful method to teach as well as learn the ICT domain and also that was very helpful to explore the possibilities of ICT education without limiting it to the face-to-face session in the class room”.

Considering the feedback and the output from the analysis of facial behavior, the researcher applied enhancement possibilities in the next section. On some occasions the researcher achieved the expected skills with similar exercises incorporating the same activity level in the model. At the initial stage, during the activities (i) to (iv) teachers did several syntax and logical errors. During the above mentioned latter part, activities were achieved through group and on-line individual activities successfully. Finally, they reflected on using the blended approach and hence, they were able to utilize the resource, achieve learning outcomes and obtain the expected skills through this process. To obtain a successful yield from this model, the researcher and other stakeholders applied reflective learning methodologies as in section 6.6 in Chapter 6 and according to the guidance given by the principles of the reflective learning circle as shown in Table 6.7.

The following final outcomes were obtained from activity model 4. Teachers carried out their teaching and learning activities according to the first five stages of Bloom's taxonomy and each level of Bloom's taxonomy covered all four steps in Kolb's experiential learning circle. Teachers prepared the above mentioned technologies and embedded teaching and learning materials to achieve the learning outcome of the course unit. Finally, they prepared the evaluation paper to determine student achievement of the learning outcomes specified in the

course unit through the first five stages of Bloom's taxonomy and Kolb's experiential learning circle using the activities mentioned in the activity model 4 in appendix 14.

5th (Fifth Activity Model – Implementation of Sixth Stage activities in Bloom's Taxonomy

The 5th activity model and sixth stage activities of Bloom's Taxonomy were implemented as described in section 6.6 in Chapter 6. The researcher obtained feedback from teachers, an ICT instructor and an NIE consultant and also analyzed facial behavior during the session. Considering the outcome at this stage, the researcher applied enhancement possibilities in the next section.

Towards finding solutions to activity 5, the researcher provided sufficient time to solve the questions in the 5th activity model Appendix 14. Teachers were able to develop the answer using the outcome from the face-to-face session, from the course materials provided by the researcher. A few teachers used on-line materials. Subsequently, a brainstorming session was conducted to fine-tune the answers obtained, since the teachers appeared to have acquired a fair knowledge of problem solving activities.

The answers were strengthened using on-line materials and peer-to-peer discussions as mentioned in activity Model 6 in Appendix 14. Subsequently facilities were provided to enhance an answer as a group activity and finally facilities were provided to drive an optimum solution to the question. Meanwhile, similar types of problem solving questions were introduced and solved to enhance their skills further.

The final outcomes realized from activity model 5 are as follows. Teachers performed their teaching and learning activities according to the first six stages of Bloom's taxonomy and each levels of Bloom's taxonomy covered all four steps in Kolb's excremental learning circle. They prepared technologies and embedded teaching and learning materials to achieve the learning outcome mentioned in the course unit. Finally, they prepared the evaluation paper for their students to determine student achievement of the learning outcomes specified in the course unit covering the first six stages of Bloom's taxonomy and Kolb's experiential learning circle. The activities mentioned in activity model 5 are shown in appendix 14.

Subsequently, the applicability, importance and benefits of using Bloom's Taxonomy, Kolb's Experiential Learning Circle, brainstorming sessions, Reflective practicing in problem solving, evaluation and role model in the teaching and learning process were elaborated on. Finally, motivation and guidance to use the teaching and learning methodologies as recommended and specified in the model with their teaching-learning paradigm as against using ad-hoc methodologies much in use were provided. On some occasions the researcher achieved the expected skills incorporating more similar exercises.

In the initial stages of the 5th activity model (during the activities (i) to (iv)) teachers did a few activities with several syntax and logical errors. The latter part of the 5th activity model was successfully realized through group activities and on-line individual activities. Finally,

teachers decided on using the blended learning approach and hence, they were able to utilize the resources, achieve learning outcomes and master the expected skills through this process. The quality of the proposed model was tested and improved based on the feedback of stakeholders and by analyzing the facial behavior of stakeholders. Finally, the quality of the model was gradually improved applying the reflective learning methodologies described in Section 6.6 of Chapter 6 according to the guidance given in the principles of Kolb's experiential learning circle as shown in reflective learning circle Table 6.3 in Chapter 6. During the series of workshops, teachers reflected on the use of Bloom's taxonomy, Kolb's reflective learning circle practice, on-line learning, use of educational resources in the World Wide Web (WWW), peer discussions, importance of and how to use the role model in the development of ICT activities in schools.

According to the methodology described in Appendix 14, a series of activities were performed as follows:-

Throughout the series of activities, teachers reflected as follows:

Initially, teachers' knowledge was limited to that which was obtained from the face-to-face session and to what was given in course materials. After introducing e-materials, on-line help, standard educational sites, teachers tried to enhance their answers while their knowledge was also updated according to international expectations. Because of this, teachers were motivated to use internet resources as well as educational technologies to enhance their knowledge. And also they were encouraged to strengthen their knowledge through e-discussion forums. Because of this, teachers learned how to find other alternative answers and they tried to enhance their answer further indicating teachers' reflective practice behavior. Finally, based on the enhanced teachers' answers, a brainstorming session was held to fine-tune the final answer. Because of this, teachers as well as the researcher performed reflective practicing behavior to derive the final answer.

To test the success of the methodology, feedback was obtained from teachers and their facial behavior was observed during the session as described of section 6.6 of Chapter 6. At the end of the session, a discussion was held about their motivation, improvement and where weaknesses of the methodology observed.

The researcher applied the output of the sample feedback and facial reactions for the enhancement of the same activity with similar but different examples and on some occasions applied it to the next activity level. These actions taken were based on the stages of the reflective learning circle.

At the end of the workshops, stakeholders gave successful feedback for the implementation of the model and deliberated on the usefulness regarding the implementation of the model in the schools system.

The sample for final feedback from ICT teachers is represented are as follows.

Feedback from Participant 3 – ICT teacher, Thurstan College, Colombo 03

“Today is the last day of the program. We learned a lot of new things. The Main advantage of this model is how to teach new things using new technologies and educational methodologies. We try to implement this model in our schools with our students to the maximum. Further, we are aware about how to motivate students to self-learning, how to perform problem solving activities and how to apply blended learning technologies into the learning paradigm via group activities and several other techniques (e.g. brainstorming sessions)”

Feedback from Participant 4 – ICT Teacher, Anula Vidyalaya, Nugegoda

“We are teaching ICT to A/L classes. We teach Python language to prepare students for national examinations. When we want to teach session of programming, we did self-learning and the same thing were delivered to our students and there was no broad knowledge of the subject domain. During the series of workshop sessions, we understood, to learnt, how to think and how to learn ICT technologies in a creative manner, how to provide guidance to improve the creativity of students using blended and using standard technologies in education. Finally, we thank sir, for the opportunity he gave us. Further, I will take this opportunity to thank Sir on behalf of the students of Anuala Vidyalaya”

Participant 1 – ICT teacher Samudradevi Balika Vidyalaya, Nugegoda

Today is the last date of the series of the workshop sessions. I think it is good; today is not to be the last day of the series of work sessions. A Few minutes earlier, we discussed about the importance of this model with other teachers who participated in the session. In the past, we were not provided with this type of creative workshop sessions to enhance our knowledge. This experience will never be forgotten in my life because Noel sir gave us a different approach to solve programming techniques via a blended leaning lecture series. Further, our thinking abilities changed during this course model. This model implies how to think out of the box. Further, in addition to that in the past, I did not have any idea about the preparation of a question paper in a methodical way. But due to this workshop, I would be able to prepare a question paper according to the levels of Bloom’s taxonomy. This facilitates proper evaluation according to the learning objectives”.

ICT Instructor

“From this teacher training program, I learned more techniques such as python programming, blended learning and how to construct our things using online materials without obtaining help from others. I think this program is successful and I can’t say there were any weaknesses. The minor issue was on the last day, some session were done quickly and it felt a little difficult but during the homework session it was solved in the proper manner because it was part of on line self-leaning. Finally, I want to say this model is very successful, it can be applied to the ICT development process of Schools in Sri Lanka”.

6.11 Implementation Of The Proposed Model In Respective Schools

Activities, Implementation Procedure and Results of the Teacher-Student and Peer-to-Peer Student Model

The activities used in “Master-Trainer and Teacher Model” and the “Peer-to-Peer Teacher model” were applied to the implementation of “Teacher-Student Model” and “Peer-to-Peer Student model” using the role model approach as discussed in Chapters 2 and Chapter 6.

Initially, teachers conducted the face-to-face session using course materials provided at the teachers’ workshop sessions as in the role model approach. Some teachers had also prepared daily course materials and activity sessions based on the experience obtained from the series of workshop sessions. Further, teachers provided facilities to conduct peer student group discussions as they learned from the series of workshops at the university.

In implementing the model in the respective schools, teachers introduced blended learning approaches learned at the workshops. Teachers applied the application model activities learnt from the workshops at the university in a reflective and enhanced manner. On some occasions, the researcher gave feedback through classroom observation sessions.

The application models were implemented and tested fulfilling the specified requirements in selected schools using the Role Model approach as described in section 2.4.3 of Chapter 2 and using the design approach shown in section 6.6 of Chapter 6. Teachers were able to fine-tune the application model with their students with the help of the researcher. At the beginning, students also used face-to-face activities towards their learning process. After a series of lessons, they were motivated to use blended approaches to enhance the learning process. Based on the feedback of students, teachers and the ICT instructor, the researcher was able to judge the success of the application model through the facial behavior of the students and outcome of the inferential statistics analysis.

6.12 Evaluation Of The Proposed Application Model

The final evaluation of the proposed application model is based on the outcomes of students’ activities carried out by the trained teachers in three different schools with the help of researcher.

A sample of 26 students from Anula Vidyalaya, 16 students from Thurston College and 19 students from Samudradevi Balika Vidyalaya were selected based on availability. Students’ knowledge about programming and problem solving was tested at six (6) levels. They were face-to-face, activity level 1, activity level 2, activity level 3, activity level 4, and activity level 5. The mean mark of each block at each treatment level was calculated and is given in the Table 6.6.

Further, during the implementation, test cases were performed. In all test cases, common evaluation activities were given. These activities were prepared at the implementation of the application model stage with teachers. The following Table 6.6 shows the students’ mean marks for different treatments.

Table 6.6: Mean marks of each block at each treatment

Treatment	Block		
	AnulaVidyalaya	Thurstan College	Samudra Devi Balika Vidyalaya
(1) Face-to-face	40.50	47.25	42.00
(2) Activity Level 1	42.20	49.25	43.67
(3) Activity Level 2	46.21	51.80	47.74
(4) Activity Level 3	50.35	56.06	54.72
(5) Activity Level 4	55.20	59.60	58.39
(6) Activity Level 5	60.00	67.31	63.00
	N1=26	N2=16	N3=19

According to the above results, it was concluded that there is a gradual increase of students' performance when proper implementation of the application model is carried out. For each treatment, Paired T-test described in section 2.3 in chapter 2 was used and the following outcomes were obtained. As input to the paired T-test, mean data given in Table 6.6 was used. Further, Paired t-test was used to test the improvement between the levels of each treatment.

The following six hypotheses were tested.

Let $\mu_1, \mu_2, \mu_3, \mu_4, \mu_5, \mu_6$ were the population mean population mean marks at Face-to-Face, Activity Level 1 to Activity Level 5 respectively.

Hypothesis XXVI (Treatment of Face-to-Face versus Activity Level 1)

$H_0: \mu_1 = \mu_2$ (mean values are same in both treatments)

$H_1 : \mu_1 < \mu_2$ (mean marks of Treatment 1 < Treatment 2)

Or

$H_0: \mu_1 - \mu_2 = 0$

$H_1: \mu_1 - \mu_2 < 0$

The Table 6.7 shows the outcome of paired T-test according to the Hypothesis XXVI

Table 6.7 Paired T- test for Face-to Face and Activity Level 1

	N	Mean	StDev	SE
				Mean
Activity Level 1	3	43.2500	3.5444	2.0463
Activity Level 2	3	45.0400	3.7193	2.1473
Difference	3	-1.7900	0.18248	0.10536

95% upper bound for mean difference: -1.48236

T-Test of mean difference = 0 (vs < 0): T-Value = -16.99 P-Value = 0.002

According to Table 6.7, at 5% significant level P value of the T-test is 0.002 (< 0.05).

Therefore, H_0 can be rejected. There is enough evidence to say that $\mu_1 < \mu_2$. In other words, Activity Level 1 has made an improvement with the ICT specialization for GCE (O/L) students' performance compared to the Face-to-Face Activity.

Hypothesis XXVII (Treatment of Activity Level 1 versus Activity Level 2)

$H_0: \mu_2 = \mu_3$ (mean values are same in both Treatments)

$H_1: \mu_2 < \mu_3$ (mean marks of Treatment 2 < Treatment 3)

Or

$H_0: \mu_2 - \mu_3 = 0$

$H_1: \mu_2 - \mu_3 < 0$

Table 6.8 shows the outcome of paired T-Test according to the Hypothesis XXVII.

Table 6.8 Paired T- test for Activity Level 1 and Activity Level 2

	N	Mean	StDev	SE Mean
Activity Level 1	3	45.0400	3.7193	2.1473
Activity Level 2	3	48.5833	2.8888	1.6679
Difference	3	-3.54333	0.86077	0.49697

95% upper bound for mean difference: -2.09219

T-Test of mean difference = 0 (vs < 0): T-Value = -7.13, P-Value = 0.010

According to Table 6.8, at 5% significant level P value of the T-test is 0.010 (< 0.05). Therefore, H_0 can be rejected. There is enough evidence that $\mu_2 < \mu_3$. In other words, Activity Level 2 has produced an improvement in ICT students' performance as compared to Activity Level 1.

Hypothesis XXVIII (Treatment of Activity Level 2 versus Activity Level 3)

$H_0: \mu_3 = \mu_4$ (mean values are the same in both treatments)

$H_1: \mu_3 < \mu_4$ (mean marks of treatment 3 < treatment 4)

Or

$H_0: \mu_3 - \mu_4 = 0$

$H_1: \mu_3 - \mu_4 < 0$

The Table 6.9 shows the outcome of paired T-test according to the hypothesis XXVIII.

Table 6.9 Paired T- Test for Activity Level 2 and Activity Level 3

	N	Mean	StDev	SE Mean
Activity Level 2	3	48.5833	2.8888	1.6679
Activity Level 3	3	53.7100	2.9860	1.7240
Difference	3	-5.12667	1.60615	0.92731

T-Test of mean difference = 0 (vs < 0): T-Value = -5.53 P-Value = 0.016

According to Table 6.9, at 5% significant level P value of the T-test is 0.016 (< 0.05). Therefore, H_0 can be rejected. There is enough evidence that $\mu_3 < \mu_4$. In other words, Activity Level 3 has produced an improvement in ICT students' performance as compared to Activity Level 2.

Hypothesis XXIV (Treatment of Activity Level 3 versus Activity Level 4)

$H_0: \mu_4 = \mu_5$ (mean values are same in both treatments)

$H_1: \mu_4 < \mu_5$ (mean marks of Treatment 4 < Treatment 5)

Or

$H_0: \mu_4 - \mu_5 = 0$

$H_1: \mu_4 - \mu_5 < 0$

Table 6.10 shows the outcome of paired T-test according to the hypothesis XXIV.

Table 6.10 Paired T- activity Level 3 and Activity Level 4

	N	Mean	StDev	SE Mean
Activity Level 3	3	53.7100	2.986	1.724
Activity Level 4	3	57.7300	2.273	1.3123
Difference	3	-4.0200	0.72173	0.41669

5% upper bound for mean difference: -2.80326

T-Test of mean difference = 0 (vs < 0): T-Value = -9.65, P-Value = 0.005

According to Table 6.10, at 5% significant level P value of the T-test is 0.005 (< 0.05). Therefore, H_0 can be rejected. Further, there is enough evidence that $\mu_4 < \mu_5$. In other words, Activity Level 4 has produced an improvement in ICT students' performance as compared to Activity Level 3.

Hypothesis XXX (Treatment of Activity Level 4 versus Activity Level 5)

$H_0: \mu_5 = \mu_6$ (mean values are same in both treatments)

$H_1: \mu_5 < \mu_6$ (mean marks of treatment 5 < treatment 6)

Or

$H_0: \mu_5 - \mu_6 = 0$

$H_1: \mu_5 - \mu_6 < 0$

Table 6.11 shows the outcome of paired T-test according to the hypothesis XXX.

Table 6.11 Paired T- Activity Level 4 and Activity Level 5

	N	Mean	StDev	SE Mean
Activity Level 4	3	57.7300	2.273	1.3123
Activity Level 5	3	63.4367	3.6745	2.1215
Difference	3	-5.7067	1.73754	1.00317

95% upper bound for mean difference: -2.77743

T-Test of mean difference = 0 (vs < 0): T-Value = -5.69 P-Value = 0.015

According to Table 6.11, at 5% significant level P value of the T-test is 0.015 (< 0.05) Therefore, H_0 can be rejected. There is enough evidence that $\mu_5 < \mu_6$. In other words, Activity Level 5 has made an improvement in ICT students' performance as compared to Activity Level 4.

In addition to the outcome of the hypothesis testing, the following Figure 6.3 and Figure 6.4 show performance of students with different activities.

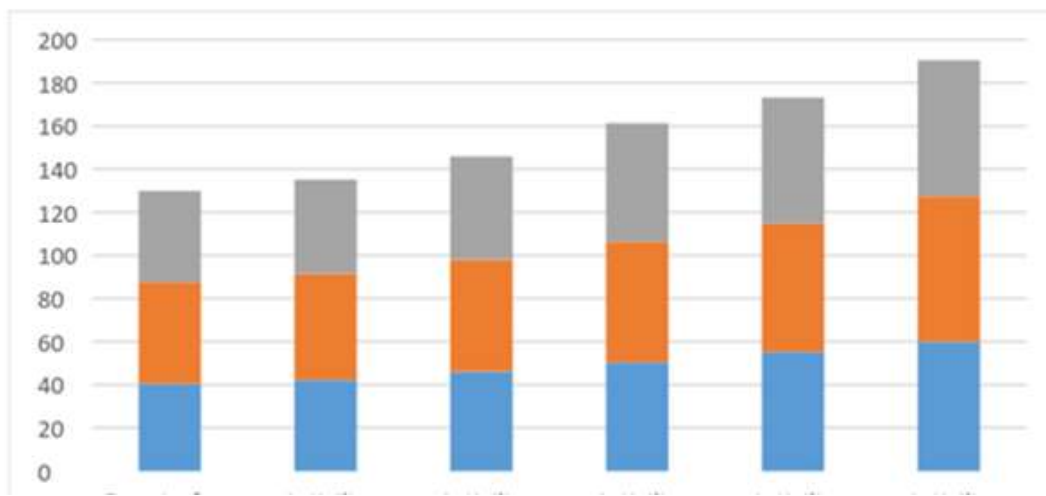


Figure 6.3 Stack chart to represent Students' performance in different activities in three schools

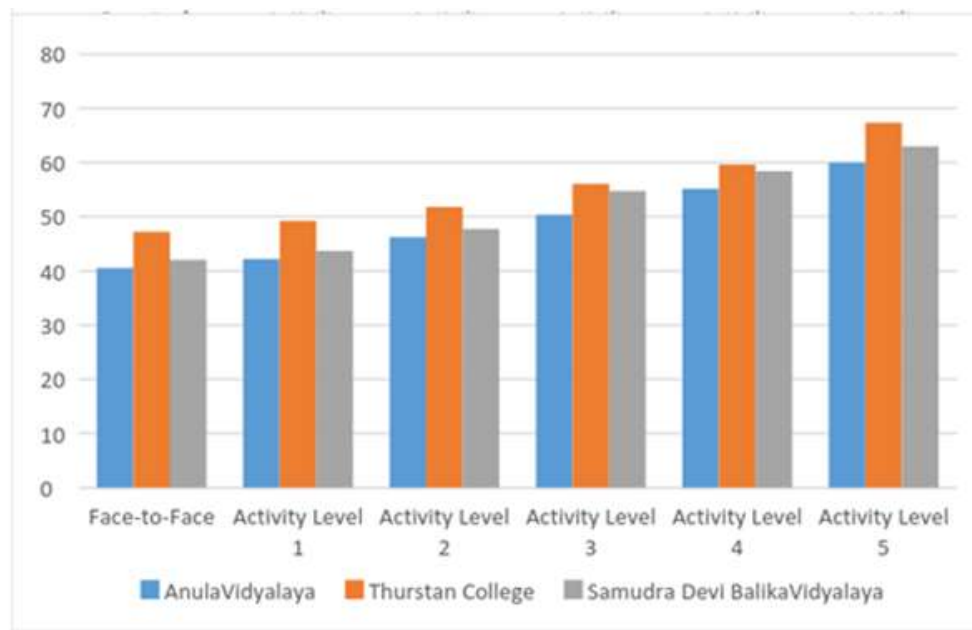


Figure 6.4 Bar chart to represent Students' performance in different activities in three schools

The above graphs show students' performance increasing at each activity level. Further, all the schools show a pattern of increase in the performance behavior.

According to the inferential outcomes and the graphical representation, it was concluded that student performances increased through the activities contained in the activity series in implementing the proposed application model.

To investigate any schools wise variations (analyze the difference between the groups) in the above conclusion, the following analysis of variance statistical model (ANOVA) was used.

ANOVA Test for comparison of performance in School-wise

To test the difference between schools performance-wise in connection with the outcome of the implemented application model, the following hypotheses was used.

Hypothesis XXXI

H_0 : students' performance in Anula Vidyalaya, Samudra Devi Balika Vidyalaya and Thurstan College are the same

H_1 : students' performance are different at least one school from others.

Or in other words,

H_0 : $\mu_{\text{Anula}} = \mu_{\text{thurston}} = \mu_{\text{samudradevi}}$

H_1 : At least one mean is different from the others

Table 6.12 One-way ANOVA: marks versus school

Source	DF	SS	MS	F	P
school	2	114.2	57.1	0.93	0.416
Error	15	920.2	61.3		
Total	17	1034.3			

S = 7.832 R-Sq = 11.04% R-Sq(adj) = 0.00%

Individual 95% CIs For Mean Based on Pooled StDev

Level	N	Mean	StDev	-----+-----+-----+-----+-----
AnulaVidyalaya	6	49.077	7.583	(-----*-----)
Samudra Devi Bal	6	51.587	8.435	(-----*-----)
ThurstenCollege	6	55.212	7.442	(-----*-----)

-----+-----+-----+-----+-----

45.0 50.0 55.0 60.0

Pooled StDev = 7.832

P value of ANOVA is 0.416. So that 95% confidence interval level p value is greater than α (0.05). Therefore, H_0 cannot be rejected. There is no evident that performances are different school wise. 95% confidence interval for mean marks also confirm the same (confidence intervals are overlap). According to the outcome of the above statistical model, it was concluded that students' performance increase is same in all three schools.

The application model confirmed its validity through the explored statistical models. It is interesting to note that the general view of the teachers who participated in the testing of the application model in schools was that the model looks feasible towards enhancing the quality of ICT education in Sri Lanka.

CHAPTER 7: Summary and Conclusions (Phase II)

7.1 Introduction

The conclusions pertaining to the Objectives 1 – 4 were presented in Chapter 6. This chapter presents the conclusions related to Objective 5: “To derive an application model of selected dimensions to enhance the quality of ICT Specialization subject for GCE (O/L) curriculum in Sri Lankan schools”. This chapter also discusses the recommendations, potential development possibilities, limitations of the study and recommendations for future work.

Based on the outcomes from Phase I, the variables: software (X_4), curriculum implementation facilities and issues (X_5), and research development activities (X_8) (Please see Table 6.1) were selected as the inputs for the development of the proposed application model in Phase II.

7.2 Summary And Conclusion Of The Teacher Training And Student Application Model

The proposed prototype application model aimed at increasing skills levels of both teachers’ and students of ICT was based on Kolb’s experiential reflective learning circle together with other pedagogical techniques. This application model used Internet resources, LMS and other blended learning techniques, information transmission mechanisms through peer discussions, teamwork and pedagogical techniques as against the conventional context with higher utilization of hardware resources.

In use, this application model proved to be helpful as it helped increase the skills level of both parties. The outcome from the application model against the traditional face-to-face learning activities were evaluated using the principles of Bloom’s Taxonomy, blended learning approaches, activity based learning, stakeholders’ feedback, brainstorming sessions, peer discussions, role model approach of teaching referred to as pedagogical techniques and the Seven Universal Facial Expressions Theory. Applying the principles of Bloom’s Taxonomy helped increase participants’ confidence with the ability to identify learning objectives precisely in the areas of teaching, learning and evaluation. As a result, it is evident that the proposed application model promotes more progressive achievement toward higher order cognitive skills, than the traditional face-to-face teaching and learning activities.

Blended learning approaches (especially e-learning resources, web based training, LMS) embedded in the application model were found to promote the learning process of ICT education. While peer discussions helped enhance the teaching and learning process in ICT education, problem solving capabilities with critical thinking abilities and team work activities contributed equally. This is seen as different from the existing context. All in all, the Blended learning approach with teamwork activities manifests problem solving activities in an innovative manner as against the existing context.

During the implementation of the proposed application model, the use of open source software products was found to provide cost effective opportunities for the ICT specialized educational activities. Therefore, productivity appeared to be high in comparison to the conventional closed source environment, probably due to low cost solutions and virus free

features inherent in open source environments. With regard to compatibility, open source software version showed a positive impact in the implementation of the ICT specialization subject. As such, it can be concluded that the usage of open source software products provide a more feasible (in terms of legal, ethical, economical, technical and operational) implementation environment for the ICT specialization subject for GCE (O/L) as against the existing closed source software environment.

Applying rules of Kolb's Experiential Learning Circle together with other techniques in the implementation stage of the application model, the researcher, the ICT instructor and teachers could reflect and as such, it was possible to fine-tune this application model to achieve the learning outcomes in a successful manner as against the existing context. Applying pedagogical techniques helped enrich the application model to increase students' academic performance. Therefore, it can be stated that Kolb's experiential learning circle practices are useful to achieve expected international standards and learning outcomes with better quality than with the existing methodologies.

Traditional role model techniques help the teachers to transmit the knowledge from teacher to students. Going beyond, reflection and other pedagogical techniques, together with the role model enriched in the application model were found to be helpful to eliminate barriers in the existing teaching and learning activities. It was also found that the application model provides a feasible platform towards teaching and learning activities in innovative manner and could provide better academic performance than in the existing context. This observation, apparently helps conclude that the Role Model approach of teaching along with the other pedagogical techniques promote the academic achievement in ICT education than the conventional context.

Stakeholders' feedback, facial behavior and facial behavior analysis of the participants were greatly useful to evaluate the effectiveness of the application model for ICT education in the research study. Implemented in the application model, teacher "happy mode" increased by approximately 24% compared to Face-to-Face Session. It suggests that the stakeholders' feedback evaluation mechanisms were of help to monitor the quality status of the academic process. The evaluation process of quality status is greatly important to determine the present quality level of ICT education in Sri Lankan schools against international standards. Further, it is concluded that the outcomes of the evaluation process of stakeholders' feedback were of help to increase the academic performance of students and are able to achieve the international indicators in ICT education.

The study reveals that sharing of experience and utilization of resources gets maximized with the implementation of this application model. Accordingly, this application model can be used to utilize the existing resources, as well as to elevate the quality of ICT education in Sri Lankan schools up to international standards.

Based on the outcome from the hypothesis testing of students' for each activity in the application model, it was shown that academic performances were raised gradually in the 1st Activity Level with respect to the Face-to-Face Activity Level. Further, academic

performances were raised in the 2nd Activity Level with respect to the 1st Activity Level and so-on. It kept increasing continuously to cover all the activity levels in the application model. Based on the outcomes, it could be concluded that each and every activity level in the proposed application model helped raise student academic performance and skills development. Further, learning objectives of the ICT specialization subject for GCE (O/L) can be achieved as at an acceptable level in implementing the proposed application model.

The null hypothesis H_0 : "Students performance in different Schools is the same" was tested using ANOVA and could not be rejected at 95% confidence interval. There is no evidence to say that academic performances are different by schools. As such, there is no difference between schools in student academic performance increases. The application model is, therefore, feasible to enhance the quality of ICT education in Sri Lanka.

7.3 Recommendations

ICT specialization subject for GCE (O/L) can be performed utilizing the existing resources based on the recommendations provided in the prototype application model. In addition, other primary and secondary ICT educational activities can be implemented in a phase by phase manner creating an ICT culture, using sufficient human resources and infrastructure facilities with appropriate curriculum and evaluation processes.

ICT is a versatile subject for critical thinking skills in a prominent human requirement. However, for the purpose, the current system of ICT education in Sri Lanka appears to be deficient in content areas. The relevant content part in this regard is problem solving and design algorithms, which is given less emphasis. The proposed application model includes problem solving and algorithm designing activities embedded with pedagogical and new technologies related to ICT. The suggested activities relate to programming concepts, problem solving and algorithms and provide greater critical thinking abilities to students as well as to teachers in the system. The outcomes obtained from the tryout of model will, undoubtedly, help develop teachers' and students' skills with programming concepts, problem solving and algorithm skills. Therefore programming concepts, problem solving and designing algorithm skills in the application model are recommended as highly helpful to develop critical thinking skills in students.

This study proves that Free and Open Source software (FOSS) products are appropriate to fulfill all the software requirements of the ICT curriculum. It also prevents the school system from unnecessary intellectual property problems. As per the recommendation provided and the outcomes obtained from the application model, the expected standards of ICT education can be achieved if Sri Lanka uses FOSS and OSS. Moreover, skillful students and teachers get provided with an un-interrupted service with the use of FOSS. Therefore, it is recommended that administrative authorities encourage the use of FOSS or OSS.

The Principles of Kolb's experiential learning circle should be incorporated in the teaching and learning process in ICT education to provide greater skills to teacher trainers, teachers. Well established and tested methodologies like Kolb's Experiential learning circle, real feedback and on site observations (implementers and training authorities observed strengths,

weaknesses and real applicability) will be greatly helpful in the elimination of weaknesses in the developed application model, while encouraging further developments.

Blended learning (e.g. web based training, LMS, e-learning) is an influential pedagogical strategy to provide more facilities to achieve international standards with ICT education.

An important taxonomy as Bloom's Taxonomy and Kolb's Experiential Learning Circle should be incorporated in the teacher training programs as shown in the proposed model. Further, if one introduces Bloom's Taxonomy for the teaching, learning and evaluation processes as presented in the application model, better performances from both teachers and students can be achieved.

HR development in ICT educational activities should be embedded for use by relevant authorities to facilitate the pedagogical transformation and motivations of ICT teachers. Curriculum development and teacher training authorities related to ICT education should incorporate activity based learning techniques aligned with the different skill levels of Bloom's taxonomy to provide substantial skills and sound knowledge to ICT teachers, as well as students.

A hybrid version of the role model and peer-to-peer discussions may provide great benefits to the teacher and the student group than the individual mode. Brainstorming sessions improve critical thinking behavior, explore different angles of thinking and learn to respect others' ideas than the traditional face-to-face classroom learning as associated with ICT education. Feedback from stakeholders and outcomes from facial analysis provide great help to avoid unproductive practices in the implementation of ICT education.

The expected quality of ICT education can be obtained through continuous monitoring and evaluation. The pedagogical and blended learning activities along with continuous evaluation and monitoring activities provide new innovations and enhancement of ICT skills of students, as well as teachers.

The cooperation of all the stakeholders in the ICT education process will help raise the quality of ICT education. If one implements the proposed application in the schools' system, resource utilization can be maximized. Hence, this may be a good advantage for a developing country like Sri Lanka. Further, students' performance can be increased and the failure rate decreased. Hence, a developing country like Sri Lanka, can achieve international standards in ICT education in an incremental manner. Finally, implementing the application model in a successful manner with a proper platform for further research and development will lead to the achievement of the country's national goals related to education.

7.4 Difficulties, Issues In The Implementation Of The Model And Suggestions To Improve The Model

The negative attitudes and difficulty to change the existing habits of teachers and other educational leaders gave rise to difficulties with the proper implementation of the proposed application model. Further, the lack of awareness among principals regarding ICT education was instrumental in the difficulties experienced in the further enhancement of the model.

Absence of an ICT policy for the development of ICT education in Sri Lanka is a great challenge and hence, it is a difficult task to maintain expected ICT standards.

Some teachers and students lack competency in English. Therefore, they are reluctant to use e-learning approaches and lead peer discussions. The modified version of this application model can be used to improve communication skills of in-service teachers. On some occasions it is difficult to capture the live environment due to the school's rules and regulations. If one monitors the entire lecture series in practice at school level more accurately, comprehensive facial analysis can be used to fine-tune the application model further.

7.5 Limitations Of The Research Study

Facial analysis was performed using the manual method. If one used image processing techniques in computer science, more accurate results can be obtained. The researcher implemented and tested the model amidst numerous barriers and issues in relation to: financial constraints, workload of teachers and students. However, if this model is implemented by the relevant authorities, substantial benefits can be obtained. Further, as a way of fine-tuning the application model; this should be tested in rural areas also.

As a future involvement, a user training manual has to be developed for training and implementation purposes. According to the literature review, it was revealed, that nine factors contribute towards the maintenance of quality ICT education. But this study considered only three variables due to various practical issues. If one considered the other remaining appropriate factors with high level contribution from relevant authorities, a more enhanced version can be developed. Further, the application model tryout was limited to ten ICT teachers in the Colombo district. More enhanced results can be obtained using the teachers from rural areas with higher samples. Further, the 2nd stage application model tryout process was limited to three schools and sixty one (61) students in Colombo district. If the tryout model was extended to more schools and from rural areas as well, the outcome would have been better with a more fine-tuned product as against the existing context.

The lack of proper English among ICT teachers and students is another concern as the majority of existing blended approaches did not fully support the Sinhala and Tamil language interfaces. However, this study is limited to ICT specialization subject for GCE (O/L) curriculum. The remaining areas in ICT education enhancement in Sri Lankan schools are: ICT specialization subject for GCE (A/L), ICT specialization subject for grades 3-9 and ICT in education.

7.6 Recommendations For Future Work

This study investigated only a blended learning approach, software usage and pedagogical techniques towards improvement and concluded that the pedagogical quality of human resource facilities and its strengths for the implementation of ICT specialization subject for GCE (O/L) curriculum are not at a satisfactory level. Therefore, the remaining factors such as: maintenance and sustainability, policy matters, supportive initiatives, curriculum etc. need attention to enhance quality improvement and have yet to be evaluated.

The study also concluded that there are implementation issues and outcomes that are not at a satisfactory level for the implementation of Programming and Problem Solving in the grade 11 curriculum. Moreover, the study concludes that the Programming and Problem Solving unit is most important as it correlates substantially with other course units in the curriculum. Such correlated course units are Information Systems, Web designing, ICT and Society, Individual project units in the ICT specialization subject in the Grade 11 curriculum. The study considered only the enhancement of the Programming and Problem Solving unit and there are provisions to apply the proposed application tryout model for other correlated course units in the ICT specialization subject for the GCE (O/L) curriculum.

The requirements towards National goals and Budget allocations are also not explored in this study. Hence, the higher authorities should pay attention to these areas too for the successful development of ICT education in Sri Lankan schools.

The study has shown that, the existing infrastructure facilities are adequate to implement the ICT specialization subject for the GCE (O/L) curriculum in Sri Lankan schools. Comprehensive investigations on infrastructure for all ICT educational course units conducted in Sri Lankan schools are needed. Further, District-wise, there are no infrastructure disparities in schools conducting ICT specialization subject for GCE (O/L) in Sri Lanka. Yet, Schools' category-wise, there are infrastructure disparities in schools conducting the ICT specialization subject for GCE (O/L) in Sri Lanka. Therefore, there are avenues to investigate the nature of disparities existing in different schools' categories.

The study has also shown that the computer maintenance and sustainability plan for the implementation of the ICT specialization subject for GCE (O/L) curriculum is not up to a level of satisfaction. Therefore, under an empirical research environment, further studies and recommendations are needed for the development of ICT education in Sri Lankan schools. The proposed application model too can be further enhanced with appropriate research.

According to the study, it was shown that support from the administration and supportive initiatives for the implementation of ICT specialization subject for GCE (O/L) in Sri Lankan schools is up to a satisfactory level. However, a detailed study on this factor could reveal avenues that exist for further enhancement.

It was shown that there is a definite lack of research and development activities carried out in regard to education related to ICT in Sri Lankan ICT. If one investigates the research and development possibilities on site, more fine-tuned research activities can be performed. The outcomes of the Seven Universal Facial Expressions of Emotional Methodology can be further enhanced using the image processing techniques in computer science. It was also observed that if the application model implementation and further enhancement was performed with the pre-service ICT teacher group, rather than with the in-service teachers (due to the existing workload and lack of changing behavior), more innovative outcomes are likely.

References

1. Abby, R. (2008). Factors Influencing Educational Quality and Effectiveness in Developing countries, GTZ.
2. Adam, R., & Estes, A. (2011). The U.N. Declares Internet Access a Human Right. USA.
3. Adam, S. (2004). Using Learning Outcomes. Report for United Kingdom Bologna Seminar, Retrieved 12 3,2012, from <http://www.qualityresearchinternational.com/glossary/learningoutcomes.htm>
4. Afshari, M., Barker, K., & Wong, S. (2010). principals' level of Computer use and some contributing factors. International journal of education and information Tehnology, 2(4),213-220.
5. Ainley, J., Fraillan, J., & Haber, J. (2006). Assessing Student Technology Literacy at National Level. San Diego.
6. Alexandra House. (2009). The importance of ICT in primary and secondary Schools. Ofsted .
7. Alice, K. Y., & Kolb, D. A. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. Learning Styles and management , 193-212.
8. Ananthakrishnan, M. (2007). Mumbai towards a National Policy on ICT in School Education in India-2007-2008. Bombay : Developmental informatics Lab, KReSIT, IIT Bombay .
9. Anindya, K. B. (2007). Towards a National Policy on ICT in School Education in India . Kalkata : panchayast and RD Department , Government of West Bengal, Kalkata .
10. Anindya, K. B. (2008). Towards a National Policy on ICT in School Education in India. Kalkata: Government of West Bengal.
11. Aqsha, M. L., & Awang, A. (2011). The use ICT in teaching islamic subjects in Brunei Darussalam , International Journal of english and Information Technology , 1(1),216-224.
12. Arivanandan, M. (2007). Towards a National Policy on ICT in School Education in India. Chennai: Indian Institute of Madras.
13. Arvind, K. (2007). National Policy on ICT in School Education in India. Arvind Kumar Globus infocom Ltd.
14. Bandura, A. (1971). Social learning theory. New York: General Learning Press.
15. Banerjee, A. K. (2008). Towards a National Policy on ICT in School Education in India . Kalkata : panchayast and RD Dept., Govt. of West Bengal.
16. Becta. (2002). The Impact of Information and Communication Technologies. UK: Becta.
17. Becta. (2005). Open Source Software in Schools . Retrieved 12 12, 2009, from <http://www.becta.org.uk/publications>: <http://www.becta.org.uk/publications>.
18. Bee, T. L., & Chia, H. S. (2008). Exploring the extent of ict adoption among . International Journal of Computing and ICT Research, 2(2), 19-36.
19. Belawati, T. (2002). Malaysia , ICT in Education. UNESCO .
20. Bishop, A. (2002). Critical Reflections on Web Based Education - A students'

- Perspective . Distance Education , 23(2), 231-236.
21. Boitshwarelo, B. (2009). Exploring Blended Learning for Science Teacher Professional Development in an African Context. *International Review of Research in Open and Distance Learning*, 12(2),113-129.
 22. Brandimonte, M., Einstein, G. O., & Mc Danial , M. A. (2014). *Presspective Memory - Theory and Application* . New York: Psychology Press.
 23. Cairncross, F. (2006). ICTs for education and building human capital. Retrieved 2 7, 2010, from <http://www.itu.int/osg/spu/visions/papers/educationpaper.pdf>
 24. Carizo, J. M. (2011). ICT as Social Shaping Technology. Retrieved 3 06, 2012, from *ICT as a Social Shaping Technology: Potentials and Limitations:* <http://www.scribd.com/j.../64449038-ICT-as-Social-Shaping-Technology>
 25. Chai, C. S., Hwee, J., & Tsai, C. C. (2013). A Review of Technological Pedagogical Content Knowledge. *Educational Technology and Society* 16(2), 31-51.
 26. Chan, F.-M. (2001). *ICT in Malaysian Schools: Policy and Strategies*. MAE Educational Technology Division, Ministry of Education.
 27. Chapman, D., & Adams, D. (2002). *Education in Developing Asia*. Manila: ADB.
 28. Charles, A. (2004). *Gap Analysis - Overview of Indentify Gaps*. Texas: Dana Centre .
 29. Churches, A. (2009). Bloom's Digital Taxonomy. newzeeland, Retrieved 4,12,2012, from <http://achurches@kristin.school.nz>.
 30. Computer Resource Centre. (2009, 10,2).Course details,. Unpublished lecture notes, Computer Resource Centre, Lumbini, Colombo, Sri Lanka.
 31. Cusack , B., Gurr, D., & Schiller, J. (1999). The Impact of Technology on work of Educational Leaders. *ICT Leadership in school education* , 80(3), 227-240.
 32. Day, C., Harris, A., & Hadfield, M. (2001). Challanging the orthodoxy of effective school leadership. *Internation Journal of Leadership in Education:Theory and Practice* , 4(1), 39-56.
 33. Debande, O., & Ottersten, E. k. (2004). A tool Empowering and Developing the Horizon of the Learner. *Information and Communication Technologies*, Vol. 15 (2) 31-60.
 34. De Mel, T. (2005). *Education for Economic Development and Prosperity* . Sri Lanka : UNESCO.
 35. De Silva, C. H. (2009). *ICT Education in Sri Lankan Schools*. Villach, Austria: Kassel University Press.
 36. Deaprtment of Examination. (2008). General certificate of education (Ord. Level) Examination, 2008,December, Information & Communication Technology. Colombo : Departmenet of Examination of Sri Lanka.
 37. Distance Education Modernization project. (2010). *Distance education in Sri Lanka* . Retrieved 9 3, 2012, from www.nodes.lk: www.nodes.lk.
 38. Department of Censun and Statistics . (2009). Department of Census and Statistics, *Census on Computer literacy of Sri Lankan Schools - 2009*. Retrieved 10 21, 2010, from ww.statistics.gov.lk/CLS/BuletinComputerLiteracy_2009.pdf
 39. Dissanayake, A. (2007). *ICT in Education Sri LAnka*. Colombo: Ministry of Education.
 40. Dixit, V. (2007). *Towards a National Policy on ICT in School Education in India*.

- New Delhi: National Institute for Smart Government.
41. Department of Education . (2008). General certificate of education (Ord. Level) Examination, 2008,December, Information & Communication Technology, Dept.of Examination of Sri Lanka, 2008. Colombo: DOE,MOE.
 42. Eberly College of Science. (2012). Random Sampling and other Sampling Methods. Retrieved 10 25, 2014, from <https://onlinecourses.science.psu.edu/stat100/node/18>
 43. Emily, B., Theo, W., & Henny, M. (2012). An approach to learning by construction. International Journal of Education and Development using Information and Communication Technology, 8(3), 43-61.
 44. Gibbs, G., & Habeshaw , T. (1997). Preparing to Teach: An Introduction to Effective Teaching in Higher Education (Interesting ways to teach) (2 ed.). UK: Technical and Educational Service Ltd.
 45. Gibbons, J. D. (1976). Nonparametric Methods for Qualitative Analysis. New York: Mc Graw Hill.
 46. Gray, J. (2000). Data Mining: Concepts and Techniques. Canada: Morgan Kaufmann.
 47. Gulati, S. (2008). Technology-enhanced learning in developing nations: International Review of Research in Open and Distance Learning, 9(1), 50-62.
 48. Gunawardene, G. (2008). Towards a New Education Act for General Education, National policy framework on general education, draft, national committee for formulating a new education act for general education . Colombo : NEC,Sri Lanka.
 49. Gurra, D., Drysdale, L., & Mulford, B. (2006). Models of successful principle leadership . School Leadership and Management , 24(4), 371-395.
 50. Hawk, T., & Shah, A. (2007). Decision Science . Journal of Innovate Education, 5(5), 72-79.
 51. Healey , M., & Jenkins, A. (2000). Learning cycles and learning styles: Kolb's experiential learning theory and its application in geography in higher education. Journal of Geography, 99(3).185-195.
 52. Hinett, K. (2011). Improving learning through reflection. the international journal of the higher education academy , 194-202.
 53. Hooijberg, R., & Dension, D. (2002). what makes leaders effective ? Switzerland: International Institute of Managment Development .
 54. International Bureau of Education, United Nations Educational, Scientific and Cultural Organization. (2002). Quality Education and Key Role of Teachers . USA: UNESCO.
 55. Ontario Certified Teacher development. (2007). Towards a National Policy on ICT in School Education in India. Concept Note for e-Discussion Series towards a National Policy on ICT in School Education: Communities in Dialogue @ UN Solution Exchange.
 56. Information Communication Technology for Development and Education. (2007-2008). Concept Note for e-Discussion Series towards a National Policy on ICT in School Education . India : Towards a National Policy on ICT in School Education in India.
 57. International Telecommunication Union. (2015). ITU-F Focus Group on Smart Sustainable Cities . Telefoniya: Silvia Guzman.

58. Isaacs, S. (2007). ICT for Education in Malawi. Retrieved 12 10, 2009, from www.infodev.org/en/Document.414.pdf: www.infodev.org
59. Jabareen, Y. (2009). Building a Conceptual Framework : philosophy, definition, and procedure . Technion City, Haifa: Israel Institute of Technology .
60. Josh, P., Jewell, B., Christina, G., & Christina, A. (2014,). Bloom's Revised Digital Taxonomy. Retrieved 2 05, 2015, from <http://www.celt.iastate.edu/teaching-resources/effective-practice/revised-blooms-taxonomy/>
61. Kamal, S., Rateb, D., & Ei-Tawil, M. (2009). The impact of ICT investment on economic development in Egypt. The electronic Journol on Information systems in developing Countries, 1(2), 1-19.
62. Kashrado, M., Acosta, F., & Nyandiere, C. (2006). ICT infastructure, Applications,Society and Education. Strathmore University ICT conference. Nairobi: Strathmore University press.
63. Katz, R. (2002). The ICT infastructure . EDucause .
64. Ken, B. (2009). BusinessStatistics : Contemporary Decision Making 6th Edition . Wiley.
65. Khalid, A. (2009). Barriers to the successful Intergration and Learnig Enviroment. RMIT University.
66. Khan, S. (2010). Comparing Recursive and Iterative Factorial function- Khan Academy .
67. Khslid, A. B. (2009). Barriers to the succesful Intergation of ICT in teachin and Laerning Enviroments. Eursai Journal Article of Mathamatics (Technology and Education), 235-245.
68. Khvilan, E. (2002). ICT in Teacher Education. UNESCO.
69. Khvilon, E., & Patru, M. (2002). ICT in Education - A curriculum for schools and programme of teacher development. UNESCO.
70. Kolb, D. A. (1984). Experiential Learning. Englewood Cliffs: Prentice Hall.
71. Krathwohi, D. R. (2002). A Revision of Bloom's Taxonomy. AN overview Theory into Practice , 41(4), 94-102.
72. Kshankhow, T. (2007). ICT and Non formal Education in Thialnd . Bangkok .
73. Lai, K.-W. (2011). Digital technology and the culture of teaching and learning in education. Australasian Journal of Educational Technology, 27(8), 1263-1275.
74. Lake House. (2008, 5 1). Decrease the O/L Results due to Neutralization Procedure of High Rank Educational Authorities. Silumina News Paper.
75. Landrum, H., & Prybutok, V. (2009). Measuring IS systems: Service Quality with SERVQUAL . Informing Science- The international Journal of an emmerging Transdiscipline , 12(2),540-548.
76. Laohajarsang, T. (2011). The current status of Thiland ICT education. Bangkok: Infomation Service Centre.
77. Lashley, C., & Barron, P. (2006). The Learning Style preprecences of hospitality and tourrisum students : Observation from international and cross-cultural study. International Journal of Hospitality Management, 25(4), 552-569.
78. Leary, A. (1999). Importance of Internet to Education. Retrieved 12 7, 2000, from e-How: http://www.ehow.com/facts_5758670_importance-internet-education.htm.
79. Lewis, J. A. (2010). The government Open system software policy, 75-86, Singapore.

80. Lim, Lim, C. P., & Hang, D. (2003). An Activity theory approach to Research of ICT integration in Singapore Schools. National Institute of Education .
81. Liyanage, D. (2004). Education Technology in the Next Decade. Colombo: National Education Commission.
82. Magdeleine, L. D., & Henk, S. G. (2007). Learning through assessment. Proceedings ascilite Singapore, 88--94. Singapore.
83. Manas, M., Rakesh, P., & Akhouri, P. (1998). Facial Expressions of Emotions and Schizophrenia: A Review. Schizophrenia Bulletin , 24(1),399-412.
84. Mansell, R. (2010). Information and Communication Technologies for Development: Assessing the Potential and the Risks. United Kingdom : LSE Research.
85. Mansfield, S. (2007). Curriculum theory and practice . SERA Annual Conference. Scottish educational research publication, 32(2), 156-163.
86. Mapatuna, M., & Premaratna, H. (2008). IT in Sri Lanka & professional issues., Colombo: University of Colombo School of Computing.
87. Master, N. (2011). Educational statistics . Retrieved 4 2, 2012, from <http://www.nationalmaster.com/graph/eud-edu-spe-education-spending-of-gdp>.
88. McMahon, G. (2009). Critical Thinking and ICT Integration in a Western Australian Secondary. Educational Technology & Society, 12 (4), 269–281.
89. Mickle, C., & Lindblom, Y. (2007). The Role of Academic's conceptions on the relationship between Research and Training. International Journal for Academic Development, 4(3),123-130.
90. Mingxing, C., Jintao, Z., Ping, S., & Xiaohui, L. (2009). Three-Tier Knowledge Management System Based on .NET. J. Software Engineering & Applications, 2:40-43.
91. Ministry of Human Resources, G. O. (2011). National ICT Policy on ICT in School Education. Dept of School Education and literacy .
92. Minnesota, U. Class Room Observation Instrument. Retrieved 09 17, 2009, from <http://www1.umn.edu/ohr/teachlearn/resources/peer/instruments/index.html>:
93. Ministry of Education. (1999). Circular No. 99/45. Ministry of Education. Colombo: Ministry of Education.
94. Ministry of Education. (2004). Circular No 2004/23, Ministry of Education . Colombo: Ministry of Education.
95. Ministry of Education. (2004). Circular No. HRD/PPR/2002/9. Colombo: Ministry of Education.
96. Ministry of Education. (2005). MOE, Circular No.2005/29 . Colombo: Ministry of Education.
97. Ministry of Education. (2006). School Census -2006 Preliminary Report. Colombo: Ministry of Education.
98. Ministry of Education. (2007). Literacy Rate- Sri Lanka. Retrieved 10 08, 2008, from <http://www.moe.gov.lk>..
99. Ministry of Education. (2008). SchoolNet. Retrieved 09 24, 2009, from www.schoolNet.lk: www.schoolnet.lk
100. Ministry of Education. (2009). National Policy on ICT in School Education and Literacy. Colombo : Ministry of Education, Department of School Education and

- Literacy.
101. Ministry of Education. (2011). Education_First_in_SL.pdf. Retrieved 03 24, 2012, from Education First in Sri Lanka: http://www.moe.gov.lk/english/images/publications/Education_First_in_SL.pdf
 102. Ministry of Education, Thailand .(2007). Toward a Learning Society in Thailand. Retrieved 1 10, 2012, from <http://www.moe.go.th>: www.moe.go.th
 103. Ministry of Education, India. (2007). Towards a National Policy on ICT in School Education in India. ICTD & Education.
 104. Ministry of Education, Australia. (2009). Digital Education Revolution . Retrieved 12 3, 2012 from <http://www.digitaleducationrevolution.gov.au>
 105. Ministry of Education, India. (2009). Draft National Policy on ICT (Information Communication Technology) in school Education. India: Ministry of Education, India.
 106. Ministry of Education, Malaysia.MOE-Malaysia. (2007). Secondary Schools in Malaysia . Retrieved 10 2, 2009, from <http://www.moe.gov.my/tayang.php>.
 107. Ministry of Education , Singapore. (2005). ICT in Education . Retrieved 11 25, 2008, from <http://www.moe.gov.sg/43seameoc/downloads/singapore>
 108. Ministry of Education , Thailand MOE-Thailand . (2011). Thailand case study one on ict integration into education . Retrieved 12 03, 08, from http://www2.unescobkk.org/education/ict/resources/JFIT/schoolnet/case_studies/Thailand ICT.doc.
 109. Ministry of Higher Education. (2009). NHEMIS Data Store . Retrieved 04 03, 2010, from <http://www.mohe.gov.lk>: www.mohe.gov.lk
 110. Mulford, B. (2003). School Leaders: Changing roles and impact on school effectiveness. Tasmania: Education and Training Policy division,OECD.
 111. Mulford, B. (2006). School and student learning: What do we know? E-journal retrieved 2 8,2012, from www.slc.edu.ubc.ca/eJournal/Issue%204/index.htm .
 112. Mungamuru, N., Kaliyaperumal, K., Sreedhar, A., & Patharaj, J. (2012). The Role of ICT in the Economic Development of North East Africa: Eritrea. Journal of Emerging Trends in Computing and Information Sciences, 3(3), 310-319.
 113. Nagarjuna. (2008). Consultaion on national poicy on ICT school education. New Delhi: MOE.
 114. Nation-India . (2011). Educational Statistics, India. Retrieved 4 7, 2012, from Educational Statistics : <http://www.nationmaster.com/graph/eud-spe-education-spending-of-gdp.pdf>
 115. National Collage of Education. (2004). Wayamba national college of education. Retrieved 9 6, 2009, from <http://www.wncoe.slt.lk/>: <http://www.wncoe.slt.lk/>
 116. National Education Commision . (2007). School Information Communication Technology Policy Frame Work. Colombo: NEC.
 117. National Institue of Education. (2006). GCE (O/L) information Technology Course materials, National Institute of Education, Sri Lanka . Retrieved 09 15, 2009, from <http://www.nie.lk>: <http://www.nie.lk>
 118. National Institute of Education . (2007). GCE (O/L) information Technology Course materials . Retrieved 2009, from <http://www.nie.lk> : www.nie.lk
 119. National Institute of Education. (2008). Information and communication

- technology – Grade 11, teacher’s instruction manual, Dept. of information and communication technolog. Maharagama: NIE.
120. National Institute of Education. (2008-2009). Information and communication technology GCE (A/L) syllabus-2009, Department of Information Technology . Maharagama: NIE|
 121. National Institute of Education NIE. (2009). ICT education, National Institute of Education . Retrieved 09 17, 2009, from www.nie.lk: www.nie.lk.
 122. National Institute of Information Technology. (2007). ICT @ school in India. Retrieved 25 07, 2012 from [http://www.niit.com/services/solutionsforgovernment/ITEducationForSchoolsICT @ school in India](http://www.niit.com/services/solutionsforgovernment/ITEducationForSchoolsICT@schoolinIndia),
 123. Novento, F. (2007). ICT curriculum development for Primary and Secondary schools. UNESCO.
 124. Nwachukwu P, A. E. (2007). ICT and Distance Education Programs in a Sub-Saharan African Country, *Journal of Information Technology Impact*, 7(3), 181-194.
 125. Organization for Economic Co-operation and Development . (1996). *The Knowledge Economy* . Retrieved 2 11, 2012 from *The Knowledge Economy & ICT*: <http://www.oecd.org/sti/sci-tech/1913021.pdf>
 126. Organization for Economic Co-operation and Development. (2004). *Learning for Tomorrow's World- First Results from PISA* . Paris: OCED.
 127. Organization of Eastern Caribbean States OECS. (2001). *ICT policy document for the Education System*. St Lucia : OECS Education Reform Unit.
 128. Oliver, R. (2002). *The role of ICT education in Higher Education for the 21st Century*, *ICT as a right agent for education*. Australla .
 129. Oliver, R. (2011). *The role of ICT in Higher education higher eucation for the 21st century* . *ICT as a Change Agent for Education* , 235-245.
 130. Ololube, N. P. (2006). Appraising the relationship between ICT usage and integration and the standard of teacher education programs in a developing economy. *International Journal of Education and Development using ICT* , 2(3), 215-222 .
 131. Ololube, N., Uboru, A., & Egbezor, D. (2007). *ICT and DIstance Education Program in a Sub-Sararan African Country*. *Journal of Information Technology Impact* , 7(3), 181-194.
 132. Osmani, M. E. (2010). *Virtual Tutoring: An Online Environment for Scaffolding* . *Journal of turkish science education*, 7(3), 3-12.
 133. Otto, T., & Albion, P. (2002). *Principal's Belifs about teaching with ICT : A model of promoting* . Retrieved 2 9, 2013, from *ICT and Teaching* : <http://core.ac.uk/download/pdf/11040077.pdf>
 134. Panitchpakdi, S. (2006). *The digital divide report- ICT diffusion Index-2005*. New York: United Nations.
 135. Pasztor, A., & Molnar, G. (2013). *Validity and effectiveness of Computer-based versus face-to-face testing in first grade*. *European Conference for the Research on Learning and Instruction* (pp. 301-310). Germany: Munich.
 136. Patti, S. (2008). *ICT as a core and Elective Subject - Issues to Consider*. Gesci.

137. Pedro, H. K. (2004). Technology in School Education, ICT and the Knowledge Society . Enrique Hinostraza S.
138. Philips, A., & Nehal, B. (2005). Human Rights and Public Goods: Education as a Fundermental Right in India. New York: New york, school of law.
139. Piet, K., & Magriet, S. (2005). ICTs for Secondary Education, Specilised Training Course. UNESCO.
140. Prensky , M. (2004). The Emerging Online Life of the Digital Native . Retrieved 07 08, 2012, from The Emerging Online Life: The_Emerging_Online_Life_of_the_Digital_Native-03.pdf
141. Prpad. (1999). Economic Survey of Asia and the Pacific. Retrieved 03 20, 2010, from <http://www.unescap.org/stat/ge/box-ch8.asp>: www.unescap.org/stat/ge/box-ch8.asp
142. Rajen, V. (2008). Towards a National Policy on ICT in School Education in India. India: Technology for the People.
143. Ropke, I. (2009). Integration of ICT in everyday life-exploration of transition processes in an environmental perspective. Denmark: Ropke, InGe.
144. Sara, H., David, H., & Leonard, W. (2010). Teacher Factors Influencing Classroom Use of ICT in Sub-Saharan Africa. Itupale Online Journal of African Studies, Vol 2 (2010) 39- 54.
145. Schiller, J. (2003). working with ICT: Perceptions of Australian principals. Journal of educational Administration, 42 (2),49-82.
146. Shahin, J., & Flnger , M. (2000). The History of European Information Society : Shifts from G2G. Rome: European Commision .
147. Shaheen, e., & Kavita, J. (2008). Open Source Software in Education . Retrieved 9 21, 2010, from <http://creativecommons.org/licenses/by-sa/3.0.pdf>.
148. Simith, M. K. (2000). Curriculum theory and practice- the encyclopedia of informal education . Retrieved 11 21, 2009, from <http://www.inted.org/bobilio/b-curric.html>: www.inted.org/bobilio/b-curric.html.
149. Sitenen, J. (2007). People and ICT Development. Netherland: IICD.
150. SLT. (2007). SLT,Annual Report – 2007. Colombo: SLT.
151. Svinicki, M. D., & Dixon, N. M. (1987). The Kolb Model mofified for class room activities . College Training , 35, 141-146.
152. Syed, & Amin, U. (2012). An Effective use of ICT for Education and Learning by Drawing on Worldwide Knowledge, Research, and Experience. International Journal of Educational Management.
153. Terima, K. (2010). ICT in Education - Malaysian Experence . MOE.
154. Tinio, V. (2003). ICT in education. New York: United Nations Development Program.
155. Transport, (2003). National ICT Policy, Tenzania. Retrieved 5 8, 2009, from <http://www.tzonline.org/pdf/ictpolicy2003.pdf>.
156. Univeersity Grants Commission. (1984). Report of the Committee appointed to review Admission Policy . Colombo: UGC .
157. Univeersity Grants Commission. (1987). Report of the Committee appointed to review Admission Policy. Colombo: UGC.
158. Univeersity Grants Commission. (2007). University Grants Commision - Unversity

- Admission Hand Book - 2007. Colombo: UGC.
159. United Nations Educational, Scientific and Cultural Organization . (2002). ICT in Education - a curriculum for schools and programme of teacher development. Evgueni Khvilon, Mariana Patru.
160. United Nations Educational, Scientific and Cultural Organization. (2006). ICTs and Educational Indicators. Statistical Unit, UNESCO.
161. United Nations Educational, Scientific and Cultural Organization . (2004). ICT Lessons Learned Series . Thiland: Asia and the pacific regional for Education.
162. United Nations Educational, Scientific and Cultural Organization. (2005). Approchers to ICT development at School Level. Retrieved 12 23, 2009, from <http://www.edu.ge.ch/cptic/prospective/projets/unesco/en/areas.html>.
163. United Nations Educational, Scientific and Cultural Organization. (2007). Supervision: A Key component of a Quality Monitoing System. Retrieved 3 20, 2011, from <http://www.iiep.unesco.org/supervision/sup-mod1.pdf>.
164. United Nations Children's Fund. (2000). Defining Qualify in Education. The International Working Group on Education. Florence: UNICEF.
165. Unwin, L. (2004). ICT & Education in Africa :Partnership, Practice & Knowledge Shairng . Review of African Political Economy , 31(99),150-160.
166. Vanderlinde, R., Van Braak, J., & Tondear, J. (2010). Using an online tools to support School Based ICT policy planning in education. School Based ICT planning.
167. Vassilios, M., & Nelly, K. (2012). course curricular design and development of the M.sc. programme in the field of ict in education forsustainable development. Journal of Teacher Education for Sustainability, 14(2), 5–40.
168. Venkatesh, H. (2007). Inputs from Red Hat India (Pvt) Ltd for the National policy on ICT in education. Inputs from Red Hat India (Pvt) Ltd for the National policy on ICT in education” Venkatesh Hariharan , Red : Red Hat India (Pvt.) Ltd.
169. VisualEmotion . (2010). Seven Universerly recognised Facial Expressions of emotion. Retrieved 2 21, 2012, from Visual Emption LLC: <http://www.facscodinggroup.com/universal-expressions>.
170. Vithanage, D. (2004). Draft initial ICT policy for ICT education. Colombo: MOE.
171. Wagner, D. A., & Day, B. (2005). Monitoring and Evaluation of ICT education Project- A hand book devolping countries . USA: Infodev,World Bank.
172. Walke, L. (2009). open Source Software: What School Leaders Should Know . Retrieved 3 21, 2011, from <http://opensourceschools.org.uk/book/export/html/5922>.
173. Wategama, N., & Wickramasinghe, H. (2003). Regional Human Development Report Promoting ICT for Human Development in Asia . UNDP,Sri Lanka.
174. Werner B. Korte, T. H. (2006). Benchmarking Access and Use of ICT in European Schools 2006. New York : empirica Schriftenreihe.
175. Wood, D. S. (2003). A Comparision of Group-Administtered Survey. An International Journal of Police Strategies and Management , 26(2), 329-340.
176. Yau , C. (2013). R Tutorial with Bayesian Statistics Using OpenBUGS Kindle Edition. amazon.com

Appendix 1: Student's Questionnaire

සමීක්ෂණ දිස්ත්‍රික්කය	කලාපය	පාසල

තොරතුරු තාක්ෂණ අධ්‍යයනයේ ඵලදායිතාව

සෙවීම සඳහා ප්‍රශ්නාවලිය

සිසුන් සඳහා

1.0 සිසුන්ගේ මූලික තොරතුරු

1.1 ශ්‍රේණිය/වසර : 10 වසර 11 වසර

1.2 ස්ත්‍රී පුරුෂ භාවය : ගැහැණු පිරිමි

2.0 ඔබ පාසැලට පැමිණෙන්නේ කුමන දුරක සිටද?

- 1 = 1 – 5 km දක්වා
- 2 = 6 – 10km දක්වා
- 3 = 11 – 20km දක්වා
- 4 = 20 – 50km දක්වා
- 5 = 51 km වැඩි

2.1 ගෙදර සිට පාසැලට යාමටත් පාසැලේ සිට ගෙදරට ඒම සඳහා දිනකට වැය වන කාලය වනුයේ දල වශයෙන්,

- 1 = පැයක් දක්වා
- 2 = පැය 1 කට වැඩි සහ පැය 2 දක්වා
- 3 = පැය 2කට වැඩි සහ පැය 3 දක්වා
- 4 = පැය 3කට වැඩි සහ පැය 4 දක්වා
- 5 = පැය 4ට වැඩි

3.0 පාසැලේ සාමාන්‍ය තොරතුරු

ඔව් නැත නොදනී

3.1 ඔබගේ පාසැලේ පරිගණක විද්‍යාභාරයක් තිබේද?

3.2 තොරතුරු තාක්ෂණ විෂය ඉගැන්වීමට අවශ්‍ය භූරුවරුන් සිටීද?

3.3 ඔබගේ පාසැලේ ජාල පහසුකම් තිබේද?

3.4 ඔබගේ පාසැලේ අන්තර් ජාල පහසුකම් ඇතිද?

ඉහත 3.4 ඔව් නම් පමණක් 3.5 සිට 3.7 දක්වා පිළිතුරු සපයන්න

3.5 විෂය කරුණු ලබා ගැනීමට අන්තර් ජාලය ඔබ විසින් පරිහරනය කර තිබේද?

ඔව් නැත

3.6 School Net වෙබ් අඩවියට සම්බන්ධවී තොරතුරු ලබා ගැනීමට භූරුවරුන් ඔබ යොමුකර තිබේද?

3.7 3.6 ට ඔව් නම් School Net වෙබ් අඩවියට සම්බන්ධ වී විෂය කරුණු ඔබ තනියම ලබා ගෙන තිබේද?

4.0 වෙනත් කරුණු

- | | ඔව් | නැත |
|--|--------------------------|--------------------------|
| 4.1 ඔබ ගෛරදී හෝ වෙනත් ස්ථානයකදී අන්තර් ඡාල පහසුකම් පරිහරණය කර ඒ පිළිබඳ මනා අවබෝධයක් තිබේද? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.2 කාල සටහන අනුව, තොරතුරු සංනිවේදන තාක්ෂණ විෂයේ සිද්ධාන්ත ඉගෙන ගැනීමට අවස්ථාවක් පැසැල තුළ දී ලැබේද? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.3 තොරතුරු සංනිවේදන තාක්ෂණයේ ප්‍රායෝගික පන්ති පහසුකම් ඔබට ලැබේද? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.4 ඔබ විද්‍යුත් තැපෑල භාවිතා කරනවාද? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.5 ඉගෙනුමේ ගැටළු විසඳා ගැනීමට විද්‍යුත් තැපෑල භාවිතය පිළිබඳව පාසැලෙන් උනන්දු කරවන්නේද? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.6 විද්‍යුත් තැපෑල සඳහා ඉංගීසි අකුරු යොදා සිංහලෙන් පණිවිඩය සකසන්නේද? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4.7 එම ප්‍රායෝගික පන්ති වලදී අඩුපාඩුකම් ඇති වන්නේ නම් ඒ සඳහා සාධක ලෙස ඔබට පෙනෙන්නේ | | |

4.7.1	අවශ්‍ය තරම් පරිගණක නොමැති කම	<input type="checkbox"/>	<input type="checkbox"/>
4.7.2	අවශ්‍ය පරිදි ඉරුවරුන් නැතිකම	<input type="checkbox"/>	<input type="checkbox"/>
4.7.3	ප්‍රායෝගික පත්ති වලදී කිරීමට නිශ්චිත කාර්යභාරයන් සඳහන් නොකර සිටීම	<input type="checkbox"/>	<input type="checkbox"/>
4.7.4	ඒ සඳහා නිශ්චිත කාල සටහන් නොතිබීම.	<input type="checkbox"/>	<input type="checkbox"/>
4.7.5	විෂය නිර්දේශයට අනුව අවශ්‍ය මෘදුකාංග හා උපදෙස් නොලැබීම.	<input type="checkbox"/>	<input type="checkbox"/>

විෂය කරුණු පිළිබඳ

5 හා 6 ප්‍රශ්න සඳහා පහත දී ඇති 1,2,3,4,5 වලින් සුදුසු අංකයක් තෝරා කොටුවේ සඳහන් කරන්න. ඔබ 10 වසරේ නම්, 5 වන ප්‍රශ්නය පමණක්ද 11 වසරේ නම් ප්‍රශ්න අසා 5 හා 6 යන දෙකටම පිළිතුරු සපයන්න.

1 = ප්‍රයෝගික හා සිද්ධාන්ත මනා ලෙස තේරුම් ගත හැකි අතර, එහි යෙදීම් නිසිආකාරව කල හැකි ය.

2 = ප්‍රයෝගික හා සිද්ධාන්ත යම් මට්ටමකට තේරුම් ගෙන ඇති අතර,
ප්‍රායෝගික ගැටලු විසදීම සඳහා ප්‍රමාණවත් දැනුමක් නොමැත.

3 = සුලු වශයෙන් අවබෝධ කරගත හැකි වේ.

4 = වැඩි කොටසක් නොතේරේ

5 = එම ඒකකය තවම පාසැලේ උගන්වා නොමැත

5.0 10 වසරේ පාඨමාලා ඒකක

- 5.1 තොරතුරු තාක්ෂණයේ මූලික සිද්ධාන්ත
- 5.2 දත්ත නිරූපනය හා එහි අභ්‍යන්තර ක්‍රියාකාරකම්
- 5.3 වදන් සැකසුම (Word Processing)
- 5.4 විසුරුම් පත්‍රිකා (SpreadSheet)
- 5.5 ප්‍රදර්ශන පැකේජ (Presentation)
- 5.6 දත්ත සමුදායන් කළමනාකරණය(Database management)
- 5.7 පරිගණක ජාල හා අන්තර් ජාල කටයුතු

1	2	3	4	5
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.0 11 වසර සඳහා

- 6.1 තොරතුරු පද්ධති (Information Systems)
- 6.2 පරිගණක වැඩසටහන්/සංකල්ප (Programming Concepts)
- 6.3 වෙබ් අඩවි නිර්මාණය (Web Designing)
- 6.4 තොරතුරු තාක්ෂණය හා සමාජය (ICT and Society)
- 6.5 කේවල ව්‍යාපෘතිය (Individual Project)

1	2	3	4	5
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7.0 තොරතුරු තාක්ෂණය විෂය ඉගෙනගැනීමේදී ඔබ මුහුණ දෙන දුෂ්කරතා වනුයේ

		ඔව්	නැත
7.1	ඉංග්‍රීසි දැනුම අඩුකම	<input type="checkbox"/>	<input type="checkbox"/>
7.2	භාරවරුන් අඩුකම හෝ වෙනත් හේතූන් නිසා විෂය නිර්දේශය නිසි පරිදි ක්‍රියාත්මක නොවීම.	<input type="checkbox"/>	<input type="checkbox"/>
7.3	නිසි පරිදි සකස් වූ ප්‍රායෝගික ක්‍රියාකාරකම් මගින් ප්‍රායෝගික දැනුම නොලැබෙන නිසා	<input type="checkbox"/>	<input type="checkbox"/>
7.4	ඒ සඳහා වෙන් වූ පොතපත නොමැති කම	<input type="checkbox"/>	<input type="checkbox"/>
7.5	තොරතුරු සංනිවේදන තාක්ෂණය විෂයන්ට වෙන් වූ නිසි පරිදි සැකසූ උපකාර පත්ති නොතිබීම.	<input type="checkbox"/>	<input type="checkbox"/>
8.0	අනෙකුත් විෂයන් ඉගෙනීමට තොරතුරු තාක්ෂණය මෙවලමක් ලෙස යොදා ගැනීම.		
		ඔව්	නැත
8.1	වෙනත් විෂයන් ඉගෙන ගැනීමට (ගණිතය / විද්‍යාව/ඉතිහාසය) වැනි තොරතුරු තාක්ෂණය මෙවලමක් ලෙස පරිහරණය කරනවාද?	<input type="checkbox"/>	<input type="checkbox"/>
8.2	ජාතික අධ්‍යාපනික ආයතනයේ හෝ වෙනත් ආයතනවලින් සපයා ඇති අධ්‍යාපනික තොරතුරු අඩංගු (විෂය කරුණු ඉගෙනීමට) සංයුක්ත හැටි ඔබ පාසැලේදී භාවිත කරනවාද?	<input type="checkbox"/>	<input type="checkbox"/>

		ඔව්	නැත
8.3	විෂය නිර්දේශය ගුරු හා සිසු අත්පොත් හා අධ්‍යාපනික තොරතුරු ජාතික අධ්‍යාපනික ආයතනයේ වෙබ් අඩවියෙන් ලබාගෙන ඇතිද?	<input type="checkbox"/>	<input type="checkbox"/>
8.4	තොරතුරු තාක්ෂණය මෙවලමක් ලෙස යොදා ගෙන වෙනත් විෂයයන්හි ව්‍යාපෘති ඔබ පාසැලේ කර ඇතිද?	<input type="checkbox"/>	<input type="checkbox"/>

9.0 වෙනත් තොරතුරු

9.1	ඔබ පාසැලේ භාවිතා කරන ක්‍රියාකාරී පද්ධතිය 1 = Windows ක්‍රියාකාරී පද්ධතිය 2 = Open Source (Linux ,Ubanto) වැනි 3 = ඉහත 1 හා 2 පද්ධති 4 = ඒ පිළිබඳ කිමට දැනුමක් නොමැත	<input type="checkbox"/>
-----	--	--------------------------

9.2	ඔබ පාසැලේ භාවිතා වන යෙදීම පැකේජ වනුයේ 1 = (Microsoft Office) මයික්‍රො සොෆ්ට් ඔෆිස් 2 = Open Office 3 = ඉහත දෙකම 4 = මේ පිළිබඳ කිමට ප්‍රමාණවත් දැනුමක් නොමැත	<input type="checkbox"/>
-----	---	--------------------------

	ඔව්	නැත
9.3 ICT විෂයට අදාළ ඇගයීම් / කණ්ඩායම් ව්‍යාපෘති වැනි දේ කරනවාද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.4 ඔබ තොරතුරු තාක්ෂණ විෂයට උපකාරක පංති යන්නේද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.5 උපකාර පන්තියෙන් ප්‍රායෝගික පුහුණුව මනාලෙස ලැබෙන්නේද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.6 ඔබ පාසැලේ පරිගණක විද්‍යා සංගමයක් (Computer Society) තිබේද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.7 9.6 ඔව් නම් ඔබ එහි සාමාජිකයෙක්ද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.8 ඔබට ගෞරව පරිගණකයක් තිබේද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.9 9.8 ඔව් නම් එයට අමතර අන්තර් ජාල පහසුකම් ලබා ඇතිද?.....	<input type="checkbox"/>	<input type="checkbox"/>
9.10 ඔබට E-mail address එකක් ඇතිද? එයින් විද්‍යුත් ලිපි ගනුදෙනු කරන්නේද?...	<input type="checkbox"/>	<input type="checkbox"/>
9.11 අන්තර් ජාලය විවිධ අධ්‍යාපනික කටයුතු හෝ වෙනත් එදිනෙදා කටයුතු..... වලට යොදා ගන්නේද?	<input type="checkbox"/>	<input type="checkbox"/>

ඔබ දැක්වූ සහයෝගයට ස්තූති වන අතර එය ඔබු පරපුරේ තොරතුරු තාක්ෂණ විෂය නැගී විමට හේතු වේවා යැයි විශ්වාස කරමින් ඔබ දැක්වූ ප්‍රතිචාරය ඉතා අගය කොට සලකමි.

නොයෙල් ප්‍රනාන්දු

ජ්‍යෙෂ්ඨ කථිකාචාර්ය

කොළඹ විශ්ව විද්‍යාල පරිගණක අධ්‍යයන ආයතනය.

කොළඹ 07

Appendix 4 – Case study schedule for NIE Authorities

The following information is intended to be collected through interviews from selected relevant authorities of the National Institute of Education (NIE).

When implementing ICT education in Sri Lankan schools, what kind of problems and issues are faced by the NIE? (Skills of Teachers, Infrastructure facilities, lack of trainers, financial issues, policy matters, curriculums), Status of the present ICT education.

Pre-service and In-service Teacher training methodologies, problems and issues in connection with different ICT programs in the Sri Lankan educational system, role of NIE in connection with ICT teachers and ICT master trainers' related to the training programs (whether it includes practical and theory or both) , Are workshops, regular seminars conducted? Availability of Master plan for teacher training, implementation models etc.

Status of the course materials (paper, multimedia educational CD's, Web Contents) CD's, accessibility to students and teachers, curriculum revision methodologies, determination of compatibility with international standards.

Research and development in connection with the curriculum, teacher training and other implementation issues

Co-operation of other organizations (e.g. MOE, NCOE, NEC, Provincial educational officers etc.) in the development of ICT education in Sri Lanka.

Application of following pedagogical techniques for teacher training programmes:

Kolb's experiential learning circle, Bloom's Taxonomy, Role Model, Stakeholders' feedback, Class room observation.

NIE views regarding new teaching trends in ICT education (ICT education, LMS, E-learning, Blended Learning, and TV programmes, Virtual Class room).

Research activities in connection with the enhancement of ICT education

Appendix 5 – Case study schedule for MOE Authorities

- What are the programmes that were implemented and will be implementing to enhance the ICT education?
- What are the strengths and weaknesses of the present ICT education in Sri Lanka educational system in connection with infrastructure facilities, computers, networking, schoolNet facilities etc.?
- What are the ICT resource allocation criteria, resource utilization, and alternative solution for school that lack of ICT equipment, a sustainability and maintenance plan? What are the steps taken to overcome the above mentioned problems and issues in connection with ICT education?
- What is the acquisition procedure of computers, software and hardware and other equipment related to ICT education?
- What kind of teacher training programmes were provided to enhance ICT education, status of the present ICT cadre positions, recruitment and teacher assignment for ICT course units conducted at schools
- Did you prepare any course materials for ICT education and ICT in education? , need assignments
- This is in connection with GCE(O/L) ICT curriculum, what is the number of students in a class, how many periods are allocated for the ICT subject (for theory and practical separately), learning day per academic year, number of ICT periods per week
- Do you conduct Teacher evaluation methodologies in connection with ICT education
- What are the main aims and objectives of providing an OLPC computer to a school child? Were the objectives achieved?
- Practical problems and issues in connection with the implementation of OLPC programme at schools
- What is the teacher requirement procedure , cadre, training requirements, training possibilities for in-service and pre-service teachers, master plan for teacher training, availability of implementation models,
- What are the monitoring procedures of the progress of ICT education at school, zones, provinces and ministry level
- What is the monitoring procedure of the implemented programmes and their smooth functionalities, what are the shortcoming and excesses in facilities, training requirements,
- What are the Expected activities of CRC centers?
- Is MOE developing course contents for ICT education and ICT in education?
- Are workshops, seminars conducted regularly to update teachers?
- What are the recommended software used for school and teacher training programs and their cost?
- How does MOE encourage use of initiative programs like development of schools web sites, ICT completions (quiz and projects) etc.
- How is use of SchoolNet, LMS, e-learning, blended learning, virtual learning encountered as development initiative of ICT education among the students and teachers as a way of elimination of 100% face to face teaching and maximum utilization of the above resources.

Appendix 6: Case study schedule for CRC officers and Provincial/zonal officers / ICT center coordinators

The main role of the CRC's and MOE expectation from CRC's

Present status of the CRC's in relation to infrastructure, equipment and Human resource programmes

Available programs at CRC's and Target group of students and their performance

Investigation of the possibility of conducting teacher training programmes at CRC's

Investigation of possibility of the use of CRC's resources, schools that lack ICT facilities

Performance and progress of CRC courses and their strengths and weaknesses

Cooperation and co-ordination between CRC's and MOE, Provincial educational offices,

Zonal educational offices and respective schools

Proposal for the development of CRC's and How CRC's could contribute to the enhancement of ICT education in Sri Lankan schools

Maintenance and sustainability plan of CRC's

Main role of Provincial and zonal educational offices and ICT center coordinators in connection with development of ICT education in Sri Lankan schools

Strengths and weaknesses of the above mentioned officers in connection with development of ICT education in Sri Lankan Schools

What would they expect from MOE, NIE or other relevant authorities to enhance ICT education in Sri Lankan?

What are the proposal and suggestions to improve ICT education in Sri Lankan Schools from the above mentioned officers' point of view?

How can interaction (coordination) between the high level management and low level operation management be improved in the development of ICT education in Sri Lanka, capabilities and weaknesses of the above mentioned officers to enhance ICT education.

Appendix 7: Informal Interview Schedule for NEC Officers

Status and vision of ICT education policy in Sri Lankan Schools

Importance of ICT policy to plan ICT education

The present Status of draft policies initiated on several occasions

Reasons for the delay in implementation of ICT policy for ICT education

The problems and issues due to the lack of policy for ICT education

Appendix 8: Informal Interview Schedule for ICT experts in Universities

The main objectives of ICT education in the expectation of success of higher education and industry requirements

The present status of ICT education in Sri Lanka compared to other developed and developing countries, If Sri Lanka has passed other countries, what are the major reasons for this?

Availability of right instructions and guidelines from the relevant authorities to implementers in ICT education.

Availability of adequate Teacher training and teacher updating programs to achieve the objectives

Do ICT curricula meet international standard and benchmarks?

Do Curricula achieve the country expectation and national goals?

Are ICT teachers skillful enough to teach ICT curricula in a successful manner?

What is the Status of Students capability as learning ICT education as expected

Availability of Infrastructure, computers and other related equipment to achieve objectives

Are curricula compatible with industry requirements

Does the English language barrier create problems in ICT education?

Accessibility of our students and teachers in modern trends in ICT education

Investigation of the school systems in the used modern computer applications such as LMS, e-learning, blended learning techniques to enhance the ICT education

The status of students' performance at the national evaluation when compared to other subjects in the same baskets

Steps taken to enhance the ICT education in Sri Lankan schools to achieve the expected objectives and outcomes

Appendix 9: Informal Interview Schedule for ICT Industry experts

Investigation of The ICT curriculum contents versus required output to industry requirements

The different kinds of software usage needed for school education

The different kinds of hardware usage and skills needed for the industry

The kind of supportive initiative incorporated with school education

Appendix 10: Class room observation form:

Faculty _____ Date of observation _____

Peer Observer _____

1.0 Basic class room observation

- Is lesson conducted in the computer lab or the normal class room?
- If it in the lecture room whether it is a practical oriented unit or theory oriented course module?
- If it is a theory oriented course module, does the teacher explain using examples, diagrams and clear explanation in an acceptable manner? Did they use a multimedia projector?
- If it is a theory unit and if they used the computer lab to give instructions, was it that convenient for students as well the teacher
- If it was a practical unit, could students access computers adequately?
- If they were shared, were weak students de-motivated further or does motivation exist
- Are there any other minimum facilities (e.g. Internet, software, etc) to facilitate conduct of lesson?
- Are there any documented practical sheets for practical sessions?
- Are Practical sessions compatible with the curriculum objectives
- Was their motivation of students by teacher to ask question, propose suggestions related to current topic
- Capability of teachers to answer student's questions evident?
- Do teachers encourage use of students' peer education activities in the practical session?

2: Development of learning objectives

- Are objectives for the class given verbally, written, or not at all?
- Are specific instructional outcomes used?
- Are objectives discussed at the end of class?

3 Selection and use of instructional materials:

- Do websites and other audiovisual materials have a clear purpose?
- Are all the above materials relevant to the topic?
- Were they explained using diagrams, examples and appropriate object to facilitate understanding of contents

4 Educational climate for learning:

- Are students and the teacher interested and enthusiastic?
- Is humor used appropriately?
- Is the atmosphere of the classroom participatory?
- Did the teacher make eye contact with students?

5 Variety of instructional activities:

- Does the timing of classroom activities take attention spans into consideration?
- Does the teacher involve students in deciding on what issues to discuss?

6 Preparation for class session:

- Provide examples that show preparation by teacher.
- Do students know what preparation (reading or other assignments) they should have completed prior to the class?

Appendix 11: Workshop observation schedule

Observe the punctuality of teachers in connection with attending and participating in workshops

Observe the preparation of teachers for the workshop

Understand the initial skill level of teachers on a particular section of the GCE (O/L) curriculum

Conduct the workshop session using active learning principles (lecture breaks, lesson objectives at the beginning, lesson summarization and hand on exercises, through peer learning, etc.) and observe the behavior of participants.

Observe the learning interest of teachers

At end of the session, randomly check the skill levels of teachers on the session

Determine the level of problem solving skills giving hands on exercises and determine the problem solving skills with educational qualifications, experience

Observe the interest of teachers to learn new trends in ICT

Study the ability of teachers in teaching through peer education techniques

Determine the suitability of the venue for conducting a workshop and facilities (infrastructure and other related equipment)

Availability of course materials for the workshop

Determine teachers' feedback on workshop

Observe the ability of teachers to learn about peer education and blended learning

Determine the communication, technical and team working skills of teachers

Determine the status of teachers to express ideas and opinions more effectively and with self-confidence on ICT education

Observe the teachers in connection with have they express their creativity.

Observe the domain knowledge of administrators and organizers of the workshop with the aim of determining the ability at judging the progress of the workshop.

Appendix 12

Infrastructure Facilities (X₁)

Table 1.1 Availability of a computer laboratory in their schools from students' point of view

District	Total Students	Number of computer labs in their schools	Percentage of computer labs in their schools	Percentage %	don't Know	Percentage %
Total	1295	1270	98%	24	2%	1 0%
Colombo	510	498	98%	12	2%	0 0%
Gampaha	257	247	96%	10	4%	0 0%
Puttalam	217	214	99%	2	1%	1 0%
Hambantota	193	193	100%	0	0%	0 0%
Nuwara Eliya	118	118	100%	0	0%	0 0%

Table 1.2 Main power supply source for school education activities

	Total	Main Electricity	Percentage %	Solar Power	Percentage %
Total	32	32	100%	0	0%
Colombo	11	11	100%	0	0%
Gampaha	7	7	100%	0	0%
Puttalam	4	4	100%	0	0%
Hambantota	7	7	100%	0	0%
Nuwara Eliya	3	3	100%	0	0%

Table 1.3 Availability of computer network and internet facilities in schools

Availability of Networking Facilities	Availability of Networking Facilities				Availability of internet Facilities	
	Students' Questionnaire		Principal's Questionnaire		Students' Questionnaire	
	Yes %	No %	Yes %	No %	Yes %	No/Don't know %
Total	75%	25%	75%	25%	83%	17%
Colombo	73%	27%	73%	27%	84%	16%

Gampaha	57%	43%	57%	43%	72%	28%
Puttalam	75%	25%	75%	25%	90%	10%
Hambantota	86%	14%	86%	14%	75%	24%
Nuwara Eliya	100%	0%	100%	00%	99%	1%

Table 1.4 Number of working computers in the schools from the principal's point of view

	Total	Average No of Computers per school
Total	31	23
Colombo	11	29
Gampaha	7	15
Puttalam	4	6
Hambantota	6	28
Nuwaraliya	3	36

Table 1.5 Computer student ratio of students who are doing ICT as a subject

	Average Number of working Computers	Number of ICT students	Computer/Student Ratio
Total	136	1650	12
Colombo	29	573	20
Gampaha	15	325	21
Puttalam	6	158	26
Hambantota	28	466	17
Nuwara Eliya	36	128	4

Table 1.6 Number of breakdown computers in schools

District	Number of breakdown computers per schools
Total	3
Colombo	4
Gampaha	3
Puttalam	1
Hambanthota	5
Nuwara-Eliya	4

Table 1.7. The required information in connection with ICT specialization subject about those who are doing ICT as a subject for the GCE (O/L) examination

Description	No of Units
Maximum number of students in present class	40
Number of periods assigned for ICT subject in grade 10 and 11	208
Number of practical hours assigned for ICT subject in grade 10 and 11	102
Number of working days per academic year	202
Number of effective learning weeks per year	35
Effective percentage of Lab utilization	90%
Number of ICT periods per week (grade 10 and grade 11 both)	3 Each

Human Resource Facilities (X₂)

Table.1.8 Difficulties to implement ICT specialization subject in grade 10 and 11 in relation to human resource facilities.

Difficulties	%
Un-filed ICT Vacancies	38%
Lack of adequately trained ICT teachers	81%
Non-ICT appointments who perform ICT specialization subject	52%
Lack of ICT teachers	22%

Tablexx.1.9 Duration of training obtained by teachers to teach ICT subject

	Total	Up to 20 Days		21 Days to 1 Month		1-3 Months		3 Months to 1 Year		More than 1 Year	
			%		%		%		%		%
Total	48	5	10%	3	6%	6	13%	14	29%	20	42%
Colombo	19	1	5%	1	5%	3	16%	7	37%	7	37%
Gampaha	9	1	11%	0	0%	3	33%	2	22%	3	33%
Puttalam	6	1	17%	0	0%	0	0%	2	33%	3	50%
Hambantota	10	2	20%	2	20%	0	0%	1	10%	5	50%
Nuwara Eliya	4	0	0%	0	0%	0	0%	2	50%	2	50%

Table 1.10 Are teachers expecting well organized training programs to teach ICT subject in a quality manner?

	Total	Yes	Percentage %	No	Percentage %
Total	48	48	100%	0	0%
Colombo	19	19	100%	0	0%
Gampaha	9	9	100%	0	0%
Puttalam	6	6	100%	0	0%
Hambantota	10	10	100%	0	0%
Nuwara Eliya	4	4	100%	0	0%

Table 1.11 Student information at Lumbiniya Computer Resource Center

Year	After O/L	After A/L	Total
1998	156	460	616
1999	684	480	1164
2000	885	574	1459
2001	1309	742	2051
2002	429	340	769
2003	734	457	1191
2004	605	245	850
2005	230	193	423
2006	205	189	394
2007	183	89	272
2008	194	90	284
Total	5614	3859	9473

Maintenance and sustainability issues (X₃)

Table 1.12 Computer Breakdown ratio in different districts

District	Average Number of Working Computers	Average Number of not working Computers	breakdown Ratio
Total	23	3	13%
Colombo	289	4	1%
Gampaha	15	3	20%
Puttalam	6	1	17%
Hambantota	28	5	18%
Nuwara Eliya	36	4	11%

Table 1.13 – Availability of computer maintenance mechanism from MOE or provincial educational officers

	Total	Yes	Percentage %	No	Percentage %
Total	47	19	40%	28	60%
Colombo	19	5	26%	14	74%
Gampaha	8	3	38%	5	63%
Puttalam	6	3	50%	3	50%
Hambantota	10	5	50%	5	50%
Nuwara Eliya	4	3	75%	1	25%

Table 1.14 Are there any Computer maintenance agreements from the MOE or any other authorities - principal's points of view

	Total	Yes	Percentage %	No	Percentage %
Total	32	11	34%	21	66%
Colombo	11	3	27%	8	73%
Gampaha	7	2	29%	5	71%
Puttalam	4	2	50%	2	50%
Hambantota	7	3	43%	4	57%
Nuwara Eliya	3	1	33%	2	67%

Table 1.15 - Do you have the ability to maintain a computer network- Principal's point of view?

	Total	Yes	Percentage %	No	Percentage %
Total	32	14	44%	18	56%
Colombo	11	5	45%	6	55%
Gampaha	7	2	29%	5	71%
Puttalam	4	2	50%	2	50%
Hambantota	7	4	57%	3	43%
Nuwara Eliya	3	1	33%	2	67%

Table 1.15a - Issues and problems that affect ICT education – lack of upgradable possibilities of computers and other equipment

	Total	strictly effected	Percentage %	Slightly affected	Percentage %	not effected	Percentage %
Total	47	29	62%	11	23%	7	15%
Colombo	19	15	79%	2	11%	2	11%
Gampaha	8	7	88%	0	0%	1	13%
Puttalam	6	2	33%	2	33%	2	33%
Hambantota	10	4	40%	5	50%	1	10%
Nuwara Eliya	4	1	25%	2	50%	1	25%

Software (X4)

Table 1.16 Ability of teachers to install the required operating systems/application software and troubleshooting

	Total	Yes	Percentage %	No	Percentage %
Total	47	16	34%	31	66%
Colombo	19	4	21%	15	79%
Gampaha	9	1	11%	8	89%
Puttalam	6	1	17%	5	83%
Hambantota	9	8	89%	1	11%
Nuwara Eliya	4	2	50%	2	50%

Curriculum implementation issues (X₅)

Table 1.16 Issues and problems that affect to implementation of ICT specialization subject for Grade .

Issue	%
Lack of text Books	41%
Lack of Library Facilities	52%
Lack of English Knowledge	51%
lack of proper guidance from the relevant authorities	75%
lack of enhanced methodologies	57%
lack of clearly defined practical session in the time table	51%

Table 1.17 Usage and application of pedagogical techniques

Techniques	usage and application in the teacher training programs	usage and application in teaching and learning process in their schools
Kolb's reflective learning circle	2.04%	2.04%
Bloom's Taxonomy	2.04%	2.04%
Blended learning technologies	2.04%	2.04%
Stakeholders feedback	8.16%	2.04%
Classroom observation	2.04%	2.04%
Role model	2.04%	2.04%
Activity based teaching and learning programs	2.04%	2.04%

Supportive initiative (X₇)

Table 1.18 : Availability of Supportive initiative

Name of the Supportive Initiative	%
Availability of the web site in the school	66%
Connected to the SchoolNet	73%
Usage of e-mail to solve the day-to-day problems	54%
Availability of a computer society in the school	52%
Membership of the computer society (out of the availab	65%
Availability of computer facilities in student's residen	59%
Availability of computer facilities in teacher's residen	39%
Usage of computers in school for administration	84%

Table 1.19 Principals' trained information about the computer education and e-citizenship program

	Total	Yes	Percentage	No	Percentage
Total	32	19	59%	13	41%
Colombo	11	7	64%	4	36%
Gampaha	7	4	57%	3	43%
Puttalam	4	3	75%	1	25%
Hambantota	7	2	29%	5	71%
Nuwara Eliya	3	3	100%	0	0%

Research and Development (X₈)

Table 1.19: Principals attitude towards the ICT subject will improve students' knowledge, usage of hi-tech instruments, self-problem solving and critical thinking abilities, improvement of attitudes than any other subject

	Total	Maximum level	Percentage	Acceptable Level	Percentage	Slightly	Percentage	No	Percentage
Total	32	20	63%	11	34%	1	3%	0	0%
Colombo	11	5	45%	6	55%	0	0%	0	0%
Gampaha	7	4	57%	2	29%	1	14%	0	0%
Puttalam	4	4	100%	0	0%	0	0%	0	0%
Hambanthota	7	6	86%	1	14%	0	0%	0	0%
Nuwara Eliya	3	1	33%	2	67%	0	0%	0	0%

Table 1.20 Recommendation to the enhancement of ICT specialization in Grade 10 and 11

Recommendation	%
Knowledge sharing through group projects and presentations	88%
Knowledge sharing using internet facilities	97%
knowledge sharing through the schoolNet	91%
knowledge sharing through e-learning-conference and virtual classroom concept	88%
knowledge sharing using blended learning technologies	61%
Use of the existing traditional technologies rather than using the blended learning approaches	0%

Appendix 13: Flexibility of Free and Open Source Usage

Financial investigation and alternative solution for software

Based on the informal interview conducted with the MOE authorities, it can be believed that usages of quality software were concerned about the high cost. Further, they were very concerned with ethics (avoid use of pirated software) in connection with software products. As a result of this, they are trying to introduce open source products for ICT education in Schools. Based on their information the following were presented as follows.

At present, there are 9717 schools functioning (MOE, 2011) and 4888 schools have computer labs. If it is assumed that each lab has 23 computers the financial implications for software can be considered as in Table 5.2

Table 1 licensed software Price table (prices based on, March 2010 Rates)

Item name	Unit price	For present computer labs (4888)	For all schools in future (9717)
Microsoft windows operating system (client)	RS.7000/=(for one machine)*23	786.96 million	1564.43 million
Microsoft windows server (enterprise edition)	Rs.70000/=(for one server)	342.16 million	680.19 million
Microsoft office package	Rs 5000/=(per one server)	24.44 million	48.59 million
Virus protection	Rs.3000/=(Per one server)	14.66 million (per one server)	29.15 million
Total price for the year		1168.22 million	2322.36 million

If school systems use Open Source Software with the aim of saving money and improving the critical thinking abilities of students, the government can save 2322.36 million Rupees and that money can be used to provide computers or other resources to schools that do not have computer facilities in their schools. For example, the government can purchase 46672 computers for the national educational system and hence can decrease the computer student ratio in schools.

Further, Alternative software for the smooth implementation of the school curriculum can be used as follows.

If developing countries use FOSS for their teaching/learning purposes, they can provide more skills to teachers and students and the other school community .In addition to the above; the financial benefits also can be obtained. Further, FOSS provides deeper knowledge and critical thinking abilities to the school community (Banerjee, 2008).The following describes the suitability of FOSS rather than the use of other Non-FOSS for school education.

As an alternative solution, provision of FOSS operating systems for classroom and/or administrative computers (e.g. Red Hat Linux, SuSE Linux, Ubuntu and other Linux from Oracle etc.) against the different versions of Microsoft Operating Systems can be considered. As application software, provision of application software for classroom and/or administrative (the two office suites (the relatively low-cost StarOffice and the free OpenOffice) is of particular importance (Becta, 2005)

Further, Open Office has around 92 different languages. It includes the following features and programs and are able to perform more features than the closed source operating systems. (UNESCO, UNESCO, Report of the discussion on Free and Open Source Software (FOSS) for Open Educational Resources, 2006, <http://oerwiki.iiep.unesco.org/in2006>)

- a) OpenOffice Writer: text processor, equivalent to MS Word.
- b) OpenOffice Draw: 2D vectorial graphics, equivalent to MS Word graphic tools.
- c) OpenOffice Calc: spread sheet, equivalent to MS Excel.
- d) OpenOffice Impress: presentation, equivalent to MS PowerPoint.
- e) OpenOffice Base: database, equivalent to MS Access.
- f) OpenOffice Math: formula or equation editor, no feature equivalent in MS Office.
- g) OpenOffice Pdf Generation: no feature equivalent in MS Office.

For creative designs, More advanced graphics packages are sometimes necessary to produce 2-dimensional (or 3dimensional) illustrations, process photography, put together texts and illustrations, and layout pages, posters, leaflets, text books and other educational resources in the school system.

Further, Popular commercial graphic software packages in the market are: (UNESCO, UNESCO, Report of the discussion on Free and Open Source Software (FOSS) for Open Educational Resources, 2006, <http://oerwiki.iiep.unesco.org/in2006>) CorelDraw, Publisher, MS Visio, Illustrator, PageMaker, Adobe Photoshop, In-Design, 3D Studio MAX, Maya, AC3D, Aladdin 4 D, Animation, Carrara etc. All the above Software products are closed source and commercial products while their features, facilities and developing capabilities are low with respect to the FOSS graphics software available in Web (Walke, 2009) (i) Scribus (professional page lay-out) an excellent alternative to MS Publisher, Quark Xpress, Adobe PageMaker or Adobe in Design to lay out any document. (ii) Inkscape (2D vectorial graphics) Equivalent to Adobe Illustrator (iii) Dia (diagram creation) Similar to MS Visio. (iv) QCad (2D CAD) a kind of AutoCAD software limited to 2-dimensional graphics. (v) Gimp (2D graphics and photo) Equivalent to Adobe Photoshop. (vi) Blender (3D graphics) -A powerful 3D modelling, animation, rendering, post-production interactive creation and playback package. (vii) Terragen (3D scenery generator and rendering) Generates photorealistic landscape and special effects in 3D.

These can be used both by teachers and by students; there were many references to them in the case studies (UNESCO, UNESCO, Report of the discussion on Free and Open Source Software (FOSS) for Open Educational Resources, 2006, <http://oerwiki.iiep.unesco.org/in2006>)

Further, learning management software is useful in learning management system systems; another aspect of the open source movement on education is the rapid usage of open source Learning Management Systems (LMS) tool and other learning applications. LMS tools are used mostly to create and manage the learning contents on the web. Example LMS tools are (i) Moodle ,(ii) Babington,(iii) claroline,(iv)Dokeos (v) .LRN etc. these LMS tools compatible with (i)Linux, UNIX, Windows, Mac OS X, FreeBSD, and any other systems that support PHP,(ii)Shibboleth, Linux, Microsoft, Mac OS X or UNIX ,(iii) Microsoft, Linux/GNU, Mac OS X, compiles with SCORM and IMS/QTII , (iv)supports SCORM import and LDPA. Data can be imported using CVS or XML files, and (v)LORS central, Curriculum, LORS management, .LRN Ecommerce, Project Manager, Page Editor, Staff List, Syllabus, Expense Tracing) respectively.

In addition to the above, a major area of software used in the school education systems is web designing, programming and multimedia etc. Similar to the above, there are a lot of collections of commercial closed source software currently used in the schools system and money is spent on the purchase of Non-FOSS products. All the above features in the commercial software or more features and flexibility to the education system are embedded in FOSS software and all Sri Lankan educational system can fulfill their software requirement through FOSS solutions

Appendix 14: Activity Models

The following five (05) activities were performed through a series of workshops

Activity Model 1

This sample activity model covers the first level of Bloom's taxonomy (key words are used according to verbs given in Table 6.3 in Chapter 6) and it was implemented according to the guidance given in Kolb's customized reflective learning circle given in Table 6.7 in Chapter 6.

Implementation of theFirst stage of activities of Bloom's Taxonomy

Ex.1 .1 Define the basic data types used in Python programming language. List how different data types can be used to solve applications in problem solving activities. You may use simple examples.

The above activities were performed as follows:

Stage 1: Activities in connection with the concrete experience in Kolb's experimental learning circle

- (i) Provided lecture notes, e-materials, sample solved related questions.
- (ii) Granted access to online help facilities with the python programming language.
- (iii) Provided facilities for peer discussion to further strengthen individual answers.

Stage 2: Activities in connection with the Reflective observation in Kolb's experimental learning circle

- (i) Conducted brainstorming session in connection with the different data types in python, their applications and how to apply these data types with activities related to problem solving with real life applications.
- (ii) Provided environment to judge own solutions in connections with different data types and applications.
- (iii) Provided facilities to maintain a reflective log in connection to the outcomes to the question in activity model 1.

Stage 3: Activities in connection with the Abstract conceptualization in Kolb's experimental learning circle

- (i) Conducted a series of lectures in connection with the following methodologies: Bloom's Taxonomy and its application, blended learning approaches (e.g. To use e-materials, educational web sites, familiarizations with LMS, on-line courses in connection with the data types and application in python etc.).
- (ii) Provided facilities to use stage 1 of Bloom's taxonomy in connection with data types and their application.
- (iii) Provided guidance to design learning activities using the first level of Bloom's taxonomy to achieve the learning outcomes. Provided guidance to prepare examination questions using the first level of Bloom's taxonomy.
- (iv) Provided facilities to discuss Exercise 1.1 through an on-line discussion forum based on individual answers and explored the possibilities of enhancing the definition using e-materials through educational web sites.
- (v) Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes coming under the first level of Bloom's taxonomy.
- (vi) Provided facilities to use LMS activities in connection with activities and evaluation related to the different data types and problem solving activities in python programming languages using the first level of Bloom's taxonomy.
- (vii) Provided facilities to discuss within peer-peer student groups and master teacher-student approach related to the first level of Bloom's taxonomy.

Stage 4: Activities in connection with the Active experimentation in Kolb's experimental learning circle

- (i) Provided a brainstorming session to encourage use of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement.
- (ii) Provided facilities to prepare own learning materials using Peer-discussion, blended learning approach (e-learning materials, LMS), brainstorming sessions according to the first level of Bloom's taxonomy.
- (iii) Provided facilities to design own evaluation materials using the above mentioned methodologies for practice with their students according to the first step of Bloom's taxonomy

Activity Model 2

This sample activity model covers the second level of Bloom's taxonomy (key words are used according to verbs given in Table 6.3 of Chapter 6) and it was implemented according to the guidance given in Kolb's customized reflective learning circle given in table 6.7 of Chapter 6.

Implementation of Second Stage activities of Bloom's Taxonomy

Ex.2 Consider the following python programming segment

Import math # makes the math library available.

```
def main():
print("This program finds the real solutions to a quadratic")
print()
a, b, c = eval(input("Please enter the coefficients (a, b, c): "))
discRoot = math.sqrt(b * b - 4 * a * c)
    root1 = (-b + discRoot) / (2 * a)
    root2 = (-b - discRoot) / (2 * a)
print()
print("The solutions are:", root1, root2 )
main()
```

- a) **Discuss** what the above python code is intended for.
- b) **Describe** similar built-in-functions available in the python library and discuss their application in the problem solving domain.
- c) **Recognize** which data types can or cannot be in different built-in-functions of python.

Stage 1: Activities in connection with the concrete experience in Kolb's experimental learning circle

- (i) Provided lecture notes, e-materials, sample solved questions in connection with solving quadratic equations and related theories.
- (ii) Granted online help facility access in the python programming language and related facilities to use built-in-functions that can be used to solve mathematical problems.
- (iii) Provided facilities through lecture notes and e- materials to identify data types for use with different built-in-functions available in the python library.
- (iv) Provided facilities for peer discussion to further strengthen individual answers asrelated to the three factsabove.
- (v) Further, necessary resources were provided to obtain the output of the above program.
- (vi) Provided necessary manuals to show how to eliminate the errors in the program and give similar questions to de-bug as supplied in the Note set provided by the researcher.

Stage 2: Activities in connection with the Reflective observation in Kolb's experimental learning circle

- (i) Brainstorming sessions were conducted in connection with the use of: built-in-function, and to identify the errors in a program, interpreting correct python codes with suitable built-in-functions available in the python library and interpreting other built-in-functions that can be used to solve mathematical applications.
- (ii) Provided environment to judge their solutions in connection with built-in-functions and its applications.
- (iii) Provided facilities to maintain a reflective log in connection with the outcomes to the question in activity model 1.

Stage 3: Activities in connection with the Abstract conceptualization in Kolb's experimental learning circle

- (i) Conducted a series of lectures in connection with the following methodologies: Bloom's Taxonomy and its application, blended learning approaches (e.g. To use e-materials, educational web sites, familiarizations with LMS, on-line courses in connection with the built-in-functions and its various application in the domain).
- (ii) Provided facilities to use stage 2 of Bloom's taxonomy in connection with the built-in-functions and application, debugging and obtain results from executing different sample programs.
- (iii) Provided guidance to design learning activities to achieve the learning outcomes using the second level of Bloom's taxonomy.
- (iv) Provided guidance to prepare examination questions using the second level of Bloom's taxonomy.
- (v) Provided facilities to discuss activities and similar sample activities through an on-line discussion forum based on individual answers and explore possibilities to enhance the definition using e-materials through educational web sites.
- (vi) Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes contained in the second level of Bloom's taxonomy.
- (vii) Provided facilities to use LMS activities in connection with activities and evaluation related to the different built-in-functions, de-bugging and problem solving activities in photon programming languages using the second level of Bloom's taxonomy.
- (viii) Provided facilities discussed within peer-peer student groups and master teacher-student approach related to second level of Bloom's taxonomy.

Stage 4: Activities in connection with the Active experimentation in Kolb's experimental learning circle

- (i) Provided a brainstorming session to encourage the use of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement.
- (ii) Provided facilities to prepare their own learning materials using Peer-discussion, blended learning approach (e-learning materials, LMS), brainstorming sessions according to the second level of Bloom's taxonomy.
- (iii) Provided facilities to design their own evaluation materials using the above mentioned methodologies to practice with their students keeping to the second level of Bloom's taxonomy.

Activity Model 3

This sample activity model covers the third level of Bloom's taxonomy (key words are used according to verbs given in Table 6.3 of Chapter 6) and it was implemented according to the guidance given in the Kolb's customized reflective learning circle given in Table 6.7 in Chapter 6.

Implementation of Third Stage activities of Bloom's Taxonomy

Ex.1 **Write** (construct) a pseudo code algorithm to convert Fahrenheit (f) to centigrade (c)

Hint: $c = 5/8 * f + 32$

Ex. 2 If one executes the following python program segment, what would be the expected output?

```
x = [100,200,300,400]
```

```
foriin x:
```

```
printi
```

This will output: 100 200 300 400

Ex.3 **Write** a python to get the summation of the first 10 odd numbers. Type the program and de-bug if there any errors and finally show the answers?

```
foriinrange(1,20, 2):
```

```
sum=sum+i
```

```
printi
```

Ex 4: **illustrate** the output of the following python program segment?. Your answer should include manual execution of the work

```
x =6
```

```
while x >0:
```

```
print x
```

```
x = x - 1
```

Will output: 6 5 4 3

And similar questions to activity model 3 were given to achieve the learning outcomes mapped with the third level of Bloom's taxonomy.

Stage 1: Activities in connection with the concrete experience in Kolb's experimental learning circle

- (i) Provided lecture notes, e-materials which included flow charts, pseudo code algorithms in relation to the different forms of respective techniques.
- (ii) Provided lecture notes, e-materials, sample solved questions in connection with repetitive techniques and related theories.
- (iii) Granted online help facility to access repetitive techniques and provided facilities to observe use of respective techniques with different problem solving activities.
- (iv) Provided lecture notes and e- book chapters to identify real uses of respective techniques.

- (v) Provided facilities for peer discussion to further strengthen individual answers related to the four facts above.
- (vi) Further, necessary resources were provided to obtain the output of the above sample programs
- (vii) Provided necessary manuals to debug program codes.

Stage 2: Activities in connection with the Reflective observation in Kolb's experimental learning circle

- (i) Brainstorm sessions and students' individual and group presentations were conducted in connection with the use of: repetitive statements, identifying errors in a program that includes different types of repetitive statements. How to debug python codes including repetitive statements that could be used in problem solving activities were also dealt with.
- (ii) Provided environment to judge their solutions in connection with repetitive statements and applications.
- (iii) Provided facilities to maintain a reflective log in connection with the outcomes to the question in activity model 3.

Stage 3: Activities in connection with the Abstract conceptualization in Kolb's experimental learning circle

- (i) Conducted a series of lectures in connection to the following methodologies: introductory session of repetitive statements, Bloom's Taxonomy and its application related to the 3rd stage of Bloom's Taxonomy, blended learning approaches (e.g. To use e-materials, educational web sites, familiarization with LMS), and on-line courses in connection with the repetitive statements.
- (ii) Provided facilities to use stage three of Bloom's taxonomy in connection with repetitive statements and the application domain.
- (iii) Provided guidance to design learning activities to achieve the learning outcomes using the third level of Bloom's taxonomy.
- (iv) Provided guidance to prepare examination questions using the third level of Bloom's taxonomy.
- (v) Provided facilities to discuss Exercises (Ex1 to Ex5) through an on-line discussion forum and discussed enhancement possibilities through e-materials available on different educational web sites.
- (vi) Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes related to the third level of Bloom's taxonomy.
- (vii) Provided facilities to use LMS activities in connection with activities and evaluation related to the different repetitive statements and problem solving activities in python programming languages using the third level of Bloom's taxonomy.
- (viii) Provided facilities to discuss within peer-peer student groups and master teacher-student approach related to the third level of Bloom's taxonomy.

Stage 4: Activities in connection with the Active experimentation in Kolb's experimental learning circle

- (i) Provided brainstorming sessions to encourage the usage of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement in connection with repetitive statements.
- (ii) Provided facilities to prepare their own learning materials through Peer-discussion, blended learning approach (e-learning materials, LMS), brainstorming sessions to achieve the learning outcomes using the third level of Bloom's taxonomy.
- (iii) Provided facilities to design their own evaluation materials using the above mentioned methodologies for practice with their students according to the third level of Bloom's taxonomy.

4th Activity Model

Implementation of Fourth and Fifth Stage activities of Bloom's Taxonomy

Exercise 1

(i) Individual work

Draw a flow chart to determine the grade of students' marks based on the following criteria.

Criteria: Marks ≥ 75 then "A GRADE"

Marks ≥ 60 and < 69 then "B GRADE"

Marks ≥ 50 and < 59 then "C GRADE"

Marks ≥ 40 and < 49 then "B GRADE"

Otherwise "F GRADE"

- (ii) **Convert** the above flow chart algorithm to a pseudo code algorithm.
- (iii) **Convert** the above pseudo code algorithm into a python programming code.
- (iv) **Test** the program written in part (iii) above using a suitable set of data values.
- (v) Through a hands on session, **conclude** the manual answers.
- (v) Compare and contrast the results of part (iv) and (v).

Group work

- (i) Provided facilities to conduct discussion forums with trainers through an on on-line environment.
- (ii) Provided facilities to discuss the different algorithms written by different trainers in a face-to-face session.
- (iii) Trained them to explore different approaches to solutions through peer discussion.
- (iv) Finally, introduced reflective practice approaches to the trainers as a way of finding an optimum solution through different approaches.
- (v) Significantly, provided the role model concept of how to learn philosophy through the training sessions of their students.

Stage 1: Activities in connection with the concrete experience in Kolb's experimental learning circle

- (i) Provided lecture notes, e-materials which included flow charts, pseudo code algorithms in relation to the different forms of problem solving activities similar to the above activity.
- (ii) Provided lecture notes, e-materials, sample solved questions in connection with problem solving techniques and related theories.
- (iii) Granted online help facility access for problem solving scenarios and provided facilities to observe usage of different day-to-day problem solving activities.
- (iv) Provided facilities for peer discussion to further strengthen individual answers in relation to the three facts above.

Stage 2: Activities in connection with the Reflective observation in Kolb's experimental learning circle

- (i) Brainstorming sessions and students' individual and group presentations were conducted in connection with the following: use of decision making activities, repetitive statements and other identified fundamental concepts.
- (ii) Provided environment to judge their solutions in connection with day-to-day problem solving activities.
- (iii) Provided facilities to maintain a reflective log in connection with the outcomes to the question in activity model 4.

Stage 3: Activities in connection with the Abstract conceptualization in Kolb's experimental learning circle

- (i) Conducted a series of lectures in connection with the following methodologies: introductory session of repetitive statements, Bloom's Taxonomy and its application related to the 4th stage of Bloom's Taxonomy, blended learning approaches (e.g. To use e-materials, educational web sites, familiarization with LMS, on-line courses in connection with the complete problem solving activities).
- (ii) Provided facilities to use stage four and five of Blooms taxonomy in connection with simple day-to-day problem solving activities.
- (iii) Provided guidance to design learning activities to achieve the learning outcomes using the fourth and fifth levels of Bloom's taxonomy.
- (iv) Provided guidance to prepare examination questions using the fourth and fifth levels of Bloom's taxonomy.
- (v) Provided facilities to discuss similar problem solving activities through an on-line discussion forum and discussed possibilities of enhancing through e-materials available on different educational web sites.
- (vi) Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes related to the fourth and fifth levels of Bloom's taxonomy.
- (vii) Provided facilities to use LMS activities in connection with activities and evaluation related to the different problem solving activities in python programming languages using the fourth and fifth levels of Bloom's taxonomy.

- (viii) Provided facilities to discuss within peer-peer student groups and master teacher-student approach related to fourth and fifth levels of Bloom's taxonomy.

Stage 4: Activities in connection with the Active experimentation in Kolb's experimental learning circle

- (i) Provided brainstorming sessions to encourage the usage of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement in connection with simple problem solving activities which are related to the level of GCE(O/L) ICT specialization subject domain.
- (ii) Provided facilities to prepare their own learning materials through Peer-discussion, blended learning approach (e-learning materials, LMS) and brainstorming sessions to achieve the learning outcomes using fourth and fifth levels of Bloom's taxonomy.
- (iii) Provided facilities to design their own evaluation materials using the above mentioned methodologies for practice with their students according to the fourth and fifth stages of Bloom's taxonomy.

5th Activity model

Implementation of Sixth Stage activities of the Bloom's Taxonomy

Ex.1

- (i) Draw a flow chart to determine the number of days for a particular month considering the criteria given below. You may assume there are two inputs given as month and year

Criteria:

The following month has 31 days:

January, March, May, July, August, October, December

April, June, September, November months have 30 days each.

If year is a leap year and month is equal to February, then there are 29 days

If year is not a leap year and month is equal to February then there are 28 days

- (ii) Convert the above flow chart algorithm to a pseudo code algorithm
- (iii) Convert the above pseudo code algorithm into a python code
- (iv) Test the program written in part (iii) above using a suitable set of data values
- (v) Justify, why you use such techniques to solve the problem
- (v) Discuss the improvement possibilities of the algorithm written by you.
- (vii) Compare and contrast the preference of program written by you with your peers' answers

The above activities were performed as follows:

- i. Time provided to write individual answers for each trainee in the class.
- ii. Conducted a brainstorming session to solve the problem in a face-to-face manner.

- iii. Strengthened and enhanced the answer derived by the brainstorming session using an on-line discussion forum and exploring alternative answers through e-materials and educational web sites to the given questions as well as similar questions.
- iv. Provided facilities to discuss the answer peer-peer in a face-to-face manner.
- v. Provided facilities to construct optimum answer as a group activity.
- vi. Final discussion with trainer to justify the enhanced answer.
- vii. Discuss the importance of Bloom's Taxonomy, Kolb's reflective Learning Circle, brainstorming sessions and reflective practice in problem solving and evaluation.
- (viii) Importance of applicability of Role Model.

Stage 1: Activities in connection with the concrete experience in Kolb's experimental learning circle

- (i) Provided lecture notes, e-materials which included flow charts, pseudo code algorithms in relation to the different forms of critical thinking problem solving activities similar to the above activity.
- (ii) Provided lecture notes, e-materials, sample solved questions in connection with critical thinking problem solving techniques and related theories.
- (iii) Granted online help facility access for problem solving scenarios and provided facilities to observe usage of critical thinking and innovate different day-to-day problem solving activities.
- (iv) Provided facilities to peer discussion to further strengthen their individual answers related to the above three facts.

Stage 2: Activities in connection with the Reflective observation in Kolb's experimental learning circle

- (i) Brainstorming sessions and students' individual and group presentations were conducted in connection with the: usage of decision making activities, critical thinking problem solving activities on different application areas.
- (ii) Provided environment to judge their solutions in connection with creative thinking problem solving activities.
- (iii) Provided facilities to maintain a reflective log in connection with the outcomes to the question in activity model 5.

Stage 3: Activities in connection with the Abstract conceptualization in Kolb's experimental learning circle

- (i) Conducted a series of lectures in connection with the following methodologies: introductory session to create innovative solutions, Bloom's Taxonomy and its application related to the sixth stage of Bloom's Taxonomy, blended learning approaches (e.g. To use e-materials, educational web sites, familiarization with LMS, on-line courses in connection with the creative thinking problem solving activities).
- (ii) Provided facilities to use stage six level of Blooms taxonomy in connection with innovative problem solving activities.
- (iii) Provided guidance to design learning activities to achieve the learning outcomes using the sixth level of Bloom's taxonomy.

- (iv) Provided guidance to prepare examination questions using the sixth level of Bloom's taxonomy.
- (v) Provided facilities to discuss similar problem solving activities through an on-line discussion forum and discussed enhancement possibilities through e-materials available on different educational web sites.
- (vi) Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes related to the sixth level of Bloom's taxonomy.
- (vii) Provided facilities to use LMS activities in connection with activities and evaluation related to the different critical thinking problem solving activities in python programming languages using the sixth level of Bloom's taxonomy.
- (viii) Provided facilities to discuss within peer-peer student groups and master teacher-student approach related to the sixth level of Bloom's taxonomy.

Stage 4: Activities in connection with the Active experimentation in Kolb's experimental learning circle

- (i) Provided brainstorming sessions to encourage the usage of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement in connection with critical thinking and innovative creations in ICT.
- (ii) Provided facilities to prepare their own learning materials through Peer-discussion, blended learning approach (e-learning materials, LMS) and brainstorming sessions to achieve the learning outcomes using the sixth level of Bloom's taxonomy.
- (iii) Provided facilities to design their own evaluation materials using the above mentioned methodologies for practice with their students according to the sixth level of Bloom's taxonomy.

Appendix 15 : Sample Answers of the Activity model

First stage activities of the Bloom's Taxonomy

Ex.1 .1 Define the basic data types used in Python programming language?

Data Types Available in Python

Python has a rich selection of data types and associated operators and functions to manipulate them. While most of these data types are either available in a language like C, or can be defined within the language, Python provides them from the outset. These native data types closely parallel those required for many common programming tasks, and usually do so in a natural manner with a rather low overhead in initial learning by the novice programmer. For the moment, we will restrict our discussion to avoid the introduction of some of the more object oriented aspects of programming that are available in Python, such as classes. The following table provides a brief listing of some basic data types available in Python of particular use in scientific programming.

Data type	Description and examples
integer	signed integer, 32 bits, \pm 2147483647
float	64 bit double precision, like 1.23 or 7.8e-28
long integer	arbitrarily large integer, trailing L, 234187626348292917L, 7L
octal integer	base-8 integer, leading 0 as in 0177
hexadecimal integer	base-16 integer, leading 0x as in 0x9FC
complex	real and imaginary parts written as 3 + 4j or 1.23 - 0.0073j
character string	ordered collection of characters, enclosed by pairs of ' , or " characters
list	ordered collection of objects, like [1,22,[321,'cow'],'horse']
dictionary	collection of associated key: data pairs like {'first':'alpha','last':'omega'}
tuples	similar to lists, like ('hen','duck'),('rabbit','hare'),('dog','cat')
file	disk files as in: file1 = open('data.01','r'); data = file1.read()

Integers

An integer in Python, also known as a 'numeric literal', is simply a name used for a numeric value. For this reason, these values are commonly called integers even if they are assigned the value of a real number in the form of an integer and a decimal value. Any numeric value can be assigned to it at any time, overwriting the previous value. **To assign a value to an integer variable, one writes a statement after the following template:**

<numeric literal name> = <numeric literal value>

Some examples are:

x = 1500

pi = 3.14

Strings - Part 1

A string literal, or string, holds any combination of letters and numbers you would like it to hold. Any number it holds, however, is not treated like a numerical value but is preserved as if it were a word.

One way to think about the difference between a number as a string and a number as a numeric literal is to consider a credit card. The credit card numbers themselves are an example of an integer value; you can add to them and subtract from their value. The credit card, however, preserves the numbers in a set format, complete with spaces. A string does the same thing. While you can multiply and divide the number of the credit card as an integer, you cannot break up the value by the way it is written. To do that you need a string. In this way, an integer represents a quantity, a string represents a quality.

Strings - Part 2

Because a string represents words and numbers in the format they are assigned, Python uses quotes to indicate their value. Trying to assign a string value without quotes looks like you are trying to assign the value of one string to another. If the string does not yet exist, Python will tell you so. To assign a value to a string, one uses the following template:

```
<name of string> = '<value of string>'
```

Examples of variable assignments are:

```
gettysburg = "four score and seven years ago..."
writ = 'habeas corpus'
Catch22 = ""no win situation""
postcode = "91101-2509"
```

"Wait a minute!", I hear you say, "You said that Python uses quotes to offset string values. You used single quotes in the template and then used single, double and triple quotes in the examples. Which is right?" The fact of the matter is that Python allows all of them. You get to choose which you want to use. Python does not care. All Python asks is that you close the value with the same kind that you opened it (otherwise, Python will not know where you mean the quotes to be part of the value or to signify the end of the string). If you begin a value with double quotes, you must end it with double quotes. The following are therefore **WRONG**:

```
name = 'Joanna Sebastian Bach"
body = "Sargasso See'
city = ""Ed in burgh"
```

Lists

Assigning Values to a List

A list is, as the name suggests, a series of values. In Python, these values are assigned by placing them within square braces and separating them by commas like this:

```
<name of list> = [ <value>, <value>, <value> ]
girls = ['sugar', 'spice', 'everything nice']
lotto = ['26', '12', '23']
addends = [4, 34, 7]
```

Note that 'addends' is comprised of integer variables while the others are comprised of strings, as the quotes suggest.

A list can contain any type of Python object -- even other lists.

```
>>> lotto[2] = addends
>>> print lotto
['26', '12', [4, 34, 7]]
```

Tuples

In Python, a tuple may be defined as a finite, static list of literals (numeric or string). For our purposes, a tuple is very similar to a list in that it contains a sequence of items. It differs from a list in that it cannot be changed once it is created. One can index, slice and concatenate, but one cannot append or alter the values of the tuple after it has been initialized. **To initialize a tuple, one encloses the values in parentheses and separates them by commas.**

```
directions = ('north', 'south', 'east', 'west')
coordinates = (45, 34, 48, 32)
print directions[3]
print coordinates[1]
```

output:

```
west
34
```

Dictionaries

Defining a Dictionary

Dictionary is the Python term for an associative array. An array is, like a list, a series of values in two dimensions. An associative array gives one a way of accessing the values by a key, a term associated with the value instead of an item's index number.

Initializing a dictionary, one offsets the keys and values in curly braces. Each key-value pair is separated from the others by a comma. For each pair, the key and value are separated by a colon. The key of each member is offset in quotes. A sample dictionary is as follows:

```
my_dictionary = { "author" : "Andrew Melville",
                  "title" : "Moby Dick",
                  "year" : "1851",
                  "copies" : 5000000
                }
```

Appendix 16: Course material for Fundamental of Python programming Language and enhancement of problem solving using blended leaning approach

Python Language

Fundamental of Python programming Language and enhancement of problem solving using blended leaning approach

Python is a programming language, as are C, FORTRAN, BASIC, PHP, etc. Some specific features of Python are as follows:

- (i) An interpreted (as opposed to compiled) language. Contrary to e.g. C or FORTRAN, one does not compile Python code before executing it. In addition, Python can be used interactively: many Python interpreters are available, from which commands and scripts can be executed.
- (ii) Free software released under an open-source license: Python can be used and distributed free of charge, even for building commercial software.
- (iii) multi-platform: Python is available for all major operating systems, Windows, Linux/Unix, MacOS X, most likely your mobile phone OS, etc.
- (iv) a very readable language with clear non-verbose syntax
- (v) A language for which a large variety of high-quality packages are available for various applications, from web frameworks to scientific computing.
- (vi) A language very easy to interface with other languages, in particular C and C++.
- (vii) Python is a programming language that work more quickly and integrate your systems more effectively.
- (viii) Python has immediate gains in productivity and lower maintenance costs.
- (ix) Python is free to use, even for commercial products, because of its OSI-approved open source license.
- (x) At present, category 4 also uses python as the programming language.

Introduction to python

Python is an easy to learn, powerful programming language. It has efficient high-level data structures and a simple but effective approach to object-oriented programming. Python's elegant syntax and dynamic typing, together with its interpreted nature, make it an ideal language for scripting and rapid application development in many areas on most platforms.

The Python interpreter and the extensive standard library are freely available in source or binary form for all major platforms from the Python Web site, <http://www.python.org/>, and may be freely distributed(one can freely download from the above site and version is 2.7 and release date is 9th September 2012). The same site also contains distributions of and pointers to many free third party Python modules, programs and tools, and additional documentation.

How to download the python

- Download Python
- One can download python from the following web site
- www.python.org/getit/
- Installing Python

How to download python under the windows O/S platform

- Download Python from <http://www.python.org>
- Install Python.
- Run Idle from the Start Menu.

How to download python under the Mac OS X O/S platform

357

- Download Python from <http://www.python.org>
- Install Python.
- Python is already installed.
- Open a terminal and run python or run Idle from Finder.

How to download python under the Linux O/S platform

- Download Python from <http://www.python.org>
- Install Python
- Chances are you already have Python installed. To check, run Python from the terminal.
- If not, install from your Distribution's package system

Interpreted Languages

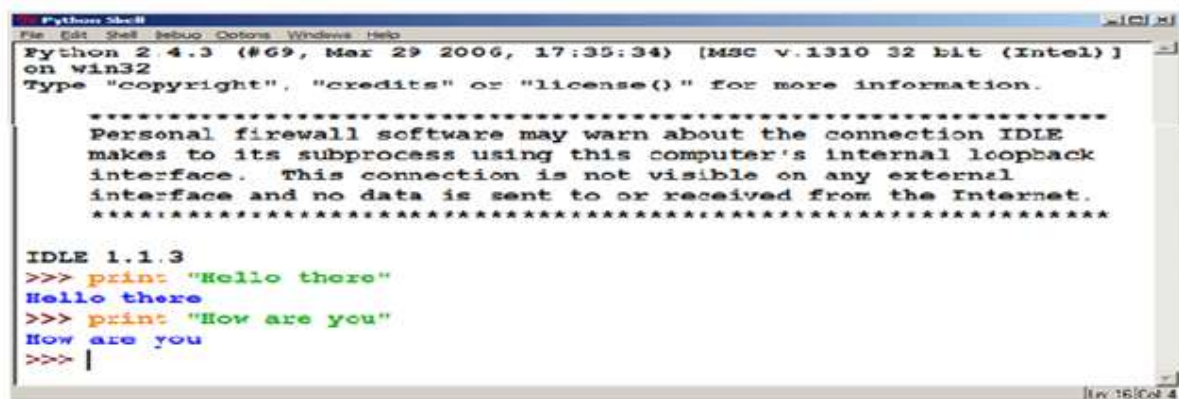
Not compiled like many other languages (Java, C, C++)

- Code is written and then directly executed by an interpreter
- Type commands into interpreter and see immediate results

Python Fundamentals

Python is an interpreted language. It is no need to compile like other languages (e.g. Java, C, and C++). Any code of the python program code can write in directly and then directly executed by an interpreter. One can Type commands in to interpreter and see immediate results quickly.

Syntax of the python GUI, simple command and intermediate result is given in figure 1.1 as below



```
Python Shell
File Edit Shell Debug Options Windows Help
Python 2.4.3 (#69, Mar 29 2006, 17:35:34) [MSC v.1310 32 bit (Intel)]
on win32
Type "copyright", "credits" or "license()" for more information.

*****
Personal firewall software may warn about the connection IDLE
makes to its subprocess using this computer's internal loopback
interface. This connection is not visible on any external
interface and no data is sent to or received from the Internet.
*****

IDLE 1.1.3
>>> print "Hello there"
Hello there
>>> print "How are you"
How are you
>>> |
```

Figure 1.1 python interface and simple code

The print statement

A Python program's code can be just written in the command line or directly type in a file using Idle (python GUI) to get the answers.

E.g. 1 just types the command in the command line as follows:

```
>>>Print ("Hello world")
```

And immediately get the answers as follows if there no any bugs.

Answer: Hello Word

```
>>>
```

E.g. 2: Under a program name, one can type the command, save, interpret and get the answers. In python language, extension py is used. As answer given in E.g.1, expected output can be obtained easily.

Comments statements in Python

Symbol is used to write comment statement in a python program. The syntax of the comments statement is as follows:

#comment text (one line)

E.g. # This is my First python Program

Exercise 1

Test the validity and real execution of the following python code in the command mode as well as GUI manner

```
# This is my First python program
```

```
Print ("Hello, I am a student of GalkandaMahaVisyalaya")
```

```
Print ("I am in Grade 11 and my favorite subject is ICT specialization Subject ")
```

```
Print
```

Basic data types

Consider the following example

To get yourself understand, type the following stack of instructions

E.g 1

```
>>>a = 3
>>>b = 2*a
>>>type(b)
<type 'int'>
```

```
>>> print(b)
6
>>>a*b
18
```

The above code explore as follows

Initially assign a=3
a will take as a integer value
Then assigned b=2*a
The value of b is equal to 6
Further if you type the command type (b)
Then it will give b as an integer data type
According to the print statement it will print answer as 6
The last statement multiply a and b and then return answer as 18

E.g 2 One can consider the following set of commands

>>>b =	>>>b + b
'hello'	'hellohello'
>>>type(b)	>>>2*b
<type 'str'>	'hellohello'

Initially string hello will store in a variable b

If one executes the type command it will display data type as string

In the next statement b+b

It will print as Hellohello

Further, one executes 2*b, it will print as hellohello

E.g. 3 to get yourself started, type the following stack of instructions

```

>>>a = 3
>>>b =
2*a
>>>type(
b)
<type
'int'>
>>>
print (b)
6
>>>a*b
18
>>>b =
'hello'
>>>type(
b)
<type
'str'>
>>>b + b
'hellohell
o'
>>>2*b
'hellohell
o' ,

```

It will concatenate the string as hellohello

Again if one perform the mortification operation

Note that python does not declare the type of an object before assigning its value. In C, conversely, one should write:

```
int (a);
a = 3;
```

Numerical types

Integer variables:

```
>>> 1 + 1
2
>>> a = 4
```

The data type can be used to store whole numbers. If one print the above a, it will display value as 4.

Float variables

```
>>>c = 2.1
```

If one displays the type of the variable in c, then it will print it as float

Complex (a native type in Python!)

e.g.

```
>>>a=1.5+0.5j
>>>a.real
1.5
>>>a.imag
0.5
```

Boolean variables

This can be used test whether the expression is true or false

```
e.g. >>>test
>>>3 > 4
False
```

```
e.g >>>type(test)
<type 'bool'>
```

Expressions

Expression: A value or operation(s) to compute a value

Example: 1+4*3

ArithmeticOperators:

Operators	Meaning
+ - * /	Add, subtract, multiply, divide
**	Exponentiation
%	Modulus(Remainder)

A Python shell can therefore replace your pocket calculator, with the basic arithmetic operations +, -, *, /, % (modulo) natively implemented:

```
>>>7 * 3.
1024
21.0
>>>8%3
2
>>>2**10
```

Integer and float divisions yield is float

e.g Integer division

```
>>>3/2
1
```

Use floats:

```
>>>3/2.
1.5
```

Alternative for integer and float divisions

e.g1 >>>3//2 give 1

```
>>>3. /2 give 1.5
```

e.g 2 >>>a = 3

>>>b = 2

>>>a/b

1

e.g 3 >>>a/float(b)

1.5

Scalar types: int, float, complex, bool:

>>>type(1)

<type 'complex'>

<type 'int'>

>>>a = 3

>>>type(1.)

>>>type(a)

<type 'float'>

<type 'int'>

>>>type(1. + 0j)

Type conversion:

>>>float(1)

1.0

Variable:

Variable: A named piece of memory that stores a value

Assignment: stores a values into a variable

Syntax :

Name =expression

Examples

X=5

Gpa=3.14

Variables can be used in expressions

x+4 is 9

Values supplied to a command as you run it

Syntax

Command (value)

Command (value,value,.....value)

Example

```
print (sqrt(25))
print (sqrt(15+10*10+6))
x=5
print (sqrt(16)+x)
```

math command

Function name	Description
abs(value)	Absolute value
ceil(value)	Rounds up
cos(value)	cosine,inradians
floor(value)	Rounds down
log10(value)	logarithm,base10
max(value1,value2)	Larger of two values
min(value1,value2)	smaller of two values
round(value)	Nearest whole number
sin(value)	sine, in radians
sqrt(value)	square root

To use these commands, place this line at top your program:

From math import*

Input

input: Reads a number from the user's keyboard

-Example:

```
age=input("how old are you")
print ("your age is", age)

print ("you are ", age, "years old")
print ("you have ", 65-int(age)," years remaining for your retirement ")
```

Output:

```
How old are you? 53
Your age is 53
You have 12 years remaining for your retirement
```

Python programming language

Control Statements

If statement: Executes a set of commands only if a certain condition is True. Otherwise, the commands are skipped.

Syntax:

If **condition:**

Statements

Example 1:

```
gpa=int(input("what is your Z-SCORE"))
if gpa>2:
    print ("welcome, you are eligible for a degree ")
else:
    print ("sorry, you are not eligible for a degree")
```

Multiple conditions can be chained with elif

Exercise 2

```
a=10
if a==1:
    print (1)
elif a==2:

print (2)
else:
    print ("a lot")
```

Exercise: Write a program for determine the grades

Hint : marks ≥ 75 "A GRADE"

marks ≥ 60 and < 69 "B GRADE"

marks ≥ 50 and < 59 "C GRADE"

marks ≥ 40 and < 49 "B GRADE"

Otherwise " F GRADE"

Logical operations

Operator	Meaning	Example	Result
=	e q u a l	$1+1==2$	True
!=	doesnotequal	$3.2!=2.5$	True
<	lessthan	$10<5$	False
>	greaterthan	$10>5$	True

< =	lessthanor equalto	126<=1 00	False
> =	greaterthan orequalto	5.0>=5. 0	True

Logical expressions can be combined using logical operators

Operator	Example	Result
and	(9!=6)and(2<3)	True
or	(2==3)or(-1<5)	True
not	not(7>0)	False

Exercise 4 : Write a program for determine number of days per a particular month

For loops

The for statement in Python differs a bit from what you may be used to in C or Pascal. Rather than always iterating over an arithmetic progression of numbers (like in Pascal), or giving the user the ability to define both the iteration step and halting condition (as C), Python's for statement iterates over the items of any sequence (a list or a string), in the order that they appear in the sequence.

Example 1

```
# measure some strings
word=["cat","windows","defenestrate "]
for w in word:
    print (w,len(w))
```

Format 1:

```
for name in range(start,end):
```

Statements

Format 2:

```
for name in range(start,end,step):
```

statements

Repeats for values **start**(inclusive) to **end**(exclusive)

Example 2 :

```
for i in range(2,6):
    print (i)
```

Output 2: 3 4 5

Example 3

```
for i in range (15,0,-5):
    print (i); print("Squired is ");print(i*i)
```

Output is:

15 squired is 225

10 squired is 100

5 squired is 25

Example 4: write a python program to get the summation of first ten square numbers

Example 5

```
x = [100,200,300,400]
```

```
foriin x:
```

```
print (i)
```

This will output: 100 200 300 400

The next example uses a negative step (the third argument for the built-in range function):

Example 6

```
foriinrange(10,0, -1):
```

```
printi
```

This will output: 10 9 8 7 6 5 4 3 2 1

Break and continue Statements, and else Clauses on Loops

The break statement, like in C, breaks out of the smallest enclosing for or while loop. Loop statements may have an else clause; it is executed when the loop terminates through exhaustion of the list (with for) or when the condition becomes false (with while), but not when the loop is terminated by a break statement. This is exemplified by the following loop, which searches for prime numbers:

364

Exercise 7

```
for n in range (2,10):
```

```
    for x in range (2,n):
```

```
        if n%x ==0 :
```

```
            print (n,"equals","*",n/x)
```

```
            break
```

```
    else:
```

```
        # loop fell through without finding a factor
```

```
        print (n,"is a prime number")
```

```
2 is a prime number
3 is a prime number
4 equals 2 * 2
5 is a prime number
```

```
6 equals 2 * 3
7 is a prime number
8 equals 2 * 4
9 equals 3 * 3
```

The continue statement, also borrowed from C, continues with the next iteration of the loop:

Exercise 8

Write a program to determine the number is an odd or even from the number sequence 2 to 10

```
for num in range (2,10):
    if num % 2 == 0:
        print ("found an even number ",num)
        continue
    print ("found a number ",num)
```

Answer:
found an even number 2
found a number 3
found an even number 4
found a number 5

found an even number 6
found a number 7
found an even number 8
found a number 9

Exercise 9

Fibonacci series

Write a python program to print a Fibonacci series up to n

Defining Functions

We can create a function that writes the Fibonacci series to an arbitrary boundary:

Exercise 9

```
def fib(n):
    print("print a Fibonacci series up to n")
    a,b=0,1
    while a<n:
        print(a,end=" ")
    a,b=b,a+b
    print()
```

Answer : Print a Fibonacci series up to n

0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 987 1597

While loops

A while loop repeats a sequence of statements until some condition becomes false. For example:

```
x =5
while x >0:
    print x
    x = x - 1
```

Will output: 5 4 3 2 1

Python's while loops can also have an 'else' clause, which is a block of statements that is executed (once) when the while statement evaluates to false. The break statement inside the while loop will not direct the program flow to the else clause. For example:

```
x = 5
y = x
while y > 0:
    print y
    y = y - 1
else:
    print x
```

This will output: 5 4 3 2 1 5

In some languages, there is no post-condition loop.

Breaking, continuing and the else clause of loops

Python includes statements to exit a loop (either a for loop or a while loop) prematurely. To exit a loop, use the break statement

```
x = 5
while x > 0:
    print x
    break
    x -= 1
print x
```

This will output: 5

The statement to begin the next iteration of the loop without waiting for the end of the current loop is 'continue'.

```
l = [5,6,7]
for x in l:
    continue
print x
```

This will not produce any output.

The else clause of loops will be executed if no break statements are met in the loop.

```
l = range(1,100)
for x in l:
    if x == 100:
        print x
        break
```



```

else:
print x, " is not 100"
else:
print "100 not found in range"

```

Branches

There is basically only one kind of branch in Python, the 'if' statement. The simplest form of the if statement simple executes a block of code only if a given predicate is true, and skips over it if the predicate is false

For instance,

```

>>> x = 10
>>> if x > 0:
...   print "Positive"
...
Positive
>>> if x < 0:
...   print "Negative"
...

```

You can also add "elif" (short for "else if") branches onto the if statement. If the predicate on the first "if" is false, it will test the predicate on the first elif, and run that branch if it's true. If the first elif is false, it tries the second one, and so on. Note, however, that it will stop checking branches as soon as it finds a true predicate, and skip the rest of the if statement. You can also end your if statements with an "else" branch. If none of the other branches are executed, then python will run this branch.

```

>>> x = -6
>>> if x > 0:
...   print "Positive"
... elif x == 0:
...   print "Zero"
... else:
...   print "Negative"
...
'Negative'

```

3.3.2 for/range

Iterating with an index:

```

for i in range(4):
...: print(i)
...:
0 1 2 3 4

```

Example 2

But most often, it is more readable to iterate over values:

```
for word in ('cool','powerful','readable'):  
    print('pythan is ', word)
```

Python is cool

Python is powerful

Python is readable

Example 3

continue the next iteration of a loop.:

```
>>>a = [1, 0, 2, 4]  
>>> for element in a:  
    ... if element == 0:  
        ... continue  
    ... print 1. / element
```

```
...
```

```
1.0
```

```
0.5
```

```
0.25
```

Example 4

```
vowels='aeiouy'
```

```
for i in 'powerful':
```

```
    if i in vowels:
```

```
Answer :a,e,u
```

Keeping track of enumeration number

Common task is to iterate over a sequence while keeping track of the item number.

- Could use while loop with a counter as above. Or a for loop:

```
In [13]: for iin range(0, len(words)):
```

```
....: print(i, words[i])
```

```
....:
```

```
....:
```

Example 5

```
words=('cool','powerful','readable')
```

```
for index,item in enumerate (words):
```

```
    print (index, item)
```

```
0 cool
```

```
1 powerful
```

```
2 readable
```

Defining functions

Function definition

```
In [56]: deftest():
```

```
....: print('in test function')
```

```
....:
```

```
....:
```

```
In [57]: test()
```

```
in test function
```

```
def test():
```

```
    print (' in test function')
```

```
test()
```

Return statement

Functions can optionally return values.

```
In [6]: defdisk_area(radius):
```

```
...: return 3.14 * radius * radius
```

```
...:
```

```
In [8]: disk_area(1.5)
```

Out[8]: 7.0649999999999995

```
defdisk_area(radius):
```

```
    return 3.14*radius*radius
```

```
disk_area(1.5)
```

Note: By default, functions return None.

Note: Note the syntax to define a function:

- the def keyword;
- is followed by the function's name, then
- the arguments of the function are given between brackets followed by a colon.
- the function body ;
- and return object for optionally returning values

Appendix 18: List Of Publications

Publications emerged from the Study

- 1.0 MGNAS Fernando**, MB Ekanayke, Quality Improvement of ICT Education through Pedagogical Transformation – In the Sri Lankan Context, 2014 International Conference on Advance Education and Management [ICAEM2014] January 03~05, 2014, Beijing, China. Publisher: DESTech Publications Ins.
- 2.0 MGNAS Fernando**, MB Ekanayke Enhancement of ICT Education through Blended Learning Technologies for Secondary Education in Developing Countries: in the Sri Lankan context, 5th International Conference of Education, Research and Innovation- 19th November -21st November 2012 ISBN: 978-84-616-0763-1, Publisher: IATED- Madrid (Spain)
- 3.0 MGNAS Fernando**, MB Ekanayke, “Enhancement of ICT Education through FOSS solutions in Developing Countries in terms of Sri Lankan Observations”, 4th International Conference “ICT for Learning Languages, Florence, Italy, October 20th -21st 2011. ISBN: 978-88-7647-677-8, Publisher: Simonelli Editore Sede Legale e Direzione Operativa, Volume 1. pp 67
- 4.0 MGNAS Fernando**, MB Ekanayke “Present Status of ICT Education at the Secondary Level in Sri Lanka”. The 2nd conference of Indian Ocean Comparative Education Society (IOCES) under the theme, “Globalization of Education: Convergence towards a world culture of schooling” to be held at the Villa College QI Campus, Male, Republic of Maldives, September 16-18, 2011.
- 5.0 MGNAS Fernando**, MB Ekanayke “Sustainable Quality improvement ICT Education in the Secondary schools for developing countries through the Sri Lanka Experience”, 2nd International conference on society and information

Technology (ICSIT) , 2011,Volume 1.pp 93-99, 27th-30th March 2011, Orlando, Florida,USA,

6.0 MGNAS Fernando, MBEkanayeke “Enhancement of University Education through introduction of New Changes, feedback and Reflection”. 2nd International conference on Academic informing Science and Engineering (AISE) 27th-30th March 2011 vol 2 ,pp544-351 Orlando, Florida,USA.

7.0 MGNAS Fernando, MBEkanayeke ,Sustainable Quality Improvement of ICT education in Secondary School Curriculum of Sri Lanka, for the Conference on “Foundation & Operational Research for Development, Sri Lanka Foundation Institute, Sri Lanaka, October 2008 and Sustainable Quality Improvement of ICT Education in Secondary School Curriculum of Sri Lanka Journal of Humanities and Social Sciences; Vol 1, No 1 (2009) Fernando, MGNAS; University of Colombo, School of Computing' Sri Lanka,Ekanayake, MB; Technical Education Development Project, Sri Lanka,2010-12-09