STUDENTS' CRITICAL THINKING SKILLS, ATTITUDES TO ICT AND PERCEPTIONS OF ICT CLASSROOM LEARNING ENVIRONMENTS UNDER THE ICT SCHOOLS PILOT PROJECT IN THAILAND

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Research Portfolio submitted in fulfilment of the requirements for the award of the degree of
Doctor of Education

School of Education, University of Adelaide

May 2007

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LIST OF ABBREVIATIONS

NEA	**:**	The National Education Act of B.E. 2542
OBEC	**:**	The Office of Basic Education
NCEI	**:**	New Classroom Environment Instrument
CCTT	**:**	Cornel Critical Thinking Skills Test
TAT	**:**	Teachers' Attitudes Toward Information Technology
CCTST	**:**	California Critical Thinking Skill Test
HLM	**:**	Hierarchical Linear Modelling
GW	**:**	Group Work
COOP	**:**	Co-Operation
RS	**:**	Relationships in Class
TS	**:**	Teacher Support
OO	**:**	Order and Organisation
INV	**:**	Student Involvement
COMPE	**:**	Competition

ABSTRACT

This portfolio of research aimed to examine the integration of Information and Communication Technology (ICT) into computer-based classroom learning environments in Thailand. The study was exploratory, investigating to what extent schools in the Thai ICT schools pilot project had classroom learning environments which were related to two student outcomes (critical thinking skills and attitudes to ICT); and to what extent the classroom learning environments were associated with certain teacher characteristics.

The portfolio is presented in three parts. Part 1 reviewed the research literature related to the importance of ICT in education; the ICT classroom learning environments; student attitudes to ICT; students' critical thinking skills; and the role of the teacher in the ICT classroom. From this review, a theoretical research model was developed, based on teacher characteristics, student characteristics and student perceptions of ICT classroom learning environments as predictors of the two student outcomes. Four specific research propositions were formulated from the model to guide the investigation.

Part 2 of the research portfolio reports the quantitative investigation of the ICT schools pilot project in Thailand. Data were collected by means of questionnaires from 150 students in eight of the ICT pilot project schools in relation to students' background characteristics, their perceptions of actual and preferred classroom learning environments, students' critical thinking skills and attitudes to ICT. In addition, questionnaire data on teachers' background characteristics were collected from 16 teachers involved in the project. The associations among the teacher, student and classroom environment predictor variables in relation to the two student outcomes were analysed using SPSS and HLM software programs. The results, discussed in relation to the four research propositions, generally supported the research model.

A complementary qualitative investigation of the Thai ICT schools pilot project is reported in part 3 of the portfolio. This involved an analysis of school based documents, which had been collected officially in the course of the project, in order to identify school level outcomes. In addition, 30 students and five teachers from 10 schools in the ICT pilot project were interviewed to ascertain their views on the advantages, the limitations and the future of the project. The interview transcripts, translated into English, were analysed thematically. The researcher was also able to observe ICT integrated into various subject lessons in 22 classrooms, from each of the schools in the ICT project, and to evaluate them according to Bloom's Taxonomy of learning outcomes. The qualitative results provided important insights into the quantitative study in Part 2.

In the conclusion to the portfolio, the results of the quantitative and qualitative studies are synthesised in a discussion of the four research propositions. Importantly, the findings led directly to useful recommendations on how computer-based learning environments can be improved. The findings of this study have major implications for the role of teachers in ICT classrooms and for school management in providing the necessary equipment and support.

DECLARATION

I declare that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution, and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed: ……………………………………….

Methinee Wongwanich Rumpagaporn

Date: ……………………………………….

ACKNOWLEDGEMENTS

Throughout my research journey in the doctoral program, there have been many wonderful relevant people who have provided support and helpful assistance in the preparation and completion of this thesis.

I began my research journey with Professor Kevin Marjoribanks who was the previous principal supervisor. It was a great time in which he provided the direction to generate the theoretical framework of my thesis. So I wish to express my deep appreciation to Professor Kevin Marjoribanks for his helpful guidance and for giving me the motivation to proceed with this thesis through his generous and patient attention, and invaluable encouragement. Importantly, he has inspired me how to be a great teacher in my students' eyes.

My thesis would not have been completed without my great principal and co-supervisors. My sincere appreciation is expressed to Dr. Margaret Secombe who is my principal supervisor for her always continuing support and persistent encouragement, her meticulous critical reading, and endless patience to listen. My warmest thanks to Professor Robert Crotty, who willingly provided his many hours that went into careful reading and editing of each new draft during the writing up stage. My sincere thanks also go to Dr. Sivakumar Alagumalai and Dr. I Gusti Ngurah Darmawan, who provided wonderful support to me during the analysis of quantitative data, particularly with statistical techniques that were used in this thesis, with their friendly and helpful guidance. Importantly, all of my supervisors have each made invaluable suggestions in their own special ways, academically and personally, to motivate me to stand firm on my own research path.

In addition, I wish to express my gratitude to the teachers and students at the model ICT schools under the ICT schools pilot project in Thailand who volunteered to participate in questionnaire surveys, interviews, and classroom observations. Without their cooperation, this study would not have been possible. Also particular thanks to all the school principals who allowed me to intrude into teachers' working lives by observing school and classroom management and spending hours talking with me. As well, I would like to thank Ms Wipaporn Nithipreechanon, the project coordinator of the Thai ICT schools pilot project, for her help with data collection and information I needed from Thailand.

I wish to express my appreciation to several friendly and helpful academic and administrative staff for sharing their time and making the environment conducive to effective study. I specially wish to thank Ms Mary Brownlee, Dr. Margaret Scott, and Ms Wendy Zweck.

I also thank my colleagues at School of Education, particularly Ms Megan A. Yin Chyn Kek. She has helped me sincerely to get through all the hard and trying times in life through her willing support and sharing the same journey with me. Her company has made my wonderful and happy time here more enjoyable.

I also owe a debt of deep gratitude to my mother, father, mother-in-law, father-in-law, sister, sister-in-law, and my younger brother for their unconditional love and the sacrifice which they have made during this study period through their constant support and encouragement.

My sincere thanks go to my husband, Mr. Itdhiporn Rumpagaporn, for his resignation from his professional and secure work in financial and banking sector in Thailand in order to stay with me until I completed my thesis. His prayers, loyal support, and his technological and computer skills and knowledge led to the final completion of this thesis.

My special appreciation is extended to Mr. James Skipp and Ms Vanessa Whittaker, for their kind support and helpful advice on the research results and their interest from the commencement of this thesis. Finally, I would like to express my grateful thanks to the Business Education Division in the Vocational Education Department of the Faculty of Education at Kasetsart University, Thailand, for offering me this once-in a life time opportunity to earn a doctoral degree I never dreamed of achieving.

DEFINITION OF TERMS

In the current study, there are some important terms, which need to be clearly defined. These are as follows:

Electronic mail*

E-mail (email) is an online communication tool, which is a way of sending messages and data to other people by means of computers connected together in a network.

ICT-integration into teaching and learning process

The use of ICT integrated into teaching and learning process among classroom learning environments through computers or other ICT equipments in various subject lessons in eight groups of basic subjects that included (a) Thai language, (b) mathematics, (c) science, (d) social studies, (e) religion and culture, (f) health and physical education, (g) art, career and technology-related education, and (h) foreign languages in schools.

Information and Communication Technology (ICT) or Information Technology (IT)*

In terms of education, Information and Communication Technology or Information Technology is the study of the use of computers, the internet, video, and other technology as a tool to assist in teaching and learning in a variety of subject areas at school that includes multimedia (computing and teaching terms), CD-ROMs and other software, television, radio, cameras or digital cameras, and other electronic equipment.

Internet*

The internet is a computer networking system that provides connecting links between computer users and other networks through the use of computer.

Leading ICT teachers

The leading ICT teachers are the model teachers who received training in technological knowledge and skills for integrating ICT into teaching and learning process from the supervising universities or other relevant training organisation. These teachers transferred their basic and advanced understanding and their technological knowledge and skills to subject teachers who were teaching in other subjects in the eight groups of basic subjects at model ICT schools. These leading ICT teachers enabled other subject teachers to be accustomed to the use of ICT-integration in their teaching and learning process among classroom learning environments with ICT.

Model ICT schools

Model ICT schools are the model or pilot schools that are applying and integrating ICT into the teaching and learning process and the learners' development activities in classroom learning environments with ICT at their own schools. There were 13 model ICT schools in the first stage of the Thai ICT schools pilot project. The schools pilot project provides ICT equipment, particularly computers, to classrooms to incorporate ICT into teaching and learning and support school managements through the use of ICT in their schools.

Multimedia*

In terms of learning and teaching process in classroom learning environments with ICT, multimedia refers to the use of several different ways of giving information or providing instructional materials, such as video, television, camera or digital cameras, slide for students' learning. In computing terms, it means using sound, picture and film, in addition to text on a screen.

Subject teachers

Subject teachers refer to those who are teaching in one or more of the eight groups of basic subjects in model ICT schools in Thailand. The subject areas are as follows:

- Thai Language;
- Mathematics;
- Science;
- Social Studies;
- Religion and Culture;
- Health Education and Physical Education;
- Art, Career and Technology-Related Education; and
- Foreign Languages.

These teachers received continuous training in basic and professional technological knowledge and skills from the leading ICT teachers, in order to apply ICT to developing their students' body of knowledge. They teach the students in a particular subject area through integrating ICT into their teaching and learning process in their classroom learning environments.

* These definitions are paraphrased from Oxford Advanced Learner's Dictionary of Current English. London: Oxford University Press, 2005.

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INTRODUCTION TO THE PORTFOLIO

Introduction

In Thailand, the National Education Act of B.E. 2542 (1999)('the NEA') provides the guidelines for educational reform. Section 24 in Chapter 4 of the NEA stipulates that in organising the learning process, the educational institutions and agencies concerned shall take into account the following aspects:

(a) provide training in thinking process, management, how to face various situations and application of knowledge for obviating and solving problems;
(b) organise activities for learners to draw from authentic experience; drill in practical work for complete mastery; enable learners to think critically and acquire the reading habit and continuous thirst for knowledge (Office of the National Education Commission, 1999, p.11).

This statement aims to ensure that the learning process for students starts with curiosity and is followed by planned learning activities. Through teacher-student interaction, teachers encourage students' thinking skills, such as reasoning, decision making, reflecting, making inferences, and problem solving. It is intended that students are assisted to learn critical thinking skills such as gathering knowledge, comprehension, application, analysis, synthesis, and evaluation in classrooms where supportive learning environments are presented. Such settings encourage students to engage cognitively and emotionally with the learning tasks (Asian Development Bank, 2002).

Recently, Thailand has placed an emphasis on the use of technologies in education to facilitate the improvement of teaching and learning processes (Office of the National Education Commission, 2003). It was anticipated that the adoption of new technologies would also enhance higher-order thinking skills, critical thinking skills, and systematic thinking skills for all students (Office of the National Education Commission, 2004).

As part of its planning for the introduction of new technologies, the Thai government in 2003 set up the Information and Communication Technology (ICT) schools pilot project. The purpose of the project was to provide a model in teaching and learning by integrating ICT through the teaching and learning process into classroom learning environments. The aim was for these model ICT schools to use ICT as a teaching and learning tool. In addition, they would use ICT to facilitate independent self-paced learning for all students.

This present study aimed to investigate how effectively Information and Communication Technology was being integrated into teaching and learning in the elementary and secondary schools involved in the ICT schools pilot project in Thailand. The study examined to what extent these model ICT schools had classroom learning environments that were related to students' critical thinking skills; student attitudes to ICT; and to what extent the classroom learning environments were associated with certain teacher characteristics.

The ICT schools pilot project in Thailand

There have been a number of definitions of ICT, which are derived from different studies. For example, UNESCO (2003, p.75) uses the term ICT to describe:

> the tools and the processes to access, retrieve, store, organise, manipulate, produce, present and exchange information by electronic and other automated means. These include hardware, software and telecommunications in the forms of personal computers, scanners, digital cameras, phones, faxes, modems, CD and DVD players and records, digitised video, radio and TV programmes, database programmes and multimedia programmes (Anderson, 2005, p.5).

In addition, the Teacher Training Agency (TTA) documentation defines ICT as including ‘computers, the internet, CD-ROM and other software, television, radio, video, cameras or digital cameras, and other electronic equipment’ (Capel, Leask, & Turner, 2001). Therefore, as ICT includes hardware, software and telecommunications, it is seen to be the means of supporting student learning via the use of electronic mail (email) also.

Interestingly, Australia’s national goals for schools in the 21st century typify what many other nations are striving towards in the use of technology. Included in Australia’s set of goals is the statement that “… when students leave schools they should be confident, creative and productive users of new technologies, particularly Information and Communication Technologies, and understand the impact of those technologies on society…” (Ministerial Council on Education Employment Training and Youth Affairs, 1999).

In Southeast Asia, ICT has been recognised as a new mechanism to increase quality and equity in education. Most governments in the SEAMEO (Southeast Asian Ministers of Education Organisation) region have laid out impressive national ICT policies and strategies for education. For example, Malaysia has declared a Vision 2020 Plan for industry and education that has established a “Multi-media Super Corridor” close to the nation’s capital, and has developed prototype “Smart Schools”, with the goal that all schools in Malaysia should be Smart Schools by 2010. The Outline Prospective Plan aims to:

(a) have a quality workforce which is knowledgeable with highly tuned thinking skills, able to use technology and new resources optimally, to combine creativity and innovation effectively and has a diversity of skills and knowledge in the use of ICT

(b) produce students who are knowledgeable and ICT literate and able to use technology for the betterment of themselves, their communities and their nation (Downes, 2003, p. C5).

Thailand also views ICT as one tool for achieving its overall national objectives in social, political, economic, and educational development. In Thailand, the use of the vast potential of ICT is recognised as a gateway to wider democratic participation, to increased wealth distribution, to greater social benefit provision, and to enhanced quality of life for all Thai people (Office of the National Education Commission, 2003). The value of providing ICT for quality and equity in education is perceived as essential for both basic and life-long education (Office of the National Education Commission, 2004). However, despite the substantial introduction of ICT in Thailand in the recent past, human and social development has not been emphasised as outcomes of the new technologies. The National Economic and Social Development Board (NESDB) showed that in Thailand most of the ICT-related enterprises were geared towards facilitating communication and providing general information and knowledge, with little contribution to human and social development (Office of the National Education Commission, 2002).

Realising the essential role of technologies for education in enhancing the competitiveness of Thailand and its people in a knowledge-based economy and society, both the 1997 Constitution of the Kingdom of Thailand and the 1999 National Education Act (NEA) identified the possible importance of computer technologies for education (Office of the National Education Commission, 2002).

Sections 40 and 78 of the 1997 Constitution and Section 63 to 69, in Chapter 9, of the 1999 National Education Act proposed that major action be taken to promote the use of technologies for education. These actions included: (a) the establishment of an organisation to introduce ICT, (b) the development of ICT policies and plans, (c) the planning of infrastructure and networking systems, (d) the construction of materials and other technologies for education, and (e) the development of educational personnel and learners in the use of ICT.

The National Electronics and Computer Technology Centre (NECTEC) set up the National IT (Information Technology) policy in 2001, under the supervision of the Ministry of Science and Technology, in cooperation with the National Economic and Social Development Board (NESDB) and relevant agencies in the private sector. The policy, which was approved in March 2002, stipulated five specific strategies relating to e-Government, e-Commerce, e-Industry, e-Education, and e-Society. In particular, strategies for e-Education included the training of teachers, development of content, networking of educational administration systems, increase of ICT usage, and the development of ICT infrastructure. It was proposed that by 2010, two goals should be achieved: (a) all schools would be able to connect with the IT network, and (b) computers or IT would be used as part of the teaching and learning process at all levels of education (primary, secondary and higher education).

As part of its ICT strategy, the Ministry of Education set up the ICT schools pilot project. It was a three-year pilot project (from fiscal year October 2003 to fiscal year October 2006) to be conducted at six primary and six secondary schools in Bangkok, suburbs around Bangkok, and other urban areas of Thailand. The main objectives of the ICT schools pilot project were to apply and integrate ICT into teaching and learning process among classroom learning environments with ICT by developing the students' body of knowledge and promoting students' self developing learning through learners' development activities in elementary and secondary model ICT schools under this project (Office of the National Education Commission, 2002).

The Thai ICT schools pilot project proposed that computers or ICT "…would be used to apply ICT in developing the body of knowledge for students as well as integrating ICT into the teaching and learning process and promoting learner development activities at elementary and secondary levels of education. In addition, the theory of Constructionism will also be applied in the teaching and learning process among classroom learning environments with ICT…" (Office of the National Education Commission, 2002, p.35). The Ministry of Education of Thailand gave three main reasons for establishing the project. The main objectives were as follows: (Bureau for Innovative Development in Education, 2004a)

- to provide encouragement for the use of computers and other forms of technology for student self-learning through ICT-related technologies such as computers and/or the internet, and so on.

- to promote and support more positive teachers' and students' attitudes toward ICT usage by enhancing and developing thinking skills, including higher-order thinking, creative thinking, critical thinking, systematic thinking, and relevant other thinking skills for students in ICT classroom learning environments.

- to improve teaching skills and teaching and learning practices for school teachers leading to an increase in the effectiveness of ICT integration in classroom learning environments (Bureau for Innovative Development in Education, 2004a).

In addition, the Ministry set out four major aims of the pilot project. The main aims were as follows:

(a) to facilitate individualising the learning process needed for student self-learning, leading to improved student achievements;

(b) to encourage teachers to improve the quality of learners through teaching and learning process to enhance a variety of thinking skills such as higher-order thinking, creative thinking, critical thinking, systematic thinking, and other relevant thinking skills;

(c) to motivate positive teachers' and students' attitudes toward the use of ICT as a teaching and learning tool; and

(d) to prepare students to have a competitive advantage in educational achievements in terms of a high and effective quality workforce (Bureau for Innovative Development in Education, 2004a).

The Ministry offered the following guidelines for implementing and integrating ICT through the teaching and learning process in the model ICT schools under the Thai ICT schools pilot project. They recommended that: (Bureau for Innovative Development in Education, 2006b).

<u>In relation to Basic Infrastructure</u>, schools should:

- Establish electronic closed networks in school, including intranet or LAN for the use of ICT in classroom learning environments;
- Provide wide access to the internet (through the world wide web of networked computers) for teaching and learning processes in classroom learning environments with ICT use; and
- Provide a variety of ways in which ICT can be used in teaching to support students' learning through ICT usage such as computers, the internet, CD-ROM and other software, television, radio, video, cameras or digital cameras, and other electronic equipment.

In regard to the Teaching and Learning Process, schools should:

- Plan or set learning objectives that integrate ICT applications into the teaching and learning curriculum.

In the area of Learning Resources, schools should:

- Develop and establish school websites;
- Operate knowledge or school management systems and best practice for ICT classroom learning environments;
- Provide legal software for school teachers who use ICT integrated into their subject lessons and need to observe privacy, for example, data protection and copyright (e.g., strict limits on the reproduction of materials authored by others, which includes placing such material on school web sites and appropriate authorisation for any personal details of individuals held on computer); and
- Collect ICT equipment, including media, models, innovation, ICT resources, ICT materials, and so on in standard form as ICT learning sources, ICT learning centres or E-Libraries.

In regard to Learners and Students, schools should:

- Develop skills and knowledge of teachers and students to understand how ICT can support their teaching and learning in various subject areas; and
- Encourage teachers to set learning development activities for students that involve searching for information or materials from the internet so as to continuously improve knowledge in all basic subjects.

In relation to Administration and Management, schools should:

- Have school administrators control, monitor and assess teaching and learning processes by integrating ICT and report the relevant results to school administrators;
- Fund supportive teaching and learning process and practices with the utilisation of ICT for school teachers;
- Prepare an operational/strategic plan for the next 3-5 years to identify ways to further develop the use of ICT for teaching and learning processes;

- Motivate cooperation with local communities, private organisations and other relevant organisations to participate and contribute ICT resources for teaching and enriching the classroom learning environment; and
- Provide a benchmark for other schools to assist them to improve the teaching and learning process through the use of ICT within their respective learning communities (Bureau for Innovative Development in Education, 2006b).

The model ICT schools in the pilot project included:

Primary schools:

(1) Duangwipha School
(2) Kalahomeutit School
(3) Anubanwatlukkaeprachachnutit School
(4) Prathomthanbinkompangsan School
(5) Wat Sommanus School
(6) Anurajprasit School

Secondary schools:

(1) Puttajak Wittaya School
(2) Wat Khemaphirataram School
(3) Patai Udom Suksa School
(4) Thamuangrat Boorung School
(5) Wat Bowonniwet School
(6) Chaichimplee Wittayakom School
(Bureau for Innovative Development in Education, 2004b)

One year after the project began, in 2004, two new schools applied to participate in the pilot project – Prathom Thammasat School and Samakkee Wittayakom School (Bureau for Innovative Development in Education, 2006b). Therefore, in the course of the project (fiscal year 2003 to fiscal year 2005), there were a total of 14 model ICT schools. However, 13 of these were located in Bangkok and surrounding suburbs. The one exception was Samakkee Wittayakom, which was in Chiangmai in the northern area of Thailand.

These model ICT schools have used ICT, particularly computers, to apply in developing students' body of knowledge and integrating ICT into teaching and learning among classroom learning environments with ICT and promoting students' self developing learning through learners' development activities which were co-established by teachers and students in schools. In addition, all model ICT schools have been supervised by one of the supervising universities such as Kasetsart University (KU), Silpakorn University (SPU) (Sanamchandra Palace Campus), King Monkut's University of Technology Thonburi (KMUTT), King Monkut's Institution of Technology North Bangkok (KMITNB), Chulalongkorn University (CU), Thammasat University (TU), and Maephaluang University (MPLU). Each university supervised at least one primary school and one secondary school during the entire project.

There were three major participants that developed and generated the ICT schools pilot project in Thailand.

(a) The Office of the Basic Education Commission (OBEC)

The main responsibility of the OBEC was coordinating and conducting the Research Development (R&D) between supervising universities, the model ICT schools, and the relevant institutions. So the OBEC was the principal coordinator, which sought specific participation from related government or private organisations, such as the Ministry of Information and Communication Technology, the National Science and Technology Institution, the National ICT Learning Centre, and other relevant institutions. These organisations provided the technical knowledge and resources to stimulate and support the use of instructive tools for classroom activities within ICT learning environment. These included communication tools, searching tools, multimedia tools, and authoring tools via the teaching and learning process in various subject areas in eight groups of basic subjects: (1) Thai Language (2) Mathematics (3) Science (4) Social Studies (5) Religion and Culture (6) Health Education and Physical Education (7) Art, Career and Technology-Related Education (8) Foreign Languages.

(b) The Supervising Universities

The seven supervising universities had the role of developing and stimulating new teachers' basic knowledge and the skills necessary for both subject teachers and leading ICT teachers to integrate ICT into the teaching and learning process in their classrooms. In particular, each teacher in model ICT schools had applied ICT in developing students' basic knowledge, integrated ICT into the teaching and learning process, and promoted students' self learning through learner development activities. In shaping and directing the use of ICT, they were guided by the supervising universities (Bureau for Innovative Development in Education, 2006b).

Kasetsart University (KU) supervised four model ICT schools as follows:

- Wat Sommanus School
- Prathomthanbinkompangsan School
- Anurajprasit School
- Patai Udom Suksa School

King Monkut's University of Technology Thonburi (KMUTT) supervised two model ICT schools:

- Duangwipha School
- Chaichimplee Wittayakom School

King Monkut's Institution of Technology North Bangkok (KMITNB) supervised two model ICT schools:

- Kalahomeutit School
- Wat Khemaphiratataram School

Silpakorn University (SPU) (Sanamchandra Palace Campus) supervised the following two model ICT schools:

- Anubanwatlukkaeprachachnutit School
- Thamuangrat Boorung School

Chulalongkorn University (CU) supervised two model ICT schools as follows:

- Wat Bowonniwet School
- Puttajak Wittaya School

The two additional model ICT schools, Prathom Thammasat School and Samakkee School were supervised by Thammasat University and Maephaluange University, respectively.

(c) The Model ICT schools

The model ICT schools applied and integrated ICT into teaching and learning process in their classroom learning environments with ICT. The teachers developed the students' body of knowledge and promoted students' self-learning through activities, which were co-established with students in schools. These model ICT schools sought the participation of the government or private sector to enable teachers to integrate ICT into the various lessons in the eight subject areas of their classrooms, by providing ICT equipment, computer facilities, or personnel, or by providing innovative ideas for the teaching and learning process.

The ICT schools pilot project in Thailand was planned to be implemented in three stages.

Stage 1: Preliminary and Basic Knowledge of ICT Application

The first stage was carried out during the fiscal year 2003 (starting from 1st October 2002 and ending on 30th September 2003). In the first year, the three main parties worked together to conduct Research and Development (R&D) concerning ICT for education in elementary and secondary schools. It was then necessary to decide on the operational details of the pilot project. These included:

- Selecting schools, at both elementary and secondary levels, to join the project;
- Coordinating the three major participants (the OBEC, supervising universities, and the model ICT schools);
- Devising a strategic plan for each model ICT school as part of the development of teachers, students, curriculum, and school administration;
- Cooperating with the relevant private or government institutions which participated in this project;

- Gathering information, drawing conclusions, and reporting on the overall performance of each model ICT school. (Bureau for Innovative Development in Education, 2004b)

Stage 2: Strength and Sustainability of the Thai ICT schools pilot project

The second stage took place during the fiscal year 2004 (starting from 1^{st} October 2003 and ending on 30^{th} September 2004). In the second year, the model ICT schools aimed to develop the ability of students and teachers to use ICT as a teaching and learning tool in their ICT classroom environments. Details about the steps undertaken in this part of the project's operation are provided in the following section. They included:

- Setting up a meeting to plan for the whole of the operating year (fiscal year 2004);
- Developing the basic understanding of knowledge and computer skills, including basic ICT applications, for teachers to integrate ICT into teaching and learning process in their classroom environments;
- Setting up ICT activities which enabled the students to learn by themselves according to their interest through opportunities available in society or developing other resources, such as an ICT Camp, or an ICT Club;
- Enlarging the positive effects of the development of ICT on school stakeholders (students, parents, teachers, school staff, local community, and other relevant parties) in terms of positive attitudes, ICT efficiency, and effectiveness;
- Using ICT for school administration (database management system) and the teaching and learning process generally;
- Monitoring and assessing the major achievements, which occurred over the two year period. (Bureau for Innovative Development in Education, 2004b)

Stage 3: Promoting the model and administration

During the fiscal year 2005 (from 1^{st} October 2004 to 30^{th} September 2005), the last stage of the project was carried out. This involved the following activities:

- Setting up a meeting to plan for the whole of the operating year (fiscal year 2005);
- Developing an understanding of knowledge and computer skills continuously, including basic and advanced ICT applications, which were necessary for school

teachers or staffs to integrate ICT into the teaching and learning process in their classroom environments, given the existing circumstances;

- Integrating ICT as a learning tool in different ways into the eight groups of basic subjects, including (1) Thai language, (2) mathematics, (3) science, (4) social studies, (5) religion and culture, (6) health education and physical education, (7) art, career and technology-related education, and (8) foreign languages and formulating extra activities for students' learning;
- Publishing knowledge and skills needed for ICT application to enable teachers to better promote the development of the teaching and learning process;
- Gathering data, drawing conclusions, and reporting the overall performance of each model ICT school, in relation to students' and teachers' outcomes;
- Setting up the academic conference which exhibited the highlight outcomes of students and teachers in ICT applications in schools. (Bureau for Innovative Development in Education, 2004b)

The structure of the portfolio

The major purpose of this present study was to investigate how far ICT was being used effectively in the elementary and secondary schools involved in the ICT schools pilot project in Thailand. The present study examined to what extent the model ICT schools had classroom learning environments that were related to student outcomes in terms of students' critical thinking skills and students' attitudes toward ICT, and to what extent classroom learning environments were associated with certain teacher characteristics.

The portfolio is made up of three parts.

PART 1 (ICT, Classroom Learning Environments, and Student Outcomes) contains two sections that review relations among teacher characteristics, ICT classroom learning environments, and two student outcomes (students' critical thinking skills and attitudes toward ICT). I introduce the importance of the use of ICT in the first section. Research in each of these areas is discussed in the second section. From the review of this literature, I develop a theoretical framework and propose a research model which was used to guide the investigation. From these, I formulate a set of research propositions used in the investigation described in Part 2 and 3.

PART 2 (Quantitative Investigation of the ICT Schools Pilot Project in Thailand) covers the study's quantitative design, methodology, analysis, and findings. The first section describes the Thai teachers and students from model ICT schools who participated in my research through questionnaires, interviews, and classroom observations. This is followed by a description and application of the instruments that were used to collect the quantitative data. In the last section, the findings of the analysis of quantitative data by using statistical software programs (SPSS and HLM) are reported.

PART 3 (Qualitative Investigation of the ICT Schools Pilot Project in Thailand) presents the qualitative analysis of school based reports and evaluations. The second section covers details on data collecting through interviews and classroom lesson observations. The qualitative analysis and findings are then presented in the last part.

In the conclusion to the Portfolio, I draw together and discuss the key results of the study, integrating both the quantitative and qualitative findings. Implications and recommendations for teachers and school management are presented, followed by a proposal for the direction of future research. The study concludes with the overall findings of the investigation and suggests how the results might be used to enhance the incorporation ICT into teaching and learning in all Thai schools so that students' critical thinking skills are promoted and their attitudes toward ICT enriched through their participation in classroom learning environments with ICT.

PART 1

ICT, CLASSROOM LEARNING ENVIRONMENTS AND STUDENT OUTCOMES

1.0 INTRODUCTION

Research on using ICT in classroom learning environments to stimulate the teaching and learning process has become one of the most important areas of contemporary educational research. The relevance of students' perceptions of ICT classroom learning environments in predicting students' critical thinking skills and their attitudes to ICT, as well as research on student outcomes in ICT classroom learning environments in relation to teacher characteristics, are now important areas of investigation, because of the widespread incorporation of ICT into schools.

Numerous investigations have examined various aspects of students' perceptions of their classroom learning environments. These studies tend to look at the perceptions of psychosocial characteristics of the classroom learning environments at the elementary, secondary and higher education levels (Fraser, 1986, 1994, 1998a, 1998b; Fraser & Tobin, 1991; Taylor, Fraser, & Fisher, 1997; Taylor, Fraser, & White, 1994).

In Thailand, there have been few attempts, however, to relate student outcomes (e.g., students' critical thinking skills and students' attitudes toward ICT) to students' perceptions of ICT classroom environments. There have been only a few studies of ICT classroom learning environments and none has examined student perceptions of ICT classroom learning environment under the Thai ICT schools pilot project. The present study is significant as it is one of the first studies of the classroom learning environments using ICT in Thailand.

Part 1 is divided into the following sections:

Section 1 focuses on research that has investigated the importance of the use of ICT in classroom learning environments where the teacher is seen as having the key role in the integration of ICT into classroom learning environments.

Section 2 presents research that has examined classroom learning environments in various ways: (a) research on using environment instruments (b) research on the relation between students' perceptions of general classroom learning environments and student outcomes, and (c) research on the relation between students' perceptions of classroom learning environments with the use of ICT and student outcomes.

Section 3 discusses research that has examined the relation between students' perceptions of classroom learning environments, students' critical thinking skills, and their attitudes toward ICT. In particular, this involves (a) research on critical thinking skills (b) research on classroom learning environments and critical thinking skills, and (c) research on the use of ICT in classroom learning environments and student outcomes in terms of students' critical thinking skills and students' attitudes toward ICT.

Section 4 examines the links between teachers' characteristics (i.e., teachers' individual characteristics, teachers' critical thinking skills, and teachers' attitudes towards the use of ICT), ICT classroom learning environments, and students' critical thinking skills and their attitudes toward ICT.

Section 5 presents a research model to examine associations between teachers' characteristics, students' perceptions of the use of ICT in classroom learning environments, and student outcomes.

In the following section, I present evidence relating to the use of ICT in classroom learning environments and describe ways of using ICT in schools and in other educational contexts.

1.1 THE USE OF ICT IN CLASSROOM ENVIRONMENTS

1.1.1 Introduction

This section presents arguments for the importance of the integration of ICT, especially in the form of computers, into classroom learning environments. In particular, the teacher is seen as having the key role in introducing ICT into classroom teaching and learning in both primary and secondary schools.

1.1.2 ICT in Classroom Learning Environments

ICT, particularly in the form of computers and online networks, is growing in schools worldwide. Computers have been used in education for over 30 years as a tool to assist in teaching and learning in a variety of academic disciplines. A considerable body of research demonstrates that their importance has accumulated over that period.

Research carried out in the mid-1990s for the National Council for Educational Technology (NCET) provided reasons for using Information Technology (IT) in schools. It showed the following benefits from ICT-integration into the teaching and learning process (Capel et al., 2001, p.41).

(a) Interactive technology motivates and stimulates learning;
(b) Difficult ideas are made more understandable when IT makes them visible;
(c) IT gives students the power to try out different ideas and to take risks;
(d) Computer simulation encourages analytical and divergent thinking;
(e) Using IT makes teachers take a fresh look at how they teach and the ways in which students learn; and
(f) Students make more effective use of computers if teachers know how and when to intervene.

Many professional educators in the field of educational computing such as Olson (1988), Rieber (1994), and Lynch (1990), have described computers as being interactive and suggested that they changed the relationship structures within the classroom. Carter (1990) asserted that the introduction of new technologies had the capacity to construct a totally new environment. Scott, Cole, and Engel (1992) observed that using computers as a medium of communication, rather than trying to program the machines to teach students or getting the students to program the machine, was a recent concept. Educational Technology was in the early stages of a revolution that was barely perceived and full of potential (Schwen, Goodrum, & Dorsey, 1993). In addition, characteristics within classroom learning environments such as openness, community, and interpersonal interaction, could be enhanced through the use of advanced technologies (Ahmad, Piccoli, & Lves, 1998).

Technology was seen as a powerful tool for curricular restructuring because it offered educators innovative ways to enhance student learning and student outcomes (Campoy, 1992; Office of Technological Assessment, 1995). But what would make the use of technology truly valuable would be how it might encourage learners to develop and test the creation of new knowledge systems (Privateer, 1997). Privateer further pointed out that educators must focus on the use of technology to incorporate and stimulate new pedagogical theories rather than just strictly to deliver course materials.

According to Alessi and Trollip (2001), computer based instruction had many benefits such as:

(a) learning with computers takes less time;
(b) lesson materials are handed out easily and cheaply;
(c) students work at their own pace and convenience; and
(d) students are also offered the opportunity for extensive practice, through which their motivation is stimulated.

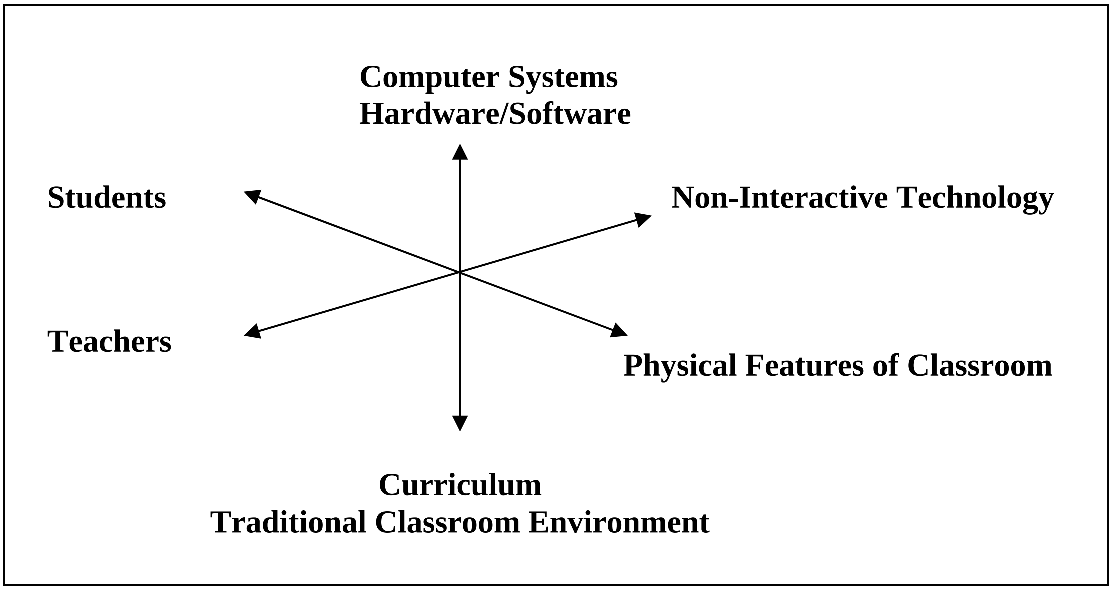
Educational associations have been advocating a more meaningful use of technology in schools (International Society of Technology Education, 1992). They proposed integrating computer skills into content areas, suggesting that these should not be taught in isolation and that separate "computer classes" did not really help students learn to apply computer skills in meaningful ways. There was increasing recognition that computer literacy was not about how to operate computers, but how to use technology as a tool for organisation, communication, research, and problem solving. This was an important shift in approach and emphasis.

Christmann, Badgett, and Lucking (1997), as well as Kulik and Kulik (1991) proposed that learning effectiveness and efficiency could be improved through the use of computers. Gleman and Melmed (1996, p.93) after a number of surveys, indicated that educational technology had “significant potential for improving students’ learning”. Both the research and the experience of practitioners suggested that this could be achieved when technology was properly implemented.

Incorporating multimedia and computer assisted instruction into the undergraduate curriculum has been seen as a useful adjunct to the processes of learning. For example, Yaverbaum, Kulkarni, and Wood (1997) indicated that integrating multimedia into the traditional learning environment not only enriched the style of presentation, but had the added capability of increasing the learners’ retention. In addition, a strength of the multimedia presentation was its ability to provide an environment that was not only dynamically visual and auditory, but in many cases was interactive through its multimedia presentation (Najar, 1996; Yaverbaum et al., 1997). Interactive presentations required interactive learners. Therefore, by accepting that the active learner involved in relevant activities had an advantage over the passive learner who just listened, interactive multimedia could provide a more enriched learning environment than the more traditional passive learning approaches.

Newhouse (2001a) indicated that classroom learning environments which incorporated computers could be depicted by the model shown in Figure PF1-1. Although he recognised that computer systems and non-interactive technology were part of the context of the curriculum, he considered that it was more helpful to present them as separate entities in the complex pattern of classroom relationships. The complexity of this pattern of relationships increased, as both ICT hardware and software interacted with the other elements of the traditional classroom learning environment.

Figure PF1- 1: A Model of the Relationships of Computer Systems to the Elements of the Classroom Learning Environment (Newhouse, 2001a)



In any discussion of the use of computers in classrooms, based on this relationship model, it is necessary to consider the relationship between humans and computers in the category named in the Figure PF1-1 as Computer Systems Hardware/Software (Lynch, 1990). These relationships assist in determining the particular roles of the computer systems, teachers and students.

Therefore, computer supported learning environments are those in which computers are used to either maintain a learning environment or to support student learning (DeCorte, 1990; Mercer & Fisher, 1992; Mevarech & Light, 1992). Additionally, the increased use of computers in classrooms has led to several studies that evaluated the effectiveness of computer-assisted learning (Fisher & Stolarchuk, 1997 November; Schuh, 1996; Teh & Fraser, 1995b). Levine and Donisa-Schmidt (1995), for example, investigated relationships between student gender, computer experience, and students' perceptions of their classroom environments in science classes. The experimental group used a computer-based classroom environment. The control group used a traditional classroom environment. The study examined 1,009 students in grade 7 in relation to cognitive involvement, scope and novelty of science tasks, peer relations, computer contribution to learning, student responsibility, and student-teacher interactions. Levine and Donisa-Schmidt (1995, p.163) concluded:

> The most meaningful differences between the two groups were observed in the climate dimensions relating to the degrees of student involvement in the learning process and the perception of their own responsibility for learning. Interaction effects of student gender, computer ownership, and instruction were found, suggesting that the computer-integrated classroom has the potential to reduce differences in student perception regarding the positive roles computers can play in science learning.

ICT also has the potential to improve the teaching and learning process so that the use of ICT can be an effective complement to conventional teaching and learning practices (Vries, Naidu, Jegede, & Collis, 1995). For instance, an analysis of successful teaching and learning with ICT in New Zealand showed that student learning was a key outcome related to ICT-integrated into teaching and learning. In the study, Central School was able to explain a series of skills to be acquired and a sequence of applications that allowed students to demonstrate their skills in a significant context. The school also specified its intention to develop learners who could process information and learn independently through ICT-integrated into teaching and learning process. Learning with ICT was thus considered to be a means of nurturing meaningful communication, creativity, design and problem solving (Ramsay, 2001). In addition, the use of computers in Central School involved a change in the relationships between students and teachers and between students and their peers. In particular, the increased interaction between students appeared to give them greater power than previously in the dynamics of classroom learning.

Since the use of computers in classrooms alters the power relationships within the environment, the roles of teachers and students are likely to change. Computers cannot easily be integrated into classrooms to create computer supported learning environments without a better understanding of the interaction between teachers and students or between students and their classmates (Olson, 1992). Rowe (1993) made the point that:

> Obviously, the more effective uses of computers in education will require new patterns of interaction between students and teachers, changes in the social organisation of the classroom, the adaptation of curricula and alternative purposes and modes of student evaluation (Rowe, 1993, p.5).

The changing roles of teachers and students were reflected in different ways of organising the classroom and the new teaching and learning strategies employed. Fulton (1998) pointed out that effective use of ICT to develop "learning, communication, and information skills is the result of many factors, chief of which are the teacher, his or her competence, and ability to shape technology-based learning activities to meet student learning needs" (Fulton, 1998, p.60). It follows that if technology is to be integrated successfully into classroom instruction, teachers must be able to display successful mastery of the technology themselves. Accordingly, technology use by students depends on the ability of teachers to integrate technology into their teaching process.

Drenoyianni and Selwood (1998) looked at two groups of teachers who adopted a variety of rationales for the use of ICT, particularly computers. They found three rationales: (a) developing computer awareness (social), (b) improving computer literacy (vocational), and (c) supporting learning and teaching in their classroom learning environments with ICT.

Several researchers acknowledged the potentially adverse consequences of unfavourable attitudes toward computers by students on academic and professional development. Dunn and Ridgway (1991a; 1991b) found that computers were used to elicit basic technological skills and knowledge from students, to motivate them, and to encourage the development of students' communication computer skills. Kaput (1989) indicated that there was evidence that students who learned in a computer environment had quite different affective responses to learning tasks than students who did not.

Pope-Davis and Vispoel (1993), for example, assessed the influence of microcomputer training on students' attitudes toward computers. Included in the sample were 194 undergraduate and graduate students, 107 of whom took a microcomputer training course, while 87 students did not received no computer training. The results indicated as follows.

(1) Students who received microcomputer training demonstrated less anxiety, more confidence, and more interest in using computers than students who received no training.
(2) There were no significant gender differences in attitudes at the beginning or end of the study.

(3) Attitudes toward computers improved significantly over time with computer training but did not change without training (Pope-Davis & Vispoel, 1993, p.83).

In conclusion, there have been many previous research studies to support and exhibit the importance of the use of ICT-integration into the teaching and learning process, particularly in the form of computers. However the teacher was seen as having the key role among classroom learning environments with ICT, at all educational levels (primary, secondary, or higher). These related studies indicated that student learning outcomes, in relation to certain teachers' characteristics, are currently important areas of investigation.

1.2 RESEARCH ON CLASSROOM LEARNING ENVIRONMENTS

1.2.1 Introduction

This section reviews research that has been done on classroom as learning environments and their association with student outcomes. It then goes on to consider specifically research on classroom environments, which have ICT and how these are related to student academic outcomes and attitudes to ICT.

1.2.2 Research involving Classroom Learning Environments

Research in education that concentrates on classroom learning environments has produced encouraging results leading to an enhancement of the teaching and learning process. A great deal of progress has been made in the conceptualisation, assessment, evaluation and use of classroom learning environment questionnaires (Fraser, 1989). This research area has considered all school levels from primary school to university; urban and rural settings; cross-national studies that include Western and Non-Western countries; actual and preferred forms of classroom learning environments; and comparisons of teachers' and students' perceptions of their classroom learning environments.

Considerable interest has been shown internationally in the conceptualisation, measurement and investigation of perceptions of the psychosocial characteristics of the classroom learning environment at all levels (e.g., Fraser, 1994, 1998a, 1998b; Fraser & Walberg, 1991; Taylor et al., 1997; Taylor et al., 1994). Also, a major interest of relevant previous research has been the examination of relationships between students' cognitive and affective learning outcomes and their perceptions of the psychosocial characteristics of their classroom environments (Fisher, Henderson, & Fraser, 1995, 1997; Fraser, 1986, 1994; Fraser & Fisher, 1982; Fraser & McRobbie, 1995; Fraser & Tobin, 1991; Goh & Fraser, 1995; Haertel, Walberg, & Haertel, 1981; McRobbie & Fraser, 1993; Teh & Fraser, 1995a; Wong & Fraser, 1996).

1.2.3 Instruments Used

The development of instruments to be used in classroom learning environment studies began in the 1960s in conjunction with an evaluation of Harvard Project Physics in 1968 (Walberg & Anderson, 1968), and the development of the Learning Environment Inventory (LEI) to evaluate a new curriculum innovation. In addition, Moos developed the classroom learning instrument, beginning with the construction of the Classroom Environment Scale (CES) (Moos, 1968; Trickett & Moos, 1973).

Classroom learning environments can be used not only to provide significant information about students' perceptions of classroom environment, but also, as Fraser (1998a) emphasised clearly, to examine relationships between classroom learning environments and student outcomes.

In addition, the association between learning environment variables and student outcomes has provided a rationale and focus for the application of learning environment instruments. More recent research on classroom learning environments has focused on the development and use of instruments to evaluate classroom learning environment qualities from the students' perceptions of their classroom learning environments (Fraser & Tobin, 1991). At the same time, instruments which measure the relationship between environmental variables and student outcomes have been developed and tested (Tobin & Fraser, 1998). These include (1) the Classroom Environment Scale (CES), (2) Individualised classroom Environment Questionnaire (ICEQ), (3) My Class Inventory (MCI), and (4) Questionnaire on Teacher Interaction (QTI), and so on (Fraser, 1998a).

For example, Fraser (1998a) described nine major questionnaires for assessing student perceptions of classroom psychosocial environments, including the four listed above, and in addition, the Learning Environmental Inventory (LEI), the College and University Classroom Environment Inventory (CUCEI), the Science Laboratory Environment Inventory (SLEI), the Constructivist Learning Environment Survey (CLES), and What Is Happening In this Class (WIHIC). He suggested that such scales were regularly being revised with amendments to items and scale formats. In addition, he reviewed the application of these instruments to 12 major lines of previous research which had focused on:

(1) Associations between outcomes and environments;
(2) Evaluating educational innovations;
(3) Differences between student and teacher perceptions;
(4) Whether students achieve better in their preferred environment;
(5) Teachers' use of learning environment perceptions in guiding improvements in classrooms;
(6) Combining quantitative and qualitative methods;
(7) Links betweens different educational environments;
(8) Cross-national studies;
(9) The transition from primary to high school;
(10)Incorporating educational environment ideas into school psychology;
(11) Incorporating educational environment ideas into teacher education; and
(12) Incorporating educational environment ideas into teacher assessment (Fraser, 1989, p.28).

Using the Science Laboratory Environment Inventory (SLEI), some researchers examined students' cognitive and affective outcomes. For example, McRobbie and Fraser (1993) examined associations between classroom learning environments and student outcomes. A sample of 1,594 senior high school chemistry students in 92 classes in 52 schools in Brisbane, Australia, responded to an instrument (the SLEI) that assessed five dimensions of chemistry classroom environments (Cohesiveness, Open-endedness, Integration, Rule Clarity, and Material Environments), and student outcomes, encompassing two skills and four attitude measures. The results showed that "students' perceptions of classroom psychosocial environment account for appreciable amounts of variance in student outcomes beyond that attributable to student characteristics such as general ability" (McRobbie & Fraser, 1993, p.83).

Fisher, Henderson and Fraser (Fisher et al., 1995) used the Questionnaire on Teacher Interaction (QTI), to investigate associations between student outcomes and perceived patterns of teacher-student interaction for a sample of 489 senior high school biology students in Australia. This study confirmed the reliability and validity of the QTI when used in senior biology classes.

> Generally, the dimensions of the QTI were found to be significantly associated with student attitude scores. In particular, students' attitude scores were higher in classrooms in which students perceived greater leadership, helpful or friendly, and understanding in their teachers' interpersonal behaviours. Conversely, students' attitude scores were lower in classrooms in which students perceived greater uncertainty, dissatisfaction, admonishing, and strictness in their teachers' interpersonal behaviours. If biology teachers want to promote favourable student attitudes to their class and laboratory work, they should ensure the presence of these interpersonal behaviours… Biology teachers can make use of this instrument to monitor students' views of their classes, investigate the impact that different interpersonal behaviours have on student outcomes, and provide a basis for guiding systematic attempts to improve this aspect of their teaching. Furthermore, the QTI could be used in assessing changes that result from the introduction of new curricula or teaching methods, and in checking whether the teacher's interpersonal behaviour is seen differently by students of different gender, abilities, or ethnic background (Fisher et al., 1995, pp. 131-132).

Aldridge, Fraser and Huang (1999) undertook a cross-cultural study of classroom learning environments in Australia and Taiwan. The study described the validation and use of an English and Mandarin version of the "What Is Happening in This Class (WIHIC)" questionnaire which was first developed by Fraser, Fisher and Mcrobbie (1996) for junior high school science classes. Data were collected from 1,081 students in 50 classes in Australia and from 1,879 students in 50 classes in Taiwan. The data indicated that:

> Australian students consistently perceived their classroom environments more favourably than did students in Taiwan on all scales. In contrast, Taiwanese students had a more positive attitude towards their science classes…students from Australia and Taiwan responded to questionnaire items in ways that were meaningful to their own situations and were often influenced by social and cultural factors…The learning environments created in each country were found to be influenced by the nature of the curriculum, with the more examination driven curriculum in Taiwan leading to more teacher-centred approaches in the classroom. Consequently, emphases considered important to science education in Western Australia, such as involvement, are not always as important or possible in Taiwan (Aldridge et al., 1999, p.60).

Wahyudi and Treagust (2004) used a modified form of the WIHIC, when they investigated the nature of science classroom learning environments in rural and urban lower secondary schools in Indonesia. They collected data from approximately 1,400 students and their teachers in 16 schools. The Indonesian version of the WIHIC had seven scales with eight items per scale (Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity). The results were expressed as five assertions.

(1) The Indonesian version of the modified WIHIC was a valid and reliable instrument for measuring the classroom learning environment.
(2) There were significant differences between students' perceptions of the actual and preferred learning environment, with students tending to prefer a more favourable classroom environment than the one which they actually experienced.
(3) Female students generally held slightly more positive perceptions of both actual and preferred learning environments.
(4) Students held less favourable perceptions of both actual and preferred learning environments than did their teachers.
(5) There were significant differences in students' perceptions of the actual classroom learning environment, depending on the schools' locality, with students in rural school holding less favourable perceptions than students in urban and suburban schools. Students in urban and suburban schools perceived their classroom environments similarly, with the exception that students in

> urban schools perceived greater cooperation and less teacher support than did students in suburban schools (Wahyudi & Treagust, 2004, pp. 59-60).

Ferguson and Fraser (1999) used the QTI, associated with the MCI, to investigate changes in students' perceptions of classroom learning environments across the primary-secondary transition. They also included the role of gender and school size as influencing factors in the changed learning environments. This study identified both positive and negative changes in learning environment perceptions during the transition from primary to secondary school, but these changes were related mainly to school size. The researchers concluded that:

> Changes in learning environment across primary and secondary school transition are related to school size and, therefore, school programs devised to support students during the primary-to-secondary school transition need to take into account the degree of change, which students undergo in terms of school size… Students from small-sized primary schools experienced larger deteriorations in learning environment dimensions than did the students from medium-sized primary schools…. students whose secondary school was on the same site as their primary school reported the most favourable changes in perceived learning environment during transition (Ferguson & Fraser, 1999, p. 381).

In the following section, I present the findings from research which investigated the relationship between students' perceptions of learning environments and student outcomes.

1.2.4 Associations between Students' Perceptions of Learning Environments and Student Outcomes

The association between classroom learning environment variables and student outcomes has provided a rationale for and focus for the application of classroom learning environment instruments. Thus, there has been an acceptance of the classroom learning environment as a significant variable in predicting educational outcomes. It seems that the evaluation of classroom learning environments is as important as evaluating other student factors (e.g., students' characteristics) and learning outcomes. Fraser (1998a) emphasised the importance of assessing students' perceptions of their classroom learning environments, because of their impact on student outcomes.

In an analysis involving Australian secondary school students, Dart, Burnett, Boulton-Lewis, Campbell, Smith, and McCrindle (1999) investigated relationships between students' perceptions of the classroom learning environment, approaches to learning, and self-concept as a learner, by using the ICEQ and the Learner Self Concept Scale respectively. Data were collected from 484 students from 24 classes in two metropolitan secondary schools in Brisbane, Australia. They concluded:

> Deep Approaches to learning were significantly related to classroom learning environments which were perceived to be highly personalised and to be encouraging active participation in the learning process and the use of investigative skills in learning activities. High learner self concept was positively associated with Deep Approaches to learning and with classrooms perceived as high in personalisation. It was negatively associated with Surface Approaches to learning. Differences in perceptions of learning environments and approaches to learning in relation to student gender and level of schooling were small (Dart et al., 1999, p.137).

The relationship between academic efficacy and a number of variables concerning the classroom psychological environment was examined by Dorman (2001). A sample of 1,055 mathematics students from Australian secondary schools responded to an instrument that assessed ten dimensions of mathematics classroom environments: student cohesiveness, teacher support, investigation, task orientation, cooperation, equity, involvement, personal relevance, shared control, student negotiation. The findings illustrated that "classroom environment relates positively with academic efficacy" (Dorman, 2001, p.243). Dorman's study, however, was only concerned with mathematics classrooms.

Fisher, Fraser, and Rickards (1997) determined associations between science and mathematics students' perceptions of their classroom learning environments, their individual cultural backgrounds and gender, their attitudinal, and achievement outcomes. Data were collected from 3,994 students of various cultural backgrounds in 182 science and mathematics classes from 35 coeducational secondary schools in Western Australia and Tasmania. The students completed a survey including the QTI, attitude to class scale, and questions relating to cultural background. The researchers concluded that “Generally, the dimensions of the QTI were found to be significantly associated with student attitude scores. In particular, students’ attitude scores were higher in classrooms in which students perceived greater leadership, helping or friendly, and understanding behaviours in their teachers. Females perceived their teachers in a more positive way than did males, and students from an Asian background tended to perceive their teachers more positively than those from the other cultural groups used in the study” (Fisher, Fraser et al., 1997, p.2).

Wong and Fraser (1996) undertook a study of classroom learning environments in Singapore. They investigated the relationship between students’ perceptions of their chemistry laboratory classroom environment and their attitudes toward chemistry. Their sample of 1,592 Grade 10 chemistry students in 56 classes in 28 government schools in Singapore responded to the Chemistry Laboratory Environment Inventory (CLEI) instrument that assessed five dimensions of chemistry classroom environments (Student Cohesiveness, Open-endedness, Integration, Rule Clarity, and Material Environments). The findings showed:

> … ‘Integration’ and ‘Rule Clarity’ were strong and consistent predictors of the attitudinal outcomes. This implies that students’ attitudes towards chemistry are likely to be enhanced in chemistry laboratory classes where laboratory activities are linked with the theory learned in non-laboratory classes and where clear rules are provided … The findings from this study serve to provide more evidence to support the science laboratory environment-attitude linkage (Wong & Fraser, 1996, p.100).

Wong and Fraser’s study was notable in drawing attention to the material environment in contrast to the psychological one.

A large study in the U.S. investigated associations among student gender, subject area, and grade level differences in students’ perceptions of their classroom learning environment. The study included 13,000 students drawn from 96 urban elementary, middle, and high schools in the U.S. Waxman and Huang (1998) concluded that:

> Female students generally reported higher scores for their perceptions of the learning environment than did male students. There were very few differences by subject area, but there were many statistically and educationally significant differences by grade level. In general, middle school classes had less favourable perceptions of their learning environment than did either elementary or high school classes" (Waxman & Huang, 1998, p.95).

Majeed, Fraser, and Aldridge (2002) examined the relationship between students' satisfaction and learning mathematics in Brunei, Darussalam. Data were collected from 1,565 junior high school mathematics students in 81 classes in government schools, using the original five scale, 38 items, version of the MCI. The results revealed that:

> The classroom learning environment is related to students' satisfaction in mathematics classes…Student cohesiveness had the strongest (and positive) association with satisfaction, while difficulty was negatively and significantly associated with satisfaction at student and class levels for both the simple correlation and multiple regression analysis…the mathematics classroom environment was perceived more favourably by boys than by girls (Majeed et al., 2002, p.221).

The strongest tradition in past classroom environment research has involved investigation of associations between student outcomes and their perceptions of psychological characteristics of their classroom. In general, higher achievement on a variety of outcome measures has been associated with classroom perceived by students as having order and organisation, cohesion and goal direction (Dart et al., 1999).

Several previous research studies of the classroom environment, however, have demonstrated that measures of perceived classroom environment can predict student learning. For instance, Haertel, Walberg and Haertel (1981) carried out a meta-analysis which encompassed 823 classes in eight subject areas and represented the perceptions of 17,805 students in four nations. They found that student achievement was enhanced in those classes, which students felt had greater cohesiveness, satisfaction and goal direction and less disorganisation and friction.

A few years later, Fraser (1986) gave a table of 45 studies of associations between classroom environment and various student cognitive, affective and behavioural outcomes. Further investigations since that time have served to strengthen the relation between students' perceptions of classroom learning environments and student outcomes (Majeed et al., 2002; Taylor et al., 1994).

Sinclair and Fraser (2002) indicated that teachers who received support and training could use feedback based on a students' viewpoints to improve their classroom environments. Data were from 10 middle grade (Grade 6-8) teachers and 43 classes of students in urban North Texas school district. They completed the Elementary and Middle School Inventory of Classroom Environments (ICE) that assessed four dimensions of classroom environments (Cooperation, Teacher Empathy, Involvement, and Task Orientation). The findings were as follows.

(1) Factor and item analyses supported the internal consistency reliability of a four-factor version of the perceived and preferred forms of the ICE for both the individual student and the class mean as the units of analysis.
(2) The perceived and preferred environments of different classes were described, based on profiles of classroom environment scores from teachers selected from the original sample.
(3) Teachers' perceived and preferred scores were more positive than their students, and the perceived environments fell short of the preferred environments for both students and teachers.
(4) Classroom environments could be improved by teachers who received support and training as suggested by researchers (Sinclair & Fraser, 2002, pp. 319-322).

Mink and Fraser (2005) also followed the research tradition of investigating associations between student-perceived classroom learning environments and students' achievement and attitudinal outcomes. The purpose of their research was to evaluate if the implementation of the Project SMILE (Science and Mathematics Integrated with Literacy Experiences) positively influenced the classroom environment and student attitudes towards reading, writing, and mathematics at the elementary school. Data were collected from 120 grade 5 students in Florida, U.S. The classroom environment scales of Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness, based on the MCI and attitude scales derived from the 1988 National Assessment of Educational Program (NAEP) Attitude Survey, displayed adequate internal consistency, reliability and validity in both the pre-test and post-test for the attitude questionnaire and for both the actual and preferred forms of the MCI. In their conclusions, they suggested:

> …Student satisfaction is higher in classes that have a more positive classroom environment in terms of less friction, less competition and, particularly, more cohesiveness…This points to the desirability in revising SMILE in-service programs in ways that contributed teachers to create classroom learning environments that are more cohesive, less competitive and have less friction…Overall, both the quantitative and qualitative data supported the effectiveness of Project SMILE in terms of providing the elementary (K-5) mathematics classroom with a positive classroom learning environment and with positive attitudes. (Mink & Fraser, 2005, pp.80-83).

While many past learning environment studies have employed techniques such as multiple regression analysis, a few have used multilevel analysis, which takes account of the hierarchical nature of classroom settings (Bock, 1989; Bryk & Raudenbush, 1992; Goldstein, 1987). Recently, however, several studies have compared the results from Multiple Regression Analysis with those from an analysis involving the Hierarchical Linear Model (HLM).

Goh and Fraser (1995) investigated relationships between psychosocial climate and two student outcomes (attitude toward mathematics and mathematics achievement) among a sample 1,512 grade 5 students in 39 mathematics classes from 13 schools in Singapore. This study used the MCI to measure classroom climate. In addition, student outcomes were assessed by the Liking Mathematics Scale (LMS) and Mathematics Exercise (ME), respectively. They compared results from two different methods of analysis that included Multiple Regression Analysis and Hierarchical Linear Model Analysis. They concluded that:

> …Associations were found between students' outcomes and their perceptions of classroom environment. Of the four scales of classroom climate (Cohesion, Competition, Friction, and Task Orientation), friction was the strongest predictor of

> student achievement. Also, more cohesive classes with less friction among class members were associated with more positive student attitudes toward mathematics and outcomes (Goh & Fraser, 1995, p.33).

Similarly, Goh and Fraser (1998) examined associations between two aspects of classroom learning environment (interpersonal teacher behaviour and classroom climate) and student outcomes (attitude toward mathematics and mathematic achievement) in 13 primary mathematics classes in Singapore. This study used two different learning environment instruments. First, a primary level version of QTI was developed, validated and used in research application. Second, the MCI was adapted and cross-validated for use in Singapore. Data from both these instruments were collected from 1,512 grade 5 students in 39 mathematics classes. For the analysis of environment-outcome associations, simple, multiple and canonical correlation analyses and multilevel (hierarchical linear model) analyses were conducted, using two units of analysis – the individual student and the class mean. The findings revealed that:

> In particular, better achievement and student attitude which were found in classes with an emphasis on more teacher leadership, helping or friendly and understanding behaviours and less uncertain behaviour, and also in classes showing more cohesion and less friction...These findings inform educators and researchers about how to improve student achievement and their attitudes by giving greater emphasis to learning environment aspects correlated positively to students' outcomes and less emphasis to dimensions negatively correlated with student outcomes (Goh & Fraser, 1998, p.222).

Wong, Young, and Fraser (1997) investigated relations among students' attitudes towards chemistry and their perceptions of chemistry laboratory environments. Data were collected from 1,592 Grade 10 students in 56 chemistry classes in Singapore and both Multiple Regression and HLM were used in the data analysis. This study found that in general:

> …The HLM results supported those of the Multiple Regression Analysis in this study… However, the HLM analyses did not support the finding from the Multiple Regression Analysis that Open-endedness was significantly negatively associated with the Attitude to Scientific Inquiry in Chemistry…Students in chemistry

> laboratory classes in Singapore which integrated knowledge learnt from regular chemistry theory classes have positive attitudes to scientific inquiry, adopt scientific attitudes and enjoy chemistry lessons…Chemistry laboratory classroom environments which exhibit favourable levels of student cohesiveness, open-endedness in laboratory activities, integration between theory and experimental work, clear rules and adequate equipment and physical environment are linked with positive chemistry related attitudes among students (Wong et al., 1997, p.458).

Yore, Anderson, and Shymansky (2002) investigated relationships among science achievement of students in the Science Co-op Local Systemic Change project, student attributes, classroom teachers' characteristics, and classroom factors. Data were from both students (1,134 Grade 3 students and 1,482 Grade 6 students) and teachers (98 Grade 3 teachers and 78 Grade 6 teachers) in 38 school districts and 74 elementary schools. This study involved the HLM. HLM was judged to be the appropriate statistical analysis for this study, since the variables were from multiple levels and defined by nominal or ordinal scales. Moreover, the central goal of the study was to model the nested relationships within the variables, with no intention of exploring the existence of latent variables inherent in structural equation modelling (Bryk & Raudenbush, 1992; Hayduk, 1987). The findings showed:

> Student achievement could be accounted for by student attributes, classroom teacher characteristics and classroom environment. The relationships of students' gender, awareness, and attitudes with achievement were described. Teacher characteristics and classroom factors influenced the weightings of significant student attributes. Awareness of the nature of science significantly influenced science achievement while attitude toward science, school science, and science and technology careers negatively influence science achievement. Significant gender influence was found for Grade 6 students but not Grade 3 students (Yore et al., 2002, p.2).

Kotte, Lietz, and Lopez (2005) examined relationships between students' background factors and students' achievements. Data were collected in 2000 from 15- year- old students in the OECD Program on International Student Assessment (PISA) in Germany and Spain. However, the data analysis indicated that different factors were involved. Data were analysed by HLM software. The results revealed that "Both countries performed significantly below the OECD average not only in Reading but also in Mathematics and Science" (Kotte et al., 2005, p.113):

> Much of the differences between the two education systems apparently stemmed from the fact that in Germany much of the variance was associated with the school level whereas most of the differences in performance between students in Spain were associated with the student level. Thus, efforts to improve reading achievement in Germany would have to focus on supporting schools whereas in Spain remedial action would revolve around providing increased assistance at the individual student level (Kotte et al., 2005, p.123).

The research studies discussed above provided consistent support for the associations between the students' perceptions of classroom learning environment in general terms and a variety of student outcomes, both cognitive and affective. In the following section I review some examples of research that have examined the relation between students' perceptions of classroom learning environments (which have specifically included ICT) and student outcomes.

1.2.5 Associations between ICT Learning Environments and Student Outcomes

High expectations of the beneficial effects of the use of computer technology on student outcomes in teaching and learning classroom environments have generated much interest in research into the effective use of computers in the classroom, where the aim has been to measure any improvement in motivation and achievement (Dwyer, 1994; Fabry & Higgs, 1997; Johnson, Cox, & Watson, 1994; Schofield, 1995).

Many of the findings recorded in the literature point to technology's positive effects on the teaching and learning process in classroom environments and student achievements (Fabry & Higgs, 1997).

A study of 2,300 students aged between 8 and 16 in England and Wales, concluded that computers were good motivators which could compound students' interests, increase enjoyment in learning environments, contribute to positive concentration and focusing, ensure sustained involvement, pose challenging opportunities, as well as improving presentations and according students greater pride in their work (Johnson et al., 1994). Many researchers reported that children liked computers and were very motivated to use them. From the perspective of children, the advantages of computing are that they have infinite patience, never get tired, are impartial to ethnicity and gender, and are great motivators for learning (Christensen, 1998).

Teh and Fraser (1995a) examined associations between computer-assisted learning (CAL), students' achievements, and students' attitudes. Data were collected from 671 students from 24 CAL geography classes in 12 high schools in Singapore. The Geography Classroom Environment Inventory was developed to assess Gender Equity, Investigation, Innovation, and Resource adequacy in CAL geography classes. The researchers concluded as follows.

(1) The students' perceptions of classroom psychosocial environment accounted for appreciable amounts of variance in students' outcomes beyond that attributable to students' characteristics.
(2) The relationship between each of the four environment scales and both the achievement and attitude outcomes was strong and consistent.
(3) A new classroom environment instrument was developed and validated specially for computer-assisted learning in geography (Teh & Fraser, 1995b, pp. 13-14).

A number of studies explored students' perceptions of their classroom environment in computer-supported science classrooms and compared it to students' perceptions of the traditional science classroom environments. It was believed that the introduction of computers into science classrooms heralded a new era in science education, due to the potential that this approach has for enhancing science understanding and for contributing to overcome difficulties in more traditional science classrooms. Several teachers integrated internet usage into traditional classroom environments by posting notes, computer laboratories, and assignments on the school's homepage (Cox, 1992; Lazarowitz & Huppert, 1993; Reif, 1985).

Raaflaub and Fraser (2002) investigated psychosocial factors in learning environments where laptop computers were used in science and mathematics classes. Data were from 1,173 Grade 7-12 students in 73 mathematics and science classrooms in four co-educational independent boarding and day schools in Ontario, Canada. The sample students responded to the modified WIHIC questionnaire, the TEST of Science-Related Attitudes (TOSRA), and the Computer Attitudes Survey (CAS). These two attitudes scales were included to permit investigation of predictors of classroom environment (student gender and subject area), and of associations between science and mathematics classroom learning environments and students' attitudes. The study's findings were found as follows.

(1) Generally the classroom environment in classes using laptop computers was more favourable for girls than boys and for science subjects than mathematics subjects.
(2) The modified WIHIC questionnaire and attitude scales were reliable and valid for use in Grade 7-12 mathematics and science classrooms where laptop computers were used.
(3) Differences between actual and preferred environments scores were statistically significant for all scales, with students preferring a more favourable classroom environment than the one that they perceived that they were actually getting.
(4) Boys scored higher than girls on attitude towards subject and attitude towards computers, but girls had higher scores than boys on preferred Teacher Support, on actual and preferred Cooperation, and on actual and preferred Equity (Raaflaub & Fraser, 2002, pp.25-26).

Churach and Fisher (1999) examined that relationships between student's internet usage, the constructivist classroom environment, and students' attitudes towards science. The study included quantitative and qualitative analyses based on 431 students in 5 Hawaii Catholic high schools. They found that:

> … Student's internet usage has a positive effect on classroom environments in science classes…Positive associations exist between student's internet usage and

> the CLES scales of Critical Voice, Shared Control, Uncertainty, and Student Negotiation…The internet usage seems to be much more social than one may imagine. These findings vary between boys and girls, and yet both sexes are affected positively by their individual use of the internet. Finally, the role of the teacher played a large part in how valuable internet usage was to students. It was the individual teacher that seemed to be instrumental in keeping their students focused on the task at hand, whether that was accomplished through assigned projects or simply made part of the on going structured curriculum (Churach & Fisher, 1999, p.15).

Newby and Fisher (2000) used a two-level hierarchical model to investigate the relationships between computer laboratory environments and student outcomes at university level. The study included 208 students who took computer courses within the Business School at Curtin University of Technology in Western Australia. The results showed that:

> … Computer laboratory environment variables have statistically significant associations with students' attitudes towards computers and the course. These would suggest that computer laboratory courses should be integrated with concept theory and other non-computer classroom classes, that computer work should be open-ended in nature, and that the hardware and software equipments should be taken into account when designing computer exercises and assignments…The findings further showed that, among the attitudinal variables, students' perceptions of the usefulness of computers affect their enjoyment, which reduced anxiety as well… (Newby & Fisher, 2000, pp.64-65).

The increased use of computers in classrooms has led to many studies evaluating the effectiveness of computer-assisted learning (Fisher & Stolarchuk, 1997; Schuh, 1996; Teh & Fraser, 1995a) and investigating the associations between student genders, computer experiences and perceived classroom environments (Levine & Donitsa-Schmidt, 1995). Their investigation extended to the study of computers and classroom learning environments at all education levels (elementary, secondary, and higher education levels).

Mucherah (2003) examined the classroom climate in social studies classrooms using technology. The study included 306 Grade 7-8 students from 14 classrooms in three public urban middle schools in U.S. He used both quantitative and qualitative instruments. Data were collected from three instruments, including Classroom Climate Questionnaire (CCQ), classroom observations, and teacher interviews. The findings were found as follows.

(1) Social studies classrooms tend to de-emphasise innovation, involvement with computers, and competition with computer.
(2) Providing computers in the classroom is not enough to create consistently positive influences on classroom learning environments in social studies.
(3) Teachers need sufficient training or in-service education on how to incorporate technology into teaching and learning process in their classroom instruction relating especially to the required curriculum.
(4) Students and teachers view the classroom environment in social studies somewhat differently with regard to computer use. Most teachers emphasised classroom climate aspects, including teacher support, student interaction, and involvement in class activities. Students see their classes as being highly controlled by teachers and most activities being structured by the teachers.
(5) Technology use is more frequent in other subject areas such as science rather than in social studies.
(6) The curriculum and lesson plans in social studies often do not have clear-cut places for technology use (Mucherah, 2003, pp.50-54).

Another study by Maor and Fraser (1996) examined relationships between students' and teachers' perceptions of inquiry-based computer classroom environments, a computerised database and curriculum materials. This study involved from 120 Grade 11 students and 7 teachers from computing science classes in 4 schools in Perth, Australia. The results were shown as follows.

(1) Teachers perceived the classroom more positively on several scales of the learning environment than did their students in the same classrooms.
(2) Students had a significantly more positive attitude toward their computer-based classroom learning environments.

(3) The increase in students' perceptions scores on the Investigation and open-ended scales suggested that the program created a supportive learning environment for the development of inquiry learning and also the promotion of higher-level thinking skills.
(4) The computerized learning environment permitted students to develop scientific literacy, which is advocated by science curriculum reformers.
(5) One teacher changed his role to become a facilitator who guided students to use the opportunities to develop their inquiry skills and higher-level thinking skills.
(6) Interaction with a computerized database provides students with enhanced opportunities to develop inquiry skills, such as interpreting graphs, constructing hypotheses, testing viability, and generating creative questions (Maor & Fraser, 1996, pp.414-416).

At the higher education level, Crump and Rennie (2004) examined students' perceptions of their tertiary programming learning environment and compared the perceptions of student subgroups based on student gender and arrival status. Data were taken from 125 students from first-year tertiary programming at three Wellington tertiary institutions. These students completed the actual and preferred versions of the College and University Classroom Environment Inventory (CUCEI) in the last semester of their first year of study. The results were demonstrated as follows.

(1) The majority of students perceived the equity of their actual and preferred as similar.
(2) New Zealand and new-arrival females indicated that they would prefer a more equitable learning environment than the males.
(3) The new-arrival males perceived equity less favourably than the other subgroups for the classroom environment in actual form.
(4) The results from student interviews revealed differences amongst the student subgroups, suggesting that there were areas of dissatisfaction not obvious from the survey data (Crump & Rennie, 2004, p.310).

The next section goes on to consider the link between the ICT classroom learning environments, students' critical thinking skills, and attitudes to ICT.

1.3 STUDENTS' PERCEPTIONS OF CLASSROOM LEARNING ENVIRONMENTS, STUDENTS' CRITICAL THINKING SKILLS, AND ATTITUDES TO ICT

There are many previous studies which have demonstrated that technology enhanced classroom learning environments significantly and positively impacted on the development of students' critical thinking skills, as well as their attitudes towards ICT.

1.3.1 Critical Thinking Skills

The concept of critical thinking is not new. It has been a focus of educational reform movements throughout educational history. Definitions of critical thinking vary greatly. Critical thinking skills, as defined by the experts discussed below, have been integral to the definition of critical thinking adopted for this study.

Ennis (1985) defined critical thinking as comprising three essential parts. The first part was a problem-solving process in a context of interacting with the world and others. The second part was a reasoning process, informed by background knowledge, and previously acceptable conclusions which resulted in drawing a number of inferences through induction, deduction, and value judgment. The last part was a decision about what to do or what to believe. It can be concluded from Ennis's approach that critical thinking involves not only general critical thinking skills but also dispositions towards critical thinking and an eventual decision on how to act.

Similar analysis has been given by the prominent educator, Beyer (1990), who strongly argued that critical thinking was defined as ability and readiness of individuals to reflect on their own and others' thinking in relation to its truth, value and validity in a logical argument. He also differentiated between critical thinking and other types of thinking such as problem-solving, creative thinking, and decision-making. In his view all these processes were interrelated, but could be differentiated from one other, as each one of them served a specific purpose.

Moreover, Beyer summarised what he regarded as the six elements of critical thinking as follows.

(1) *Dispositions:* Good critical thinkers are disposed to scepticism, questioning the accuracy, authenticity, plausibility, or sufficiency of whatever is presented to them.

(2) *Criteria:* Criteria are conditions that must be met for something to be judged as faithful or authentic.

(3) *Argument:* In critical thinking, an argument is a proposition with its supporting evidence and reasoning. The major purpose of an argument in critical thinking is to convince or persuade.

(4) *Reasoning:* Reasoning is what holds an argument together. We attempt to ascertain the strength of a conclusion by examining reasoning and logical relationships.

(5) *Point of view:* Point of view relates literally to the position from which a person perceives and makes meaning of things. A person's point of view develops from prior experiences, cultural background, values, expectations, interests, and existing knowledge.

(6) *Procedures for applying criteria and judgment:* Socratic questioning is possibly the most broadly used procedure in critical thinking. This type of questioning seeks to clarify information, to identify a point of view, to discover assumptions, to distinguish factual claims from value judgments, and to detect flaws in reasoning (Beyer, 1990).

According to Paul and Willsen (1995), critical thinking was a purposeful and systematic method of thought. They explained that critical thinking skills involved a highly systematic process where there was clear support for solid reasoning, precision, and awareness of thought. Finally, the authors suggested that if the educational establishment was truly interested in the education of its students than it seriously needed to examine the ways it conceptualised critical thinking skills.

According to Paul's study, dispositions to disciplined and self-directed thinking could be taught. He maintained that critical thinking was constructed from skills, such as spotting conclusions, examining premises, forming conclusions, and diagnosing fallacies. Thus, he proposed that critical thinking be constructed as "disciplined, self-directed thinking which exemplifies the perfection of thinking appropriate to a particular mode or domain of thinking" (Paul, 1989, p.2). Critical thinking conceptualised in this way must be taught with a focus on developing fair-minded, critical thinkers, who were willing to take into account the interests of diverse persons or groups regardless of self-interest. Paul called it the dialogical or dialectical thinking model.

In addition, there has been an useful definition suggested by educators in the psychological field. Lipman defined critical thinking as follows:

> "…critical thinking is skillful, responsible thinking that facilitates good judgments because it (1) relies upon criteria, (2) is self-correcting, and (3) is sensitive to context" (Lipman, 1995, p.146).

It is one of the best definitions on critical thinking, because Lipman integrates the concepts of standards (criteria for evaluation), skills (especially cognitive) and personal judgments (making good choices) into a comprehensive educational package.

Current research in the field of cognition and brain theory has pointed toward a classroom learning environment that emphasised opportunities to gain these skills and put them into practice. Ramirez and Bell singled out two important factors.

(1) *Interaction rather than isolation*: Knowledge and expertise were developed when students had an opportunity to interact with resources that included their peers, teachers, experts from various fields, and print and electronic text and databases.

(2) *Cognitive research*: Students learned best when the tasks involve meaningful contexts, activities, and problems so that they could actively construct their own knowledge and develop the ability to apply what they learned to new situations (Ramirez & Bell, 1994, p.26).

Facione, Facione, and Sancez (1994, p.28) observed that:

> Educating good critical thinkers is more than developing critical thinking skills. A complete approach to developing good critical thinkers includes nurturing the disposition toward critical thinking, an effort…integral to insuring the use of critical thinking skills outside the narrow instructional setting.

Therefore, among the numerous studies investigating the relationship between students' perceptions of classroom learning environments and their academic achievements, some research has been directed specifically at outcomes in term of students' critical thinking skills. In the following section, I present findings which illustrate the nature of the relationship between traditional classroom learning environments and students' critical thinking skills.

1.3.2 Associations among Students' Perceptions of Classroom Learning Environments and Students' Critical Thinking Skills

Hager, Sleet, and Kaye (1992) examined the critical thinking abilities of vocational teachers using the Cornell Critical Thinking Test (CCTT) Level X. They pointed out that being a good thinker was a major component of being an effective teacher.

Paul and Elder, of the National Council for Excellence in Critical Thinking, made some suggestions about students' critical thinking and training in developing their students' thinking skills in their lessons. Elder pointed out that students needed opportunities to take thinking apart, that is, to analyse their own thinking according to standards of clarity, accuracy, relevance, logic, and fairness. In addition, Paul showed that teachers should encourage students to summarise what others have stated, elaborate on concepts and ideas, relate topics to their own knowledge and experiences, give examples to clarify and support ideas, and make connections between related concepts. He further suggested developing student's creative and critical reasoning through basic building blocks of thinking, such as the following:

- Beginning with clearly stated goals and purposes for study and inquiry;
- Formulating and forming problems and questions;
- Developing a defensible perspective and point of view;
- Assessing resource materials and texts for honesty and fairness;
- Questioning assumptions and biases;
- Making valid inferences; and
- Evaluating consequence of judgments and reasoning Paul and Elder (cited in, Black, 2004).

In relation to critical thinking, Porter (1991) showed a possible multidimensional framework for the general education model. He indicated that students bring a set of knowledge content, a variety of thinking skills, and attitudes toward critical thinking into the classroom environment. These student characteristics were modified through learning activities and their experiences, students' practices and pedagogy, and curriculum. He concluded that the final product was the students' outcomes, one of which could be the critical thinking skill.

Similarly, Aretz, Bolen, Devereux presented a multidimensional framework for the assessment of critical thinking in college students. They collected data from 53 senior students who attended the United States Air Force Academy. The sample of participants included 44 males and 9 females aged between 21 and 23 years. The results were shown as follows.

(1) A multimethod approach focused on the assessment of the three major components of critical thinking, including knowledge, thinking skills, and attitudes.

(2) This multidimensional assessment framework was a viable solution to the problem of using a single instrument to assess critical thinking in college students (Aretz, Bolen, & Devereux, 1997, Fall, p. 12).

In the following section I review a variety of educational research that has examined relations between some of these factors, specifically in the context of an ICT classroom.

1.3.3 Associations among ICT Classroom Learning Environments and Students' Critical Thinking Skills

Some studies have concentrated on investigating the development of student thinking skills through the use of the computer. Hopson, Simms, and Knezek (2001-2002) showed that using technology in the classroom could be the start of motivating, increasing and improving problem solving, decision-making, collaboration and higher-order thinking skills for students. Moreover, it was essential for other professional educators as well, to try to make the link between technology in the classroom, students' attitudes toward learning, and increasing higher-order thinking skills. In addition, there was considerable evidence to suggest that when the classroom computing environment was collaborative, it created new possibilities in the teaching and learning process.

In order to enhance the learning process in classroom, technology must be harnessed to support the students' learning processes. Morgan (1996) explained what was required of teachers. After they had identified the concepts that students were required to learn and the links to what students already knew, then it was time to consider how technology could be used to enhance the classroom leaning environment. Morgan further identified the following four checkpoints:

(1) How does technology provide students with multiple exposures to variations of concepts?
(2) How does technology increase student productivity?
(3) How does technology actively involve students in the learning process? and
(4) How does technology engage students at the higher levels of Bloom's Taxonomy? (Morgan, 1996, p.51)

In writing about computer applications that serve as 'mindtools', Jonassen et al. (1998) asserted that students need to think deeply about the content being learned in order to represent the technological or computer knowledge with tools, such as spreadsheets and databases. In that sense, such tools could facilitate the process of meaning-making, by helping students collect, organise, remember, and retrieve information, while making decisions on what is being represented. This kind of critical thinking skill was a primary goal of schooling, and children needed exposure to such a medium, and more opportunities to acquire and practice the accompanying skills.

Marjanovic reported a study of learning and teaching in a synchronous collaborative environment. He tried to describe how such an environment was created by combining an innovative methodology for “same-time, same-place” interactive learning and the technology also called electronic classroom learning, which is designed to provide not only communication but rather Computer-Mediated Collaboration (CMC). The result of this study concluded that “this learning method has the potential to improve students’ problem solving, critical thinking skills and communicative skills”. He further suggested that “teachers are transformed from ‘information delivery specialists’ into guides and facilitators of learning” (Marjanovic, 1999, p.137, p.129).

Using technologies effectively in education required shifting the focus from teaching to learning, with more and more of the learning coming under the control of the learner. Researchers advocated active, not passive learning, learning tasks and apprenticeships that relied on authentic relevant problem-solving, sustained and challenging work in individualised setting, collaborative groupings, emphasis on higher-order thinking skills, complex problem solving, projected-based and thematic syntheses of subject matter, greater student involvement, and students’ control over their own learning (Ramirez & Bell, 1994). For example, in regard to the Information Technology (IT) in Education and Children Project, teachers and researchers in a large-scale study conducted in 23 classrooms across 16 countries around the world, reported that IT-using students showed higher levels of cognitive skills, developed new strategies for working with peers, were very motivated and became more self-confident in their work (Ahern, 1996).

Hopson (1998) also sought to determine the relationships between the technology enriched classroom environment and the student development of higher-order thinking skills and student attitudes toward computer. A sample of 86 Grade 5 and 80 Grade 6 students completed the Ross Test of Higher Cognitive Processes and the Computer Attitude Questionnaire (CAQ). The test consisted of 105 items grouped into seven subsections, which judged the effectiveness of curricula or instructional methodology designed to teach the higher-order thinking skills of analysis, synthesis, and evaluation as defined by Bloom.

In addition, the CAQ assessed 65 questions combined to measure eight attitudes. In his findings, Hopson concluded as follows:

(1) The technology enriched learning environment enhanced the development of the higher order thinking skills of evaluation.
(2) Technology was the catalyst for restructuring and redesigning the classroom to create an environment that promoted and encouraged the development of the higher order thinking skills of evaluation.
(3) Technology was the tool that allowed the students to move beyond knowledge acquisition to knowledge application.
(4) The introduction of technological resources transformed the role of the teacher from lecturer to facilitator/guide.
(5) The technology enriched classroom environment had a significant and positive effect on student attitudes for Computer Importance, Motivation, and Creativity (Hopson, 1998, pp.47-49).

Cotton (2001) also skilfully suggested that an improvement in student achievement was directly related to the teacher’s ability to find the most suitable and innovative, as well as most vibrant, way to develop students’ thinking skills. For example, the use of Computer-Assisted Instruction (CAI) had been proven to correlate with intellectual growth and the achievement gains of students.

The relationship was very clear in Chinawong Sringam’s work (2001) which focused on the improvement of adult student learning outcomes by integrating ICT into distance education provision in Thailand. The results indicated as follows.

(1) Students developed their critical thinking skills through ICT-integration into teaching and learning process.
(2) The computer-based discussion could actually replace the face-to-face discussions without any deleterious impact on student learning outcome.
(3) The learning technology implemented did not have a negative impact upon student learning performances.

(4) The teachers or facilitators needed to get involved to encourage students to actively engage at the higher level. The discussion topics were also important as they can lead students to generate more messages in a higher level of engagement. Teachers/facilitators needed to carefully consider the multiple levels of the topic (not just the 'whats', but the 'hows', and 'whys'), as it would affect the depth of student engagement and the quality and quantity of interactivity.

(5) The adoption of ICT-integration into teaching and learning did not harm the academic performance of such students, and seemed to improve critical thinking skills in small groups. It might also have other positive benefits such as greater flexibility in learning, a broadened experience of computing technologies and enhanced independent learning skills (Sringam et al., 2001, pp. 240-243).

A more recent study in the U.S., Kuh and Vesper (2001) suggested that increasing familiarity with computers was positively related to developing other important skills and competencies, including social skills, such as self-development learning, thinking analytically and logically synthesising ideas and concepts, writing clearly and effectively, and working effectively with others.

There was evidence which related the positive effects of computer use on cognitive learning outcomes in science. Maor and Fraser's (1996) research, conducted in a secondary school, used a computer in the context of the inquiry approach to science teaching. The results showed that students had a significantly more positive attitude toward their computer-based classroom learning environment. As a result, learning was demonstrated to have improved in a number of science skills, such as reading data, interpreting graphs, manipulating variables, constructing hypotheses, ability to conduct experiments, to raise creative questions, to draw conclusion, and to think critically (Maor & Fraser, 1996).

A review of the impact on students and teachers of the use of ICT conducted by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) summarises key findings on the use of ICT in assessing the creative and critical thinking skills of learners (from 4-18 years old). Whereas many of the findings reported from these studies concerned the effectiveness of ICT-based assessment tools from the point of view of the teachers, the review did outline research findings on the effects of computer-based assessment on learning. These investigations found that computer-based assessment could enable students to demonstrate their thinking abilities and skills more effectively and to develop better understanding (Evidence for Policy and Practice, 2003).

Most of the studies examining the impact of ICT on learning were focused at the individual course level with “impressive” results (Hibbs, 1999). In addition, computer use has been shown to enhance productive collaboration among students (Alavi, 1994) and to encourage higher levels of student participation in and better contributions to class-related activities than in traditionally organised classrooms (Oblinger & Maruyama, 1996). According to Mallam and Wee (1998) communicating electronically achieved greater equality in participation because everybody was able to provide input to the discussion anonymously; the anonymity ensured that every idea was considered on its own merit, not on the basis of where it came from. Because the ideas were shared simultaneously rather than sequentially, there was a parallel processing of ideas and broader participation occurred efficiently (Mallam & Wee, 1998).

Sinclair, Renshaw and Taylor (2004) used computer laboratory research to examine two groups of ninth graders participating in a one-class period laboratory. The study focused on the effectiveness of using CAI to teach logarithmic graphing and dimension analysis, and found that computer-assisted instruction (CAI) not only enhanced rote memory skills (learning without understanding) but also improved higher order critical thinking skills. A number of researchers reached the conclusion that “CAI has a strong positive on teaching, especially at the K-12 and lower university levels” (Child, 1998).

It can be concluded that the best context for learning critical thinking skills is interactive and built upon taking individual responsibility for academic achievements. The results appear undeniable that technology implemented in the classroom learning environment can improve student learning outcomes in term of students’ critical thinking skills.

In the following section I review some research that has examined associations between students’ perceptions of classroom learning environments with ICT and students’ attitudes towards ICT.

1.3.4 Associations among ICT Classroom Learning Environments and Students' Attitudes toward ICT or Computer

Concerning students' attitudes toward computers and ICT, a number of research reports investigated associations among students' perceptions of classroom environments with ICT and students' attitudes toward ICT or computers by using various types of attitude scales.

King (1994-1995) examined Grade 7 students' attitudes toward computers and student attitudes toward school in Australia. Use of the computer was a government-sponsored electronic-learning project. Two instruments were used in this study. The first was a computer-anxiety index consisting of 26 positively worded Likert-type items. The second instrument was used to measure students' perceptions of the quality of their school life. He found that the computers positively increased the students' attitude toward computers.

Orabuchi (1992) did a four-month experimental study, which was designed to determine the effectiveness of CAI. She found that CAI students' scores were significantly higher than non-CAI group in inference, generalisation, and mathematics problem solving. The results showed also that the CAI group was higher in self-concept, attitude toward school, attitude toward computers, and tasks they could do with computers.

Wodarz conducted an experimental study in elementary school in Phoenix, Arizona, to investigate the effects of computer usage on elementary students' attitudes, motivation, and students' achievement in mathematics. The Iowa Test of Basic Skills was used for students' achievement, and a survey was used to measure attitudes and motivation. The items to measure attitudes and motivation "were written using Miyashita and Knezek's attitude survey as a guide" (Wodarz, 1994, p.64). Experimental group scores were significantly higher than the control group in mathematics achievement, but no significant difference existed in attitudes and motivation.

McKinnon, Sinclair, and Nolan studied the impact of the integrated curriculum into teaching and learning process, which included extensive use of computers in New Zealand (Grade 8-10). They used a variety of methods to collect data on 415 students. They employed an "education questionnaire (Nicholls, Patashniick & Nolen, 1985)…to monitor the development of students' attitudes and motivation" (McKinnon, Sinclair, & Nolan, 1997, p.7). They also developed the Computer Attitudes Questionnaire (CAQ) to monitor students' attitudes towards learning with and about computers. The study found that students in the integrated program had significantly more positive attitudes towards computer than did students in the traditional program.

Sacks, Bellisimo, and Mergendoller (1993-1994) studied the attitudes toward computer and computer use by Grade 10-12 students in a small urban school district in Northern California. Researchers examined student gender differences in computer use and attitudes toward computers. They used a 30 item questionnaire concerning students' attitudes toward computer use. The questionnaire was a Likert-type instrument yielding three subscale scores (computer anxiety, computer confident, and computer liking) and a summary score. The results were revealed as follows.

(1) Girls' attitudes toward computers improved while boys' attitudes did not.
(2) Boys' attitudes toward computers and actual computer use were relatively unrelated, while girls' attitudes toward computers and actual computer use converged.
(3) Boys' attitudes and behaviours toward computers were relatively stable, while girls' attitudes and behaviours were not stable.

Martin, Heller, and Mahmoud (1992) examined the attitudes of 8-to-12-year-old American and Soviet children toward computers. The researchers used picture data as indicators of children's attitudes to compare their responses to attitude statements and their drawings of computers. The findings showed that:

> The attitudes of the children from both countries were found to be very similar and mostly positive… The most significant student gender differences occurred in the drawings of computer users with most boys drawing males and most girls drawing females as computer users (Martin et al., 1992, p.155).

Knezek and Christensen used the CAQ to compare two types of computing curricula at a junior high school in Leander, Texas. "The first program is a traditional computer literacy… The second program, a pilot program, teaches the mandated computer literacy elements through the integration of computers within the existing 7th grade curriculum" (Knezek & Christensen, 1995, p.1). The findings indicated that students in an integrated program enjoyed the computer more than students in a traditional computer literacy. In addition, integrated-program students "rated themselves as higher in creative tendencies than their peers enrolled in computer literacy" (Knezek & Christensen, 1995, p.4). The most interesting finding was that females in the integrated group were significantly higher than males in the areas of study habits and empathy.

Knezek and Christensen (1997) used the CAQ also to compare students' attitudes toward IT at two parochial schools in North Texas. One school, located in Dallas, had all female students, the other, in Tyler, was coeducational. They found that there were similarities in students' attitudes toward IT between the two schools, but Dallas school had higher empathy ratings than the Tyler school. No significant differences were found for the areas of student motivation to study, creative tendencies, or attitude toward school.

Knezek, Christensen and Miyashita (1998) reported a study conducted by a Mexican research team. The researchers administered the CAQ to 590 Grade 9 Mexican students from different states in Mexico to measure their attitudes toward computers and attitudes toward electronic mail (email). The study found that there was strong positive attitude toward email, some differences between states on computer enjoyment and differences across states on frustration-anxiety. Girls tended to show more empathy than boys.

Almahboub investigated the attitudes toward computers and student gender differences and examined the relationships between students' attitudes toward computers and school, motivation, study habits, empathy, creative tendencies, and achievement in the Informatics field. The CAQ was administered to a sample of 562 students from 10 public middle schools in the State of Kuwait during the academic year 1999-2000. He suggested as follows.

(1) Girls had significantly more positive attitudes toward computers than did boys.
(2) There were statistically significant correlations between attitudes toward computers and attitudes toward school, motivation, study habits, empathy, creative tendencies, and achievement in the Informatics field.
(3) Girls had a stronger correlation than boys; and

(4) Students who used computers at home have more positive attitudes toward computers than did students who did not (Almahboub, 2000, pp. 65-71).

In the following section I review some research, which has investigated the influence of teachers' critical thinking skills and attitudes toward ICT on students' critical thinking skills and attitudes toward ICT.

1.4 TEACHER CHARACTERISTICS, CLASSROOM LEARNING ENVIRONMENTS WITH ICT, STUDENTS' CRITICAL THINKING SKILLS, AND THEIR ATTITUDES TOWARD ICT

The nature of classroom learning environments can be seen as essentially a school outcome, influenced by professional schoolteachers. Hay McBer (2000) found that prominent teachers established an excellent classroom learning environment and achieved superior student progress largely by displaying more professional characteristics at higher levels of sophistication within a very structured learning environment" (Hay McBer, 2000). He further illustrated that the classroom factors had reasonable correlations with elementary school students' academic progress, whereas in secondary classes there was a moderate correlation between student progress and the separation between actual and preferred classroom environments. In addition, he suggested that if teachers had information about how students perceived classroom learning environments, then they would be better placed to focus their teaching skills (e.g. teachers' high expectations, use of a variety of teaching strategies, effective planning, student management and use of homework) and professional characteristics (e.g. relating to others, leading, analytical and conceptual thinking, and professionalism).

As there was considerable agreement between students on the interpersonal behaviour of their teachers, some research had found clear perceptual differences within classes. Levy, Brok, Wubble, and Brekelmans concluded that the four main causes of differences within class perceptions were as follows.

(1) Firstly, some teachers do treat students differently depending on their students' and/or their own gender and/or ethnic individual background.
(2) Secondly, the results of varying expectations are different in relation to different teachers' characteristics. For instance, some students could have lower confidence than others and consequently need a teacher who is extremely supportive.
(3) Thirdly, within class differences could be caused by differing values and norms used by students to measure their teachers. For example, some students could observe a teacher who repeatedly checks for understanding as helpful while others might see this as intrusive.
(4) Lastly, systematic differences could occur with respect to specific characteristics of students, teachers, or classes. For instance, girls could view teachers differently than boys, or teachers could pay more attention to one group than the other (Levy, Brok, Wubbels, & Brekelmans, 2003).

Kent, Fisher, and Fraser (1995), made a distinctive contribution to learning environment research by investigating (a) the relations between students' perceptions of teacher interpersonal behaviour and teachers' personality, and (b) teacher self-perception of classroom interaction behaviour and teachers' personality. They drew the following conclusions.

(1) There was a greater positive association between teacher personality and self-perception than between teacher personality and students' perceptions of teacher interpersonal behaviour.
(2) Teacher personality appeared to be consistently associated with teacher self-image in regard to being friendly, helpful and giving freedom, responsibility and opportunity for independent work in class.
(3) Teacher personality also seemed to be related to self-perceptions of uncertainty in the classroom, of maintaining a low profile and being passive.
(4) Students' perceptions of their teachers' interpersonal behaviour was related to the personality of the teacher in regard to how much freedom and responsibility students think that they were allowed.

It is also important to consider relevant findings which identify issues that motivated teachers to use, or prevented them from integrating ICT into the teaching and learning processes in their classroom learning environments.

Christensen and Knezek (1997) examined relationships between technology integration education of teachers, their attitudes toward IT, and their students' attitudes toward computer. The participants consisted of 60 teachers from Grade 1 to Grade 5 and their students in three public elementary schools in the North Texas area. Two instruments, the Teachers' Attitudes Toward Information Technology (TATIT) and the Youth Children's Computer Inventory (YCCI), were used to measure teaches' attitude towards ICT and students' attitudes toward computer, respectively. The findings were shown as follows.

(1) The needs-based technology integration education fostered positive attitudes toward IT among elementary school classroom teachers.
(2) Positive teacher attitudes toward IT fostered positive attitudes toward computer in their students (Christensen & Knezek, 1997, pp.9-10).

Newhouse (2001b) conducted a study in the use of computers to support learning in a new mathematics course, Mathematics in Practice, and research on a Portable Computers Program. The results indicated that the teacher and teacher characteristics were the most significant reasons on whether classrooms involved computer use and the type of classroom learning environments that developed. He stated that students in these classes preferred a more open-ended, student-centred and relaxed type of classroom environment, particularly where they were able to access computer processing when and as they needed it. Furthermore, teachers could establish a varying number of types of environments. In order to better match the preferred environment of their students, teachers needed to be given a degree of freedom and supporting resources.

The need of teachers to develop technological literacy was emphasised in the early 1990's. For example, the International Society for Technology in Education (ISTE) established standards defining technological literacy for teacher education (International Society of Technology Education, 1992). The ISTE standards recommended that all teachers should be prepared in the following areas.

(1) *Basic Computer/Technology Operations and Concepts:* Teachers should use computer systems to access, generate and manipulate data.
(2) *Personal and Professional Use of Technology*: Teachers should apply instructing tools for enhancing their own professional growth and productivity.
(3) *Application of Technology in Instruction:* Teachers should apply computers and related technologies to support instruction in their grade level and subject areas (International Society of Technology Education, 1992).

In general, younger teachers are more interested in learning how to use technology since they are more familiar with learning and using it. In a later analysis of this situation, Stokes (2001) comments that “many teachers feel that it is time to bring this reality into the classroom, but the actuality (even the thought!) of handling a Personal Computer (PC) in front of ICT-literate students is often just too daunting” (Stokes, 2001).

In a previous study by Ktoridou, Zarpetea and Yiangou in 2002, at college level, the University of Cyprus and secondary schools, Cypriot English teachers admitted that although they were informed about the possible integration of technology into course EFL (English as a Foreign Language), they did not actually apply this technology in their classroom. They justified their negative attitude by referring to their lack of training, lack of experience, lack of time to prepare as well as lack of computer access. However, most of them reacted positively to the prospect of using technology in their classroom in the future.

Similarly, Child (1998) assessed the impact of the use of CAI, which allowed students to express their responses to teaching, through questionnaires to which they could respond by means of either numerical evaluation or narrative comments. Child pointed out that the impact of CAI was contained in both positive comments and negative comments from representative students who were free to praise, criticise, or say nothing. He found that the effectiveness of teaching using CAI depended on the differences in teaching style, teacher personality and teaching approaches.

The findings of Riel (1989) and others (e.g.,Van Den Akker, Keursten, & Plomp, 1992) have contributed to the ongoing debate concerning the relationship between computer use and computer-based classroom environment or culture (e.g.,Olson, 1988). In the study by

Riel (1994) it was found that while classroom organisation was not changed by computer use, patterns of interaction between students and teachers were changed. The results indicated that teachers could in fact choose to alter the classroom organisation and that computer use could be part of the motivation and/or support to do so. It certainly would appear that patterns of interaction change, particularly between the teacher and their students in their classroom learning environments with ICT.

There is evidence that teachers' perceptions of technological skills may be related to student outcomes. In Britain, Bramald and Higgins indicated that primary teachers' confidence in using ICT was correlated to teachers' ICT skills and seemed to influence academic students' achievements. They made a detailed argument that "effective teachers who used ICT were confident and comfortable with it as an enabling addition to their pedagogical armory" (Bramald & Higgins, 1999, p.97). In contrast, reluctance to use ICT was regarded as a mask for concerns about the changing role of teachers, worries about not covering the course syllabus, and fear of computer equipment.

There is evidence that teachers' computer anxiety can influence their students in their teaching and learning process in their classroom. According to Rosen and Weil's study (1990), when teachers felt negative and apprehensive about computers and were therefore reluctant to use them, their attitudes and apprehensions could be passed on to students, and students might give up academic goals or modify them. It means that teachers who are confident in computing can act as role models for students' in alleviating computer anxiety in the teaching and learning process.

In a later analysis of this aspect, in 1997, there was one interesting study in Queensland, Australia which was conducted by Russell and Bradley (1997). This study reported that 300 primary and secondary school teachers were asked about sources of computer anxiety and provided teachers with the opportunity to suggest problem solutions. They found that the teachers were very supportive of the use of computers in education, but they reported that there had been moderately low levels of teachers' computer competency. Therefore, there were two main causes to explain this negative anxiety. First of all, teachers lacked confidence in the use of computers in their teaching and learning process in their classrooms. Secondly, teachers had insufficient data concerning teachers' views of relevant professional development programs.

Another important study by Meredyth et al. (1999) commented on a large-scale Australian research that there were “differences in levels of ICT or technological skills among teachers according to school type (e.g. catholic school, public or private school), teacher gender, and level of teaching (primary or secondary educational level)”. In addition, the effects of using computers for the teaching and learning of mathematics in grades 7-10 in Victoria, Australia were explored by Forgasz (2002). He found that the influence factors and associated issues that facilitated teachers or prevented them from integrating computers into teaching and learning process in the mathematics classroom were related to (a) teachers’ computer ownership and skills, (b) teachers’ individual backgrounds in using computers in education, (c) teachers’ beliefs about ICT-integration into teaching and learning with computers, and (d) teachers’ perceptions of technological skills.

Studies in other countries have demonstrated that the use of what is called Computer-Mediated Communication (CMC) had some beneficial impacts on student learning outcomes. Using CMC applications significantly enhanced the interaction between teachers and their students and also between students and their peers (Robson, 1996). Regardless of the focus or scope of CMC environments in teacher education, Admiraal et al. (1998) found that the efficient use of telematics (i.e. computer-mediated electronic communication) and of computer conferencing was an important part of the student teacher’s learning environment in teacher education programs. The purpose of this study was to study their experience in a Dutch context, and to develop aspects, which are not widely discussed in the professional literature, such as peer monitoring strategies and the moderator role of the supervisor. This study presented the results of an evaluation of the use of computer conferencing with student teachers and supervisors in teacher education programs in four Dutch teacher education institutions. The results showed that student teachers used computer conferencing to exchange immediate classroom practices and routines. It can be concluded that CMC technologies, which are used to support and develop collaboration and the construction of knowledge, lead to a quality in students’ learning outcomes.

Other relevant studies suggested that primary teachers have differing opinions and reasons for using computers in their classrooms. Teachers’ beliefs seem to play an important and decisive role in the way that they use computers in their classrooms. Similar effects were associated with teachers' beliefs about the use of computers, teachers' patterns of the use of computer, and the way teachers' think. Drenoyianni and Selwood's (1998) study advocated "an association between teachers' beliefs about computer use and teachers' patterns of actual computer use and thus demonstrate that educational innovations are primarily and intrinsically realised in our way of thinking before they become practices" (Drenoyianni & Selwood, 1998, p.87). This way of thinking was formed not only by teachers' interpretations of official orders and requirements, but also by their knowledge of information technology and their comprehension of what teaching and learning was about.

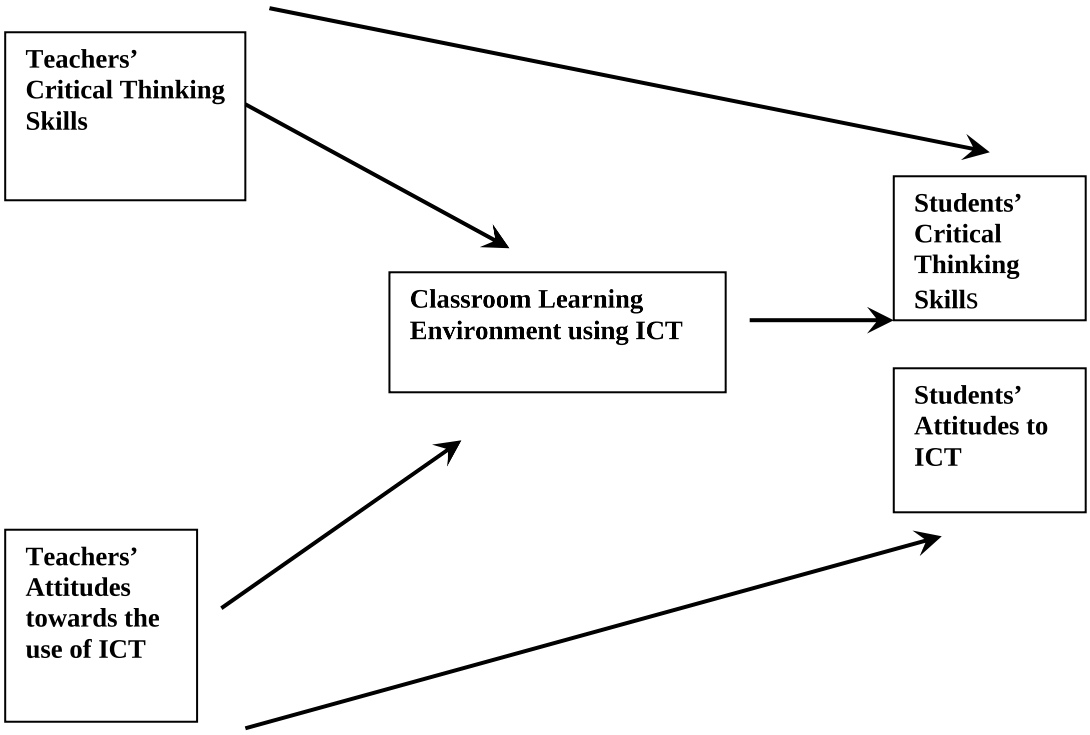
1.5 DEVELOPING A THEORETICAL FRAMEWORK FOR RESEARCHING ICT CLASSROOM ENVIRONMENTS

The review of literature in Part 1 provided evidence that there has been increasing interest in evaluating the effects of incorporating ICT into teaching and learning processes in classroom learning environments with ICT on student outcomes (students' achievements, students' attitudes, or their thinking skills). In particular it is important to evaluate teachers' attempts to use classroom learning environment investigations to guide the improvement of students' learning in their classroom learning environments by incorporating ICT into their teaching and leaning process in their schools.

1.5.1 A General Theoretical Framework

From the literature that I reviewed in the previous section, there has been scope to draw up a new theoretical framework (see in Figure PF1-2) to investigate the effect of classroom learning environments with ICT on two student outcomes (students' critical thinking skills and students' attitudes toward ICT). The starting point for the model is two teacher characteristics' critical thinking skills and attitudes to ICT, which are conceptualised as impacting directly on classroom learning environments with ICT.

Figure PF1- 2: General Theoretical Framework

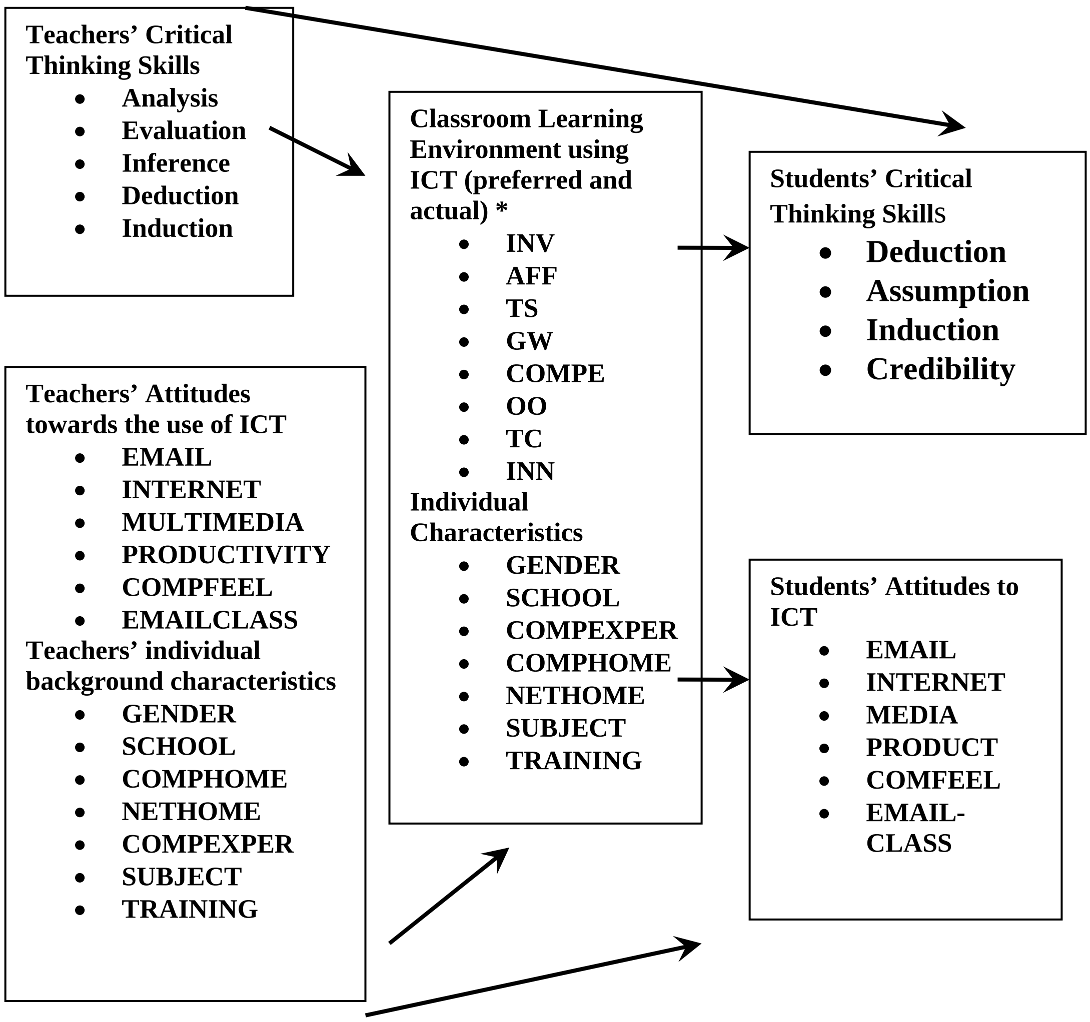


These teacher characteristics influence directly, and through the mediation of all classroom learning environments, the two key student outcomes selected for focus in this research – students' attitudes toward ICT and their critical thinking skills.

1.5.2 Preliminary Model for Analysis

From the literature reviewed, therefore, it is possible to extend the general model further by defining related predictor and outcome variables linked to a number of influence indicators. These indicator variables are presented in the preliminary model for analysis (Figure PF1-3).

Figure PF1- 3: Preliminary Model for Analysis



* INV is Student Involvement, AFF is Affiliation, TS is Teacher Support, GW is Group Work, COMPE is Competition, OO is Order and Organisation, TC is Teacher Control, and INN is Innovation

1.5.3 Research Questions

From this preliminary model, I was able to generate the main research question that was examined in the present study.

> How effectively is ICT being used to support student outcomes (students' critical thinking skills and their attitude toward ICT) in relation to certain teacher characteristics (teachers' critical thinking skills and teachers' attitudes toward ICT) in classroom learning environments with ICT in the elementary and secondary schools under the ICT schools pilot project in Thailand?

Eight specific research questions were derived from this, in order to provide the initial focus for the study.

Question 1: Why did the government of Thailand set up this project?

Question 2: What are ICT schools trying to achieve?

Question 3: Is there a relationship between students' perceptions of ICT classroom learning environments and students' critical thinking skills?

Question 4: Is there a relationship between students' perceptions of ICT classroom learning environments and students' attitudes toward ICT?

Question 5: Is there a relationship between students' perceptions of ICT classroom learning environments and students' critical thinking skills in relation to teachers' critical thinking skills and teachers' attitudes toward ICT?

Question 6: Is there a relationship between students' perceptions of ICT classroom learning environments and students' attitudes toward ICT in relation to teachers' critical thinking skills and teachers' attitudes toward ICT?

Question 7: What are students' perceptions of the classroom learning environments in ICT?

Question 8: How do students make use of classroom learning environment with ICT to improve their thinking skills?

In terms of examining the possible associations in the Preliminary Model for Analysis (Figure PF1-3), the above questions can be reduced to four research propositions.

Proposition 1: There are differences between students' perceptions of their actual and preferred classroom learning environments with ICT.

Proposition 2: The students' perceptions of ICT classroom learning environments and student outcomes differ according to students' individual background characteristics (gender, academic background, and computer experiences and computer usage).

Propositions 3: There are the relationships between students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom environments, and student outcomes (students' critical thinking skills and students' attitudes towards ICT).

Propositions 4: There are the associations among students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom environments, and student outcomes (students' critical thinking skills and students' attitudes towards ICT) in relation to certain teachers' characteristics (teachers' critical thinking skills and teachers' attitudes toward ICT).

In the analysis, these research propositions (Proposition 1 to Proposition 4) are considered in greater detail to include students' individual background, as well as different dimensions of classroom learning environments with ICT. I used both of quantitative and qualitative approaches to examine each research proposition. For the quantitative investigation, the data were analysed using multiple regression and multi level analysis techniques to examine relationships among students' individual background, students' perceptions of classroom learning environments with ICT, and student outcomes. In the case of qualitative analysis, I used students' and teachers' interviews and classroom observations for a more in-depth analysis of the associations among students' perceptions of classroom learning environments with ICT and their student outcomes in terms of students' critical thinking skills and students' attitudes toward ICT in relation to certain teachers' characteristics.

Part 2 sets out in more detail the study design research methods and analyses for the quantitative investigation of the research propositions set out above. Part 3 presents the qualitative side of the investigation.

PART 2

A QUANTITATIVE INVESTIGATION OF THE ICT SCHOOLS PILOT PROJECT IN THAILAND

2.0 INTRODUCTION

Part 2 of this portfolio of research describes a quantitative investigation of the ICT Schools Pilot Project in Thailand. The theoretical model used, and the specific research propositions investigated, were outlined at the end of Part I. The aim was to gain measures of underlying students' and teachers' characteristics, the ICT classroom environment and student outcomes in terms of critical thinking skills and attitudes to ICT in order to ascertain the extent to which these variables were related. Part 2 consists of the following three sections:

Section 1 outlines the overall research design of the investigation, the participant samples and the process of participant selection, as well as explaining the quantitative methods that were used.

Section 2 describes the instruments used, details of the properties of each instrument, and provides a rationale for their selection. The data collection included gathering information on students' perceptions of classroom learning environments with ICT, and two student outcomes (students' attitudes toward ICT use and students' critical thinking skills) in relation to teachers' attitudes towards ICT and teachers' critical thinking skills.

Section 3 presents the quantitative analysis and findings, including the validation of the survey instruments that were used to collect quantitative data. It further reports the statistical analysis and results in relation to the four research propositions.

2.1 RESEARCH DESIGN AND QUANTITATIVE SAMPLES

2.1.1 Introduction

In section 1 of Part 2, the research design is presented, followed by a discussion of the quantitative and qualitative methods employed in the study. I then provide a description of the quantitative sample selected from student and teacher participants in the ICT schools pilot project in Thailand, and explain the procedures used in the administration of quantitative questionnaires.

2.1.2 Research Design

The purpose of this study was to investigate how effectively ICT was being used in the elementary and secondary schools involved in the ICT schools pilot project in Thailand. The study examined to what extent these model ICT schools had classroom learning environments that were related to students' critical thinking skills and their attitudes to ICT; and to what extent the classroom learning environments were associated with certain teacher characteristics.

The study examined the relationships in the research model proposed in Part 1 (see Figure PF1-3). From the model the major research propositions outlined below were formulated.

Proposition 1: There are differences between students' perceptions of their actual and preferred classroom learning environments with ICT.

Proposition 2: The students' perceptions of ICT classroom learning environments and student outcomes are different by students' individual background characteristics (gender, academic background, and computer experiences and computer usage).

Propositions 3: There are the relationships between students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom environments, and student outcomes (students' critical thinking skills and students' attitudes towards ICT).

Propositions 4: There are the associations among students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom environments, and student outcomes (students' critical thinking skills and students' attitudes towards ICT) in relation to certain teachers' characteristics (teachers' critical thinking skills and teachers' attitudes toward ICT).

A research design combining quantitative and qualitative approaches was adopted to examine the relationships in the research model. I used a survey, interview, and classroom observation approach involving the collection of quantitative and qualitative data. Therefore, details of the current research design will be presented and explained in the following section.

2.1.2.1 Quantitative and Qualitative Methods

There are potential advantages in employing both quantitative and qualitative data collection methods within the same study (Krathwohl, 1993). Often, a combination of both quantitative and qualitative data collection methods can provide a fuller understanding of classroom learning environments than a single method used alone. There are two major reasons to support this idea. Firstly, the use of qualitative data collection methods in classroom learning environment research can provide greater depth and breadth to the understanding and examination of the classroom learning environment (Tobin, Kahle, & Fraser, 1990), particularly when qualitative and quantitative data collection methods are combined (Tobin & Fraser, 1998). Secondly, the use of qualitative data collection methods, such as interviews with students and teachers and classroom observations, are useful in helping to contextualise some of the quantitative findings (Patton, 2002).

As Wiersma (1995) strongly confirmed, the method of triangulation of data collection involves qualitative cross-validation, which could be conducted among different data sources or through different data-collection methods. Denzin also pointed out that "triangulation can take many forms, but its basic feature will be the combination of two or more different research strategies in the study of the same empirical units" (Denzin, 1978, p.308). Moreover, Carter (1990) argued that triangulation of data collection methods could not only increase internal validity but also reduce research bias. As Carter (1990, p.276) put it, "no single method can hope to capture the complexity of classroom life" (p.276). Similarly, Maor and Fraser's (2005) research used triangulating qualitative data with quantitative data to provide an enriched framework for evaluating the effectiveness of the learning and teaching processes in the classrooms. In adopting a mixed methods approach, they tried to not only overcome the weakness of the use of quantitative instruments, but also to solve the lack of open-ended questions that would enable participants to elaborate on their responses.

There are an increasing number of researchers using a mix of quantitative and qualitative data collection methods to study classroom environments (Fraser & Tobin, 1991; Howe, 1988; Woods, 1995). In particular, the combination of both types of data collection allows for triangulation of interpretations and reflections on classroom environment, where the perceptions of students and teachers can inform data collected by researchers directly from observation of that environment (Woods, 1995).

In one interesting research example, Keeler (1996) used a similar methodology to conduct a qualitative evaluation of a school-wide computer implementation project. She also used the triangulation of data collection methods from lesson observation field-notes, interviews, and questionnaires to substantiate the findings of her study. However, this project involved the use of only a few desktop computers in each classroom. McMahon and Duffy (1993, July) used three different types of triangulation (multiple sources, perspectives, and methods) in their Buddy System Project study, involving the networking of home and classroom computers.

Following the above examples, therefore, the current study used multiple data collection methods or triangulation of data collection methods to collect data that cut cross two or more techniques or sources. Webb (1970) called this approach methodological triangulation of the between-method type. Interviews of students and teachers were conducted to investigate students' and teachers' perceptions of their classroom learning context with ICT. Classroom observations were also organised to examine how students made use of the classroom learning environment with ICT to improve their critical thinking skills. Therefore, the analyses of this study were evaluated through a combination of quantitative and qualitative methodologies (Greene, Caracelli, & Graham, 1989) to collect data using students and teacher survey instruments, student and teacher interviews, and classroom lesson observations among classroom learning environments with ICT. These qualitative data complemented the quantitative data from the questionnaire survey instruments. Analysis of data from the questionnaire surveys provided a guide to constructing relevant interview questions.

All of these data sets were used to provide a better and fuller understanding of the associations among students' perceptions of classroom learning environments with ICT and their student outcomes (students' attitudes towards ICT and students' critical thinking skills) in relation to certain teacher characteristics.

2.1.2.2 Quantitative Methods

For students, this research used the adapted form of New Classroom Environment Instrument (NCEI), in a Thai version to measure students' perceptions of classroom learning environment with ICT. I assessed two student outcomes (students' critical thinking skills and students' attitudes toward ICT) by using standard test and attitude questionnaire, respectively. The standard test, which was used to measure students' critical thinking skills was the adapted form of Cornell Critical Thinking Skills Test (CCTT) in Thai version. I used an attitudinal questionnaire that was adapted from the Teachers' Attitudes Toward Information Technology (TAT) Questionnaire in Thai version.

For teachers, I used one questionnaire and one standard test to collect data. The adapted Teachers' Attitudes Toward Information Technology (TAT) Questionnaire in Thai version was used to assess teachers' attitudes towards ICT. In addition, I used the adapted California Critical Thinking Skill Test (CCTST) in Thai version to measure teachers' critical thinking skills.

All items in each instrument had to be translated into Thai Language in order to apply to the local context. Adapting the instruments to the Thai cultural context did not prove to be a problem. The few adjustments needed were checked through the pilot study. Every instrument was given to the student and teacher participants in sixteen classes from model ICT schools under the Thai ICT schools pilot project, as a pilot study to check the translation, approve the cultural relevance and verify the content and statistical validation of each item. Every item was checked and examined in the Thai version of the adapted instruments; there was also a back translation into English by the researcher and the panel of participants to confirm the meaning consistency. Then factor analysis and Cronbach's alpha analysis were carried out on the newly constructed instrument to ensure their validity and reliability.

The following section presents details of the research sample and data collection, research instruments, a brief overview of the quantitative and qualitative methods, followed by a discussion of how both methods contributed to the present study.

2.1.3 Quantitative Samples and Selection

2.1.3.1 Populations and Samples

The targeted population of participants for the current study were all the students and teachers who were in primary schools and lower or higher secondary schools in all 13 model ICT schools under the ICT schools pilot project in Thailand. Due to cost and time constraints, only sixth graders at primary schools and ninth graders at lower or higher secondary schools were involved in the present study. However, it was considered that students at these levels were mature enough to make valid and careful judgments to ensure useful responses to the items in questionnaire surveys and to the interviews.

The population of the present study was sampled by purposive (nonprobability) sampling techniques/methods, due to small sample sizes (150 students and 16 teachers), an easily accessible or volunteer sample population, and the greater convenience of cost and time constraints for a single researcher, as documented by previous studies (Bryman, 1988; Creswell, 2003; Tashakkori & Teddie, 2003). Tashakkori and Teddlie suggested that "purposive or nonprobability samples are samples in which the researcher uses some criterion or purpose to replace the principle of canceled random errors…researchers using purposive techniques seek to focus and, where practical, minimise the sample size, generally in nonrandom ways, so as to select only those cases that might best illuminate and test the hypothesis of the research…although purposive sampling techniques are commonly associated with qualitative methods, purposive sampling can be used within studies with either a qualitative or a quantitative orientation and are quite common in mixed methods studies" (Tashakkori & Teddie, 2003, pp. 279-280).

Step one in the selection process of schools, with their teacher and student participants, took place when I was invited to present my research proposal to all 13 ICT principals and all of the ICT teachers from these schools at the National ICT Learning Centre, in Bangkok, on 23rd November, 2004. At this meeting, I explained briefly my general research framework, research model, and major research objectives. Teachers were urged to express their willingness join in the current study, with their school principals' co-operation. Finally, it was suggested that I work with eight particular ICT schools, based on their accessibility and staff willingness. These schools confirmed their participation through a list of school names that was recorded by the Ministry of Education in Thailand. So teachers and students of these model ICT schools became the participants for my investigation. All schools preferred to use nominated school names (School A, School B, and so on) rather than their real school names.

A total of 150 Thai students and 16 teachers from eight model ICT schools constituted the sample for this study. They came from grade six at primary school level and grade nine at lower and higher secondary school level from eight schools in the ICT schools pilot project in Thailand. The participation of eight model ICT schools represented about 62 % of the 13 ICT schools in elementary and secondary education level under the ICT schools pilot project in Thailand.

These boys and girls were 10 to 15 years of age. Each class consisted of boys and girls of mixed ability, being taught the different subjects, Science, Mathematics, Computer or IT, Social Studies, English, French, and Thai Languages, by teachers trained to integrate ICT into their teaching and learning approaches. All sixteen teachers had received some basic training in integrating ICT into the classroom teaching of their particular subject area. A number had received also more advanced professional development in the area.

A brief description of the eight schools involved is given below:

School A

There were four ICT teachers who decided to join the study. They taught in mathematics, English language, and IT, respectively. They recommended 33 students (13 boys and 20 girls) to participate in the study.

School B

A total of nine students (5 boys and 4 girls) participated in the quantitative surveys in the study, recommended by one teacher who taught science. This ICT teacher volunteered to participate in the study.

School C

There were 30 students (4 boys and 26 girls) who volunteered to fill in two questionnaires and one standard test. 20 students had been studying at primary education level, and 10 students came from secondary education in the same this school. Two teachers volunteered for this school to be tested in their critical thinking skills and attitudes towards ICT. Both of them taught in the Social Studies area, including English and Thai language, respectively.

School D

One ICT teacher who participated in the study was in science. The 10 students (6 boys and 4 girls) were recommended by their teacher to join the study, if they were willing.

School E

The ICT teacher who decided to join the study taught French. The Eight students (3 boys and 5 girls) who volunteered to participate in the study were at secondary level.

School F

The ICT teacher who volunteered in the study was in the subject area of IT or Computer. There were 10 volunteer students, all girls at the primary level, who participated in the study.

School G

The 29 students (6 boys and 23 girls) who joined in the study were at primary level. The three ICT teachers who participated in the study taught IT, Science, and Mathematics, respectively. However, none of these students and teachers participated in the interview section of the study.

School H

A total of 21 primary students (10 boys and 11 girls) participated in the study. Two ICT teachers who taught Mathematics and Social Studies, respectively volunteered to participate.

TABLE PF2-1 provides a breakdown of student participants with regards to their individual background concerning the use of ICT.

Out of 150 student participants, 47 were boys and 103 were girls. In terms of computer experience, they fell into approximately equal groups. There were 80 students who had computer experience less than or equal to five years, and 70 students who had computer experience of more than five years. In addition, approximately 87 % (130 students) of all student participants had received training in the use of the computer and actually used it at home. The remaining 20 students had no computer training and did not use one at home. Among the students who used the computer at home, some 96 students used the Internet also.

Table PF2- 1: Breakdown of Student Participants by Individual Background concerning the Use of ICT

SCHOOL NAME	Number of students who volunteered to participate in the study needed to complete two questionnaires and one standard test									
	Boy Students	Girl Students	<=5 years Experience	>5 years Experience	Computer Training	Self-Study Learning	Use comp at Home	No comp at Home	Use www at Home	No www at Home
School A	13	20	18	15	31	2	25	8	15	18
School B	5	4	5	4	8	1	9	0	7	2
School C	4	26	22	8	24	6	28	2	18	12
School D	6	4	5	5	9	1	7	3	4	6
School E	3	5	4	4	7	1	8	0	6	2
School F	0	10	4	6	8	2	5	5	3	7
School G	6	23	14	15	23	6	28	1	24	5
School H	10	11	8	13	20	1	19	2	19	2
Total	**47**	**103**	**80**	**70**	**130**	**20**	**129**	**21**	**96**	**54**

Note: *(a) The participants were in grade six at primary schools or grade nine at secondary schools in eight model ICT schools under the Thai ICT schools pilot project.*

(b) Some teachers and students from School A, B, C, D, E, F, and H volunteered to participate in the interview section in the study, but there were no interview participants from School G.

As a second step, I sent official letters to the eight school principals to inform them concerning their teachers' co-operation, the research administration, and their involvement in my research. Their responses confirmed that 16 ICT teachers would participate willingly in the study.

As a last step, after I had already confirmed the teachers' names by telephone or by email, I contacted them personally to invite them to participate.

2.1.3.2 Administration and Data Collection

Each ICT teacher asked their students who would be preferred to participate in the study. Then the ICT teachers put their students' names on participant lists in code to prepare the administration of three questionnaires to them. The students' willingness to participate was most important, in order to complement the ICT teachers who had expressed their willingness to participate.

I administered the instruments to the study participants (teachers and students) myself. When I arrived at each model ICT school, the ICT teacher introduced me to their students before I proceeded. At the beginning of the process, the purpose of the study was explained briefly to the students before they were required to fill in the questionnaires. Students were assured that their answers were confidential and would be seen only by the researcher. They were also told that the study was not concerned with them as individuals but with the averages or norms of students overall. Thus, it was important for them to answer the questions honestly. Finally, I handed out three questionnaires to the students and the purpose of the questionnaire survey was briefly explained by the researcher, to ensure their understanding and responses to the questionnaire items. Students began to fill in the questionnaires only after they were clear about the instructions given.

Each student completed two questionnaire surveys and one critical thinking skill standard test. A sample of 150 students completed actual and preferred versions of the first questionnaire, which were used to assess students' perception of their classroom learning environment with ICT. In the second questionnaire, they completed schedules to measure their attitudes towards ICT use, including Using Email (E-Mail), the Internet (www), Multimedia, Computer for Student Productivity, Email for Classroom Use, and Computer

Feeling. In the last test, I used the Cornell Critical Thinking Skills Test (CCTT) to assess students’ critical thinking skills. There was no time limit for the completion of the questionnaires. However, on average each student took approximately 40 minutes to complete each questionnaire. The whole process took one afternoon of the students’ time.

A total of 150 student responses to three questionnaires were received, giving a response rate of 100%.

In order to measure teachers’ critical thinking skills and attitudes toward ICT (together with general characteristics), each ICT teacher needed to complete one questionnaire and one standard test. Both of these were administered to the 16 ICT teachers, at the time where their students were filling in the three questionnaires. For each teacher, each questionnaire took approximately 30 minutes to complete.

A total of 16 teacher responses to the two questionnaires were received, giving a response rate of 100%.

The following section describes in more detail the original and the adapted form of the quantitative instruments used and provides a rationale for their selection.

2.2 QUANTITATIVE RESEARCH INSTRUMENTS

2.2.1 Introduction

This following section provides a rationale for their selection covers the description of and rational for the instruments used to collect data on teachers’ characteristics, students’ perceptions of ICT classroom learning environments, and student outcomes (students’ critical thinking skills and students’ attitudes towards ICT). The adapted instruments in a Thai version are explained.

2.2.2 Research Instruments and Data Collection

The quantitative methods included three student research instruments and two teacher instruments. These instruments were translated in Thai version for the participants (Thai teachers and students). So each instrument was referred to as the adapted instrument in Thai version.

For students, there were three instruments which measured each student's perceptions of the classroom environments with ICT, and the two student outcomes, respectively.

The nature of the original instruments used for students and teachers is explained in this following section.

2.2.2.1 The New Classroom Environment Instrument (NCEI)

This present study involved gathering data related to a variety of levels of the psycho-social environment, concerning students' perceptions of ICT classroom environments by using classroom learning instruments. During the 1990s, Newhouse developed the NCEI based on the Classroom Environment Scale (CES) developed by Moos and Trickett (1974), with a group-workscale added from the Classroom Interaction Patterns Questionnaire (CIPQ) developed by Woods (1995). It was an instrument that was developed specifically for the computer-supported classroom environment. Newhouse (2001b) recommended that the New Classroom Environment Instrument (NCEI) be used to assess students' perceptions of their classroom learning environments which incorporated ICT. The purpose of using this instrument was not only to provide a way of classifying major aspects of the classroom learning environment, but also to compare preferred and actual class means from the perspective of person-environment fit studies (Newhouse, 2001a).

In addition, this instrument was developed to assist in classroom-based research into computer-supported learning in two forms (actual and preferred versions). The NCEI had an actual form to measure the participants' perceptions of their actual classroom learning environment and a preferred form to measure the students' perceptions of how they would prefer their learning environment to be. The actual form of the instrument was designed to allow respondents to indicate their perception of the conditions currently prevailing in the classroom. The preferred form of the instrument was designed to allow respondents to indicate the conditions they would like to prevail in an ideal classroom. Both versions had eight scales with a total of 56 items. The scales were INV (Student Involvement), AFF (Affiliation), TS (Teacher Support), GW (Group Work), COMPE (Competition), OO (Order and Organisation), TC (Teacher Control), and INN (Innovation) (See Table PF2-2 for descriptive information on the eight NCEI scales).

Table PF2- 2: Scale Description for Each Scale of the Original Form of the New Classroom Environment Instrument (NCEI)

Scale Name and Code	Description of Scale [a]
Student Involvement (INV)	Degree to which students take interest in class activities and participate in discussions. Students do additional work on their own and enjoy the class.
Affiliation (AFF)	Degree to which students feel for each other/ help each other with homework/ get to know each other easily, and enjoy working together.
Teacher Support (TS)	Degree to which the teacher directs help, shows friendship towards the students, talks openly with students, trusts them and takes an interest in their ideas.
Group Work (GW) [b]	Degree to which students are able to work collectively in class on tasks and activities.
Competition (COMPE)	Degree to which students compete with classmates.
Order and Organisation (OO)	Degree to which students tend to remain calm and quiet
Teacher Control (TC)	Degree to which teacher enforces the classroom rules. The number of rules and how easily students get in to trouble
Innovation (INN)	Degree to which students contribute to planning classroom activities and assignments/ teacher attempts to use new techniques and encourage creative thinking in the students

Note: [a] Descriptions taken from Moos and Trickett (1974, p.3) and Woods (1995, p.110)
[b] GW scale was modified from the original CIPQ. All other scales were modified from the original CES.

That is, the statements of the actual version have been summarised in Table PF2–2 (above). For the preferred version, the content was the same but statements were phrased in terms of "I would prefer…"

The response format of the NCEI was a 3-point Likert rating scale. The rating scale consisted of Often, Sometimes, and Almost Never which had scores of 3, 2, and 1, respectively. Items were arranged in cyclic order (See Table PF2-3).

A copy of the New Classroom Environment Instrument (NCEI) and the adapted NCEI in Thai version are provided in Appendix “A”.

Table PF2- 3: Allocation of Items to Scales and a Sample Item for Each Scale of the Original Form of New Classroom Environment Instrument (NCEI)

NCEI scale	No. of items	Item Nos.	Sample item
INV	7	1, 9, 17, 25, 33, 41, 49	Students put a lot of energy into what they do here. (+)
AFF	7	2, 10, 18, 26, 34, 42, 50	Students in this class get to know each other well. (+)
TS	7	3, 11, 19, 27, 35, 43, 51	This teacher remains at the front of the class rather than moving about and talking with students. (-)
GW	7	4, 12, 20, 28, 36, 44, 52	Students work by themselves rather than working together on projects in this class. (-)
COMPE	7	5, 13, 21, 29, 37, 45, 53	Students feel pressured to compete here. (+)
OO	7	6, 14, 22, 30, 38, 46, 54	This is a well-organised class. (+)
TC	7	7, 15, 23, 31, 39, 47, 55	There are very few rules to follow. (-)
INN	7	8, 16, 24, 32, 40, 48, 56	New ideas are tried out in this class. (+)

***Note**:* Items designated (+) were scored by allocating 3, 2, 1, respectively, for the responses Often, Sometimes, Almost Never. Items designated (-) were scored in the reverse manner. Omitted responses were given a score of 2.

Table PF2-4 shows the Cronbach alpha reliability coefficients for the NCEI (Newhouse, 2001a). The Cronbach alpha reliability coefficients calculated for the Competition and Teacher Control scales point to poor internal consistency.

Table PF2- 4: Cronbach Alpha Reliability Coefficients for Administrations of the Original Form of NCEI to Four Classes in 1993 and Five Classes in 1994

Scales	Preferred Reliability (Feb 1994) n=111	Actual Reliability (Mar 1994) n=111	Actual Reliability (Nov 1994) n=102	Preferred Reliability (Aug 1993) n=95	Actual Reliability (Aug 1993) n=95
INV	0.60	0.39	0.71	0.79	0.69
AFF	0.82	0.65	0.72	0.83	0.66
TS	0.75	0.45	0.69	0.84	0.75
GW	0.79	0.80	0.75	0.83	0.73
COMPE	0.33	0.10	0.25	0.65	0.23
OO	0.71	0.65	0.43	0.76	0.54
TC	0.38	0.39	0.17	0.69	0.40
INN	0.63	0.59	0.70	0.82	0.70

***Note**:* Sources: Newhouse (2001a, p.127)

Responses to the instrument were entered into a spreadsheet from which data were imported into SPSS version 11.0 to calculate Cronbach Alpha as a measure of internal consistency, and to investigate differences between means using effect sizes and t-tests. In an international comparison of studies using various classroom environment instruments, Wubbles (1993) stated that while a scale reliability coefficient of 0.7 or greater was regarded as acceptable, it was not uncommon to find reliability coefficients down to 0.2. In particular, comparisons were made between means on the preferred and actual versions of the instrument. The t-test results were reported at 0.05, 0.01, and 0.001 levels of significance. Effect sizes, as standardised mean differences, were calculated using the formula = (mean difference ÷ pooled standard deviation) which was discussed by Dunlap, Cortina, Vaslow, and Burke (1996). Sizes above about 0.50 were regarded as moderate and those above about 0.70 regarded as large (e.g.Fraser, 1989).

2.2.2.2 The Teacher Attitudes toward Information Technology (TAT) for Student Questionnaire

In this present research, the Teachers' Attitudes Toward Information Technology (TAT) Questionnaire version 3.2 a/1998 (Christensen & Knezek, 1996; Texas Centre for Education Technology(TCET), 2000) was adjusted to measure Thai students' attitudes towards Information Technology in ICT schools pilot project in Thailand. This questionnaire was developed by Christensen, R. and Knezek, G. during the second phase of the 1995-97 of Matthews Chair for Research in Education Project at the University of North Texas (Knezek et al., 1998).

Originally developed by Osgood, Suci, and Tannenbaum (1967), this instrument offered respondents a choice of opposite adjectives to describe an aspect of computer use (Semantic Differentiate Scale). These included Computers for student Productivity [CPP], Computers for Classroom Use [CCU], Computer Feeling, Electronic Mail [E-Mail] using, Internet [WWW] using, and Multimedia using. The respondents' feelings about each aspect were measured by combining their scores for their responses to each statement. The TAT questionnaire version 3.2 a/1998, adjusted for student use, is described in Table PF 2-5. (Christensen & Knezek, 1996; Texas Centre for Education Technology(TCET), 2000)

A copy of the modified of Teachers' Attitudes Toward Information Technology (TAT) Questionnaire for students and the adapted form of TAT for students in Thai version are provided in the Appendix "B".

Table PF2- 5: Description of the Adjusted Teachers' Attitudes Toward Information Technology (TAT) Questionnaire Version 3.2a/1998 for Students

Scale Name	No. of Items	Sample item
Email Using(student)	10	To me, electronic mail is:
WWW Using(student)	10	To me, using the world-Wide Web is:
Multimedia Using (student)	10	To me, multimedia is:
Computer for Student Productivity (student)	10	To me, using computers for my productivity is:
Computer Feeling (student)	10	Computers are:
E-Mail for Classroom Use (student)	11	Email is an effective means of disseminating class information and assignments

Note: The Teachers Attitudes Toward Information Technology (TAT) Questionnaire version 3.2a/ 1998 was developed by Christensen, R. and Knezek, G., based on earlier work done in 1995-96.

As shown in Table PF2-6, internal consistency reliabilities for the student TAT subscales ranged from a low of 0.91 to a high of 0.98.

Table PF2- 6: TAT Internal Consistency Reliabilities for Grade 12 Teachers From Six Texas Schools (1997)

Scale	No. Items	Alpha Reliability
Kay's Semantic (CAM) Computer Feeling	10	0.91
E-Mail Using (student)	10	0.95
Internet (www) Using (student)	10	0.96
Multimedia Using (student)	10	0.98
Computer for student Productivity	10	0.96
D'Souza's email for Classroom use	11	0.95

Note: *Source: Knezek, G., & Christensen, R.(G. Knezek & Christensen, 1998) Internal Consistency Reliability for the Teachers Attitudes Toward Information Technology (TAT) Questionnaire. Proceedings of the Society for Information Technology & Teacher Education, 2, pp. 832-833*

2.2.2.3 The Cornell Critical Thinking Tests (CCTT) for Students

There are two major reasons that I selected the Cornell Critical Thinking Skill Tests (CCTT), Level X to assess critical thinking skills for students. Firstly, Ennis, Millman, and Tomko (1985) stated that Cornell Critical Thinking Tests (CCTT), Level X was the most commonly used instrument to assess critical thinking capabilities. Secondly, it was intended to measure students' critical thinking skills for junior and high school students as well as students who were from grade four through to college level, comparable to students in the Thai ICT Schools Project.

The CCTT, Level X, which was developed by Ennis and Millman, contains 71 multiple-choice items, and is divided into four sections. They include: (1) inductive inference, (2) credibility of sources and observation, (3) deduction, and (4) assumption identification. Reliability estimates for Level X range from .67 to .90.

A copy of the original form of Cornell Critical Thinking Test (CCTT) Level X and the adapted CCTT in Thai version are provided in the Appendix "C".

From Table PF2-7, reliability and internal consistency of the Cornell Critical Thinking Skill Test estimates ranged from 0.67-0.90.

Table PF2- 7: Reliability and Internal Consistency of Cornell Critical Thinking Skill Test (CCTT)

Scales	Alpha Reliability
Inductive Inference	0.67-0.90
Credibility of sources and observations	
Deduction	
Assumption Identification	

Note: The Cornell Critical Thinking Test Level X was developed by Ennis and Millman (1989).

2.2.2.4 The California Critical Thinking Skills Test (CCTST) for Teachers

The California Critical Thinking Skills Test (CCTST) was selected to measure the critical thinking skills of Thai ICT teachers. It was an appropriate instrument to measure the educational proficiency of professional teachers in five critical thinking skills, including Analysis, Inference, Evaluation, Induction and Deduction. The CCTST was developed by Peter A. Facione (Facione & Facione, 1994). It was a standardised test made up of 34 multiple choice questions about problem statements and scenarios. College, undergraduate, and graduate students, as well as professional teachers, were the focus of the test.

A copy of the Original Form of California Critical thinking Skills Test (CCTST) and the adapted CCTST in Thai version are provided in Appendix "D".

As shown in Table PF2-8, internal consistency reliabilities for the published version of the CCTST for Form B according to the Kuder Richardson (KR)-20 was 0.71.

Table PF2- 8: The Internal Consistency of the Published Version of the CCTSC, Form B

Scales	Reliability
Analysis Skills	0.71
Evaluation Skills	
Inference Skills	
Deduction Skills	
Induction Skills	

Note: The California Critical Thinking Skills Test – Form B was developed by Peter A. Facione (1990).

In this following section, I will present the instrument which was selected to measure teachers' Attitudes towards ICT using.

2.2.2.5 The Teachers' Attitudes toward Information Technology (TAT) for Teacher Questionnaire

The Teachers' Attitudes Toward Information Technology (TAT) Questionnaire (Christensen & Knezek, 1996; Texas Centre for Education Technology(TCET), 2000) was used to determine teachers' attitudes towards Information Technology, including Computers for Professional Productivity [CPP], Computers for Classroom Use [CCU], Electronic Mail [E-Mail] Using, Internet [WWW] Using, and Multimedia Using. Table PF 2-9 provides a description of the questionnaire scales and sample items. It was measured using semantic differential scales and complemented the student TAT questionnaire to provide the assessment of the new Information Technologies (see 2.2.2.2).

A copy of the Teachers' Attitudes Toward Information Technology (TAT) Questionnaire for teachers and the adapted form of TAT in Thai version for teachers are provided in the Appendix "E".

Table PF2- 9: Description of the Teachers' Attitudes toward Information Technology (TAT) Questionnaire Version 3.2a/1998

Scale Name	No. of Items	Sample item
E-Mail Using (teacher)	10	To me, electronic mail is:
WWW Using(teacher)	10	To me, using the world-Wide Web is:
Multimedia Using (teacher)	10	To me, multimedia is:
Computer for Professional Productivity (teacher)	10	To me, using computers for my productivity is:
Computer Feeling (teacher)	10	Computers are:
E-Mail for Classroom Use (teacher)	11	Email is an effective means of disseminating class information and assignments

Note: The teachers Attitudes toward Information Technology (TAT) Questionnaire version 3.2a/ 1998 was developed by Christensen, R. and Knezek, G., based on work done in 1995-96.

As shown in Table PF2-10, internal consistency reliabilities for the teacher TAT subscales ranged from a low of 0.91 to a high of 0.96.

Table PF2- 10: Teachers' Attitudes toward Information Technology (TAT) Reliability for 1996

Scale	No. Items	Alpha Reliability
Kay's Semantic (CAM)	10	0.91
E-Mail	10	0.93
Internet (www)	10	0.95
Multimedia	10	0.96
Computer for teacher Productivity	10	0.96
D'Souza's E-Mail (email for classroom use)	11	0.95

Note: The teachers Attitudes toward Information Technology (TAT) Questionnaire version 3.2a/ 1998 was developed by Christensen, R. and Knezek, G., based on work done in 1995-96.

The section, in that follows, first discusses the validity and reliability of the adapted instruments namely NCEI, CCTT, and TAT in Thai versions through exploratory factor analysis. The results of the data analysis, using the statistical techniques of t-test, simple regression, multiple regressions, and multilevel techniques to examine Proposition 1 to Proposition 4, are then presented.

2.3 QUANTITATIVE ANALYSIS

2.3.1 Introduction

The first objective of Section 3 of Part 2 is to provide a description of the quantitative analysis used to test the validity and reliability of the adapted Thai versions of the NCEI, the CCTT, and the TAT for students, when used with students who were in model ICT schools under the Thai ICT schools pilot project. In addition, Section 3 presents the results of the analysis in relation to the four major propositions of the study.

2.3.2 Quantitative Analysis

For quantitative analyses, the present study used two kinds of t-test methods (independent and paired samples t-test methods) to compare the mean scores of two different groups, such as male and female respondents or different conditions, such as actual and preferred classroom environments, respectively. Furthermore, I investigated associations between students' individual characteristics, students' perceptions of classroom learning environments with ICT, and two student outcomes (students' critical thinking skills and students' attitudes towards ICT) through the use of using simple correlation and multiple regression analyses. Finally, associations between students' perceptions of ICT classroom environments and student outcomes in relation to teacher factors (teachers' critical thinking skills and teachers' attitudes toward ICT) were explored using hierarchical linear modelling analysis.

Questionnaire data were analysed by using SPSS for Windows (Statistical Package for the Social Science) software and HLM (Hierarchical Linear Modelling) software as well. Standard Multiple Regression and Hierarchical Multiple Regression analysis and Hierarchical Linear Modelling were used to examine the relationships in the final research model in part 2.

Many previous studies of environment-outcome associations had analysed data by using ordinary least squares or other multiple regression techniques. However, there have been a few studies, which used the Hierarchical Linear Modelling (HLM) or multilevel modelling. The analysis of these research data involved the aggregation of student level to classroom level of analysis, or, alternatively, the disaggregating of classroom variables to student level of analysis.

The development of estimation procedures appropriate for hierarchical data or multilevel data was documented by Aitkin and Longford (1986), Goldstein (1986) de Leeuw and Kreft (1986), Mason et al., (1984) and Raudenbush and Bryk (1986). Firstly, these researchers proposed statistical models for educational data, which solved the problem of aggregation bias. Secondly, these models enabled specification of appropriate error structures, including random intercepts and random coefficients, which solved the problems of misestimate precision due to the estimation of standard errors failing to include components of variance and covariance between groups, such as school levels or class levels (Raudenbush, 1988). The application of these procedures enables a more accurate calculation of the relationship between the two levels of student and classroom-teacher variables.

In this section, I indicate the nature of the instruments that were used to measure the different constructs in the General Theoretical Framework shown in Figure PF1-2. Where appropriate, I present the factor structure (factor analysis) which is most appropriate for use in exploring the data set in this present study and the alpha reliability of the predictor and outcome measures by using SPSS for Windows version 11.0, in relation to my own data from the sample 150 students. Reviews of these measures in the previous section (Part 2 of Portfolio 2) indicated that the original predictor and outcome measures had acceptable validity and reliability as well.

Exploratory factor analysis suggested the use of the adapted version in Thai version of the NCEI, CCTT, and TAT with a different arrangement of factors. To examine factor structures, I used principal component analysis, with the varimax rotation method. An exploratory factor analysis was undertaken to sample the adapted predictors and outcomes. This procedure did not lead to any restriction in the number of factors in the original instrument, but the factors were re-grouped and re-named, as result of the exploratory factor analysis of the raw data. SPSS for Windows version 11.0 was used to develop the Factor Analysis and select the factors, which were re-grouped from the previous factor structures in both the actual form and the preferred form of classroom learning environments with ICT. It also provided the Cronbach alpha reliability for the predictor and measure outcomes for the same group of students.

The discussion in the section that follow, outlines this process in relation to the predictor and outcome measures.

2.3.2.1. Predictor Measures

(a) The Adapted Form of the New Classroom Environment Instrument (NCEI) in Thai version

The NCEI (Newhouse, 2001a, 2001b) was used to assess students' perceptions of ICT classroom learning environment in both the preferred and actual forms in this research. Validation of the adapted NCEI with the sample of 150 students commenced with principal components factor analysis, followed by varimax rotation. A combination of the Screen plot test and Eigenvalues greater than one rule was used to determine the number of factors to be extracted. The Cronbach alpha reliability was also used as an index of scale internal consistency.

I started from the preferred form of ICT classroom environment. From the 56 items of the NCEI, 31 items were deleted as they had a loading less than .40 on the factor analysis.

Table PF2-11 shows the results of the factor loading for the remaining 25 items from the adapted NCEI (preferred form) questionnaire.

Table PF2- 11: Factor Structure for ICT Classroom Learning Environment – Preferred Form

Items	Factor Loading
1. Students would work in groups to solve questions raised in class.	.67
2. Students would work in groups to complete group projects.	.66
3. Students would enjoy working together on projects in the class.	.63
4. Activities in the class would be clearly and carefully planned.	.57
5. Students would do very different things on different days in class.	.52
6. Most students in the class would not pay attention to what the teacher is saying.	.50
7. Students would work together in class on group activities.	.46
8. Students would get into trouble with the teacher for talking.	.42
9. The teacher would go out of his/her way to help students.	.70
10. The teacher would be prepared to put up with problems in the class.	.57
11. The teacher would have to tell students to calm down and behave.	.51
12. Students would be quiet in the class.	.45
13. Students would share resources and work together in class.	.74
14. The teacher would encourage students to try unusual projects.	.44
15. The teacher would be more like a friend than an authority.	.44
16. If students break a rule in a class, they would be disciplined.	.75
17. Assignments would be clear so everyone knows what to do.	.55
18. The teacher would think up unusual projects for students to do.	.43
19. Students in my class would get to know each other well.	.81
20. Students would try hard to get the best mark.	.59
21. The teacher would not trust students.	.83
22. Students would not take part in class discussions or activities.	.52

continued

Items	Factor Loading
23. Some students in this class would not like each other.	.42
24. Grades would be very important in the class.	.76
25. Students would have to work for a good grade in this class.	.43
Overall Reliability	0.83

Note: Those items with a factor loading of less than 0.40 are not shown in this Table.

The value of Cronbach's alpha obtained from the present data for the overall reliability of 25 items of the adapted NCEI (preferred form) was 0.83, which was well within the level of reliability of 0.70, suggested by Watkins and Mboya (1997).

In the next step, I used SPSS for Windows version 11.0 to develop the Factor Analysis and select the factors, which had been, were grouped from the previously examined factor structures described in Table PF2-11. The final statistics of the SPSS version 11.0 report showed that 30.12 % of the variation was explained by the first seven factors. The seven factors that were generated from the varimax rotation (Varimax with Kaiser Normalization) were given new labels. Hence this research reported only those seven factors, named by researcher for the nature of the items. These are discussed in more detail below.

Factor 1: Group Work - GW
(The degree to which students would be able to work together in groups at tasks and class activities).

The details of the eight individual items which had high loadings for this preferred form factor are given in Table PF2–12.

Table PF2- 12: Factor 1 - Preferred Form of Group Work (GW): Individual Items and their Factor Loadings

Items	Factor Loading
1. Students would work in groups to solve questions raised in class.	.67
2. Students would work in groups to complete group projects.	.66
3. Students would enjoy working together on projects in the class.	.63
4. Activities in the class would be clearly and carefully planned.	.57
5. Students would do very different things on different days in class.	.52
6. Most students in the class would not pay attention to teacher saying.	.50
7. Students would work together in class on group activities.	.46
8. Students would get into trouble with the teacher for talking.	.42
Overall Reliability	0.78

The Cronbach alpha reliability for the Group Work (GW) scale in the preferred environment, consisting of eight items, was 0.78.

Factor 2: Order and Organisation - OO

(The degree to which students would behave in an orderly and polite manner and tend to remain calm and quiet during assignments and classroom activities).

Table PF2-13 gives details of the loadings on the four items making up this factor scale, in its preferred form.

Table PF2- 13: Factor 2 - Preferred Form of Order and Organisation (OO): Individual Items and their Factor Loadings

Items	Factor Loading
9. The teacher would go out of his/her way to help students.	.70
10. The teacher would be prepared to put up with problems in the class.	.57
11. The teacher would have to tell students to calm down and behave.	.51
12. Students would be quiet in the class.	.45
Overall Reliability	0.58

The Cronbach alpha reliability for the Order and Organisation (OO) scale in the preferred environment, consisting of four items, was 0.58.

Factor 3: Co-Operation - COOP

(The degree to which students and their peers would share instructional resources to achieve their tasks, individual or group projects, class activities, and so on, or students and their teachers would join together to generate student tasks).

Details of the three items in Factor 3, in the preferred form, as well as their loading, are given in Table PF2-14.

Table PF2- 14: Factor 3 - Preferred Form of Co-Operation (COOP): Individual Items and their Factor Loadings

Items	Factor Loading
13. Students would share resources and work together in class.	.74
14. The teacher would encourage students to try unusual projects.	.44
15. The teacher would be more like a friend than an authority.	.44
Overall Reliability	0.51

The Cronbach alpha reliability for the Co-Operation (COOP) scale in the preferred environment, consisting of three items, was 0.51.

Factor 4: Teacher Support - TS

(The degree to which the teacher would care for student needs and help students to succeed in their assignments).

Table PF2-15 provides details of the three items, which make up this factor scale and their loadings.

Table PF2- 15: Factor 4 - Preferred Form of Teacher Support (TS): Individual Items and their Factor Loadings

Items	Factor Loading
16. If students break a rule in a class, they would be disciplined.	.75
17. Assignments would be clear so everyone knows what to do.	.55
18. The teacher would think up unusual projects for students to do.	.43
Overall Reliability	0.55

The Cronbach alpha reliability for the Teacher Support (TS) scale in the preferred environment, consisting of three items, was 0.55.

Factor 5: Student Involvement – INV

(The degree to which students would be attentive and interested in class activities, participate in discussions, do additional work on their own and enjoy the class).

Details of the two items in Factor 5, in the preferred form, as well as their loading, are given in Table PF2-16.

Table PF2- 16: Factor 5-Preferred Form of Student Involvement (INV): Individual Items and their Factor Loadings

Items	Factor Loading
19. Students in my class would get to know each other well	.81
20. Students would try hard to get the best mark	.59
Overall Reliability	0.50

The Cronbach alpha reliability for the Involvement (INV) scale in the preferred environment, consisting of two items, was 0.50.

Factor 6: Relationships in class - RS

(The amount of help, interest, and trust the teacher manifest toward students, as well as the level of friendship that students would feel for each other).

Table PF2-17 provides details of the three items, which make up this factor scale and their loadings.

Table PF2- 17: Factor 6 - Preferred Form of Relationships (RS): Individual Items and their Factor Loadings

Items	Factor Loading
21. The teacher would not trust students.	.83
22. Students would not take part in class discussions or activities.	.52
23. Some students in this class would not like each other.	.42
Overall Reliability	0.51

The Cronbach alpha reliability for the Relationships (RS) scale in the preferred environment, consisting of three items, was 0.51.

Factor 7: Competition - COMPE

(The degree to which students would compete with each other for grades and recognition and how hard it would be to achieve high performances).

Table PF2-18 provides details of the two items, which make up this factor scale and their loadings.

Table PF2- 18: Factor 7 - Preferred Form of Competition (COM): Individual Items and their Factor Loadings

Items	Factor Loading
24. Grades would be very important in the class	.76
25. Students would have to work for a good grade in this class	.43
Overall Reliability	0.44

The Cronbach alpha reliability for the Competition (COM) scale in the preferred environment, consisting of two items, was 0.44.

In the next section I present the factor structure for the NCEI of classroom learning environment with ICT, in the actual form. From the 56 items, 32 items were deleted as they had loading less than .40 on the factor analysis. The final factor structure for the remaining 24 items is shown in Table PF2-19.

Table PF2- 19: Factor Structure for ICT Classroom Learning Environment – Actual Form

Items	Factor Loading
1. Students really enjoy this class.	.71
2. Students have to work for a good grade in this class.	.70
3. Friendships are made in this class.	.50
4. Assignments are clear so everyone knows what to do.	.40
5. Students get into groups for small group activities.	.79
6. Students work together in class on group activities.	.61
7. Students work in groups to solve questions raised in class.	.59
8. Students enjoy working together on projects in the class.	.57
9. Students get into trouble with the teacher for talking when they not supposed to.	.50
10. The teacher thinks up unusual projects for students to do.	.42
11. The teacher puts up with problems in this class.	.67
12. Some students in this class do not like each other.	.60
13. Teacher goes out of his/her way to help students.	.58
14. This teacher tries to find out what students want to learn about.	.46
15. Students are quiet in the class.	.81
16. This is a well-organised class.	.47
17. The teacher likes students to try unusual projects.	.79
18. Students work in groups to complete group projects.	.45
19. Students do extra work on their own in this class.	.43
20. Students work by themselves rather than working together on projects in his class.	.77
21. What students do in class is very different on different days.	.56
22. Students have very little say about how class time is spent.	.77
23. Students notice what grades the other students are getting.	.46
24. Students do the same type of activities everyday.	.42
Overall Reliability	0.75

Note: Those items with a factor loading of less than 0.40 are not shown in this Table.

The value of Cronbach's alpha obtained from the present data for the overall reliability of 24 items of the NCEI (actual form) was 0.75, which was well within the level of reliability of 0.70, suggested by Watkins and Mboya (1997).

The 24 items in this group were included in the factor analysis. The final statistics of the SPSS version 11.0 report showed that the variation was explained by the eight factors outlined below. It will be noted that although the names given to the re-grouped factor in the actual NCEI form are the same as in the preferred form discussed above, the description of each factor varies somewhat because of differences in the actual items retained in the two forms.

Factor 1: Co-Operation - COOP

(The extent to which students and their peers share instructional resources to achieve student tasks or class activities in both individual and group projects).

Table PF2-20 gives details of the loadings on the four items making up this factor scale, in its actual form.

Table PF2- 20: Factor 1 - Actual Form of Co-Operation (COOP): Individual Items and their Factor Loadings

Items	Factor Loading
1. Students really enjoy this class.	.71
2. Students have to work for a good grade in this class.	.70
3. Friendships are made in this class.	.50
4. Assignments are clear so everyone knows what to do.	.40
Overall Reliability	0.65

The Cronbach alpha reliability for the Co-Operation (COOP) scale in the actual environment, consisting of four items, was 0.65.

Factor 2: Group Work - GW

(The extent to which students are able to work together by grouping tasks and activities).

The details of the three individual items which had high loadings for this actual form factor are given in Table PF2–21.

Table PF2- 21: Factor 2-Actual Form of Group Work (GW): Individual Items and their Factor Loadings

Items	Factor Loading
5. Students get into groups for small group activities.	.79
6. Students work together in class on group activities.	.61
7. Students work in groups to solve questions raised in class.	.59
Overall Reliability	0.63

The Cronbach alpha reliability for the Co-Operation (COOP) scale in the actual environment, consisting of three items, was 0.63.

Factor 3: Relationships in class – RS

(The amount of help, interest, and trust the teacher manifests toward students, as well as the level of friendship that students feel for each other).

Details of the three items in Factor 3, in the actual form, as well as their loading, are given in Table PF2-22.

Table PF2- 22: Factor 3 - Actual Form of Relationships (RS): Individual Items and their Factor Loadings

Items	Factor Loading
8. Students enjoy working together on projects in the class.	.57
9. Students get into trouble with the teacher for talking when they not supposed.	.50
10. The teacher thinks up unusual projects for students to do.	.42
Overall Reliability	0.63

The Cronbach alpha reliability for the Relationships (RS) scale in the actual environment, consisting of four items, was 0.63.

Factor 4: Teacher Support – TS

(The extent to which the teacher cares for student needs and helps students to succeed in their assignments).

Table PF2-23 provides details of the four items which make up this factor scale and their loadings.

Table PF2- 23: Factor 4 - Actual Form of Teacher Support (TS): Individual Items and their Factor Loadings

Items	Factor Loading
11. The teacher puts up with problems in this class.	.67
12. Some students in this class do not like each other.	.60
13. Teacher goes out of his/her way to help students.	.58
14. This teacher tries to find out what students want to learn about.	.46
Overall Reliability	0.60

The Cronbach alpha reliability for the Teacher Support (TS) scale in the actual environment, consisting of four items, was 0.60.

Factor 5: Order and Organisation - OO

(The emphasis on students behaving in an orderly and polite manner and on the overall organisation of assignments and classroom activities).

Table PF2-24 gives details of the loadings on the two items making up this factor scale, in its actual form.

Table PF2- 24: Factor 5 - Actual Form of Order and Organisation (OO): Individual Items and their Factor Loadings

Items	Factor Loading
15. Students are quiet in the class.	.81
16. This is a well-organized class.	.47
Overall Reliability	0.35

The Cronbach alpha reliability for the Order and Organisation (OO) scale in the actual environment, consisting of two items, was 0.35.

Factor 6: Student Involvement - INV

(The degree to which students are attentive and interested in class activities and involved with each other).

Table PF2-25 gives details of the loadings on the three items making up this factor scale, in its actual form.

Table PF2- 25: Factor 6 - Actual Form of Student Involvement (INV): Individual Items and their Factor Loadings

Items	**Factor Loading**
17. The teacher likes students to try unusual projects.	.79
18. Students work in groups to complete group projects.	.45
19. Students do extra work on their own in this class.	.43
Overall Reliability	0.47

The Cronbach alpha reliability for the Student Involvement (INV) scale in the actual environment, consisting of three items, was 0.47.

Factor 7: Competition - COMPE

(The degree to which students compete which each other for grades and recognition and how hard it is to achieve high performances).

Details of the three items in Factor 7, in the actual form, as well as their loading, are given in Table PF2-27.

Table PF2- 26: Factor 7 - Actual Form of Competition (COMPE): Individual Items and their Factor Loadings

Items	**Factor Loading**
20. Students have very little say about how class time is spent.	.77
21. Students notice what grades the other students are getting.	.46
22. Students do the same type of activities everyday.	.42
Overall Reliability	0.42

The Cronbach alpha reliability for the Competition (COM) scale in the actual environment, consisting of three items, was 0.42.

Factor 8: Autonomy - AUTO
(The degree to which students do their tasks by themselves or work on their own).

Details of the two items in Factor 8, in the actual form, as well as their loading, are given in Table PF2-26.

Table PF2- 27: factor 8 - Actual Form of Autonomy (AUTO): Individual Items and their Factor Loadings

Items	Factor Loading
23. Students work by themselves rather than working together on projects in his class.	.77
24. What students do in class is very different on different days.	.56
Overall Reliability	0.41

The Cronbach alpha reliability for the Autonomy (AUTO) scale in the actual environment, consisting of two items, was 0.41.

Because there was no comparable factor of AUTO in the NCEI (preferred form), factor was dropped in subsequent analysis. When I generated the new factors from the adapted form of the NCEI, the first seven factors for actual classroom environments and the seven factors for preferred classroom environments (GW, COOP, TS, INV, RS, COMPE, and OO) were matched further for examination of the research model presented on page 122. In addition, the principal components resulted in a seven-factor structure, which explained 32.02 % of the extracted variance for the seven scales.

(b) Individual Student Background

The student background sections of the questionnaire provided space for students to indicate their gender, academic background, computer experience, and computer usage. Student background was assessed by measures of student genders (boy or girl), school levels (primary or secondary school), subject areas (Science-Technology or Social Studies-Arts), computer experience (experience in using computers), and computer usage at home (computer and internet access). The students' individual background characteristics are summarised in Table PF2-28.

Table PF2- 28: Code and Description of Student Individual Background Characteristics

Student individual backgrounds	Coded
General Background	
Gender	(0) boy (1) girl
Academic Background	
School Level	(0) Primary school (1) secondary school
Subject areas	(0) Science and Technology (Science, Math, and Computer) (1) Social and Arts (Social Study and Language)
Computer Experience	
Using computer experience	(0) 1-5 years (1) more than 5 years
Training in computer course	(0) Yes (1) No
Computer Usage	
Use computer at home	(0) Yes (1) No
Use Internet at home	(0) Yes (1) No

2.3.2.2 Outcome Measures

In the next section the two major student outcome variables (students' critical thinking skills and student attitudes toward ICT), are discussed in relation to the structure of their factors.

(a) The Adapted Form of Teachers' Attitude toward ICT (TAT) for Students in Thai Version

The principal component analysis validated all 46 items of the questionnaire, designs to measure students' attitudes toward ICT, as having loadings above 0.40. The loadings for each item are shown in Table PF2-29.

Table PF2- 29: Factor Structure of the Adapted Version of the SAT for Students' Attitudes toward ICT

Items	Factor Loading
1. Using the Internet is important.	.89
2. Using the Internet means a lot to me.	.78
3. Using the Internet is relevant.	.77
4. Computing for student productivity is relevant.	.74
5. Computing for student productivity means a lot to me.	.73
6. Computing for student productivity is important.	.72
7. Using the Internet is appealing to me.	.72
8. Using the Internet is needed.	.67
9. Email is appealing to me.	.40
10. Computing for student productivity is fascinating.	.72
11. Computing for student productivity is exciting.	.72
12. Multimedia is fascinating.	.67
13. Using the Internet is exciting.	.67
14. Using the Internet is fascinating.	.65
15. Multimedia is exciting.	.63
16. Email is fascinating.	.62
17. Multimedia is appealing.	.52
18. Computing for student productivity is appealing.	.48
19. Computers are happy.	.84
20. Computers are fulfilling.	.79
21. Computers are good.	.77
22. Computers are exciting.	.72
23. Computers are comfortable.	.72
24. Computers are fresh.	.69
25. Computers are likeable.	.61
26. Computers are calm.	.58
27. The use of email increases motivations for the course.	.79

continued

Items	Factor Loading
28. The use of email helps students to learn more.	.77
29. I prefer email to traditional class handouts as an information disseminator.	.74
30. Email provides better access to the instructor.	.73
31. Email is an effective means of disseminating class handouts.	.70
32. The use of email makes the students feel more involved.	.68
33. The use of email helps to make the course more interesting.	.68
34. The use of email helps provide a better learning experience.	.65
35. Multimedia is involving.	.84
36. Using the Internet is involving.	.77
37. Computing for student productivity is involving.	.71
38. Email is involving.	.65
39. Multimedia is interesting.	.58
40. Computing for student productivity is interesting.	.51
41. Email is important.	.71
42. Email is relevant.	.65
43. Email is needed.	.64
44. Email is interesting.	.61
45. Email is exciting.	.59
46. Email is valuable.	.45
Overall Reliability	0.94

For each student, a measure of attitude toward ICT scale was obtained by adding the scores on the 46 items; the alpha reliability of the factor scale was 0.94.

The 46 items in this group were included in the factor analysis to generate standard factors. The results showed a convergence after 18 iterations. The final statistics of the SPSS version 11.0 report showed that the variation was explained by the all six outcome factors. In addition, the principal components analysis resulted in a six factor structure which explained 51.23% of the extracted variance for the six scales. Hence this research reported on these six factors, named by this researcher for the nature of the items. A description of these factors and the loading on each item are presented below.

Factor 1: IT_CORE (The Importance of the Use of ICT)

Table PF2-30 gives details of the loadings on the nine items making up this factor scale.

Table PF2- 30: Factor 1 - The Importance of the Use of ICT (IT_CORE): Individual Items and their Factor Loadings

Items	Factor Loading
1. Using the Internet is important.	.89
2. Using the Internet means a lot to me.	.78
3. Using the Internet is relevant.	.77
4. Computing for student productivity is relevant to me.	.74
5. Computing for student productivity means a lot.	.73
6. Computing for student productivity is important.	.72
7. Using the Internet is appealing.	.72
8. Using the Internet is needed.	.67
9. E-mail is appealing.	.40
Overall Reliability	0.93

The Cronbach alpha reliability for the Importance of the Use of ICT (IT_CORE) scale, consisting of nine items, was 0.93.

Factor 2: IT_FEEL (Students' Positive Feelings in Using ICT)

Details of the nine items in Factor 2, as well as their loadings, are given in Table PF2-31.

Table PF2- 31: Factor 2 – Students' Positive Feelings in Using ICT (IT_FEEL): Individual Items and their Factor Loadings

Items	Factor Loading
10. Computing for student productivity is fascinating.	.72
11. Productivity is exciting.	.72
12. Multimedia is fascinating.	.67
13. Using the Internet is exciting.	.67
14. Using the Internet is fascinating.	.65
15. Multimedia is exciting.	.63
16. Using email is fascinating.	.62
17. Multimedia is appealing.	.52
18. Computing for student productivity is appealing.	.48
Overall Reliability	0.90

The Cronbach alpha reliability for the Students' Positive Feeling in Using ICT (IT_FEEL) scale, consisting of nine items, was 0.90.

Factor 3: COM_USE (Computer Usage)

Table PF2-32 provides details of the eight items, which make up this factor scale and their loadings.

Table PF2- 32: Factor 3 - Computer Usage (COM_USE): Individual Items and their Factor Loadings

Items	Factor Loading
19. Computers are happy.	.84
20. Computers are fulfilling.	.79
21. Computers are good.	.77
22. Computers are exciting.	.72
23. Computers are comfortable.	.72

continued

Items	Factor Loading
24. Computers are fresh.	.69
25. Computers are likeable.	.61
26. Computers are calm.	.58
Overall Reliability	0.88

The Cronbach alpha reliability for the Computer Usage (COM_USE) scale, consisting of eight items, was 0.88.

Factor 4: EMAIL_C (Electronic Mail for Classroom Use)

Details of the nine items in Factor 4, as well as their loadings, are given in Table PF2-33.

Table PF2- 33: Factor 4 - Electronic Mail for Classroom Use (EMAIL_C): Individual Items and their Factor Loadings

Items	Factor Loading
27. The use of email increases motivation for the course.	.79
28. The use of email helps students to learn more.	.77
29. I prefer email to traditional class handouts as an information disseminator.	.74
30. Email provides better access to the instructor.	.73
31. Email is an effective means of disseminating class information and assignments.	.70
32. The use of email makes the students feel more involve.	.68
33. The use of email makes the course more interesting.	.68
34. The use of email helps provide a better learning experience.	.65
Overall Reliability	0.87

The Cronbach alpha reliability for the Electronic Mail for Classroom Use (EMAIL_C) scale, consisting of eight items, was 0.87.

Factor 5: IT_INV (Involvement in ICT Use)

Table PF2-34 provides details of the six items, which make up this factor scale and their loadings.

Table PF2- 34: Factor 5 - Involvement in ICT Use (IT_INV): Individual Items and their Factor Loadings

Items	Factor Loading
35. Multimedia is involving.	.84
36. Using the Internet is involving.	.77
37. Computing for student productivity is involving.	.71
38. Using email is involving.	.65
39. Multimedia is interesting.	.58
40. Computer for student productivity is interesting.	.51
Overall Reliability	0.84

The Cronbach alpha reliability for the Involvement in ICT Use (IT_INV) scale, consisting of six items, was 0.84.

Factor 6: Email (Using Electronic Mail)

Details of the six items in Factor 6, as well as their loadings, are given in Table PF2-35.

Table PF2- 35: Factor 6 – Using Electronic Mail (Email): Individual Items and their Factor Loadings

Items	Factor Loading
41. Email is important.	.71
42. Email is relevant.	.65
43. Email is needed.	.64
44. Email is interesting.	.61
45. Email is exciting.	.59
46. Email is valuable.	.45
Overall Reliabilities	0.70

The Cronbach alpha reliability for the Using Electronic Mail (Email) scale, consisting of six items, was 0.70.

(b) The Adapted Form of Cornell Critical Thinking (CCTT) Skills for Students

Items from a students' critical thinking skill scale were used as a second outcome variable in this research. After using principal component analysis, the responses were grouped into 4 item scales which measured students' critical thinking skills. The loadings for each item are shown in Table PF2-36.

Table PF2- 36: Factor Structure of the Adapted Version of the CCTT for Students' Critical Thinking Skills

Items	Factor Loading
1.Score on deduction	.79
2. Score on assumption	.75
3. Score on credibility of sources	.78
4. Score on inductive inference	.73
Overall Reliability	0.35

An overall Critical thinking skill score for each student was obtained by adding the scores on the above 4 items. The alpha reliability of the factor scale was 0.35. The lower range of the reliability coefficients in this research could be attributed to the young age of the students (grade six and grade nine students, age 12 and 15 respectively).

I used SPSS for Windows version 11.0 to develop the Factor Analysis and extract the relevant factors. The 4 items in this group were included in the factor analysis. The final statistics of the SPSS version 11.0 report showed that the variation was explained by two outcome factors only. In the present research, Cronbach's Alpha for the two factors ranged from 0.29-0.37 (Factor one = 0.37, Factor two = 0.29). The lower range of the reliability coefficients in our research could be attributed not only to the young age of the students, but also to the small number of items involved. However, the principal components results in the two factor structure explained 62.60% of the extracted variance for the two scales.

Finally, both these factors were included in the statistical analysis, and named by the researcher as follows:

Factor 1: SCORE_1 (Deduction and Assumption Identification)

Factor 2: SCORE_2 (Credibility of Sources and Inductive Inference)

In Tables PF2-37 and Table PF2-38, the individual items, which had high factor loadings on each factor, are prescribed:

Table PF2- 37: Factor 1 - Deduction and Assumption Identification (SCORE_1): Individual Items and their Factor Loadings

Item	Factor Loading
1.Score on deduction	.79
2. Score on assumption	.75
Total Reliability	0.37

Table PF2- 38: Factor 2 - Credibility of Sources and Inductive Inference (SCORE_2): Individual Items and their Factor Loadings

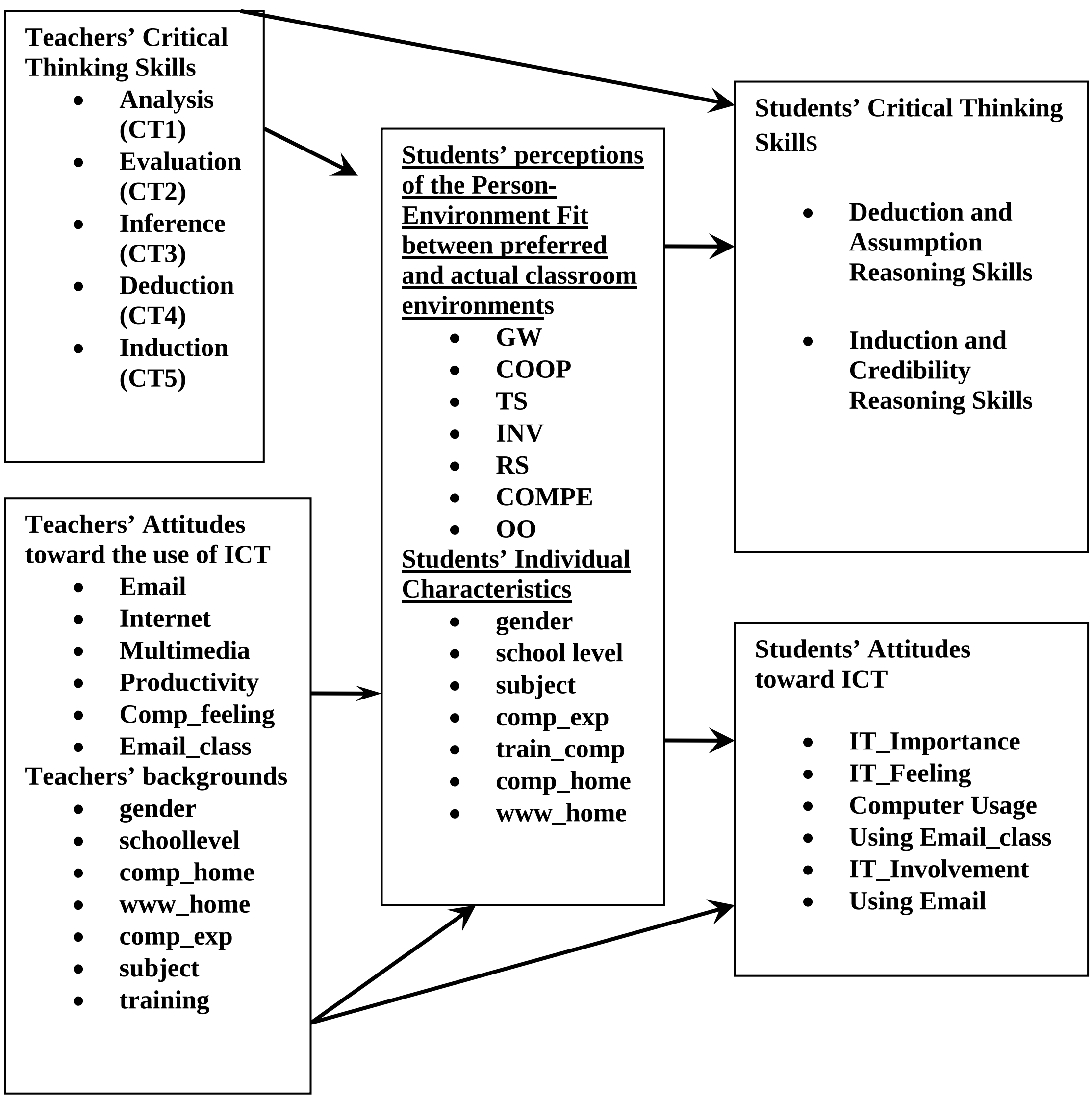
Item	Factor Loading
3. Score on credibility of sources	.78
4. Score on inductive inference	.73
Total Reliabilities	0.29

The qualitative research findings presented in Section 3.3 provide useful insights which complement these statistical results.

2.3.2.3 The Research Model Used for Analysis

The factor for analysis of the data generated by the questionnaires evaluated the development of a more specific research model, incorporating the various factors, which had been validated as making up the key concepts. In this model, the measures for the classroom environment, actual as opposed to preferred, have been interpreted as students' perceptions of the person-environment fit, terminology draw from hierarchical linear modeling (HLM) analysis. This research model, which is presented in Table PF2-1, was used as the basis for analysing the results in relation to the four research propositions. The section that follows discusses the analysis came out to investigate those propositions.

Figure PF2- 1: Final Research Model Used for Analysis



2.4 QUANTITATIVE FINDINGS

2.4.1 Introduction

This section presents the results of examining the four major research propositions (Proposition 1 to Proposition 4) of this present study. The study used two kinds of t-test methods to examine Propositions 1 and 2. Firstly, the paired sample t-test analysis was used to examine the first research proposition which compared the discrepancies between students' perceptions of their classroom environment with ICT in two forms – actual and preferred. Secondly, the independent samples t-test was used to compare the mean scores of two different grouping in relation to gender, academic background, computer experience, and computer usage in Proposition 2. The third proposition involved relationships between individual characteristics and students' perception of classroom learning environment with ICT and their outcomes (students' critical thinking skills and students' attitudes toward ICT). These relationships were explored using simple correlation and multiple regression analyses. In the case of the last proposition (Proposition 4), the hierarchical linear modeling (HLM) or multilevel modeling analysis was used to examine the relationships between student outcomes and independent predictors (individual characteristics and classroom predictors), which, in turn, were influenced by teacher factors (teachers' critical thinking skills and teachers' attitudes toward ICT).

2.4.2 Comparing Students' Perceptions of the Actual and Preferred Classroom Environments with ICT

The seventh of the research questions listed in 1.5.3 was

> What are students' perceptions of the classroom learning environments in ICT?

This related directly to the first proposition for investigation, which stated that there are differences between the students' perceptions of their actual and preferred classroom learning environments with ICT. At the analysis stage, this proposition was broken down into eight sub-propositions, to take account of the different grouping among the respondents.

Paired samples *t*-test for differences between the actual and preferred classroom learning environments with ICT was used to analyse data for this aspect of the study to examine from proposition 1.1 to proposition 1.8. As a result, this method was used to compare the mean scores for the same group in two different classroom conditions (actual and preferred), as well as for grouping within the respondents, in relation to these two sets of conditions. The purpose of investigating the sub-propositions 1.2 -1.8 in this way was to confirm the pattern of response in each grouping and to exclude the possibility of one sub-group have responses that were quite different.

Proposition 1.1

> Students' perceptions of their ICT classroom learning environments are different between their actual and preferred environments.

The preferred and actual data for the whole group of respondents were compared by effect sizes and paired samples *t*-test (dependent *t*-test). Where the *t*-test calculation was positive, it meant that actual mean scores were less than preferred mean scores (actual < preferred). In contrast, where the *t*-test calculation was negative, it meant that actual mean scores were more than preferred mean scores (actual > preferred). Effect sizes were calculated to estimate the magnitude of the differences between the actual and preferred scores, as recommended by Thompson (1998). Effect sizes were also calculated by subtracting preferred mean from actual mean and dividing by the pooled (average) standard deviation. On the one hand, where the effect size calculation was positive, it indicated that actual mean scores were higher than preferred mean scores (actual > preferred). On the other hand, where the effect size calculation was negative, it meant that actual mean scores were lower than preferred mean scores (actual < preferred). These results are given in Table PF2-39.

Results from t-tests for paired samples for differences between the actual and preferred classroom learning environments with ICT indicated that there were significant differences ($p<0.001$) between students' perceptions of their actual and preferred classroom learning environment on all of the scales used. The means and standard deviation for the two versions of the questionnaire are reported in Table PF2-39 and the same data are graphed in Figure PF2-2. As evident in Figure PF2-2, most students perceived their actual environment as being higher than what they would prefer, as their ideal classroom environment, on four classroom scales (Co-Operation, Teacher Support, Student Involvement, and Competition). Therefore, it can be inferred that most students were satisfied to study in their classroom with the four classroom characteristics, COOP, TS, INV, and COMPE. However, another interesting result suggested that most students would prefer a learning environment which was characterised by more Group Work, better Relationships, and more Order and Organisation (GW, RS, and OO). The identification of these variations between actual and preferred scales could help teachers to adopt teaching methods and strategies that might improve their classroom learning environments with ICT to support higher learning atmospheres in these three scales (GW, RS, and OO.)

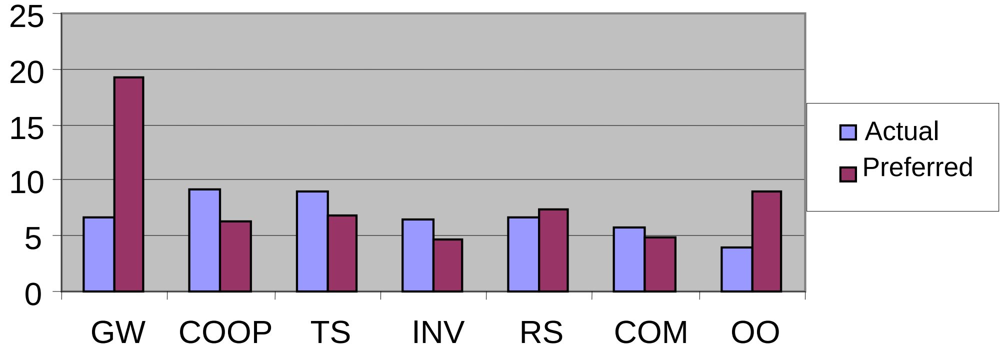
Table PF2- 39: Mean Scores, Standard Deviation and Difference between Students' Actual and Preferred Perceptions (Effect Sizes and *t*-Test for Paired Samples) (n=150)

	Mean		**S.D.**		**Differences**	
	Actual	**Preferred**	**Actual**	**Preferred**	**Effect Sizes**	**t-value**
GW	6.68	19.28	1.521	3.374	-10.15	47.692***
COOP	9.14	6.27	2.037	1.464	1.75	-15.849***
TS	9.07	6.89	1.865	1.493	1.71	-12.094***
INV	6.45	4.67	1.426	1.078	1.42	-12.411***
RS	6.65	7.41	1.559	1.420	-0.51	5.260***
COMPE	5.77	4.91	1.323	1.061	0.72	-5.735***
OO	3.98	9.02	1.000	1.823	-3.57	31.566***

***p≤0.001

Figure PF2- 2: Differences between Students' Actual and Preferred Perceptions of Their Classroom Learning Environments with ICT

Mean scores



Environment scales

Proposition 1.2:

> There are differences in students' perceptions of the ICT classroom in the actual and preferred environments for boy and girl students.

The mean scores for both actual and preferred versions in comparing boys and girls' responses are provided in Table PF2-40. These paired data were then matched for analysis. The results of this process found that most boys and girls hold more favourable perceptions of their preferred classroom environment with ICT than their perceptions of its actuality on three scales, Group Work, Relationships, and Order and Organisation (GW, RS, and OO). In particular, both boy and girl students would much prefer more emphasis on Group Work in their ideal classroom environment with ICT. Therefore, it can be inferred that most of the students would be happy with an ICT classroom atmosphere that allows them to work together in group tasks or group activities. In addition, the differences in boys, as compared to girls' perceptions of ICT classroom in the actual and preferred environments were significant ($p \leq 0.05$ and $p \leq 0.001$) on all of environment scales.

Table PF2- 40: Differences between Students' Actual and Preferred Perceptions of Their ICT Classroom Learning Environments for Boy and Girl Students (n_{boy} = 47 and n_{girl} = 103)

		Mean Scores		SD		Differences			
						Effect sizes		t-value	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
GW	actual	6.53	6.75	1.437	1.564	-4.774	-5.346	23.72***	41.92***
	preferred	18.72	19.53	3.670	3.217				
COOP	actual	9.04	9.18	1.944	2.085	1.521	1.692	-8.33***	-13.48***
	preferred	6.40	6.20	1.527	1.437				
TS	actual	9.45	8.90	1.839	1.860	1.628	1.158	-10.08***	-8.50***
	preferred	6.79	6.94	1.429	1.526				
INV	actual	6.38	6.49	1.582	1.357	1.415	1.427	-6.69***	-10.46***
	preferred	4.51	4.75	1.061	1.082				
RS	actual	6.62	6.66	1.662	1.518	-0.353	-0.594	2.19*	4.87***
	Preferred	7.19	7.51	1.569	1.342				
COMPE	actual	5.43	5.92	1.208	1.311	0.622	0.782	-2.55*	-5.23***
	preferred	4.70	5.01	1.140	1.015				
OO	actual	4.04	3.95	0.977	1.013	-3.727	-2.864	18.23***	25.70***
	preferred	9.23	8.02	1.808	1.829				

*$p \leq 0.05$ ***$p \leq 0.001$

Proposition 1.3:

> There are differences in students' perceptions of ICT classroom in actual and preferred environments for students at primary and secondary levels.

To investigate differences between students' perceptions in actual and preferred classroom learning environments with ICT for students in primary and secondary levels, a paired sample *t*-test was conducted for each scale using the within school level mean scores. A summary of the means and standard deviation of each scale for both actual and preferred forms for students from primary and secondary schools is reported in Table PF2-41. Interestingly, primary and secondary school students perceived almost the same level on the Competition scale for both the actual and preferred forms. Therefore, it can be implied that students (in primary and secondary schools) did not feel pressured to compete with their classmates. In contrast, this atmosphere tended to make them satisfied to achieve their good grades or higher study scores by comparing themselves with others. In addition, most students would prefer a learning environment, which was characterised by more Group Work (GW), Relationships (RS), and Order and Organisation (OO). It can be inferred that teachers at both primary and secondary levels need to improve the classroom atmosphere of an ICT classroom environment in relation to all of the three scales (GW, RS, and OO).

On the one hand, results from paired samples *t*-test showed that there were significant differences ($p \leq 0.001$) between students' actual and preferred perceptions for primary school students on all seven scales. On the other hand, results from paired samples *t*-test showed that there were significant differences ($p \leq 0.001$) between secondary and primary students' perceptions of ICT classroom in both the actual and preferred environments on all scales, except Competition.

Table PF2- 41: Differences between Students' Perceptions of ICT Classroom Learning Environments of Actual and Preferred Classroom Environments for School Level Differences (Primary and Secondary School) ($n_{\text{primary students}} = 132$ and $n_{\text{secondary students}} = 18$)

		Mean		SD		Differences			
						Effect sizes		t-value	
		Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
GW	actual	6.57	7.50	1.524	1.249	-5.042	-7.246	42.98***	25.22***
	preferred	19.06	20.89	3.430	2.447				
COOP	actual	9.00	10.17	2.068	1.465	1.598	2.316	-14.22***	-7.98***
	preferred	6.18	6.89	1.461	1.367				
TS	actual	9.02	9.44	1.839	2.064	1.297	1.313	-11.43***	-3.86**
	preferred	6.84	7.28	1.523	1.227				
INV	actual	6.46	6.39	1.474	1.037	1.380	1.770	-11.44***	-4.78***
	preferred	4.70	4.50	1.077	1.098				
RS	actual	6.61	6.89	1.590	1.323	-0.460	-1.177	4.41***	3.65**
	Preferred	7.31	8.17	1.452	0.852				
COMPE	actual	5.77	5.78	1.364	1.003	0.769	0.272	-5.70***	-0.94
	preferred	4.83	5.56	1.081	0.616				
OO	actual	4.02	3.72	1.034	0.669	-3.434	-5.007	28.76***	14.127***
	preferred	8.98	9.33	1.855	1.572				

**$p \leq 0.01$ ***$p \leq 0.001$

Proposition 1.4:

> There are differences in students' perceptions of actual and preferred environments in their ICT classrooms for students in Science-Technology and Social Studies-Arts subject areas.

The means and standard deviation for the two versions of the questionnaire in relation to responses of Science-Technology as compared to Social Studies-Art areas are displayed in

Table PF2-42. It shows that students who studied in different subject areas (Science-Technology and Social Studies-Arts) perceived almost the same level on the Relationships and Competition scales for both the actual and preferred forms. Therefore, particularly, it was implied that most of students from both different subject areas would favour getting supportive help and were satisfied with the nature of teachers' friendships and interest (student-teacher relationships) and the level of students' friendships (student-peer relationships) in both subject areas. A *t*-test for paired samples was performed for each scale to check the statistical significance of differences between students' perceptions of actual and preferred classroom environment with ICT for students who were in Sciences-Technology and Social Studies-Arts. Results from *t*-test for paired samples showed that there were significant differences ($p \leq 0.001$) between students' actual and preferred perceptions for students who were in both subject areas on all seven scales.

Table PF2- 42: Differences between Students' Actual and Preferred Perceptions of ICT Classroom Learning Environments on Subject Area Differences (n $_{\text{Science-Technology}}$ = 96 and n $_{\text{Social-Studies}}$ = 54)

		Mean		SD		Differences			
						Effect size		t-value	
		Science & Tech	Social& Arts	Science & Tech	Social& Arts	Science & Tech	Social& Arts	Science	Social
GW	actual	6.49	7.02	1.642	1.221	-4.791	-6.302	36.37***	31.97***
	preferred	18.72	20.28	3.463	2.987				
COOP	actual	8.93	9.52	2.063	1.950	1.614	1.752	-12.85***	-9.21***
	preferred	6.06	6.63	1.493	1.350				
TS	actual	9.09	9.04	1.947	1.726	1.426	1.109	-11.13***	-5.58***
	preferred	6.58	7.44	1.574	1.160				
INV	actual	6.40	6.56	1.518	1.254	1.429	1.443	-10.22***	-7.01***
	preferred	4.54	4.91	1.085	1.033				
RS	actual	6.67	6.61	1.690	1.309	-0.438	-0.663	3.66***	3.96***
	Preferred	7.35	7.52	1.414	1.437				
COMPE	actual	5.72	5.85	1.449	1.071	0.720	0.729	-4.46***	-3.74***
	preferred	4.81	5.09	1.079	1.014				
OO	actual	4.07	3.81	1.098	0.779	-3.120	-4.904	22.73***	23.89***
	preferred	8.93	9.19	2.017	1.415				

***$p \leq 0.001$

Proposition 1.5:

> There are differences in students' perceptions of ICT classroom in actual and preferred environments for students who had computer experiences equal or less than 5 years (≤ 5 years) and more than 5 years (> 5 years).

A summary of the means and standard deviation of each scale for both actual and preferred forms for students who had computer experience differences is reported in Table PF2-43. There were significant differences ($p \leq 0.001$) in students who had computer experiences equal to or less than 5 years (≤ 5 years) and more than 5 years (> 5 years). Statistically significant differences were observed in all seven scales. However, regardless of their experience students (in equal, less, or more than five years) perceived the Relationships (RS) scale on the same level for both the actual and preferred forms. The results appeared to suggest that most of students, whether they had less or more computer experience, were satisfied with the level of friendship that students felt for each other (student-peer relationships) and the amount of teachers' interest toward them (student-teacher relationships) in their classroom environments with ICT.

Table PF2- 43: Differences between Computer Experience Equal or Less Than 5 Years and More Than 5 Years Students' Perceptions of ICT Classroom Learning Environments ($n_{\text{less computer experience}} = 80$ and $n_{\text{more computer experience}} = 70$)

		Mean		**SD**		**Differences**			
						Effect size		**t-value**	
		<=5 years	**>5years**	**<= 5 years**	**>5years**	**<= 5 years**	**>5years**	**<=5 years**	**>5 years**
GW	actual	6.60	6.77	1.437	1.617	-5.546	-4.740	36.34***	31.19***
	preferred	19.52	19.00	3.222	3.543				
COOP	actual	9.34	8.91	1.955	2.118	1.862	1.406	-12.88***	-9.59***
	preferred	6.18	6.37	1.439	1.496				
TS	actual	8.99	9.17	1.725	2.021	1.276	1.327	-8.85***	-8.21***
	preferred	6.86	6.93	1.613	1.355				
INV	actual	6.30	6.63	1.488	1.342	1.174	1.725	-7.88***	-9.94***
	preferred	4.84	4.49	0.999	1.139				
RS	actual	6.56	6.74	1.525	1.603	-0.531	-0.501	3.63***	3.83***
	Preferred	7.33	7.51	1.376	1.472				
COMPE	actual	5.69	5.86	1.346	1.300	0.685	0.758	-3.80***	-4.39***
	preferred	4.86	4.97	1.076	1.049				
OO	actual	4.05	3.90	0.953	1.052	-3.586	-3.548	23.22***	21.44***
	preferred	8.94	9.11	1.774	1.885				

***$p \leq 0.001$

Proposition 1.6:

> There are differences in students' perceptions of ICT classrooms in actual and preferred environments those with computer training courses and those with self-learning.

The mean scores and standard deviation for two versions (actual and preferred forms) of questionnaires were reported in Table PF 2-44. The results suggested that most students who received training in computer course and those who did not would prefer a learning environment which was characterized by more Group Work (GW), Relationships (RS), and Order and Organisation (OO). Interestingly, more of the students who did not attend computer training course would prefer a learning environment which was characterized by more Group Work (GW) than those who did. Therefore, it might be implied that students who did not receive computer training had higher expectations of obtaining helpful and supportive contributions from their peers or classmates through working together to achieve their assignments by group work or task activities during class hours.

On all seven scales, there were statistically significant differences ($p \leq 0.001$) in the students' perceptions of ICT classroom environments, in two forms of actual and preferred classroom environments with ICT, for students who received computer training.

In the case of students who did not receive computer training, there were statistically significant differences ($p \leq 0.001$) in the students' perceptions of actual and preferred ICT classroom environments on five scales (Group Work, Co-Operation, Teacher Support, Involvement, and Order and Organisation). Further, there was a statistically significant difference ($p \leq 0.05$) in these students' perceptions of actual and preferred classroom environment with ICT on only one, the Relationships scale. There was a statistically significant difference ($p \leq 0.01$) in the self-learning students' perceptions of actual and preferred classroom environment with ICT on the Competition scale.

Table PF2- 44: Differences between Students' Perceptions of ICT Classroom Learning Environments in Terms of Actual and Preferred Environments for Students Who Received Computer Training and Those Who Did Not (Self-Learning) ($n_{computer\ training}$ = 130 and $n_{self\text{-}study}$ = 20)

		Mean		SD		Differences			
						Effect size		t-value	
		Train	Self study	Train	Self study	Train	Self study	Train	Self study
GW	actual	6.71	6.50	1.527	1.504	-5.073	-5.582	43.55***	19.67***
	preferred	19.25	19.50	3.417	3.154				
COOP	actual	9.12	9.25	2.069	1.860	1.630	1.692	-14.71***	-5.83***
	preferred	6.22	6.60	1.489	1.273				
TS	actual	9.19	8.30	1.913	1.302	1.338	1.079	-11.50***	-4.27***
	preferred	6.89	6.90	1.526	1.294				
INV	actual	6.46	6.40	1.431	1.429	1.426	1.381	-11.65***	-4.28***
	preferred	4.71	4.45	1.023	1.395				
RS	actual	6.68	6.45	1.566	1.538	-0.491	-0.641	4.76***	2.23*
	Preferred	7.42	7.35	1.446	1.268				
COMPE	actual	5.69	6.25	1.275	1.552	0.687	0.933	-5.02***	-2.93**
	preferred	4.88	5.10	1.083	0.912				
OO	actual	3.98	4.00	0.984	1.124	-3.603	-3.428	29.18***	12.18***
	preferred	8.94	9.55	1.769	2.114				

*$p \leq 0.05$ ** $p \leq 0.01$ ***$p \leq 0.001$

Proposition 1.7:

> There are differences in students' perceptions of ICT classrooms in actual and preferred environments for students who used computers at home and those who did not.

As seen in PF2-45, results from *t*-test for paired samples demonstrated that there were significant differences ($p \leq 0.001$) between students' perceptions of their actual and preferred in ICT classroom learning environments for students who used computers at home on all scales. For students who did not use a computer at home, there were statistically significant differences ($p \leq 0.001$) between students' actual and preferred perceptions of their ICT classroom learning environments on Group Work, Involvement and Order and Organisation. Further, there were statistically significant differences ($p \leq 0.01$) between these students' perceptions of their actual and preferred classroom learning environments with ICT on three scales (Co-Operation, Teacher Support, and

Relationships). Also, there was a significant difference ($p \leq 0.05$) between students' actual and preferred perceptions of their ICT classroom environments on Competition among students who had no home computer. Interestingly, most students regardless of their computer accessibility at home would prefer a learning environment which was characterised by more Group Work, better Relationships, and more Order-Organisation (GW, RS, and OO). Interestingly, students who could not access computer at their home would prefer a learning environment which was characterised by more Group Work than students those who had home computer access. One interpretation of these results could be that students who had less opportunity for computer use at home had higher expectations of obtaining helpful and supportive contributions from their classmates to achieve their assignments through group work or group task activities during class hours in their ICT classroom environments.

Table PF2- 45: Differences between Students' Perceptions of their Actual and Preferred Classroom Learning Environments with ICT for Students Who Used Computer at Home and Those Who Did Not ($n_{\text{computer use at home}} = 129$ and $n_{\text{no computer use at home}} = 21$)

		Mean		SD		Differences			
						Effect size		t-value	
		Home Comp	**No Home Comp**	**Home Comp**	**No Home Comp**	**Home Comp**	**No Home Comp**	**Home Comp**	**No Home Comp**
GW	actual	6.74	6.29	1.501	1.617	-5.098	-5.547	43.34***	20.26***
	preferred	19.36	18.76	3.450	2.879				
COOP	actual	9.21	8.71	2.034	2.053	1.694	1.306	-15.63***	-4.14**
	preferred	6.26	6.33	1.448	1.592				
TS	actual	9.12	8.81	1.865	1.887	1.330	1.084	-11.77***	-3.30**
	preferred	6.87	7.05	1.518	1.359				
INV	actual	6.42	6.67	1.440	1.354	1.414	1.461	-11.17***	-5.53***
	preferred	4.66	4.76	1.050	1.261				
RS	actual	6.69	6.38	1.545	1.658	-0.489	-0.671	4.52***	3.09**
	Preferred	7.42	7.38	1.440	1.322				
COMPE	actual	5.75	5.86	1.352	1.153	0.672	0.980	-5.09***	-2.65*
	preferred	4.94	4.76	1.059	1.091				
OO	actual	3.98	3.95	0.984	1.117	-3.659	-3.056	29.60***	10.82***
	preferred	9.05	8.81	1.787	2.064				

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Proposition 1.8:

> There are differences in students' perceptions of ICT classrooms in actual and preferred environments for students who used the internet at home and those who did not.

The means and standard deviation for two versions (actual and preferred forms) of questionnaires for students with and without Internet access were reported in Table PF2-46. The results suggested that most students with Internet access at home would prefer a learning environment which was characterised by more Group Work, better Relationships, and more Order and Organisation (GW, RS, OO). Results from *t*-test for paired samples demonstrated that there were significant differences ($p \leq 0.001$) between students' perceptions of their actual and preferred in ICT classroom learning environments for students who use the Internet at home on all seven scales. For students who did not use the Internet at home, there were statistically significant differences ($p \leq 0.001$) between students' actual and preferred perceptions of their ICT classroom learning environments on all scales, except Competition. However, this scale (Competition) showed a significant difference ($p \leq 0.01$) between students' actual and preferred perceptions of their ICT classroom environments. Interestingly, students who could not access the internet at their home would prefer a learning environment which was characterised by more Group Work than students those who had this opportunity. Here too, it would seen that students who had less opportunity for Internet use at home were more likely to look to their classmates for help in searching for information on the Internet to complete their individual assignments or group activities.

Table PF2- 46: Differences between Students' Actual and Preferred Perceptions of ICT Classroom Learning Environments for Students Who Used and Did Not Use the Internet (www) at Home ($n_{\text{www access at home}}$ = 96 and $n_{\text{no www access at home}}$ = 54)

	Mean		SD		Differences			
					Effect size		t-value	
	www home	No www home	www home	No www home	www home	No www home	www	No www
GW actual	6.80	6.46	1.498	1.551	-5.015	-5.412	37.64***	29.06***
preferred	19.38	19.11	3.519	3.124				
COOP actual	9.13	9.17	2.063	2.007	1.623	1.673	-12.99***	-9.04***
preferred	6.24	6.31	1.499	1.412				
TS actual	9.19	8.87	1.932	1.738	1.416	1.085	-11.62***	-5.26***
preferred	6.75	7.15	1.515	1.433				
INV actual	6.56	6.26	1.420	1.430	1.594	1.139	-10.95***	-6.20***
preferred	4.59	4.81	1.052	1.117				
RS actual	6.69	6.57	1.558	1.573	-0.472	-0.599	3.99***	3.41***
Preferred	7.41	7.43	1.491	1.297				
COMPE actual	5.84	5.63	1.439	1.087	0.776	0.596	-4.97***	-2.88**
preferred	4.85	5.02	1.114	0.961				
OO actual	3.93	4.07	0.954	1.079	-3.766	-3.256	24.66***	20.44***
preferred	9.15	8.80	1.818	1.826				

** $p \leq 0.01$ *** $p \leq 0.001$

These significant findings support proposition 1 which proposed that there are differences between the students' perceptions of their actual and preferred classroom learning environments with ICT.

2.4.3 Comparing Students' Individual Characteristics and Student Outcomes with their Perceptions of Both Actual and Preferred Classroom Environments with ICT

Proposition 2 represented an extension of the seventh research question concerning students' perceptions of the classroom learning environments in ICT. It stated that the students' perceptions of ICT classroom learning environments and student outcomes differ according to students' individual background characteristics (gender, academic background, computer experiences and computer usage). The proposition was broken down into seven sub propositions to take account of the various groupings to be found among the student respondents.

Independent samples *t*-test was used to analyse the data in relation to proposition 2.1 to 2.7. This method was used to compare the mean scores of two different student groupings (gender, academic background, computer experience, and computer usage).

Mean differences between boys and girls

According to proposition 2.1, there are differences in students' perceptions of classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills for boys and girls.

Table PF2-47 presents the mean scores on the scales of classroom learning environments with ICT and two student outcomes (students' attitudes toward ICT and their critical thinking skills) for boy and girl students. The mean scores for boys and girls on each measure were represented with the *t*-values associated with the differences in mean scores. The t-test results indicated no statistically significant differences between boys and girls on students' critical thinking skills. According to another student outcome (students' attitudes toward ICT), there were negatively significant differences ($p<0.05$) found in ICT Feeling, ICT Involvement, and Using Electronic-Mail. Such negative scores meant that girls had more positive attitudes toward ICT Feeling, ICT Involvement, and Email Use than boys. Generally, girl students had significantly higher mean scores on attitudes toward ICT than did boy students.

Furthermore, the classroom findings showed that there was a negatively significant gender difference ($p<0.05$) only on the Competition (COMPE) scale in their perceptions of actual classroom learning environment with ICT. Therefore, girls perceived the classroom environment to be more competitive than did boys. On all the other variables related to classroom learning environments, there were no significant differences between boy and girl respondents.

Table PF2-47 and Figure PF2-3 further demonstrated that, generally, girls seemed to have more favourable perceptions than boys did in terms of five scales of the actual classroom environments with ICT, whereas boys perceived a more positive classroom environment than did girls in the same classroom on only two of the seven classroom scales – Teacher Support and Order-Organisation. Figure PF2-3 depicts the results in the ideal classroom environments, where normally, girls seemed to favour more Group Work, Teacher Support, Involvement, and Competition than boys, and boys tended to prefer more Co-Operation and Order-Organisation when compared to girls. Accordingly, the results of this analysis found that, in general, girl students appeared to hold more favourable perceptions of ICT classrooms in both actual and preferred environments than boy students did.

Figure PF2- 3: Differences between Boy and Girl Students in Actual and Preferred Perceptions of ICT Classroom Environments

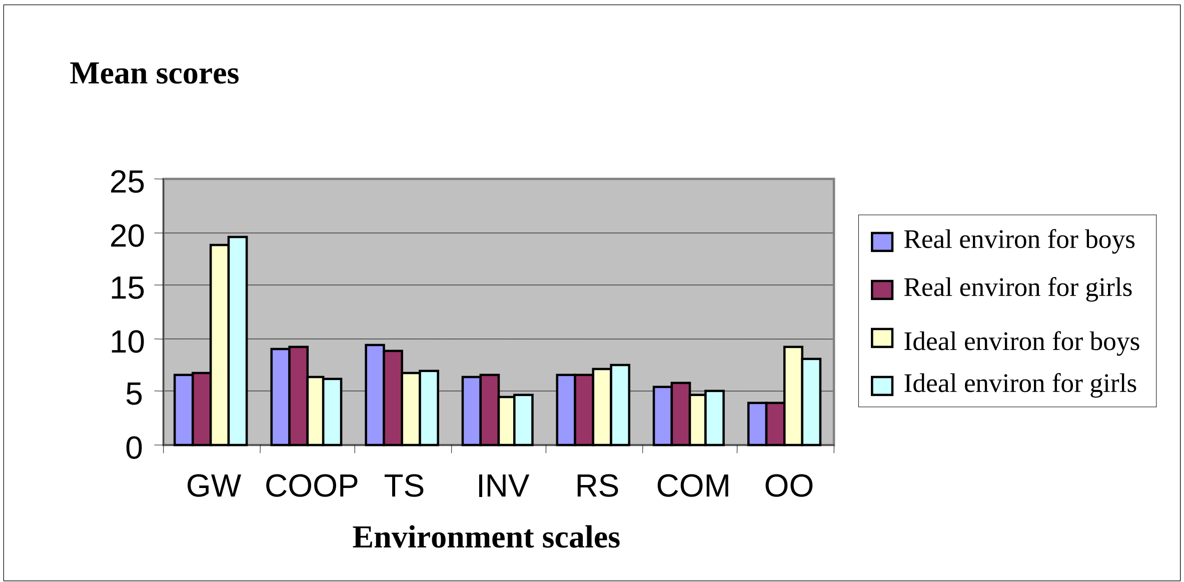


Table PF2- 47: Gender Effects on Perceptions of Classroom Learning Environments with ICT and Student Outcomes

	Variables	Mean Scores Boys (n = 47)	Girls (n = 103)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	18.72	19.53	-1.369
	actual	6.53	6.75	-0.805
	CO-Operation			
	preferred	6.40	6.20	0.777
	actual	9.04	9.18	-0.395
	Teacher Support			
	preferred	6.79	6.94	-0.586
	actual	9.45	8.90	1.667
	Involvement			
	preferred	4.51	4.75	-1.252
	actual	6.38	6.49	-0.407
	Relationship			
	preferred	7.19	7.51	-1.296
	actual	6.62	6.66	-0.157
	Competition			
	preferred	4.70	5.01	-1.656
	actual	5.43	5.92	-2.159*
	Order and Organisation			
	preferred	9.23	8.92	0.971
	actual	4.04	3.95	0.516
Students' attitudes toward ICT	**IT Importance**	53.64	57.23	1.967
	IT Feeling	47.28	52.20	-2.270*
	Computer Usage	49.79	50.10	-0.216
	Using E-Mail for Classroom	28.30	29.41	-1.001
	IT Involvement	29.79	33.79	-2.494*
	Using Email	32.47	36.08	-2.688*
Students' critical thinking skills	**Deduction and Assumption (CRI1)**	11.15	10.40	1.253
	Induction and Credibility (CRI2)	19.21	19.94	-0.808

*$p \leq 0.05$

Mean differences between students in primary grade six and students in secondary grade nine

Proposition 2.2 stated, there are differences in perceptions of classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills for students at primary and secondary level.

Table PF2-48 presents the mean scores on the scales of classroom variables and student outcomes for students who studied in classroom learning environments with ICT in grade six primary and grade nine secondary schools.

In Figure PF2-4, the results showed that students who came from grade nine at secondary level held more favourable perceptions of both actual and preferred classroom learning environments with ICT than did students from grade six at primary level on five classroom scales. The exceptions were the Student Involvement and Order-Organisation scales. It might be implied that students in grade six in primary schools seemed to pay attention or be interested in studying and doing class activities, where their classrooms had more rules and control.

In the case of actual classroom environments, however, the differences between students' perceptions of students from grade six and grade nine were negatively significant, on the two scales of Group Work and Co-Operation (GW and COOP). This meant that secondary school students perceived that there was more group work, as well as cooperation, in the classroom than did primary school students.

For the preferred classroom environment with ICT, generally, students in grade nine inclined toward higher preferred scores on six of the classroom scales than did students in grade six, with the exception of the Student Involvement scale. Interestingly, Table PF2-48 and Figure PF2-4 show that students' perceptions, in the preferred version, also differed between grade six and grade nine, and were statistically significant, for Group Work, Relationships, and Competition (GW, RS, and COM). Hence, secondary school students would prefer more group work, relationships, and competition than would primary school students.

With respect to students' critical thinking skill outcomes, students who came from grade nine seemed to have higher critical thinking scores than students who were in grade six in primary schools, as might have been expected on account of the age differences. However, the *t*-test did not indicate any significant differences in mean scores for students who were in grade six and grade nine on either of the student outcomes (students' attitudes toward ICT and students' critical thinking skills).

Figure PF2- 4: Differences between Students from Primary and Secondary School Levels in Actual and Preferred Perceptions of ICT Classroom Environments

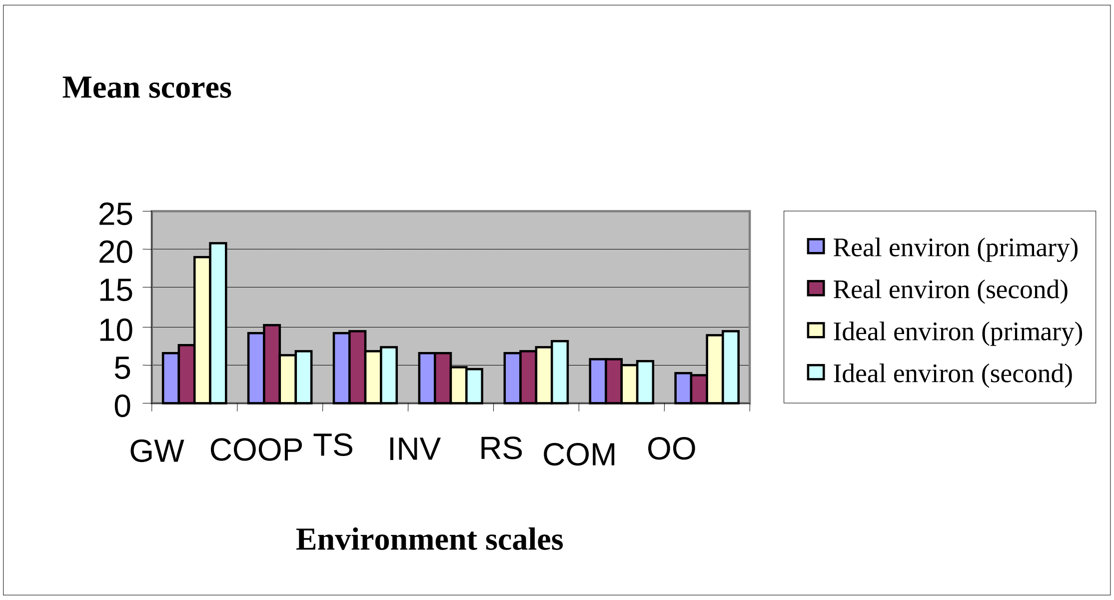


Table PF2- 48: Differences between Students at Primary and Secondary School Levels on Classroom Learning Environments with ICT and Student Outcomes

	Variable	Mean Scores Primary (n = 132)	Secondary (n = 18)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	19.06	20.89	-2.184*
	actual	6.57	7.50	-2.480*
	CO-Operation			
	preferred	6.18	6.89	-1.940
	actual	9.00	10.17	-2.313*
	Teacher Support			
	preferred	6.84	7.28	-1.166
	actual	9.02	9.44	-0.899
	Involvement			
	preferred	4.70	4.50	0.726
	actual	6.46	6.39	0.204
	Relationships			
	preferred	7.31	8.17	-2.439*
	actual	6.61	6.89	-0.701
	Competition			
	preferred	4.83	5.56	-2.798**
	actual	5.77	5.78	-0.038
	Order and Organisation			
	preferred	8.98	9.33	-0.776
	actual	4.02	3.72	1.167
Students' attitudes toward ICT	**IT Importance**	55.98	57.06	-0.408
	IT Feeling	50.83	49.44	0.439
	Computer Usage	50.27	48.00	1.113
	Using E-Mail for Classroom	29.26	27.61	1.041
	IT Involvement	32.42	33.39	-0.416
	Using E-mail	35.20	33.11	1.067
Students' critical thinking skills	**Deduction and Assumption (CRI1)**	10.52	11.44	-1.076
	Induction and Credibility (CRI2)	19.42	21.83	-1.890

$*p \leq 0.05$ $**p \leq 0.01$

Mean differences between Science-Technology and Social Studies-Arts subject areas

Proposition 2.3 mentioned that there are differences in perceptions of classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills for students in different subject areas.

From Table PF2-49 and Figure PF2-5, in most cases, students who were studying in Social Studies-Arts subject areas held more favourable perceptions in both actual and preferred classroom learning environments with ICT than did students in Science-Technology areas.

In the case of actual classroom environments, in general, students who studied in Social Studies-Arts tended to perceive a more positive classroom environment than students who studied in Science-Technology subject area. But there was only one a negatively significant subject area difference ($p<0.05$), on the scale of Group Work (GW), between students who studied in Science-Technology and Social-Studies Arts in their actual perceptions of ICT classroom learning environment. Therefore, students who studied in Social Studies-Arts perceived their classrooms as having more group work than those who in Science-Technology. It should be note that most students who studied in Social Studies-Arts subject were allowed to use and access ICT in groups through searching information from the Internet for preparing and conducting their written papers or reports. Moreover, it was possible that these students in Social-Studies areas were more familiar with classroom presentations using PowerPoint, through working together with their peers in group task activities.

In ideal classroom environments, there were negatively significant differences on four classroom scales of Group Work ($p<0.01$), Co-Operation ($p<0.05$), Teacher Support ($p<0.001$), and Student Involvement ($p<0.05$) (GW, COOP, TS, and INV) between students from the different subject areas. Accordingly, students who studied in Social Studies-Arts were found to have higher preferences on these four scales (more GW, more COOP, more TS, and more INV) than students who studied in Science-Technology.

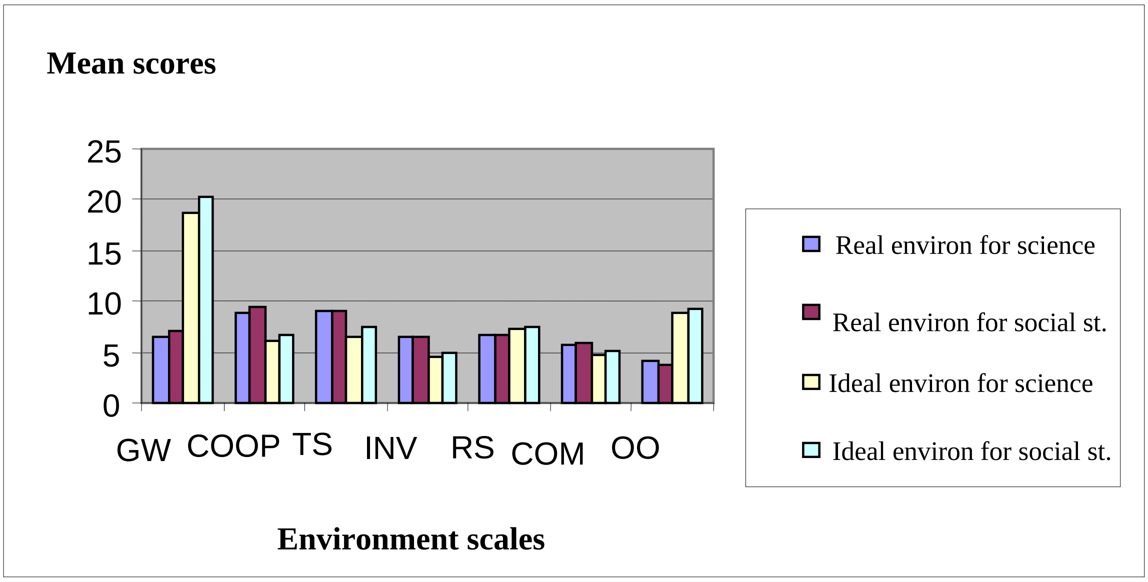
In relation to the two student outcomes, there were no statistically significant differences in the mean scores of students' attitudes toward ICT scales or in students' critical thinking scales for students who studied in the two different subject areas (Science-Technology and Social-Studies Arts).

Table PF2- 49: Differences between Students from Science-Computer and Social Study-Arts Subject Areas on Classroom Learning Environments with ICT and Student Outcomes

	Variable	Mean Scores Science & Technology (n = 96)	 Social & Arts (n = 54)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	18.72	20.28	-2.777**
	actual	6.49	7.02	-2.067*
	CO-Operation			
	preferred	6.06	6.63	-2.310*
	actual	8.93	9.52	-1.718
	Teacher Support			
	preferred	6.58	7.44	-3.517***
	actual	9.09	9.04	0.178
	Involvement			
	preferred	4.54	4.91	-2.016*
	actual	6.40	6.56	-0.657
	Relationships			
	preferred	7.35	7.52	-0.679
	actual	6.67	6.61	0.209
	Competition			
	preferred	4.81	5.09	-1.559
	actual	5.72	5.85	-0.590
	Order and Organisation			
	preferred	8.93	9.19	-0.832
	actual	4.07	3.81	1.524
Students' attitudes toward ICT	**IT Importance**	55.16	57.80	-1.487
	IT Feeling	50.34	51.22	-0.412
	Computer Usage	50.24	49.57	0.480
	Using E-Mail for Classroom	28.71	29.69	- 0.912
	IT Involvement	31.76	33.91	-1.366
	Using E-Mail	34.71	35.37	-0.499
Students' critical thinking skills	**Deduction and Assumption (CRI1)**	11.04	9.91	1.973
	Induction and Credibility (CRI2)	19.48	20.13	-0.746

*p ≤ 0.05 **p ≤ 0.01 ***p ≤ 0.001

Figure PF2- 5: Differences between Students in Two Different School Subject Areas in Actual and Preferred Perceptions of ICT Classroom Environments



Mean differences between those equal or less than 5 years and more than 5 years in computer experience

Proposition 2.4 mentioned, there are differences in perceptions of their classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills for students with different levels of computer experience.

Table PF2-50 presents the mean scores on seven scales of classroom variables and student outcomes for students who had experience in computer use for different periods (equal or less than 5 years or more than 5 years). The results indicated no significant differences ($p<0.05$) on outcome measures in both students' attitudes toward ICT and students' critical thinking skill scales for students with different levels of computer experience.

In actual classroom environments, Table PF2-50 and Figure PF2-6 illustrate that students who had longer experience in the use of the computer were found to perceive their classroom environment more positively on five of the seven classroom scales than students who had shorter experience in computer using. However, no significant computer experience differences occurred on any of the seven classroom scales in the actual classroom learning environment with ICT.

For preferred classroom environments with ICT, as showing in Figure PF2-6, students who had longer computer experience tended to have higher preferred scores on five of seven classroom scales than did students who had shorter computer experience. Interestingly, the results were positively significant in the scale of Student Involvement (INV) between students who had computer experiences more than five years and those who did not. Therefore, it was possible that students who lacked computer experience would prefer more student involvement with each other in the classroom through class activities or participating in class discussions than students who had longer experience in computer use.

As shown in Table PF2-50, this statistically significant result indicated that students who had shorter experience in computer use would prefer to participate in class activities and discussion more than students with longer experience (over 5 years). It would seem that students with more computer experience felt able to do additional work on their own and still enjoy their ICT classroom environment by themselves.

Figure PF2- 6: Differences between Students with Different Computer Experience in Actual and Preferred Perceptions of ICT Classroom Environments

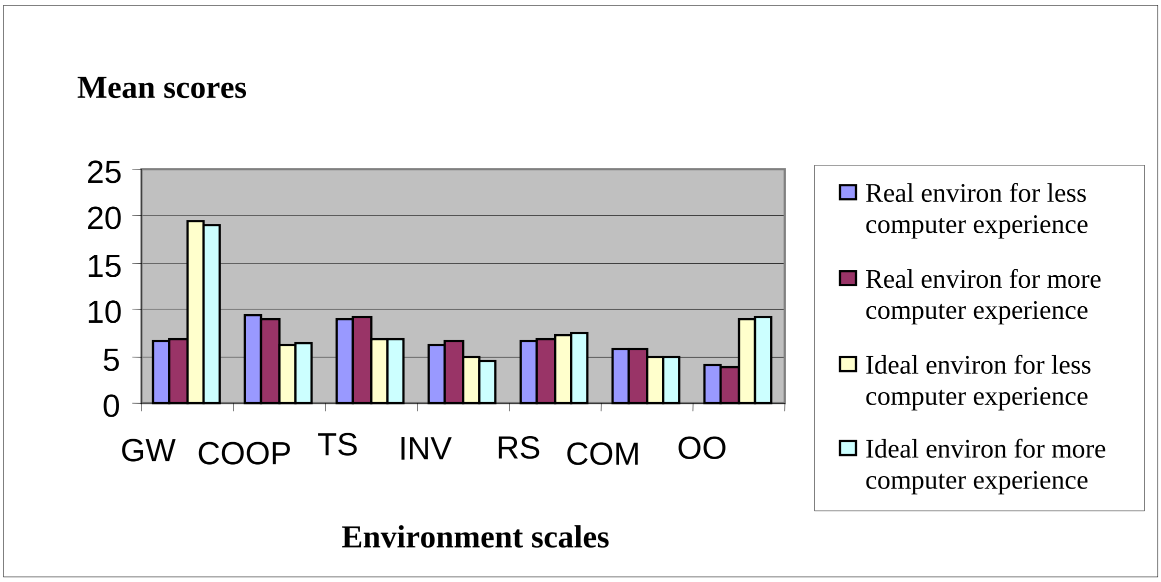


Table PF2- 50: Differences between Students with 0-5 Years and > 5 Years Computer Experience on Perceptions on Classroom Learning Environments with ICT and Student Outcomes

	Variable	Mean Scores Computer Experience 0-5 years (n = 80)	Computer experience > 5 years (n = 70)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	19.52	19.00	0.95
	actual	6.60	6.77	-0.687
	CO-Operation			
	preferred	6.18	6.37	-0.819
	actual	9.34	8.91	1.272
	Teacher Support			
	preferred	6.86	6.93	-0.269
	actual	8.99	9.17	-0.601
	Involvement			
	preferred	4.84	4.49	2.015*
	actual	6.30	6.63	-1.412
	Relationships			
	preferred	7.33	7.51	-0.814
	actual	6.56	6.74	-0.706
	Competition			
	preferred	4.86	4.97	-0.626
	actual	5.69	5.86	-0.782
	Order and Organisation			
	preferred	8.94	9.11	-0.591
	actual	4.05	3.90	0.916
Students' attitudes toward ICT	**IT Importance**	56.36	55.81	0.319
	IT Feeling	50.68	50.64	0.016
	Computer Usage	49.63	50.43	-0.603
	Using E-Mail for Classroom	28.65	29.53	-0.852
	IT Involvement	33.30	31.66	1.084
	Using E-Mail	35.01	34.87	0.110
Students' critical thinking skills	**Deduction and Assumption (CRI1)**	10.8125	10.4286	0.686
	Induction and Credibility (CRI2)	20.0125	19.3714	0.764

$*p \leq 0.05$

Mean differences between students who received training in computer courses and those who did not in computer courses

Proposition 2.5 stated that there are differences in perceptions of classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills for students who received training in computer courses and those who did not.

Table PF2-51 presents the mean scores on classroom environment scales and two outcome scales for students who received training in computer training courses, as compared to and those who did not. The statistical findings illustrate that there were no significant differences between students who received training in computer courses, as compared to and those who did not on the two student outcomes (students' attitudes toward ICT and students' critical thinking skills).

A summary of the mean scores and standard deviations of each scale for both actual and preferred forms is reported in Table PF2-51 and Figure PF2-7. The mean scores are displayed to illustrate the differences between students who received training in computer courses, and those who did not, on the variables for both actual and preferred classroom learning environments with ICT. As Table PF2-51 indicates, there was one positively significant difference in the Teacher Support (TS) scale, in the actual environment, but more in the preferred perceived environment.

From Table PF2-51, there was one positively statistically significant with being difference ($p<0.05$) for Teacher Support (TS) in actual classroom learning environments with ICT. Therefore, students who received computer training perceived their classroom environment as having more teacher support than those who had no training. In addition, the results of the study found that students who received training in computer courses seemed to perceive the classroom more positively than those who did not, on four of the seven classroom scales. With regards to students' perceptions of their ICT classroom learning environments, the analysis might be seen as suggesting that those students who received training in computer courses were trusted more by their teachers, and more interested in the content or instructional materials which were given directly to them.

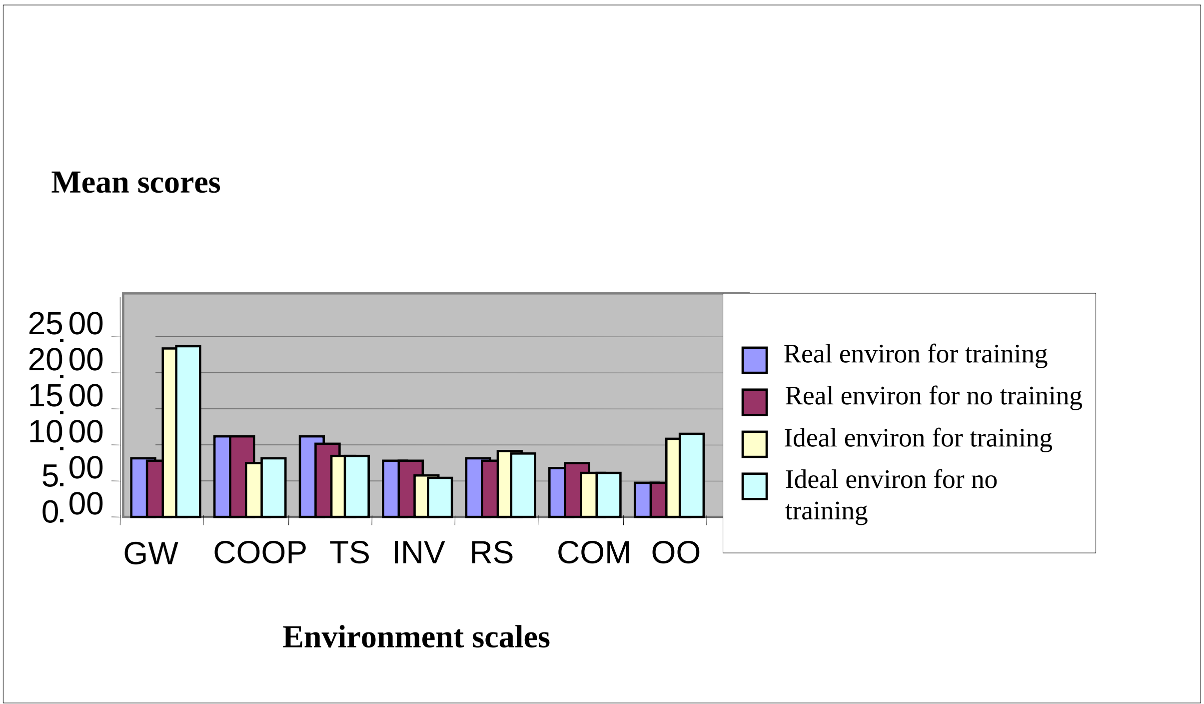
For the ideal classroom environment, there were no statistically significant differences on any of the scale of preferred classroom environments with ICT. However, students who received training in computer courses seemed to desire more Involvement and better Relationships than those students who had no training.

Table PF2- 51: Differences between Students Who Received Computer Training and Those Who Did Not on Classroom Learning Environments with ICT and Student Outcomes

	Variables	Mean Scores Training (n = 130)	 Self-Study (n = 20)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	19.25	19.50	-0.312
	actual	6.71	6.50	0.567
	CO-Operation			
	preferred	6.22	6.60	-1.095
	actual	9.12	9.25	-0.259
	Teacher Support			
	preferred	6.89	6.90	-0.021
	actual	9.19	8.30	2.012*
	Involvement			
	preferred	4.71	4.45	0.996
	actual	6.46	6.40	0.179
	Relationships			
	preferred	7.42	7.35	0.214
	actual	6.68	6.45	0.605
	Competition			
	preferred	4.88	5.10	-0.844
	actual	5.69	6.25	-1.767
	Order and Organisation	8.94	9.55	-1.401
	preferred			
	actual	3.98	4.00	-0.096
Students' attitudes toward ICT	**IT Importance**	56.64	52.65	1.592
	IT Feeling	51.11	47.75	1.119
	Computer Usage	49.91	50.60	-0.353
	Using E-Mail for Classroom	28.97	29.65	-0.449
	IT Involvement	32.72	31.35	0.612
	Using Email	35.18	33.40	0.954
Students' critical thinking skills	**Deduction and Assumption CRI1)**	10.70	10.20	0.609
	Induction and Credibility (CRI2)	19.96	18.10	1.521

$* \ p \leq 0.05$

Figure PF2- 7: Differences between Students Who Received Computer Training and Those Who Did Not in Perceptions of Actual and Preferred Forms of ICT Classroom Environments



Mean differences between students who use computers at their home and those who do not

Proposition 2.6 described that there are differences in perception of classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills for students' using the computer at home and those who do not.

As seen in Table PF2-52, there were no statistically significant differences on either scale of actual and preferred classroom environments with ICT. In addition, there were no significant differences on students' critical thinking scales between students who used the computer at their home and those who did not.

Generally, from Table PF2-52 and Figure PF2-8, it can be seen that in the most cases, students who used a computer at their home seemed to hold more positive perceptions of actual classroom learning environments than those who did not, on four of the seven scales. For the preferred classroom learning environments, in general, the results indicated that those students who used a computer at home had higher preferred scores on four of the seven scales desiring (more Group Work, more Relationships, more Competition, and more Order-Organisation) than those students who did not have a computer at home. However, there were no statistically significant differences for any scales on both actual and preferred classroom environments with ICT.

With respect to students' attitudes toward ICT, the results indicated that there were negatively significant differences ($p<0.05$) between students who used a computer at home and those who did not on two scales of students' attitudes toward ICT, namely, IT Importance and Computer Usage (IT_CORE and COM_USE). Therefore, students who used a computer at their home appeared to have IT Importance and Computer Usage less positive attitudes than students who had no home computers. It might be implied that students who accessed and used a computer at their home tended to pay less attention to study in their class hours and were not interested in using a computer for doing their assignments at their schools, because they could complete assignments at their home.

Figure PF2- 8: Differences between Those Using a Computer at Home and Those Who Did Not on Perceptions of Actual and Preferred Forms of ICT Classroom Environments

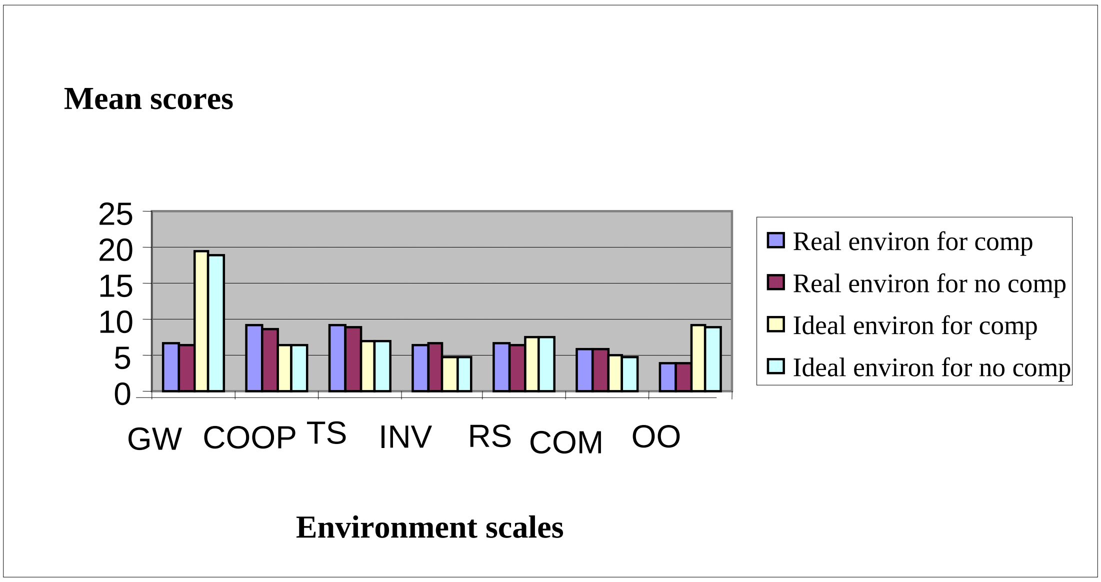


Table PF2- 52: Differences between Students Who Used Computer at Home and Those Who Did Not on Perceptions of Classroom Learning Environments and Student Outcomes

	Variable	Mean Scores Computer at home (n = 129)	 No Computer (n = 21)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	19.36	18.76	0.758
	actual	6.74	6.29	1.284
	CO-Operation			
	preferred	6.26	6.33	-0.224
	actual	9.21	8.71	1.033
	Teacher Support			
	preferred	6.87	7.05	-0.509
	actual	9.12	8.81	0.698
	Involvement			
	preferred	4.66	4.76	-0.405
	actual	6.42	6.67	-0.738
	Relationships			
	preferred	7.42	7.38	0.112
	actual	6.69	6.38	0.841
	Competition			
	preferred	4.94	4.76	0.704
	actual	5.75	5.86	-0.337
	Order and Organisation	9.05	8.81	0.569
	preferred			
	actual	3.98	3.95	0.136
Students' attitudes toward ICT	**IT Importance**	55.40	60.43	-2.059*
	IT Feeling	49.98	54.81	-1.650
	Computer Usage	49.46	53.33	-2.047*
	Using E-Mail for classroom	28.98	29.52	-0.363
	IT Involvement	32.36	33.62	-0.578
	Using E-Mail	34.50	37.71	-1.769
Students' critical thinking skills	**Deduction and Assumption (CRI1)**	10.80	9.62	1.475
	Induction and credibility (CRI2)	19.78	19.33	0.366

*p ≤ 0.05

Mean differences between students who use the Internet at home and those who do not

Proposition 2.7 stated, there are differences in perceptions of classroom learning environments with ICT, students' attitudes toward ICT use, and students' critical thinking skills between students' using the Internet at home and those who do not.

Table PF2-53 showed that there were no statistically significant differences for all scales of both actual and preferred classroom environments with ICT. In addition, there were no significant differences on students' critical thinking scales between students who accessed the Internet at their home and those who did not.

Table PF2-53 and Figure PF2-9, show that in the most cases, students who used the Internet at home seemed to hold more favourable perceptions of actual classroom learning environments than those who did not, with the two exceptional scales being Co-Operation and Competition.

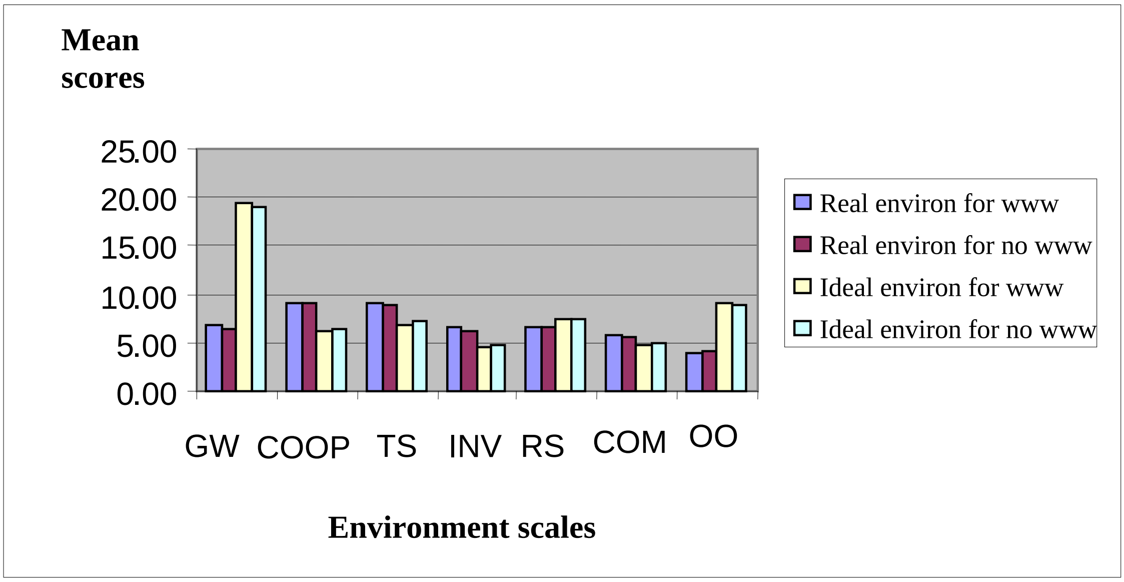
A negatively significant difference in student outcomes was found only in students' attitudes toward ICT on one scale (IT positive Feeling). Thus, students who were enabled to access the Internet at their home were found to have less IT positive Feeling (e.g., exciting, interesting, appealing, fascinating, and so on) during class hours than those who had no internet access at home. It might be implied that students who were enabled to access the Internet at their home seemed to lack the motivation to pay attention to ICT and internet use in their classroom learning environments during class hours. In addition, students who were able to access the Internet at home preferred to access the Internet at their home rather than at school, because it was more convenient or comfortable.

Table PF2- 53: Differences between Students' Using the Internet at Home and Those Who Did Not on Classroom Learning Environments with ICT and Student Outcomes

	Variable	Mean Scores www home (n = 96)	Nowww (n = 54)	t-value
Classroom Learning Environments	**Group Work**			
	preferred	19.38	19.11	0.459
	actual	6.80	6.46	1.314
	CO-Operation			
	preferred	6.24	6.31	-0.301
	actual	9.13	9.17	-0.120
	Teacher Support			
	preferred	6.75	7.15	-1.575
	actual	9.19	8.87	1.00
	Involvement			
	preferred	4.59	4.81	-1.208
	actual	6.56	6.26	1.252
	Relationships			
	preferred	7.41	7.43	-0.081
	actual	6.69	6.57	0.426
	Competition			
	preferred	4.85	5.02	-0.910
	actual	5.84	5.63	0.951
	Order and Organisation			
	preferred	9.15	8.80	1.128
	actual	3.93	4.07	-0.864
Students' attitudes toward ICT	**IT Importance**	55.32	57.50	-1.223
	IT Feeling	48.85	53.87	-2.396*
	Computer Usage	49.49	50.91	-1.025
	Using E-mail for classroom	29.24	28.74	0.465
	IT Involvement	33.14	31.46	1.061
	Using E-Mail	34.76	35.28	-0.390
Students' critical thinking skills	**Deduction and Assumption (CRI1)**	10.92	10.13	1.360
	Induction and Credibility (CRI2)	19.86	19.44	0.481

*$p \leq 0.05$

Figure PF2- 9: Differences between Students Who Used the Internet at Home and Those Who Did Not on Perceptions of Actual and Preferred Forms of ICT Classroom Environments



These findings provided only partial support for the proposition 2 which proposed that the students' perceptions of ICT classroom learning environments and student outcomes differ according to students' individual background characteristics (gender, academic background, computer experience, and computer usage).

2.4.4 Associations between Perceptions of Classroom Learning Environments with ICT and Student Individual Characteristics and Outcomes

Introduction

The third and fourth research questions concerned the possible relationship between students' perceptions of classroom environments with ICT and students' critical thinking skills and attitudes toward ICT respectively. These were linked with students' individual characteristics in Proposition 3, with stated, to there are the relationships between students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of classroom environments with ICT and student outcomes (students' critical thinking skills and students' attitudes toward ICT). Proposition 3 was broken down into two sub-propositions. The first concerned the possible mediation effects of student perceptions of ICT classroom environment between students' individual background characteristics and student outcomes. In order to validate students' perceptions of ICT classroom environments, as separate factors from students' individual characteristics, it was necessary to prove that the students' classroom perceptions had no mediating effects between students' individual characteristics and student outcomes. Once this was shown, it was possible to proceed to the seconde sub-proposition, which stated that students' background characteristics combined with students' perceptions of classroom ICT environments to have associations with student outcomes.

Analysis

The first step in the testing of Proposition 3, involved hierarchical multiple regression analysis to examine to what extent students' perceptions of ICT classroom environment mediated relationships between students' individual characteristics (gender, academic background, computer experience, and computer usage) and student outcomes (students' critical thinking skills and students' attitudes toward ICT). A second stage of analysis involved, simple correlation and multiple regression analyses were calculated to determine whether students' individual characteristics, and perceptions of classroom learning environments with ICT combined to have associations with student outcomes (students' critical thinking skills and students' attitudes toward ICT).

Principle for Person-Environment Fit

The investigation of possible associations between classroom predictors, the seven factor generated from student perceptions of classroom environments, and student outcomes in Proposition 3, and in 4 as well, were examined in terms of the match between students' preferred and actual classroom environments which was conceptualised as the person-environment fit (Fraser & Fisher, 1983). The person-environment fit was used to examine the relationships between student outcomes and the interaction between the actual classroom environment and their preferred environment (Fraser & Fisher, 1983). The study, therefore, was based on classroom environment preferences for particular ICT classroom environments, which could mediate relationships between student outcomes and the nature of the actual classroom environment. Student outcomes were measured by using two critical thinking measures (Deduction-Assumption and Induction-Credibility reasoning skills) and six ICT attitude measures (Using E-Mail, IT Involvement, E-Mail for classroom use, IT Importance, IT Feeling, and Computer Usage). The adapted NCEI in Thai version was administered to obtain students' perceptions of seven scales of actual and preferred classroom individualisation, which were used to generate seven new variables describing actual-preferred interactions (i.e., person-environment fit).

Consequently, the seven variables of person-environment interactions, or classroom predictors, can be presented as follows:

- Group Work-environment fit: Students perceived the actual-preferred interactions of those who were able to work together by grouping tasks and activities.

- Co-Operation-environment fit: Students perceived the actual-preferred interactions of students and their teacher who joined together to generate student tasks, individual or group projects, class activities or students and their peers who shared instructional resources to achieve individual tasks or group projects.

- Teacher Support-environment fit: Students perceived the actual-preferred interactions of the amount of help, friendship, and interest the teacher displayed toward students.

- Student Involvement-environment fit: Students perceived the actual-preferred interactions of students who were attentive and interested in class activities or participating in class discussion.

- Relationships-environment fit: Students perceived the actual-preferred interactions of the teacher who cared for and were interested in their needs (student-teacher relationships) or students who felt interested in one other (student-peer relationships).

- Competition-environment fit: Students perceived the actual-preferred interactions of students who competed with one other for grades and recognition and how hard it was to achieve high performances.

- Order and Organisation-environment fit: Students perceived the actual-preferred interactions of students who emphasised establishing or following a clear set of class rules in which they knew what the consequences would be if they did not follow them.

In addition, the person-environment fit was calculated by subtracting the preferred score from the actual score for each of the seven adapted NCEI scales.

To test proposition 3.1, the hierarchical multiple regression analysis was carried out for each factor of student attitudes toward ICT (Using Email, IT Involvement, Using Email for Classroom, IT Importance, IT Feeling, and Computer Usage). Each component of students' critical thinking skills (Deduction-Assumption and Induction-Credibility reasoning skills) were added to the hierarchical multiple regression equations in two stages. The size of correlations ascertained are referred to as small, medium, or large (0.10, 0.30, and 0.50, respectively) in relation to the effect sizes proposed by Cohen (1992).

In the first stage (Model 1), relations between individual characteristics (gender, academic background, computer experience, and computer usage) and student outcomes were examined. The second stage involved the full regression models (Model 2), including the variables of the person-environment fit. Both of these models, the unstandardised (b) and standardised regression (Beta) coefficients are shown in the following Table PF2-54 - PF2-61.

As with regression analyses, two important questions were asked. Firstly, whether the increment in explained variability or the prediction of a student outcome related to adding further variables was statistically significant. The second question was whether the regression coefficients that explained associations among predictors and outcomes differed between regression models. That is, were the regression relationships stable across the specifications or did they differ when later variables were added to successive models (Clogg, Petkova, & Haritou, 1995)?

The appropriate test of attenuation between models examines differences in unstandardised weights, with adjustments being made to standard errors (Clogg et al., 1995). Therefore, in this analysis unstandardised regression coefficients (b) are presented to demonstrate possible mediation effects. Additionally, I have presented the standardised on beta weights (Beta) to show the relative strength of each measure, in each regression equation.

If mediation occurred in the analyses, then the relationship between individual background characteristics and a particular outcome would be reduced, when associations involving the proposed intervening variables and outcome measures were taken into account. Baron and Kenny (1986) indicated that the variables function as mediators to the extent that they accounted for the relationships between predictors and outcomes. On the one hand, partial mediation would be indicated if the relationships were reduced, but remained significant, when associations involving the learning variables and student outcomes were taken into account. On the other hand, full mediation would occur if initial significant relations in the first stage became non-significant, after adding the associations between the intervening variables and outcomes. Where no mediation was demonstrated, it indicated that predictor and mediating variables could be regarded as separate, but interacting, factors.

Results for Student Attitude Outcomes

(a) Students' attitudes towards email (Using Electronic Mail)

In Table PF2-54, the stability of the b-weight value at 3.49 for Models 1 and 2 indicated that perceptions of the person-environment fit of ICT did not mediate the relationships between individual characteristics and students' attitudes toward E-mail. Furthermore, the Beta-weight in the final model showed that after taking into account the other predictors, only two factors, student gender and the Relationships (RS-Environment fit) had strong associations with students' attitudes toward email (Using Electronic Mail).

Table PF2- 54: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Attitudes towards ICT (Using Electronic Mail)

	Model 1		Model 2	
	b	**Beta**	**b**	**Beta**
Individual characteristics				
Gender	3.49*	0.21	3.49*	0.21
school level	-2.41	-0.10	-1.75	-0.07
Subject area	1.46	0.09	1.61	0.10
Computer Training	-2.44	-0.11	-2.55	-0.11
Computer Experience	-0.27	-0.02	-0.57	-0.04
Use computer at Home	3.39	0.15	3.41	0.15
Access the Internet at Home	-0.67	-0.04	-0.43	-0.03
ICT environment				
GW-environment fit			0.22	0.09
COOP-environment fit			0.34	0.10
TS-environment fit			-0.33	-0.09
INV-environment fit			0.66	0.15
RS-environment fit			0.80*	0.18
COM-environment fit			0.30	0.07
OO-environment fit			0.18	0.05
Multiple R	0.29		0.43*	
R^2	0.09		0.19	
Effect Size	0.10 [a]		0.23 [a]	

$* p \leq 0.05$ $**p \leq 0.01$ Effect size: [a] small

(b) Students' attitudes toward IT Involvement

In Table PF2-55, the results from b-weight indicated that the fit between actual and preferred classroom environments with ICT in full model (Model 2) did not mediate relationships between students' individual background characteristics and students' attitudes toward IT Involvement. The Beta weight in Model 2 showed that student gender, the Teacher Support (TS) and Order-Organisation (OO) environment fits had the largest associations with students' attitudes toward IT Involvement.

Table PF2- 55: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Attitudes towards ICT (IT Involvement)

	Model 1		Model 2	
	b	**Beta**	**b**	**Beta**
Individual Characteristics				
Gender	3.77	0.19	4.42*	0.22
school level	0.61	0.02	-1.39	-0.05
Subject area	1.85	0.10	2.82	0.15
Computer Training	-2.09	-0.08	-2.26	-0.08
Computer Experience	-2.04	-0.11	-2.67	-0.14
Use computer at Home	4.02	0.15	2.57	0.10
Access the Internet at Home	-3.24	-0.17	-0.70	-0.04
ICT environments				
GW-environment fit			0.03	0.01
COOP-environment fit			0.31	0.08
TS-environment fit			1.00**	0.24
INV-environment fit			0.92*	0.17
RS-environment fit			-0.83	-0.16
COM-environment fit			0.70	0.14
OO-environment fit			-1.29**	-0.27
Multiple R	0.29		0.46**	
R^2	0.09		0.21	
Effect Size	0.10 [a]		0.27 [a]	

* $p \leq 0.05$ **$p \leq 0.01$ Effect size: [a] small

(c) Students' attitudes toward electronic mail (email) for classroom use

In model 2 of Table PF2-56, the Beta weights indicated that the Group Work (GW) environment fit had the largest significant associations with differences in students' attitudes towards email for classroom use. Furthermore, the reduction of the b-weight from 0.94 to 0.72 indicated that students' perceptions of the fit between actual and preferred classroom environments with ICT did not mediate the relationships between students' individual characteristics and students' attitudes towards email for classroom use.

Table PF2- 56: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Attitudes toward ICT (email for Classroom Use)

	Model 1		Model 2	
	b	**Beta**	**b**	**Beta**
Individual Characteristics				
Gender	0.94	0.07	0.72	0.05
school level	-3.05	-0.16	-3.80*	-0.20
Subject area	1.97	0.15	1.57	0.12
Computer Training	0.46	0.03	0.17	0.01
Computer Experience	0.94	0.08	1.09	0.09
Use computer at Home	0.27	0.02	0.30	0.02
Access the Internet at Home	-0.46	-0.04	-0.32	-0.02
ICT Environments				
GW-environment fit			-0.51**	-0.26
COOP-environment fit			0.26	0.09
TS-environment fit			-0.09	-0.03
INV-environment fit			0.49	0.14
RS-environment fit			0.02	0.01
COM-environment fit			-0.37	-0.11
OO-environment fit			-0.23	-0.07
Multiple R	0.20		0.40*	
R^2	0.04		0.16	
Effect Size	0.04 [a]		0.19 [a]	

$*p \leq 0.05$ $**p \leq 0.01$ Effect size: [a] small

(d) Students' attitudes toward IT Importance

In Table PF2-57, the beta-weight in model 2 showed that student gender and computer training had the strongest associations with students' attitudes toward IT Importance. In addition, the increase in the b-weight from 3.50 to 3.92 indicated that students' perceptions of the fit of ICT for classroom did not mediate the relationships between individual characteristics and students' attitudes towards electronic mail (email).

Table PF2- 57: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Attitudes toward ICT (IT Importance)

	Model 1		Model 2	
	b	**Beta**	**b**	**Beta**
Individual characteristics				
Gender	3.50	0.16	3.92*	0.17
school level	0.25	0.01	-0.05	-0.00
Subject area	2.69	0.12	3.27	-0.15
Computer Training	-4.87	-0.16	-5.05*	-0.16
Computer Experience	-0.74	-0.04	-1.29	-0.06
Use computer at Home	5.33	-0.18	4.42	0.15
Access the Internet at Home	0.22	0.01	1.77	0.08
ICT environment				
GW-environment fit			0.16	0.05
COOP-environment fit			0.11	0.02
TS-environment fit			0.40	0.08
INV-environment fit			0.71	0.12
RS-environment fit			0.08	0.01
COM-environment fit			0.78	0.14
OO-environment fit			-0.52	-0.10
Multiple R	0.30		0.37	
R^2	0.09		0.14	
Effect Size	0.10 [a]		0.16 [a]	

*p ≤ 0.05 Effect size: [a] small

(e) Students' attitudes toward IT feeling

In Table PF2-58, the Beta weights in model 2 showed that student gender and use of Internet at home had the strongest associations with their students' attitudes toward IT feeling. In addition, the increase in the b-weight from 5.07 to 5.45 indicated that students' perceptions of the fit of ICT for classroom did not mediate the relationships between individual characteristics and students' attitudes toward IT feeling.

Table PF2- 58: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Attitudes toward ICT (IT Feeling)

	Model 1		Model 2	
	b	Beta	b	Beta
Individual characteristics				
Gender	5.07*	0.19	5.45*	0.20
school level	-2.25	-0..06	-2.63	-0.07
Subject area	1.57	0.06	2.14	0.08
Computer Training	-4.09	-0.11	-3.86	-0.11
Computer Experience	0.53	0.02	0.30	0.01
Use computer at Home	1.12	0.03	0.78	0.02
Access the Internet at Home	4,69	0.18	5.39*	0.21
ICT environment				
GW-environment fit			7.130E-02	0.02
COOP-environment fit			-6.759E-02	-0.01
TS-environment fit			0.46	0.08
INV-environment fit			0.19	0.03
RS-environment fit			1.243E-02	0.00
COM-environment fit			0.17	0.02
OO-environment fit			-0.16	-0.03
Multiple R	0.30		0.31	
R^2	0.09		0.10	
Effect Size	0.10 [a]		0.11 [a]	

*p ≤ 0.05 Effect size: [a] small

(f) Students' attitudes toward computer usage

The beta-weights in the second model, in Table PF2-59, revealed that the environments fit of Teacher Support (TS) and Order-Organisation (OO) had the strongest associations with students' attitudes toward computer use. In addition, the increase of the b-weight from 0.11 to 1.13 indicated that students' perceptions of the fit between actual and preferred classroom environments did not mediate the relationships between individual characteristics and students' attitudes toward computer usage.

Table PF2- 59: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Attitudes toward ICT (Computer Usage)

	Model 1		Model 2	
	b	**Beta**	**b**	**Beta**
Individual characteristics				
Gender	0.11	0.01	1.13	0.07
school level	-1.88	-0.08	-3.24	-0.13
Subject area	0.11	0.01	1.03	0.06
Computer Training	0.47	0.02	0.48	0.02
Computer Experience	0.47	0.03	-0.49	-0.03
Use computer at Home	3.26	0.14	2.14	0.09
Access the Internet at Home	0.31	0.02	2.23	0.13
ICT environment				
GW-environment fit			0.20	0.08
COOP-environment fit			-0.38	-0.10
TS-environment fit			0.93**	0.25
INV-environment fit			0.65	0.14
RS-environment fit			-0.41	-0.09
COM-environment fit			0.18	0.04
OO-environment fit			-1.06**	-0.25
Multiple R	0.18		0.37	
R^2	0.03		0.13	
Effect Size	0.03 [a]		0.15 [a]	

**$p \leq 0.01$ Effect size: [a] small

Results for Students' Critical Thinking Skill Outcomes

(a) Students' critical thinking skills (Deduction and Assumption)

From Table PF2-60, the Beta weights in the second model showed that students' subject areas had the strongest association with students' critical thinking skill scores (deduction and assumption). In addition, the increase of the b-weight from 0.59 to 0.70 indicated that students' perceptions of the fit between actual and preferred ICT classroom environments did not mediate the relationships between individual characteristics and students' critical thinking skills (deduction and assumption).

Table PF2- 60: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Critical Thinking Skills (Deduction and Assumption)

	Model 1		Model 2	
	b	**Beta**	**B**	**Beta**
Individual characteristics				
Gender	-0.59	-0.08	-0.70	-0.10
school level	2.3*	0.22	2.02*	0.19
Subject area	-1.90**	-0.27	-1.65*	-0.23
Computer Training	-0.36	-0.04	-0.18	-0.02
Computer Experience	-0.50	-0.07	-0.40	-0.06
Use computer at Home	-0.30	-0.03	-0.35	-0.04
Access the Internet at Home	-0.77	-0.11	-0.71	-0.10
ICT environment				
GW-environment fit			0.01	0.01
COOP-environment fit			0.18	0.12
TS-environment fit			0.10	0.06
INV-environment fit			0.08	0.04
RS-environment fit			-0.22	-0.11
COM-environment fit			0.05	0.03
OO-environment fit			0.15	0.09
Multiple R	0.30		0.37	
R^2	0.09		0.14	
Effect Size	0.10 [a]		0.16 [a]	

*p ≤ 0.05 **p ≤ 0.01 Effect size: [a] small

(b) Students' critical thinking skills (Induction and Credibility)

From Table PF2-61, the beta weights in the second model showed that students' school level had the strongest association with students' critical thinking skills (Induction and Credibility). In addition, the increase of the b-weight from 0.87 to 0.95 indicated that students' perceptions of the fit between actual and preferred classroom environments did not mediate the relationships between individual characteristics and students' critical thinking skills (induction and credibility).

Table PF2- 61: Unstandardised (b) and Standardised (Beta) Regression Coefficients for Associations between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT, and Students' Critical Thinking Skills (Induction and Credibility)

	Model 1		Model 2	
	b	Beta	b	Beta
Individual Characteristics				
Gender	0.87	0.08	0.95	0.09
school level	2.90	0.19	2.63	0.17
Subject area	-0.32	-0.03	-0.39	-0.04
Computer Training	-2.05	-0.14	-2.15	-0.14
Computer Experience	-0.71	-0.07	-0.69	-0.07
Use computer at Home	0.69	-0.05	0.59	0.04
Access the Internet at Home	-0.77	-0.07	-0.59	-0.06
ICT environment				
GW-environment fit			-0.02	-0.01
COOP-environment fit			-0.04	-0.02
TS-environment fit			0.13	0.05
INV-environment fit			-0.17	-0.06
RS-environment fit			-0.22	-0.08
COM-environment fit			0.02	0.01
OO-environment fit			-0.33	-0.13
Multiple R	0.23		0.28	
R^2	0.05		0.08	
Effect Size	0.05 [a]		0.09 [a]	

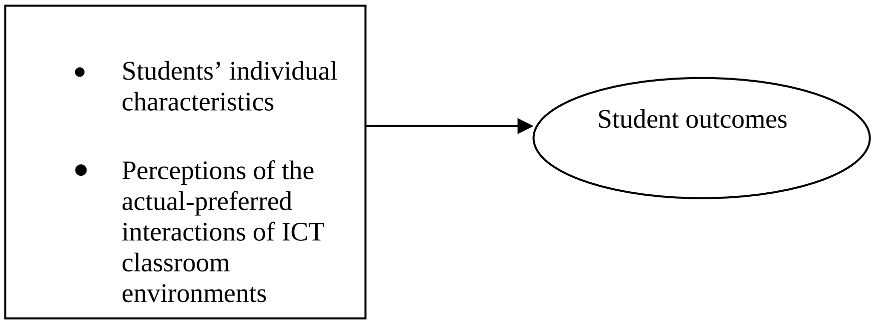
Effect size: [a] small

Key Findings from the First Stage Analysis

The associations between individual characteristics and student outcomes (students' critical thinking skills and students' attitudes toward ICT) remained unmediated by the addition of the person-environment fit. That is, student outcomes were associated directly with students' individual characteristics, as well as and their perceptions of the actual-preferred interactions of learning environments with ICT. This is in line with the research model for analysis (given on page 122), where it was proposed that students 'perceptions of the actual-preferred interactions of ICT classroom environments did not mediate relationships between students' individual characteristic and their student outcomes. Instead, they were considered a variable with the same explanatory status as students' perceptions of the actual-preferred interactions of ICT classroom environments, and not as a mediating variable.

Hence the first stage analysis of Proposition 3 demonstrated that students' perceptions of the actual-preferred interactions of classroom learning environments with ICT did not mediate the relationships between individual characteristics and student outcomes was accepted.

It was still appropriate, however, to maintain a research model of the following form:



The second stage analysis reflected the research model developed for analysis in maintaining individual characteristics and person-environment fit as separable variables influencing student outcomes. It stated that students' individual background characteristics (gender, academic background, computer experience, and computer usage) and their perceptions of ICT classroom environments combined to have associations with student outcomes (students' critical thinking skills and students' attitudes toward ICT).

Analysis

Simple correlation (r) and multiple regression (R) analyses were calculated to determine associations between students' individual characteristics, dimensions of the fit between actual and preferred classroom learning environments with ICT of the adapted NCEI, and student outcomes. Whereas the simple correlation analysis provided information about bivariate associations between outcome and independent predictors (individual characteristics and classroom scales), the multiple regression analysis provided more of a picture of the joint influence of independent predictors (individual background and classroom predictors) on each outcome (two critical thinking skills and six attitudes toward ICT). The regression coefficient (Beta) described the association between an outcome scale and a particular predictor scale (classroom environment and individual scales) when the other scales were mutually controlled. Moreover, in the analysis in this section, the size of correlations (effect sizes) is referred to as small, medium, or large when they were (Cohen, 1992) respectively 0.10, 0.30, and 0.50.

Results for Students' Critical Thinking Skills

Table PF2-62 presents two regression analyses, which examined relations among students' individual characteristics, students' perceptions of classroom learning environments with ICT, and students' critical thinking skills.

(a) Deduction-Assumption Reasoning Skills

Associations were explored between students' critical thinking outcome and each of the classroom scales and individual characteristic predictors. The multiple regression models in Table PF2-62 showed the relationships between the combined influence of the set of independent predictors and the deduction-assumption reasoning skill outcome. The results of the simple correlation analysis showed that the deduction-assumption reasoning skills were significantly ($p<0.05$), but negatively, related to students' subject areas. Deduction-assumption was significantly ($p<0.10$) and positively related to the two environment fit scales of Co-Operation and Teacher Support.

The regression coefficients (Beta) were used to identify which of the independent predictors account for unique variance in the deduction-assumption reasoning skills outcome. The results showed that students' school levels and subject areas were statistically significant ($p<0.05$) independent predictors of the deduction-assumption reasoning skill outcome. However, the multiple correlation coefficients were not statistically significant on this outcome.

As seen in Table PF2-62, the results indicated that school levels were related positively to a deduction-assumption skill outcome while subject areas had negative associations with a deduction-assumption skill outcome. Overall, the results suggested that students who came from secondary schools had higher scores on the deduction-assumption skill outcome than those who did not. According to subject areas, it appeared that students who studied in

Sciences, Maths, and Computer subject areas had higher scores for critical thinking skills (deduction and assumption) in comparison to those students who studied in Social Studies and Arts areas. However, there was no association between perceptions of the actual-preferred interactions of ICT classroom learning environments (all seven predictors) and the deduction-assumption skill outcome.

Interestingly, after taking into account independent predictors (both individual characteristics and classroom environment scales), the multiple regression analysis indicated that the multiple correlation of 0.37 was not statistically significant on deduction-assumption reasoning skills.

(b) Induction-Credibility Reasoning Skills

The results of simple correlation analysis showed that an induction-credibility reasoning skill was significantly ($p<0.05$) and positively related to students' school levels. In the case of multiple regression analyses, as shown in Table PF2-62, the results demonstrated that there were associations between individual characteristics, perceptions of the actual-preferred interactions of ICT environments, and students' induction and credibility skills.

The regression coefficients (Beta) were used to identify which of the independent predictors accounted for unique variance in induction-credibility reasoning skills. The results showed that students' school levels and computer training were the statistically significant ($p<0.10$) independent predictors of an induction-credibility reasoning skill outcome. The results in Table PF2-62 show that secondary school students had higher scores on the induction-credibility skill than primary school students. In the case of the computer training variable, there were negative associations with the induction-credibility skill outcome. The results indicated that students who received training in a computer course had higher scores of critical thinking skills in terms of induction-credibility skill in comparison to those who received no training. However, the findings indicated that there was no association between perceptions of the actual-preferred interactions of ICT classroom learning environments (all seven predictors) and the induction-credibility skill outcome.

Interestingly, after taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression analysis indicated that none of the multiple correlation of 0.28 was statistically significant on induction-credibility reasoning skills.

In conclusion, the two multiple regressions indicated that after taking into account students' individual background and all classroom predictors were not related to two students' critical thinking skills (a deduction-assumption and an induction-credibility outcomes). However, two students' critical thinking outcomes are statistically significantly correlated with two individual characteristics (subject areas and school levels) and two classroom environment scales (Co-Operation and Teacher Support). That is, the findings provided partial support for the proposition 3.2 in part of students' critical thinking skill outcomes. As well, these significant findings still provided partial support for the proposition 3 which is proposed that there are the relationships between students' individual background characteristics, students' perceptions of classroom learning environments with ICT and students' critical thinking skills (a deduction-assumption and an induction-credibility reasoning skill outcomes).

Table PF2- 62: Simple Correlation and Multiple Regression Analyses Between Individual Characteristics, Perceptions of Classroom Learning Environments with ICT as Predictors and Two Students' Critical Thinking Skill Outcomes

	Deduction and Assumption Reasoning Skills			Induction and Credibility reasoning Skills		
	r	**Beta**	***t***	**r**	**Beta**	***t***
Background						
Gender	-0.10	-0.10	ns	0.07	0.09	ns
School levels	0.09	0.19**	2.00	0.15*	0.17*	1.67
Subject areas	-0.16**	-0.23**	-2.43	0.06	-0.04	ns
Computer Experience	-0.06	-0.60	ns	-0.06	-0.07	ns
Computer Training	-0.05	-0.02	ns	-0.12	-0.14*	-1.69
Use Computer at Home	-0.12	-0.04	ns	0.03	-0.04	ns
Use www at Home	-0.11	-0.10	ns	-0.04	-0.06	ns
Actual-Environment fit						
Group Work	0.05	0.01	ns	-0.07	-0.14	ns
Co-Operation	0.15*	0.12	ns	0.02	-0.02	ns
Teacher Support	0.16*	0.06	ns	0.03	0.05	ns
Involvement	0.05	0.04	ns	-0.09	-0.06	ns
Relationships	-0.09	-0.11	ns	-0.08	-0.08	ns
Competition	0.01	0.03	ns	0.03	0.01	ns
Order and Organisation	0.12	0.09	ns	-0.11	-0.13	ns
Multiple R	0.37			0.28		
R^2	0.14			0.08		
Effect Size	0.16 [a]			0.09 [a]		

*p ≤ 0.10 **p ≤ 0.05 ***p ≤ 0.01 Effect size: [a] small

Results for Students' Attitudes toward ICT

Table PF2-63 demonstrates six simple correlation and multiple regression analyses which examined relations among students' individual characteristics (gender, academic background, computer experience, and computer usage), perceptions of the person-environment fit of classroom learning environments with ICT (Group Work, Co-Operation, Teacher Support, Student Involvement, Relationships, Competition, and Order and Organisation), and students' attitudes toward ICT (the importance role of ICT, students' feeling in ICT, attitudes in computer use, attitudes in E-Mail for classroom use, attitudes in ICT involvement, and attitudes in E-Mail use).

(a) Attitude toward ICT Importance

In relation to the attitude outcome (attitude towards ICT Importance), the multiple regression analysis in Table PF2-63 showed associations between students' individual characteristics, perceptions of the actual-preferred interaction of their ICT environments, and students' attitudes toward ICT Importance (e.g. the importance of the use of computer, the Internet, email, multimedia, and so on). Moreover, the results of simple correlated analysis revealed that students' attitudes toward ICT importance is significantly and positively ($p<0.10$ and $p<0.05$, respectively) related to student gender and the computer accessibility at home.

The regression coefficients (Beta) were used to identify which of the independent predictors accounted for unique variance in attitudes towards ICT Importance. The results showed that student gender and computer training were statistically significant ($p<0.05$) independent predictors of an attitude outcome (ICT Importance).

Multiple regression analysis, as seen in Table PF2-63, indicated that student gender was related positively to an attitude outcome (ICT importance). Normally, the results would imply that girl students had higher attitudes toward ICT Importance than did boy students. In contrast, students with different computer training had negative association with their attitudes toward ICT Importance. This meant that students who received training in a computer course had higher associations on students' attitudes toward ICT importance than those who did not. However, there was no association between students' perceptions of the actual-prefer interaction (all seven predictors) and students' attitudes toward the ICT importance.

Interestingly, after taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression indicated that the multiple correlation of 0.37 was not statistically significant on students' attitudes toward ICT Importance.

(b) Students' Positive Feeling towards the Use of ICT

Simple correlation and multiple regression analyses explored associations between attitude outcome (positive feeling towards ICT using) and independent predictors. In Table PF2-63, the results of simple correlation analysis proved that students' positive feeling toward ICT use (e.g. exciting, fascinating, appealing, and so) was significantly and positively ($p<0.10$ and $p<0.05$, respectively) associated with student gender and Internet accessibility at home.

The regression coefficients (Beta) were used to identify which of the independent predictors account for unique variance in positive feelings in ICT using. The results showed that student gender and the Internet accessibility were statistically significant ($p<0.05$) independent predictors of students' positive feelings in the use of ICT.

The results illustrated that gender difference and the difference in Internet accessibility at home had positive associations with their attitudes toward ICT feeling. It indicated that students who could not access the Internet at their home were higher on students' feeling in the use of ICT. It seemed to indicate that students who could not access the Internet at their home had higher positive feeling to the use of ICT than those who could. In contrast, students who were able to access the Internet at their home seemed to lack the motivation to pay attention to their classroom environments with ICT. Such students preferred to access the Internet at their home rather than at school, due to more convenient or comfortable access. However, there was no association of students' perceptions of the actual-prefer interaction (all seven predictors) on students' positive feeling in the use of ICT.

In Table PF2-63, the multiple regression results showed relationships between students' positive feeling (e.g. exciting, fascinating, appealing, and so on) in the use of ICT in their classroom and each of the classroom and individual characteristic scales. Interestingly, after taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression indicated that the multiple correlation of 0.31 was not statistically significant for students' feeling in the use of ICT.

(c) Attitudes on Computer Usage

Simple correlation and multiple regression analysis, as seen in Table PF2-63, were used to show the associations for students’ attitudes toward computer usage in their classroom environment with ICT. The results of simple correlation revealed that students’ attitude toward the use of computer was significantly and positively ($p<0.05$ and $p<0.10$, respectively) related to computer accessibility at home and the actual-preferred interaction of one environment scale (Teacher Support). However, one attitude outcome (attitudes to computer use) was negatively significant ($p<0.10$) associated with the actual-preferred interaction on one environment scale (Order and Organisation).

The regression coefficients (Beta) were used to identify which of the independent predictors accounted for the unique variance in attitudes toward computer use. The results showed that Teacher Support and Order-Organisation (TS and OO) were statistically significant ($p<0.01$) independent predictors of attitudes toward computer use.

The results displayed that the actual-preferred interaction of Teacher Support (TS) was related positively to students’ attitudes toward computer use. Accordingly, it might indicate that students who perceived high actual teacher support had more positive attitudes to computer usage, in comparison with students who perceived low actual teacher support. These results should be noted in relation to attitude outcome (students’ attitudes toward ICT use) is higher in classes that have a more favourable classroom environment in term of more Teacher Support. In addition, the actual-preferred interaction of Order-Organisation (OO) was related negatively to students’ attitudes toward computer use. Hence, generally, this result seemed to suggest that students who perceived high levels of rules and control in the classroom were less positive in their attitudes to computer use than those students where classroom levels of control was were perceived to be had so strong. There were no associations between students’ individual background (gender, academic background, computer experience, and computer usage) and their attitudes toward computer use.

After taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression analysis indicated that the multiple correlation of 0.37 was not statistically significant on students' attitudes toward computer use.

(d) Attitudes on E-mail for Classroom Use

Simple correlation and multiple regressions analyses were used to investigate associations between the attitudes to email outcome and the individual and classroom predictors. The results of the simple correlation in Table PF2-63 demonstrated that students' attitudes towards the use of email for classroom was significantly and positively ($p<0.05$ and $p<0.10$, respectively) related to students' perceptions of the actual-preferred interaction on two environment scales (Group Work and Order-organisation). As shown in Table PF2-63, the multiple regression results showed that students' school level and perceptions of the actual-preferred interaction of Group Work (GW) in their ICT classroom environments had a small association with students' attitudes to email use for classroom (R^2 = 16%, Effect size = 0.19).

The regression coefficients (Beta) were used to identify which of the independent predictors accounted for the unique variance in attitudes towards email use for classroom. The findings showed that students' school levels and classroom environment in terms of Group Work, were the statistically significant ($p<0.05$ and $p<0.01$, respectively) independent predictors of students' attitudes towards the use of email for classroom.

The results showed that students' school level was related negatively to students' attitudes to email for classroom use. This meant that students who studied in primary schools had more positive attitudes toward email use for classroom than students at secondary level. Students' perceptions of the actual-preferred interaction of Group Work (GW) were also associated negatively to students' attitudes in the use of email for their classroom. This result seemed to indicate that students who desire more working together with one other in their classroom, had more positive attitudes towards email use for classroom, than those students favoured Group Work less. Perhaps the students who desired to work on email in the class were those who found group work a more tense and less comfortable activity.

After taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression indicated that the multiple correlation of

0.40 was statistically significant ($p<0.05$) for students' attitudes toward email use. Students' school levels and Group Work were significant independent predictors of students' attitudes towards the use of email for classroom. That is, school level and students' perceptions of the actual-preferred interaction of Group Work in their ICT classroom learning environments combined to have a small but significant association with students' attitudes towards email for classroom use.

(e) Attitudes in ICT Involvement

Simple correlation and multiple regression analyses were used to examine the relationship between students' attitudes toward ICT Involvement and independent predictors. The results of the simple correlation analysis in TablePF2-63 demonstrated that this attitude outcome was significantly and positively ($p<0.10$) related to student gender and students' perceptions of the actual-preferred interaction on one environment scale (Teacher Support). However, students' attitudes toward ICT Involvement had negatively significant ($p<0.05$) associations with perceptions of the actual-preferred interaction of Order and Organization. In addition, the multiple regression results in Table PF2-63 demonstrated that students' characteristics (student gender and computer training), students' perceptions in the actual-preferred interactions of five classroom predictors (Teacher Support, Student Involvement, Relationships, Competition, and Order-Organisation) combined to have a small association with students' attitudes toward ICT involvement (R^2 = 21%, Effect size = 0.27).

The regression coefficients (Beta) were used to identify which of the independent predictors accounted for the unique variance in attitudes toward ICT Involvement. The findings showed that individual background (gender and computer training) and classroom predictors (TS, INV, RS, COM, and OO) were all significant independent predictors of students' attitudes toward ICT Involvement.

Of the students' individual predictors, the results revealed that student gender was related positively to students' attitudes on ICT Involvement. In contrast, differences in students' computer training were related negatively to the outcome (students' attitudes toward ICT Involvement).

For classroom independent predictors, the findings showed that students' perception between the actual and preferred environments on Teacher Support, Student Involvement, and Competition (TS, INV, and COM) were related positively to students' attitudes toward ICT Involvement. Overall, the results in Table PF2-63 suggested that students' attitudes toward ICT Involvement was more positive in classes that had a more favourable classroom environment in terms of more Teacher support, more Student Involvement, and more Competition. On the other hand, students' perception of the actual-preferred interactions of Relationships and Order-Organisation (RS and OO) were related negatively to students' attitudes to ICT Involvement. This meant, the results in Table PF2-63 indicated that students' attitude toward ICT Involvement was higher in classes that had a more favourable classroom environment in terms of less Order-Organisation.

After taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression indicated that the multiple correlation of 0.46 was statistically significant ($p < 0.05$) on students' attitudes toward ICT Involvement. In particular, individual background (gender and computer training) and classroom environments (TS, INV, RS, COM, and OO) were the significant independent predictors of students' attitudes toward ICT Involvement. These factors combined to have a small but significant association with students' attitude toward ICT Involvement.

(f) Attitudes on Email Use Generally

Simple correlation and multiple regression analyses were calculated for this outcome. The results of the simple correlation analysis in TablePF2-63 demonstrated that students' attitudes towards email use generally were significantly and positively related to individual predictors (student gender and computer accessibility) and students' perceptions of the actual-preferred interaction of two environment scales (Relationships and Student Involvement). Moreover, Table PF2-63 shows that the multiple regression between this outcome measure and the set of independent predictors indicated that student gender and students' perceptions of the actual-preferred interactions of Relationships (RS) and Student Involvement (INV) combined to have a small association with students' attitudes on the use of email generally (R^2 = 19%, Effect size = 0.23).

The regression coefficients (Beta) were used to identify which of the independent predictors accounted for unique variance in attitudes towards email use generally. The findings showed that student gender and two classroom predictors (INV and RS) were statistically significant ($p<0.10$ and $p<0.05$, respectively) independent predictors of students' attitudes towards the use of email generally.

Student gender was related positively to students' attitudes towards the use of email generally. This meant that girls had more positive attitudes towards email use in general than did boys. Similarly the actual-preferred interactions of Relationships and Student Involvement (RS and INV) were related positively to students' attitudes towards the use of email generally. Overall, the results in Table PF2-63 suggested that students' attitudes toward ICT Involvement was higher in classes that had a more favourable classroom environment in terms of more Relationships and more Student Involvement. This seemed to indicate that students whose teachers gave their more attention and showed friendly interest, had higher attitudes on email use, in comparison to students whose teachers provided less attention and less friendly interest. Furthermore, it could be implied that students who were interested in participating in class discussion or enjoyed their class activities with one other had more positive attitudes towards email use generally than those students not so eager for classroom discussion and activities.

After taking into account independent predictors (both individual characteristics and classroom environments), the multiple regression indicated that the multiple correlation of 0.43 was statistically significant ($p<0.05$) for students' attitudes towards email use generally. In particular, student gender and classroom environments (INV and RS) were the significant independent predictors of students' attitudes towards the use of email generally. In that they combined to have a small but significant association with students' attitudes towards the use of email generally.

Discussion of Stage Two Analysis of Proposition 3

The six multiple regressions indicated that after taking into account students' individual background and all classroom predictors, were indicated that the multiple correlations are statistically significant on three attitude outcomes (email for classroom use, ICT involvement, and email using).

That is, school level and students' perceptions of the actual-preferred interaction of Group Work in their ICT classroom learning environments combined to have a small association with students' attitudes towards email for classroom use. Students' characteristics (gender and computer training), students' perceptions of the actual-preferred interaction of five classroom predictors (Teacher Support, Involvement, Relationships, Competition, and Order-Organisation) combined to have a small association with students' attitude toward ICT Involvement. Student genders and students' perceptions of the actual-preferred interactions of Relationships and Student Involvement combined to have a small association with students' attitudes towards the use of email. Furthermore, the findings also provide partial support for the proposition 3.2 which is proposed that Students' individual background characteristics (gender, academic background, computer experience, and computer usage) and their perceptions of ICT classroom environments combined to have associations with students' attitudes toward ICT.

Table PF2- 63: Simple Correlation and Multiple Regression Analyses Between Individual Characteristics, Perceptions of Classroom learning Environments with ICT as Predictors and Six Students' Attitudes towards ICT Outcomes

	IT_CORE			IT_FEELING			COM_USE			EMAIL_C			IT_INV			EMAIL		
Variables	*r*	*β*	*t*	*r*	*β*	*t*	*r*	*B*	*T*	*r*	*β*	*t*	*r*	*β*	*t*	*r*	*β*	*t*
Backgrounds																		
gender	0.16*	0.17**	2.10	0.18*	0.20**	2.39	0.02	0.07	ns	0.08	0.05	ns	0.20*	0.22***	2.80	0.22***	0.21**	2.59
school level	0.03	0.00	ns	-0.04	-0.07	ns	-0.09	-0.13	ns	-0.09	-0.20**	-2.06	0.03	-0.05	ns	-0.09	-0.07	ns
subject areas	0.12	0.15	ns	0.03	0.08	ns	0.03	0.06	ns	0.09	0.12	ns	0.11	0.15	ns	0.04	0.10	ns
computer experience	-0.03	-0.06	ns	-0.01	0.01	ns	-0.01	-0.03	ns	0.07	0.09	ns	-0.09	-0.14	ns	-0.01	-0.04	ns
computer training	-0.13	-0.16**	-2.00	-0.09	-0.11	ns	-0.09	0.02	ns	0.04	0.01	ns	-0.05	-0.08*	-1.77	-0.08	-0.11	ns
use computer at home	0.17**	0.15	ns	0.13	0.02	ns	0.17**	0.09	ns	0.03	0.02	ns	0.05	0.10	ns	0.14*	0.15	ns
use www at home	0.10	0.08	ns	0.19**	0.20**	2.03	0.08	0.13	ns	-0.04	-0.02	ns	-0.09	-0.04	ns	0.03	-0.03	ns
Environments with ICT																		
GW-enfit	0.01	0.05	ns	-0.01	0.02	ns	0.01	0.08	ns	-0.28**	-0.26***	-3.05	-0.11	0.01	ns	0.11	0.09	ns
COOP_enfit	0.04	0.02	ns	0.01	-0.01	ns	-0.09	-0.10	ns	0.07	0.09	ns	0.12	0.08	ns	0.09	0.28	ns
TS_enfit	0.04	0.08	ns	0.01	0.08	ns	0.15*	0.25***	2.78	-0.02	-0.03	ns	0.16*	0.24***	2.77	-0.06	-0.09	ns
INV_enfit	0.09	0.12	ns	-0.01	0.03	ns	0.11	0.14	ns	0.12	0.14	ns	0.10	0.17**	2.06	0.18**	0.15*	1.74
RS_enfit	0.07	0.01	ns	0.02	0.00	ns	-0.03	-0.09	ns	0.04	0.01	ns	-0.03	-0.16*	-1.86	0.20**	0.18**	2.12
COM_enfit	0.13	0.14	ns	0.02	0.02	ns	0.03	0.04	ns	-0.11	-0.11	ns	0.11	0.14*	1.72	0.13	0.07	ns
OO_enfit	-0.02	-0.10	ns	-0.04	-0.03	ns	-0.15*	-0.25***	-2.81	-0.14*	-0.07	ns	-0.17**	-0.27***	-3.16	0.08	0.05	ns
Multiple R		0.37			0.31			0.37			0.40**			0.46**			0.43**	
R^2		0.14			0.10			0.13			0.16			0.21			0.19	
Effect size		0.16 [a]			0.11 [a]			0.15 [a]			0.19[a]			0.27[a]			0.23[a]	

*p ≤ 0.10 **p≤0.05 ***p≤0.01

Effect size: [a] small

2.4.5 Associations between Classroom Learning Environment with ICT and Student Outcomes in relation to Teacher Characteristics

Introduction

The fifth and sixth research questions were concerned to investigate the possible relationship between three teacher characteristics and the two student outcomes. In terms of Proposition 4 this was stated as there are associations among students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom learning environments and student outcomes (students' attitudes toward ICT and students' critical thinking skills) in relation to teacher factors (teachers' individual background characteristics, teachers' critical thinking skills and teachers' attitudes towards ICT).

Methods of Analysis Used

Multilevel data analysis was employed to examine the proposition 4 by using the Hierarchical Linear Modelling (HLM) version 6 (Raudenbush, Bryk, Cheong, & Congdon, 2004).

The general theoretical framework, which was constructed in Part 1, incorporated both individual student and teacher level variables, which could influence student outcomes (students' critical thinking skills and students' attitudes toward ICT). The multiple regression analyses described in the previous section, focused primarily on the predictor variables at the student level. These analyses were limited because they did not take into account the hierarchical nature of the study's total data, in particular, the effects of variables from the teacher level of analysis. The examination of teacher level variables was of considerable interest, but involved methodological problems, resulting from the combination of data that were obtained at different levels, regarded as lower in the case of student data and higher for teacher/classroom/school data.

Two methods, which are commonly employed when data gathered from two or more levels are combined into a single-level analysis, are as follows:

(a) the aggregation of two-level data, with the micro-level data (e.g. student) being added to the macro-level (e.g. school);

(b) the disaggregation of macro-level data (e.g. school) to the micro-level (e.g. student) (Snijders & Bosker, 1999).

Both the aggregation and disaggregation techniques typically introduce bias, leading to an over-and under-estimation of the magnitude of effects associated with variables that are aggregated or disaggregated and incorrect estimates of error. Unless these methodological problems are allowed for in the analysis of the data, both bias and incorrect estimates of error occur.

There are four potential errors associated with the aggregation of lower level to higher level data (Snijders & Bosker, 1999). These are outlined below.

(a) ***Shift of meaning***: A variable which is aggregated to the macro level refers to the macro-units, not directly to the micro-units.

(b) ***Ecological fallacy***: A correlation between macro-level variables can not be used to make assertions about micro-level relations.

(c) ***Neglect of the original data structure***: In the examination of the effects of sampling error, inappropriate tests of significance are applied, especially when some kind of analysis of covariance is to be used. When analysing multilevel data without aggregation, this problem can be overcome by distinguishing between the within-groups and the between-groups regressions.

(d) ***Loss of cross-level interaction effects***: This prevents on examination of potential cross-level interaction effects of a specified micro-level variable with an as yet unspecified macro-level variable (Snijders & Bosker, 1999, pp.13-16).

In the case of disaggregating higher level data (macro-level) to lower level data (micro-level), the distorting effect is referred to as disaggregation bias. With the disaggregation method, the same value for a group level variable is assigned to members of the same group at the individual level. A consequence of doing this is that the assumption of the independence of observations ceases to apply. Disaggregation often results in serious risks of committing type I error for the study of between group differences (higher or macro level) and unnecessarily conservative tests (i.e. too low type I error probabilities) for within group differences (lower or micro level) (Snijders & Bosker, 1999).

For the purpose of examining the impact of teachers at the classroom level (class-teacher level or level-2) on student outcomes (students' critical thinking skills and students' attitudes towards ICT) at the student level (student level or level-1) is examined, a multilevel statistical modeling technique was as the most appropriate employed (Goldstein, 2003). These techniques, as documented in prior studies (Rowe, 2001) are now commonly referred to as the application of hierarchical linear modeling (HLM).

The major advantages of the multilevel modeling technique over the multiple regression analyses, was that the use of the HLM procedures made it possible to analyse variables at the two levels (student, level-1 and class-teacher, level-2) simultaneously.

In this study, HLM was considered to be able to produce better results, with each level estimating the effect of every predictor variable in the model on student outcome variables. Moreover, the HLM procedures not only provided direct effects from the various levels but were also able to show the interaction effects between predictor and outcome variables at the two student and class-teacher levels.

Hypothesis for Two-Level HLM Model

This study therefore examined various potential relationships among variables at the student level (level-1) and at the class-teacher level (level-2) on student outcome variables (students' critical thinking skills and students' attitudes toward the use of ICT), using two-level hierarchical linear modeling (HLM) procedures, as was documented by Rowe's study (2001). Figure PF2-10preesnts a diagram of the hypothesised HLM two-level model in testing Proposition 4.

Normally, the structure of the data demands that different types of hierarchical models be formulated and tested. The data structure can be either purely hierarchical or cross-classified structure (Goldstein, 2003).

A pure or natural hierarchy is where each person belongs to one and only one organisation and the hierarchy as consists of units grouped at different levels (Goldstein, 2003;

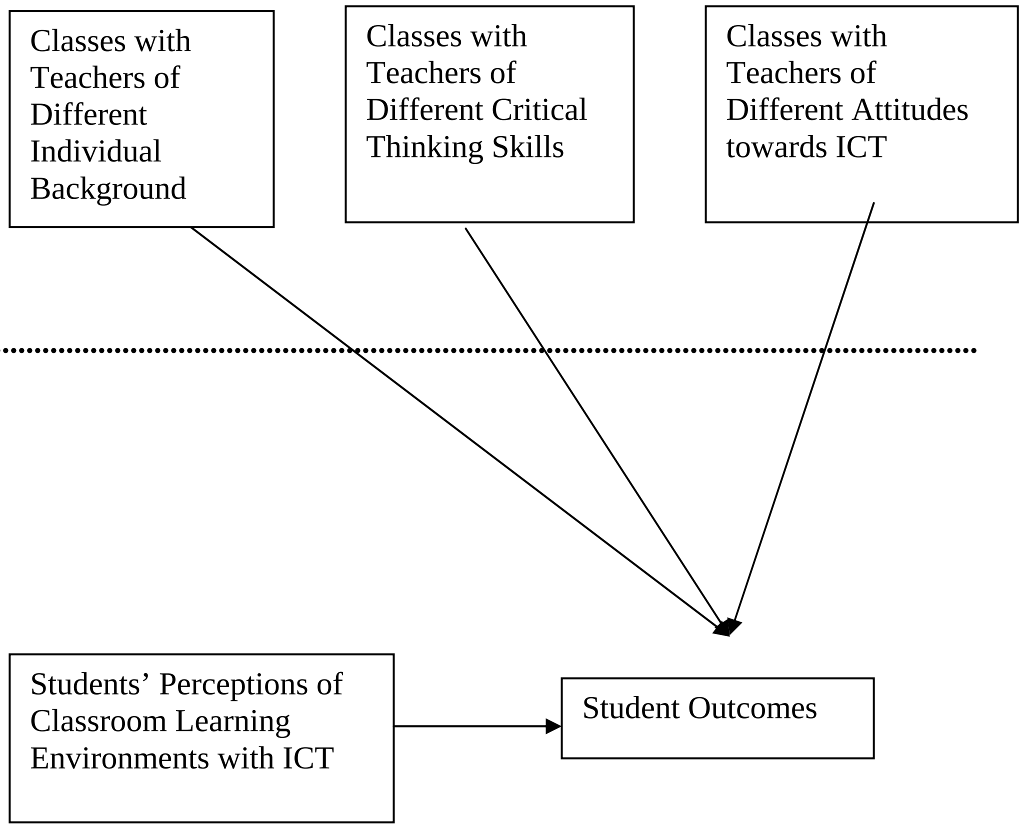
Raudenbush & Bryk, 2002). For instance, where students (level 1 units) are clustered or nested within schools (level 2 units), there is a two-level structure. With such hierarchical data structure, two or three level hierarchical models of analysis, which reflect the balanced two-way design of the classical analysis of variance, are appropriate (Raudenbush & Bryk, 2002).

However, there are cases where a single level 2 classification, level-1 unit may belong to more than one level-2 unit simultaneously (Goldstein, 2003) or where the lower-level units are cross-classified, as well as clustered, by two or more higher-level units (Raudenbush & Bryk, 2002). For instance, in most schooling systems (elementary, secondary or high school) students move from elementary to secondary or high school. It could be expected that both the elementary and secondary schools attended would influence a students' achievements or attitudes measured at the end of the school level. Therefore, to handle the complex structure of such data, a cross-classified structure would be more suitable and appropriate, because the level-2 units are of two types (from both elementary and secondary schools) (Goldstein, 2003).

In the present study, the structure of data was a natural hierarchy, in that each student (lower-level) unit belonged to one and only one classroom or teacher (higher-level) unit. Therefore, a two-level HLM model was employed to formulate and test models in the investigation of research Proposition 4 (see in Figure PF2-11). The multilevel data analyses were conducted with the HLM programme version 6 (Raudenbush et al., 2004). The HLM programme only allows one outcome variable to be analysed at any one time. Therefore, the two-level HLM model required separate analysis for each student outcome as a dependent variable (see figure PF2-11).

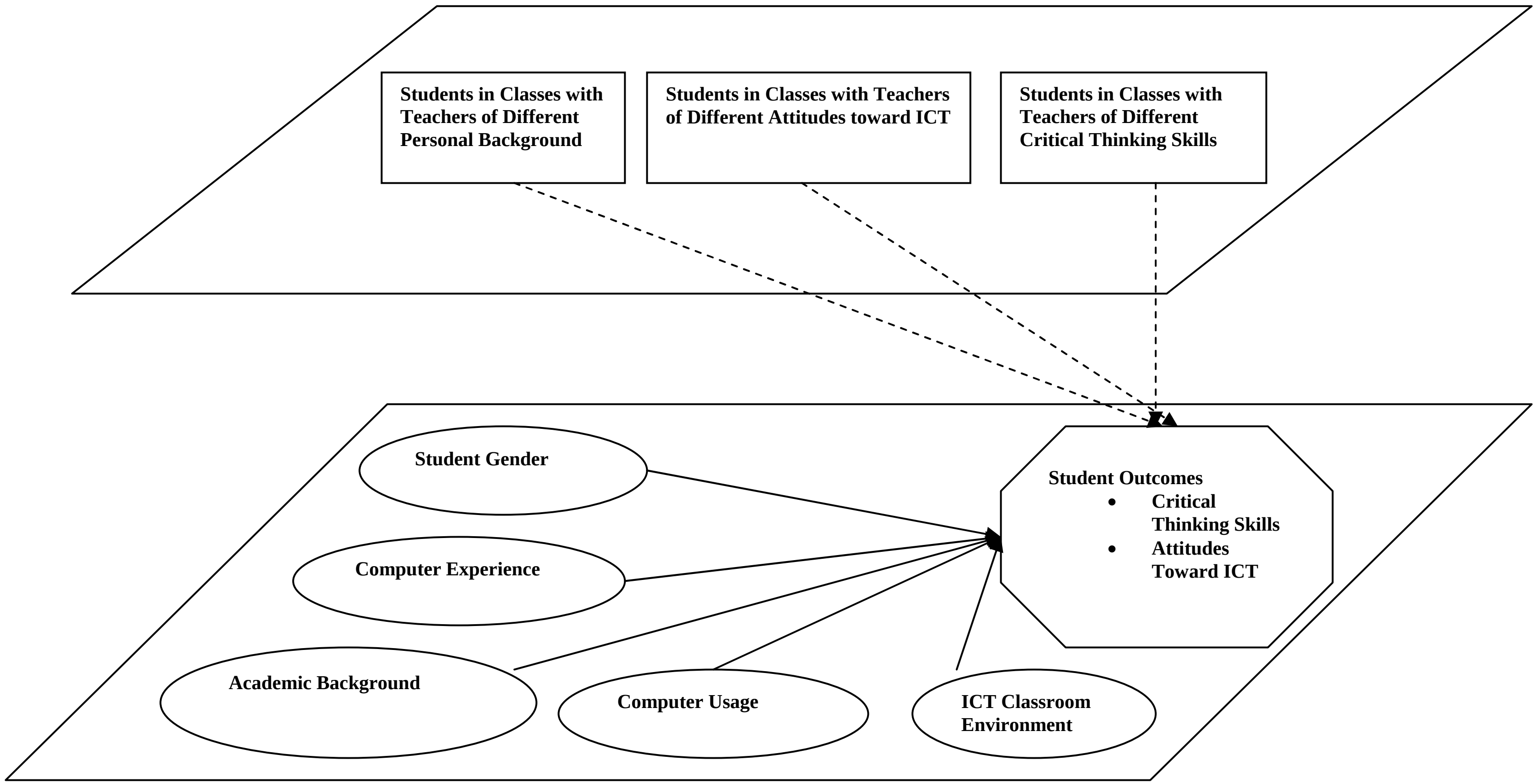
Figure PF2- 10: Diagram Showing the Hypothesised HLM Two-Level Model (Class-Teacher and Student Level) Used in Testing Proposition 4.

Class-Teacher Level



Student-Level

Figure PF2- 11: Multilevel Path Diagram Showing HLM Two-Level Hypothesises among Factors Influencing Students' Critical Thinking Skills and Students' Attitudes toward ICT



Data Structure and Variables Used

The data for this study were collected from two different levels, including 150 students at student level (level-1) and 16 classrooms at class-teacher level (level-2). The names, codes and description/comment of the variables tested for inclusion at each level (student or leve-1 level and class-teacher or level-2 level) are formulated and provided in Table PF2-64. At the student level, the students' individual characteristics (gender, academic background, computer experience, and computer usage), classroom learning environment with ICT, student outcome (students' critical thinking skills and students' attitudes toward ICT) variables were tested in the analyses reported in the previous section. At the class-teacher level, the impacts of teacher factors (teachers' individual background, teachers' critical thinking skills, and teachers' attitudes toward ICT) are hypothesised to influence student outcomes (two students' critical thinking skills and six students' attitudes toward ICT) at student level. Table PF2-64 lists the student (level-1) variables and the class-teacher (level-2) variables sed in the two level HLM analysis of data.

Table PF2- 64: List of Variables

Level	Variable Name	Variable Code	Description/comment
Level 1 (Student Level)			
Predictors	Student Gender	GENDER	0 = boy student 1 = girl student
	School Level	SCHLEVEL	0 = Student who was in primary School 1 = Student who was in secondary School
	Subject Area	SUBJEC1	0 = Students who studied in Science, Math, Computer subject 1 = Student who studied in Social-Studies & Arts subject
	Computer Training	TRAIN1	0 = Student who received training in computer course 1 = Student who did not receive training in computer course
	Computer Experience	COMEXPER	0 = Student had computer experiences equal or less than 5 years 1 = Student who had computer experience more than 5 years
	Computer at home	COMHOME1	0 = Student who used computer at home 1 = Student who did not use computer at home

continued

Level	Variable Name	Variable Code	Description/comment
	Internet at home	NETHOME1	0 = Student who accessed the Internet at home 1 = Student who did not access the Internet at home
	Group Work Environment Fit	GW_ENFIT	Perceptions of the actual-preferred interaction on a scale of Group Work (e.g. students who were able to work together in group tasks and activities); high value means high perception degree of group work (score range from -19 to -3)
	Co-Operation Environment Fit	COOP_ENF	Perceptions of the actual-preferred interaction on a scale of Co-Operation (e.g. students and their peers shared resources and worked together to achieve tasks, individual or group projects, class activities, and so on); high value means high perception degree of co-operation (score range from -5 to 9)
	Teacher Support Environment Fit	TS_ENFIT	Perceptions of the actual-preferred interaction on a scale of Teacher Support (e.g. students who were in classes with teacher who cared for their student needs and helped their students to succeed); high value means high perception degree of teacher support (score range from -3 to 7)
	Involvement Environment Fit	INV_FIT	Perceptions of the actual-preferred interaction on a scale of Student Involvement (e.g. students who were attentive and interested in class activities, participated in class discussion; high value means high perception degree of student involvement (score range from -2 to 7)
	Relationships Environment Fit	RS_FIT	Perceptions of the actual-preferred interaction on a scale of Relationships (e.g. the amount of help, friendship, and interest the teacher displays toward students); high value means high perception degree of relationships (score range from -4 to 4)
	Competition Environment Fit	COM_FIT	Perceptions of the actual-preferred interaction on a scale of Student Competition (e.g. students who competed with each other for grades and recognition and how had it was to achieve good grades); high value means high perception degree of competition (score range from -3 to 6)

continued

Level	Variable Name	Variable Code	Description/comment
	Order and Organisation Environment Fit	OO_FIT	Perceptions of the actual-preferred interaction on a scale of Order-Organisation (e.g. students who emphasised establishing and following a clear set of class rules and students knowing what the consequences would be if they did not follow them); high value means high perception degree of order and organisation (score range from -9 to 0)
Outcomes	Critical Thinking Skill Scores (Deduction and Assumption)	CRI1	Critical Thinking Skill Scores of student in Deduction and Assumption; high value means high degree of deduction-assumption reasoning skills (score range from 2 to 19)
	Critical Thinking Skill Scores (Induction and Credibility)	CRI2	Critical Thinking Skill Scores of student in Induction and Credibility scores; high value means high degree of induction-credibility reasoning skills (score range from 10 to 51)
	IT Importance	IT_CORE	Students' attitudes toward the importance of the use of ICT; high value means high perception degree of attitudes on the ICT importance (score range from 9 to 63)
	IT Feeling	IT_FEEL	Students' positive feeling toward the use of ICT; high value means high perception degree of attitudes on ICT feeling (score range from 9 to 63)
	Computer Usage	COM_USE	Students' attitudes toward the use of computer; high value means high perception degree of attitudes on the use of computer (score range from 8 to 56)
	Email for Classroom Use	EMAIL_C	Students' attitudes toward the use of email for classroom; high value means high perception degree of attitudes on the use of email for classroom (score range from 12 to 40)
	IT Involvement	IT_INV	Students' attitudes toward the involvement in the use of ICT; high value means high perception degree of attitudes on ICT involvement (score range from 6 to 42)
	Using Email	EMAIL	Students' attitudes toward the use of email generally; high value means high perception degree of attitudes on the use of email (score range from 6 to 42)

continued

Level	Variable Name	Variable Code	Description/comment
<u>Level 2 (Class-Teacher Level)</u>			
Teacher Personal Background	Teacher Gender	T_GENDER	0 = male teacher 1 = Female teacher
	School Level	SCHOOL_T	0 = Primary teacher 1 = Secondary teacher
	Subject Area	SUBJEC_1	0 = Teacher who taught in Science, math, and Computer subject 1 = Teacher who taught in Social Studies & Arts subject
	Training in Computer Course	TRAIN_1	0 = Teacher who received Training in computer course 1 = Teacher who did not received training in computer course
	Computer Experience	COM_EX1	0 = Teacher who had computer experience equal or less than 3 years 1 = Teacher who had computer experience more than 3 years
	Computer at Home	COM_H1	0 = Teacher who used computer at home 1 = Teacher who did not use computer at home
	Internet at Home	NET_H1	0 = Accessed the Internet at home 1 = Did not accessed the Internet at home
Teachers' Critical Thinking Skills	Critical Thinking skills (Analysis)	CT1	Analysis skills; high value means high degree of analysis skills (score range from 0 to 2.5)
	Critical Thinking skills (Evaluation)	CT2	Evaluation skills; high value means high degree of evaluation skills (score range from 0.5 to 4)
	Critical Thinking Skills (Inference)	CT3	Inference skills; high value means high degree of inference skills (score range from 0 to 2.5)
	Critical Thinking Skills (Deduction)	CT4	Deductive Reasoning skills; high value means high degree of deductive reasoning skills (score range from 0.5 to 3.5)
	Critical Thinking Skills (Induction)	CT5	Inductive Reasoning skills; high value means high degree of inductive reasoning skills (score range from 0 to 3)
	Total Critical Thinking Skill Scores	TOTALCT	Total scores of teachers' critical thinking skills; high value means high degree of total critical thinking skills (score range from 3 to 12)
Teachers' Attitudes Toward ICT	Email Use	EMAIL_T	The use of email; high value means high perception degree of attitudes on the use of email (score range from 39 to 70)
	The Internet Use	WWW_T	The use of the Internet; high value means high perception degree of attitudes on the use of the Internet (score range from 40 to 70)

continued

Level	Variable Name	Variable Code	Description/comment
	Multimedia Use	MEDIA_T1	The use of multimedia; high value means high perception degree of attitudes on the use of multimedia (score range from 43 to 70)
	Use of Computer for professional productivity	PRODUC_T	The use of computer for professional productivity; high value means high perception degree of attitudes on profession productivity (score range from 41 to 70)
	Computer use in classroom	COMCLASS	The use of computer in the classroom; high value means high perception degree of attitudes on the use of computer in classroom (score range from 41 to 70)
	Computer Feeling	COMFEEL	Feeling in the use of computer; high value means high perception degree of feeling on computer using (score range from 26 to 67)
	Using E-Mail for classroom	EMAILCLA	The use of email in the classroom; high value means high perception degree of attitudes on the use of email for classroom (score range from 35 to 56)
	Total Teachers' Attitudes Toward ICT	SUMATTI	Total degrees of teachers' attitudes toward ICT; high value means high perception degree of total attitudes on the use of ICT (score range from 292 to 473)

Findings

This section presents the HLM results in the examination of Preposition 4. The preliminary null model analyses are presented first, followed by the final HLM results.

Null Model Results

Initially, eight different null models were examined to obtain the amounts of variance available to be explained at each level of the hierarchy (Bryk & Raudenbush, 1992). The null model contained only the dependent variables (two students' critical thinking skills and six students' attitudes toward ICT). No predictor variables were specified at the student and class level.

The eight null models that were conducted for related to the each of the student outcomes stated below:

Students' critical Thinking skills on a scale of as follows:

(1) Deduction and Assumption (CRI1)

(2) Induction and Credibility (CRI2)

Students' attitudes towards ICT on a scale of as follows:

(3) ICT Importance (IT_CORE)

(4) ICT positive Feeling (IT_FEEL)

(5) Using Computer (COM_USE)

(6) Using email for classroom (EMAIL_C)

(7) ICT Involvement (IT_INV)

(8) Using email (EMAIL)

Table PF2-65 displays the eight null models and the calculation resulting from the analysis of variance conducted for each student outcome.

Table PF2- 65: Results of the Null Model for Student Outcomes

Deduction and Assumption (CRI1)						
Reliability Estimate	***Fixed Effect***	**Coefficient**	**Standard Error**	**T-ratio**	**DF**	**P-value**
0.66	Intercept for CRI1, B0 INTRCPT2, G00	10.63	0.43	24.79	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0 Level-1, R	1.44 3.11	2.08 9.67	15	45.21	0.000
	Intra-class Correlation					
	Tau= 2.08	Sigma square= 9.67	Tau/ (tau+sigma squared)= 0.18 (18%)			

continued

Induction and Credibility (CRI2)

Reliability Estimate	*Fixed Effect*	Coefficient	Standard Error	T-ratio	DF	P-value
0.38	Intercept for CRI2, B0 INTRCPT2, G00	19.72	0.50	39.41	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	1.27	1.60	15	24.71	0.054
	Level-1, R	4.97	24.73			
	Intra-class Correlation					
	Tau= 1.60	Sigma square= 24.73	Tau/ (tau+sigma squared)= 0.06 (6%)			

ICT Importance (IT_CORE)

Reliability Estimate	*Fixed Effect*	Coefficient	Standard Error	T-ratio	DF	P-value
0.29	Intercept for CRI2, B0 INTRCPT2, G00	56.15	0.97	58.12	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	2.14	4.56	15	21.46	0.123
	Level-1, R	10.28	105.63			
	Intra-class Correlation					
	Tau= 4.56	Sigma square= 105.63	Tau/ (tau+sigma squared)= 0.04 (4%)			

continued

ICT Feeling (IT_FEEL)						
Reliability Estimate	***Fixed Effect***	**Coefficient**	**Standard Error**	**T-ratio**	**DF**	**P-value**
0.20	Intercept for TOTAL_S, B0 INTRCPT2, G00	50.63	1.09	46.31	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	2.02	4.09	15	18.42	0.241
	Level-1, R	12.35	152.41			
	Intra-class Correlation					
	Tau= 4.09	Sigma square= 152.41	Tau/ (tau+sigma squared)= 0.03 (3%)			

Using Computer (COM_USE)						
Reliability Estimate	***Fixed Effect***	**Coefficient**	**Standard Error**	**T-ratio**	**DF**	**P-value**
0.30	Intercept for CRI2, B0 INTRCPT2, G00	49.99	0.75	66.36	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	1.69	2.86	15	22.04	0.107
	Level-1, R	7.97	63.48			
	Intra-class Correlation					
	Tau= 2.86	Sigma square= 63.48	Tau/ (tau+sigma squared)= 0.04 (4%)			

continued

Using Email for Classroom (EMAIL_C)

Reliability Estimate	*Fixed Effect*	Coefficient	Standard Error	T-ratio	DF	P-value
0.71	Intercept for TOTAL_S, B0 INTRCPT2, G00	28.97	0.84	34.52	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	2.92	8.54	15	51.91	0.000
	Level-1, R	5.64	31.79			
	Intra-class Correlation					
	Tau= 8.54	Sigma square= 31.79	Tau/ (tau+sigma squared)= 0.21 (21%)			

ICT Involvement (IT_INV)

Reliability Estimate	*Fixed Effect*	Coefficient	Standard Error	T-ratio	DF	P-value
0.54	Intercept for CRI2, B0 INTRCPT2, G00	32.32	1.04	31.18	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	3.16	9.99	15	33.13	0.005
	Level-1, R	8.77	76.89			
	Intra-class Correlation					
	Tau= 9.99	Sigma square= 76.89	Tau/ (tau+sigma squared)= 0.11 (11%)			

continued

Using email (EMAIL)						
Reliability Estimate	***Fixed Effect***	**Coefficient**	**Standard Error**	**T-ratio**	**DF**	**P-value**
0.55	Intercept for TOTAL_S, B0					
	INTRCPT2, G00	34.91	0.87	39.54	15	0.000
	Random Effect	**Standard Deviation**	**Variance Component**	**DF**	**Chi-square**	**P-value**
	Intercept for CRI1, U0	2.68	7.18	15	33.65	0.004
	Level-1, R	7.33	53.79			
	Intra-class Correlation					
	Tau= 7.18	Sigma square= 53.79	Tau/ (tau+sigma squared)= 0.12 (12%)			

The null model results from Table PF2-65 above, illustrate that the intra-class correlations of four outcomes, namely CRI2, IT_CORE, IT_FEEL, and COM_USE were only six, four, three, and four percentages respectively (6%, 4%, 3%, and 4% respectively) of the total variance. Thus, only approximately five percentages (5%) of variance in these outcomes can be attributed to level two differences, while the remaining about 95% must be related to student level differences. Therefore, these results indicate that it was inadequate to examine these variables with a HLM two-level analysis. It means that the differences in CRI2 (Induction and Credibility skills), ICT importance, ICT feeling, and Using Computer among students rested mainly at the student level. The fully unconditional HLM model (null model) depicted that HLM analyses were adequate for the four remaining outcomes, which are discussed below in relation to Table PF2-65:

(a) Deduction-Assumption Reasoning Skills

The null model results manifested that the grand mean for deduction-assumption reasoning skills was 10.63, with a standard error of 0.43, indicating a 95% confidence interval of 10.63 $\pm$ 1.96 (0.43) = (9.79, 11.47). The estimate value of variance at the class level, of students' critical thinking skills (deduction-assumption skills) was 2.08. The estimate value of variance at the student level was 9.67. Therefore, the intra-class correlation was 18%. It means that the class level effects accounted for 18% of the total variance in a deduction-assumption skills for students. The reliability estimate for students' critical thinking skills (a deduction-assumption skill) was 0.66. That indicates that students' critical thinking skills (a deduction-assumption skill) are quite reliable indicators. Consequently, for deduction-assumption reasoning skills, a HLM two-level analysis was examined.

(b) Students' Attitudes toward the use of email

The null model results revealed that grand mean for students' attitudes toward the use of email was 34.91, with a standard error of 0.87, suggesting a 95% confidence interval of 34.91 $\pm$ 1.96 (0.87) = (33.20, 36.62). The estimated value of variance, at the class level, of students' attitudes toward the use of email was 7.18. The estimated value of variance at the student level was 53.79. In addition, the intra-class correlation was 12%. This means that the class level effects account for 12% of the total variance in students' attitudes toward the use of email. The reliability estimate for students' attitudes toward the use of email was 0.55. That is, the high reliability (nearly 60%) indicates that students' attitudes towards the use of email are quite reliable indicators. Therefore, students' attitudes toward the use of email were retained for the HLM two-level analysis.

(c) Students' Attitudes toward the use of ICT Involvement

The null model results presented the grand mean for students' attitudes toward the use of ICT involvement was 32.32, with a standard error of 1.04, suggesting a 95% confidence interval of 32.32 $\pm$ 1.96 (1.04) = (30.28, 34.36). The estimated value of variance at the class level, of students' attitudes toward the use of ICT involvement was 9.99. The estimated value of variance at the student level was 76.89. In addition, the intra-class correlation was 11%. This means that the class level effects account for 11% of the total variance in students' attitudes toward the use of ICT involvement. The reliability estimate for students' attitudes toward the use of ICT involvement was 0.54. That is, the high reliability (approximately 50%) indicates that students' attitude toward the use of ICT involvement is a quite reliable indicator. Therefore, students' attitude toward the use of ICT involvement was included in the HLM two-level analysis.

(d) Students' Attitudes toward the use of email for classroom

The null model results indicated that the grand mean for students' attitudes toward the use of email for classroom was 28.97, with a standard error of 0.84, suggesting a 95% confidence interval of 28.97 $\pm$ 1.96 (0.84) = (27.32, 30.62). The estimated value of variance at the class level, of students' attitudes toward the use of email for classroom was 8.54. The estimated value of variance at the student level was 31.79. In addition, the intra-class correlation was 21%. This means that the class level effects account for 21% of the total variance in students' attitudes toward the use of email. The reliability estimate for students' attitudes toward the use of email was 0.71. That is, the high reliability (around 70%) indicates that students' attitudes toward the use of email for classroom is a reliable indicator. Thus, students' attitudes toward the use of email for classroom was further examined in two-level HLM analysis.

Final Two-level HLM Analysis and Results

This section presents the results of the final two-level HLM analyses for only three sets of data (those remaining from the Null Model analysis): (a) Deduction and Assumption Reasoning Skills [CRI1], (b) Students' Attitudes toward the use of email [EMAIL], and (c) Students' Attitudes toward the use of email for classroom [EMAIL_C]. In the case of Students' Attitudes toward the use of ICT involvement [IT_INV], no predictors had been found to be significant.

The first step involved building up the student level (level-1) model or the so-called 'unconditional' model at level-1, by adding the student level predictors to the model, without entering predictors at any of the other levels of the hierarchy. The next step undertaken was to estimate a level-2 model, which involved adding the class-teacher level (level-2) predictors into the model using the step-up strategy previously mentioned. At this stage, the level-2 exploratory analysis sub-routine available in HLM 6 was employed for examining the potentially significant level-2 predictors (as found in the output) in successive HLM runs.

In the following sections, the results for each of the three remaining student outcomes are discussed.

(a) Deduction and Assumption Reasoning Skills [CRI1]

In the two-level stage, only COOP_ENF was found to be a significant predictor of CRI1 at the student level. Two variables at the class-teacher level COM_EX1 and NET_H1, influenced CRI1 directly (fixed effect). In addition, two predictors of interaction effects (TOTALCT and COMCLASS) impacted on CRI1 at level-2.

The final model for the variable, deduction and assumption reasoning skills, at student level and class-teacher level can be denoted in Equation 1 and the results are shown in Table PF2-66.

Level 1 Model ***(Bold Italic: Grand-mean centred)***

Deduction and Assumption = $\beta_0 + \beta_1$ ***(COOP_ENF)*** +e

Level 2 Model

$\beta_0 = \gamma_{00} + \gamma_{01}$ (COM_EX1) + γ_{02} (NET_H1) + u_0

$\beta_1 = \gamma_{10} + \gamma_{11}$ ***(TOTALCT)*** + γ_{12} ***(COMCLASS)*** (Equation 1)

Direct Effects

As TABLE PF2-66 illustrates, the HLM analyses demonstrated the fixed or direct effects of student and class-teacher level constructs on students' deduction-assumption reasoning skills considered from 'γ-coefficient'. Thus, the deduction-assumption reasoning skill (CRI1) was positively impacted at the student level by COOP_ENF (γ = 0.20, $p \leq 0.05$). This finding implies that students who had positive perceptions of co-operative classroom learning environments were more likely to have higher scores for the deduction-assumption reasoning skill.

At the class level, two factors had direct or fixed effects on CRI1, COM_EX1 ($\gamma = -2.20$, $p \leq 0.001$) and NET_H1 ($\gamma = 2.62$, $p \leq 0.001$). One variable – Co-operation (COOP_ENF) - was assumed to have a fixed effect at level 2, because the reliability estimate of COOP_ENF was below 0.05. The negative effect of the differences in the length of teachers' computer experiences indicated that students in classes with teachers who had less computer experience performed at a higher level in deduction-assumption skills. It may be that students in classes with teachers who had shorter periods of computer experience had more opportunity to share learning resources and work together with their own technological knowledge. They perhaps were more likely to share instructing/learning resources and computer experiences with one other in their classroom, by using other ICT equipment such as television, video, camera, multimedia, and so on.

In addition, NET_H1 showed a positive effect on students' deduction-assumption skills (CRI1) when teachers did not use the internet at home. It could be hypothesised that students whose teachers did not access the Internet at their home, were able to generate learning or instructing resources, together with their own teachers, through accessing the internet during class periods. It seemed that students were more likely to develop and improve their deduction-assumption skills by searching for information or knowledge together with their teachers to complete class assignments.

Table PF2- 66: Final Estimation of Fixed and Interaction Effects for Students' Deduction and Assumption Skills

Fixed and Interaction Effects	γ - Coefficient	Standard error	T-ratio	P-value
Level 1/ Student-level effects				
COOP_ENF	0.20	0.08	2.53	0.013
+++ by TOTALCT on COOP_ENF	0.05	0.02	2.36	0.020
+++ by COMCLASS on COOP_ENF	-0.03	0.01	-3.34	0.001
Level 2/ Class-level effects				
COM_EX1	-2.20	0.49	-4.44	0.001
NET_H1	2.62	0.55	4.73	0.000

Note: +++ Interaction effect

Cross-level Interaction Effects

Table PF2-66 reveals a total of two cross-level interaction levels for the dependent variable, a deduction-assumption reasoning, (CRI1). Figures PF2-12 to Figure PF2-13 provide a visual representations of these interaction effects.

Figure PF2-12 illustrates the positive interaction effect between COOP_ENF and TOTALCT ($\gamma = 0.05$, $p \leq 0.05$) on the scale of deduction-assumption reasoning skills for students (CRI1). Figure PF2-12 indicated that students' perceptions of the actual-preferred interaction on the scale of Co-Operation (COOP_ENF) on deduction-assumption reasoning skills (CRI1) had a greater impact in classes with teachers who had high scores for overall critical thinking skills (induction, deduction, evaluation, inference, and analysis) (high TOTALCT). It seemed to be implied that it would be more beneficial for students with high COOP_ENF to be in classes with teachers who had high overall scores for critical thinking skills. That is, teachers with high TOTALCT appear to facilitate the participation between students and teachers or between students and their peers through class discussion, student tasks, and class activities in using ICT instructional material in their classroom environments.

Figure PF2- 12: Impact of the Interaction Effect of Students' Perceptions of Actual-Preferred Interaction of Co-Operation with Teachers' Critical Thinking Skills on Students' Critical Thinking Skills (Deduction and Assumption)

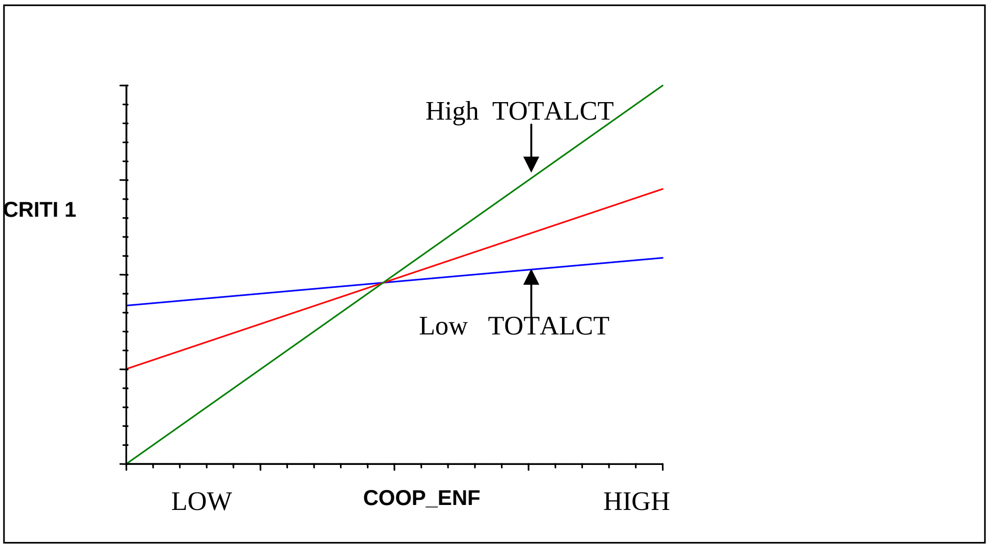
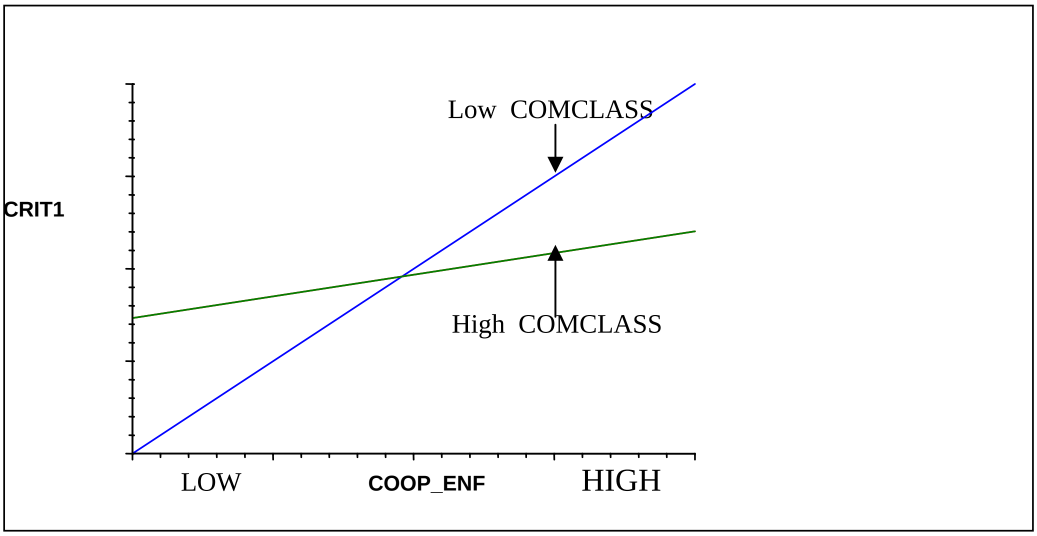


Figure PF2-13 presents the negative interaction effect for COOP_ENF and COMCLASS ($\gamma = -0.03$, $p \leq 0.001$) on deduction-assumption reasoning skills (CRI1). The positive impact of COOP_ENF on deduction-assumption skills was lessened when the students were in classes where teachers had more positive perceptions of the use of computers in their classroom (high COMCLASS). On the one hand, it could be implied that students who had more positive perceptions of the actual-preferred interaction on the scale Co-operation (would prefer more cooperation between students and their peers in the classroom) achieved higher scores in deduction-assumption reasoning skills with teachers who were interested in the use of computer in the classroom.

On the other hand, this finding can be taken to indicate that where students were taught by teachers who were less interested in using computer in their classroom, they developed higher levels of co-operation among themselves (COOP_ENF). They could share learning resources and work together in individual or group activities or student tasks, using a computer outside their classrooms, such as in the school library or the school computing room. Another possible explanation is that students with teachers who were more interested in using other instructional ICT equipments, such as television, video, camera, slides and multimedia in their classroom with ICT, may have higher deductive-assumption reasoning skills through the use of other ICT equipment than computer in the classroom.

Figure PF2- 13: Impact of the Interaction Effect of Students' Perceptions of the Actual-Preferred Interaction of Co-Operation with Teachers' Attitudes toward the Use of Computer in Classroom on Students' Critical Thinking Skills (Deduction and Assumption)



Variance Partitioning and Variance Explained

It is of interest to examine the variance components between student (level-1) and class-teacher (level-2) levels. Table PF2-67 presents this information for the fully unconditional (null) model and the final two level model. The first step, the null model, was estimated. The results in Table PF2-67 indicate that the proportions of available variance at level 1 and level 2 were 82.30% and 17.70% respectively. It means that 82 percent of the variance in the scores of deduction-assumption skills was found between the student level variables, while 18 percent could be attributed to variables at the class-teacher.

In the second step, estimates of variance components were calculated for the final, two-model, which had predictors at both level-1 and level-2. The results in Table PF2-67 explained the total available variance, with 13.02% of the variance attributed to factors at both student and class-teacher levels. The model explained around 3% of the variance available at the student level and nearly 62% of variance at the class-teacher level.

Table PF2- 67: Estimation of Variance Components and Explanation of Variance for Students' Critical Thinking Skills (Deduction-Assumption Reasoning Skills)

	Estimation of variance components between	
	Students	**Classes**
Number of Cases	150	16
Fully unconditional HLM model	9.67	2.08
Variance available at each level:	9.67 / 9.67 + 2.08 **= 82.30%**	2.08 / 2.08+9.67 **= 17.70%**
Final two-level HLM model	9.42	0.80
Proportion of variance explained by final two-level model:	9.67 – 9.42 / 9.67 **= 2.59%**	2.08 – 0.80 / 2.08 **= 61.54%**
Proportion of Total available Variance Explained:	(9.67 – 9.42) + (2.08 – 0.80) / (9.67 + 2.08) **= 13.02%**	

(b) Students' Attitudes toward the Use of Email [EMAIL] Generally

In the final stage two level of analysis at both student and class-teacher levels, two student variables (GENDER and RS_FIT) were found to be significant predictors of EMAIL at level-1. Only one variable (NET_H1) at the class-teacher level influenced EMAIL directly. In addition, one predictor of interaction effect (CT4) impacted on EMAIL at the level-2.

The final model for the variable, students' attitudes toward the use of email generally at level-1 and level-2 can be denoted in Equation 2. Details of results are illustrated in TablePF2-68.

Level 1 Model ***(Bold Italic: Grand-mean centred)***

Students' Attitudes toward the Use of Email =

$$\beta_0 + \beta_1 \text{(GENDER)} + \beta_2 \boldsymbol{(RS\_FIT)} + e$$

Level 2 Model

$$\beta_0 = \gamma_{00} + \gamma_{01} \text{(NET\_H1)} + u_0$$

$$\beta_1 = \gamma_{10} + u_1$$

$$\beta_2 = \gamma_{20} + \gamma_{21} \boldsymbol{(CT4)} \qquad \text{(Equation 2)}$$

Direct Effects

Table PF2-68 displays the direct effects that appeared from the HLM analyses of student and class-teacher level constructs on students' attitudes towards the use of email (EMAIL) generally. Thus, students' attitude toward the use of email was found to be influenced directly at the student level by GENDER and RS_FIT. GENDER ($\gamma = 5.31$, $p \leq 0.05$) had a positive impact on students' attitudes towards the use of email. It indicates that girl students had more positive attitudes towards the use of email in general than boy students.

In addition, RS_FIT ($\gamma = 0.89$, $p \leq 0.001$) had a positive effect on students' attitudes toward the use of email generally. It could be implied that students with more positive perceptions of teacher-student relationships (Relationships) in the classroom, revealed more positive attitudes toward the use of email generally. Overall girl students demonstrated more positive attitudes toward the use of email generally and had higher perceptions of teacher-student relationships in their classroom environments with ICT.

At the class level, only one predictor tested remained in the model as influencing students' attitudes toward the use of email generally. NET_H1 ($\gamma = -9.99$, $p \leq 0.001$) showed a negative effect. This means that students who were taught by teachers who accessed the Internet at home demonstrated more high positive attitudes toward the use of email generally. This finding is in contrast to the effect of NET_H1 on students' critical thinking outcomes.

There was one interaction effect for students' attitudes toward the use of email generally, as seen in Table PF2-68. One variable – students' perceptions of the actual-preferred Relationships (RS_FIT) - was assumed to have a fixed effect at level 2, because the reliability estimate of RS_FIT was below 0.05.

Table PF2- 68: Final Estimation of Fixed and Interaction Effects for Students' Attitudes toward the Use of Email Generally

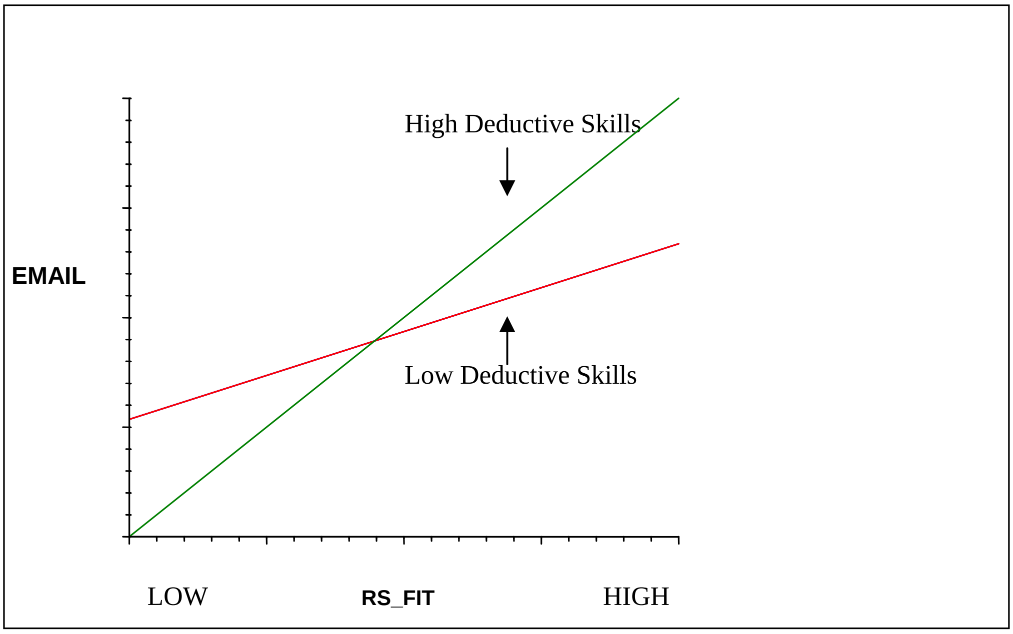
Fixed and Interaction Effects	γ - Coefficient	Standard error	T-ratio	P-value
Level 1/ Student-level effects				
GENDER	5.31	1.69	3.14	0.007
RS_FIT	0.89	0.24	3.69	0.001
+++ by CT4 on RS_FIT	0.95	0.46	2.07	0.040
Level 2/ Class-level effects				
NET_H1	-9.99	1.91	-5.23	0.000

Note: +++ Interaction effect

Cross-level Interaction Effects

Figure PF2-14 shows the positive interaction effect between RS_FIT and CT4 on students' attitudes towards the use of email generally (EMAIL $\gamma = 0.95$, $p \leq 0.05$). Figure PF2-14 also indicated that students' perception of teacher-student relationships on students' attitudes towards the use of email had a greater impact in classes with teachers who had high scores on deductive reasoning skills. It could be implied that it would be more beneficial for students with high perceptions of student and teacher relationships (high RS_FIT) to be taught in classes with teachers who had a high degree deductive reasoning skills (+++ by CT4 on RS_FIT $\gamma = 0.95$, $p \leq 0.05$). Where students had positive perceptions of effective ways of disseminating class information and class assignments between teachers and their students and were taught by teacher with high levels of deductive thinking skills, they were more likely to have positive attitudes toward email use generally.

Figure PF2- 14: Impact of the Interaction Effect of Students' Perceptions of the Actual-Preferred Interaction of Relationships with Teachers' Deductive Reasoning Skills on Students' Attitudes toward the Use of Email Generally



Variance Partitioning and Variance Explained

The variance components at between student (level-1) and class-teacher (level-2) levels are presented in Table PF2-69, for the fully unconditional (null) model and the final two-level model. In the first step, the null model, was estimated. The results showed that the proportions of available variance at student level and class-teacher level were 88.22% and 11.78% respectively. It means that approximately 88 percent of the variance in the perception level of students' attitudes toward the use of email could be found at the level of student variables, while around 12 percent could be attributed to differences at the level of class/teacher variables.

In the second step, an estimation of variance components was computed for the two-level model, which had predictors at both levels. The results overall indicated that 16.61% of the total available variance was explained by the final two-level model, around 15% of the variance available at the student level and nearly 30% of the variance at the class-teacher level.

Table PF2- 69: Estimation of Variance Components and Explained Variance for Students' Attitudes toward the Use of Email Generally

	Estimation of variance components between	
	Students	**Classes**
Number of Cases	150	16
Fully unconditional HLM model	53.79	7.18
Variance available at each level:	53.79 / (53.79 + 7.18) **= 88.22%**	7.18 / (7.18 + 53.79) **= 11.78%**
Final two-level HLM model	45.77	5.07
Proportion of variance explained by final two-level model:	(53.79 – 45.77) / 53.79 **= 14.91%**	(7.18 – 5.07) / 7.18 **= 29.39%**
Proportion of Total available Variance Explained:	((53.79 – 45.77) + (7.18 – 5.07)) / (53.79 + 7.18) **= 16.61%**	

(c) Students' Attitudes toward the Use of Email for Classroom [EMAIL_C]

In the final stage of analysis, only GW_ENFIT was found to be a significant predictor of EMAIL_C at the student level. Four variables at the class-teacher level, T_GENDER, COM_EX1, EMAIL_T, and NET_H1 influenced EMAIL_C directly. In addition, three interaction effect variables impacted on EMAIL_C at level-2.

The final model for the variable, students' attitudes toward the use of email for classroom, at level-1 and level-2 are denoted in Equation 3.

Level 1 Model ***(Bold Italic: Grand-mean centred)***

Students' Attitudes toward the Use of Email for Classroom

$$= \beta_0 + \beta_1 \boldsymbol{(GW\_ENFIT)} + e$$

Level 2 Model

$$\beta_0 = \gamma_{00} + \gamma_{01} (T\_GENDER) + \gamma_{02} (COM\_EX1) + \gamma_{03} \boldsymbol{(EMAIL\_T)} + \gamma_{00} (NET\_H1) + u_0$$

$$\beta_1 = \gamma_{10} + \gamma_{11} \boldsymbol{(COMFEEL)} + \gamma_{12} \boldsymbol{(EMAILCLASS)} + \gamma_{12} (SUBJECT1) \quad \text{(Equation 3)}$$

Direct Effects

Table PF2-70 illustrates the direct effects observed from the HLM analyses of the student and class-teacher level constructs on students' attitudes toward email for classroom use. Thus, students' attitudes toward the use of email in the classroom (EMAIL_C) were influenced directly and negatively at the student level by GW_ENFIT (γ = -0.09). It seemed that students who had a lower level of perception of the actual-preferred Group work environment (low GW_ENFIT) tended to have more positive attitudes toward the use of email in the classroom (high EMAIL_C). It could be implied that students who enjoyed working by themselves and did additional work on their own had noticeably more positive attitudes toward the use of email in the classroom than students who preferred to work together on group task or class activities. It could be implied that the use of email helped students to learn more by themselves and by doing extra work on their own, through better access to their teacher by using email as an information disseminator.

At the class-teacher level, four factors had direct effects on EMAIL_C. While T_GENDER ($\gamma = 6.77$, $p \leq 0.01$), COM_EX1 ($\gamma = 4.08$, $p \leq 0.001$) and EMAIL_T ($\gamma = 0.07$, $p \leq 0.05$) all had a positive impact on students' attitudes toward the use of email for classroom, NET_H1 ($\gamma = -2.59$, $p \leq 0.01$) showed a negative effect. Generally, students who were taught by female teachers had more positive attitudes toward the use of email in their classroom than students with male teachers. These results appeared to indicate that students in a class with teachers who had long computer experience had more positive attitudes toward the use of email for classroom. Further to this, teachers' attitude toward the use of email for classroom had a less pronounced class effect ($\gamma = 0.07$, $p \leq 0.05$). Its positive sign indicated that students with teachers, who had more positive attitudes toward the use of email for classroom, had themselves were positive attitudes toward the use of email in their classroom. Where classroom teachers preferred to use email instead of traditional class handouts as information dissemination to their classes, their students tended to have more positive attitudes toward the use of email in their classroom, due to the effective way of communicating class information and assignments.

In addition, NET_H1 showed a negative effect on students' attitudes toward the use of email for classroom. It could be hypothesised that students who were taught by teachers who could access the Internet at their home had more positive attitudes toward the use of email in their classroom.

The final estimation of fixed and interaction effects for the two-level HLM model for students' attitudes towards the use of email in their classroom are displayed in Table PF2-70. For students' attitudes toward the use of E-Mail for classroom, one variable – Group Work (GW_ENFIT) - was assumed to have a fixed effect at level 2, because the reliability estimate of GW_ENFIT was below 0.05.

Table PF2- 70: Final Estimation of Fixed and Interaction Effects for Students' Attitudes toward the Use of Email for Classroom

Fixed and Interaction Effects	γ - Coefficient	Standard error	T-ratio	P-value
Level 1/ Student-level effects				
GW_ENFIT	-0.09	0.13	-0.63	0.527
+++ by COMFEEL on GW_ENFIT	-0.03	0.01	-4.25	0.000
+++ by EMAILCL on GW_ENFIT	-0.08	0.02	-3.53	0.001
+++ by SUBJEC1 on GW_ENFIT	-0.64	0.18	-3.62	0.001
Level 2/ Class-level effects				
T_GENDER	6.77	2.08	3.25	0.008
COM_EX1	4.08	0.54	7.56	0.000
EMAIL_T	0.07	0.03	2.27	0.044
NET_H1	-2.59	0.69	-3.74	0.004

Note: +++ Interaction effect

Cross-level Interaction Effects

The results presented in Table PF2-70, revealed a total of two cross-level interaction levels for the dependent variable, students' attitudes towards the use of email for classroom (EMAIL_C). As well, Figure PF2-15 to Figure PF2-17 provide a visual representation of these interaction effects.

Figure PF2-15 illustrates the negative interaction effect between GW_ENFIT and COMFEEL (γ = -0.03, $p \leq 0.001$) on students' attitudes toward the use of email in their classroom (EMAIL_C). Students' perceptions of the actual-preferred interaction on a scale of Group Work (GW_ENFIT) and teachers' positive feeling toward the use of computer (COMFEEL) combine to influence for student attitudes toward the use of email for classroom (EMAIL_C) with (γ = -0.03, $p \leq 0.001$). This result seems to imply that students who worked in group environments (high GW_ENFIT), in classes where teachers' had lower positive feelings toward the use of computer (low COMFEEL), tended to have more positive attitudes toward the use of email in their classroom (high EMAIL_C). That is, if students were taught by teachers who felt that working with computers made their students isolated from others or found it difficult to understand computers for their own use (low COMFEEL), they tended to have more positive attitudes toward the use of email in the classroom. As well, these students appeared to be facilitated by subject teachers who encourage working together rather than on their own in using email in the classroom. The use of email could also make students feel more involved in sharing learning experiences with other students and their teachers in their classroom environment with ICT. In addition, classroom email use could help students to learn more and make lessons more interesting, enabling teachers to motivate their students to take more interest in class activities, participate in class discussions, work on group tasks, and work together through sharing with computer experiences, technological knowledge and skills.

Figure PF2- 15: Impact of the Interaction Effect of Students' Perceptions of the Actual-Preferred Interaction of Group Work with Teachers' Feeling toward the Use of Computer on Students' Attitudes toward the Use of Email for Classroom

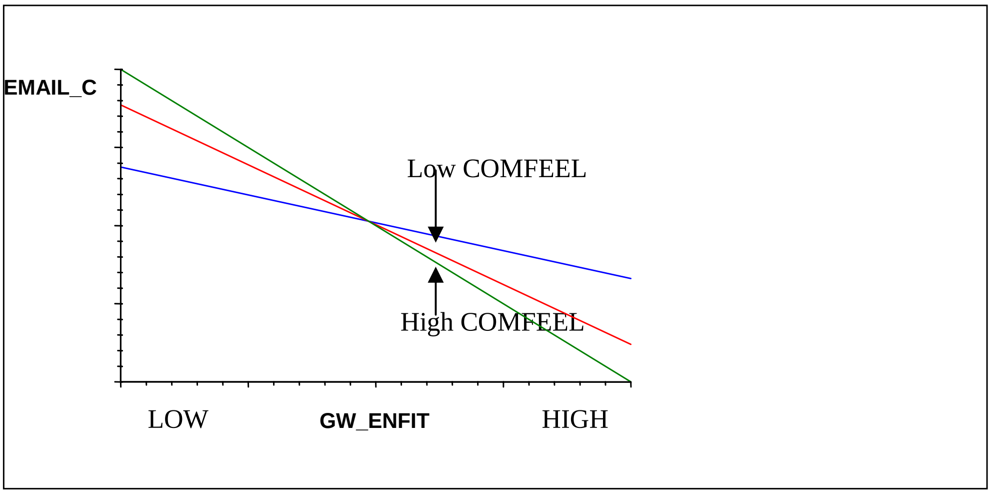


Figure PF2-16 indicates the interaction effect between students' perceptions of the actual-preferred interaction on a scale of Group Work (GW_ENFIT) and teachers' attitudes towards email use for classroom (EMAILCLA) for students' attitudes toward the use of email for classroom (EMAIL_C) with ($\gamma = -0.08$, $p \leq 0.001$). This means that students who preferred less group work (low GW_ENFIT), if and were taught by teachers with more positive attitudes toward the use of email for classroom (high EMAILCLA), tended to have themselves more positive attitudes toward the use of email in their classroom (high EMAILCLA). Where teacher used email to make students feel more involved in working together and providing better learning experiences, the students appeared to be more willingly to adapt the use of email in the classroom. They also appeared more include to work together and learn from one another through using email in the classroom (+++ by EMAILCL on GW_ENFIT $\gamma = -0.08$, $p \leq 0.001$).

Figure PF2- 16: Impact of the Interaction Effect of Students' Perceptions of the Actual-Preferred Interaction of Group Work with Teachers' Attitudes towards the Use of email for Classroom on Students' Attitudes toward the Use of Email for Classroom

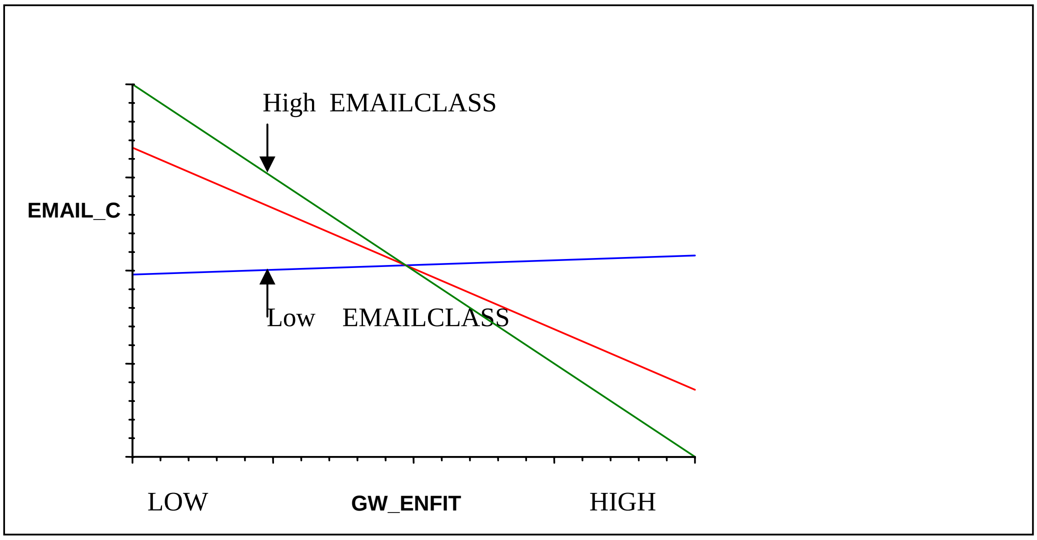
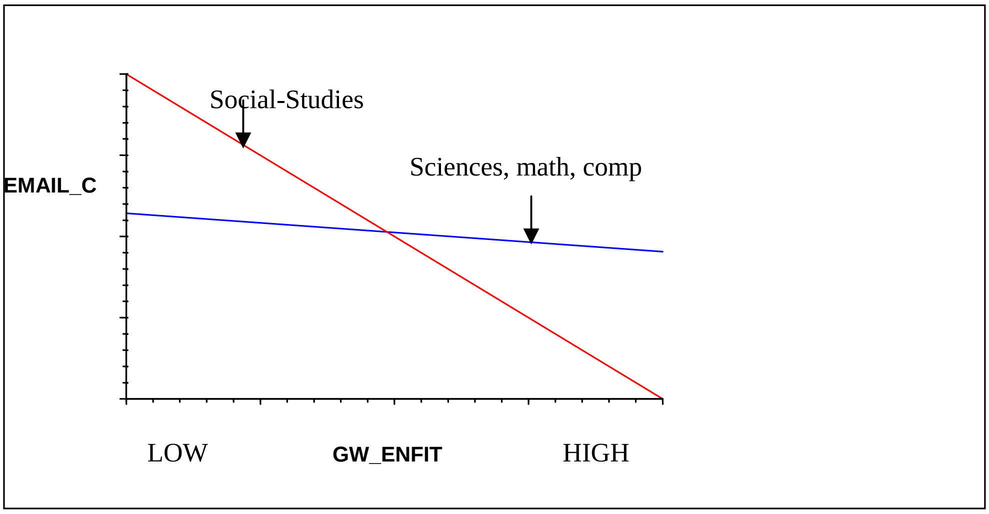


Figure PF2-17 illustrates the negative interaction effect between students' perceptions of the actual-preferred interaction on a scale of Group Work (high GW_ENFIT) and different subject areas of teachers (SUBJECT1) for students' attitudes toward the use of email for classroom (high EMAIL_C) with ($\gamma = -0.64$, $p \leq 0.001$). This result would seem to imply that among those who favoured a classroom environment with more group work, students who studied sciences, mathematics, and computer or Information Technology (IT) subjects recorded more positive attitudes toward the use of email in their classroom (high EMAIL_C) than students who studied social studies-arts subjects. That is, if students, in classes where they were able to work together with one other, were taught by science, mathematics, and computer or Information Technology (IT) teachers, who tended to be motivated to use email in their classroom, these students might be helped to learn more and find their lessons more interesting. The results would also indicate that the use of email for classroom could make students feel more preferred to work in groups to share learning experiences with one other and carry out class discussions, student tasks, group projects, and class activities.

Figure PF2- 17: Impact of the Interaction Effect of Students' Perceptions of the Actual-Preferred Group Work with Teachers Who Taught in Different Subject Areas on Students' Attitudes toward the Use of Email for Classroom



Variance Partitioning and Variance Explained

Table PF2-71 presents the variance components between student level and class-teacher level for the fully unconditional model and the final model. The results of the null model estimates demonstrated that the proportions of available variance at student level and class-teacher level were 78.82% and 21.18% respectively. This means that around 80 percent of variance in the level of attitudes toward the use of email for classroom was found between student level variables while approximately 20 percent could be assigned to differences between the variables at the class level.

In the second step, estimates of variance components were calculated for the final model, which had predictors at both level-1 and level-2. The results, given in Table PF2-71, showed that 25.29% of the total of available variance was explained by the final model at both levels. This represented around 5% of the variance available at the student level and nearly 100% of variance at the class-teacher level.

Table PF2- 71: Estimation of Variance Components and Explained Variance for Students' Attitudes toward the Use of Email for Classroom

	Estimation of variance components between	
	Students	**Classes**
Number of Cases	150	16
Fully unconditional HLM model	31.79	8.54
Variance available at each level:	$\frac{31.79}{31.79 + 8.54}$ **= 78.82%**	$\frac{8.54}{8.54 + 31.79}$ **= 21.18%**
Final two-level HLM model	30.11	0.02
Proportion of variance explained by final two-level model:	$\frac{31.79 - 30.11}{31.79}$ **= 5.28%**	$\frac{8.54 - 0.02}{8.54}$ **= 99.77%**
Proportion of Total available Variance Explained:	$\frac{(31.79 - 30.11) + (8.54 - 0.02)}{31.79 + 8.54}$ **= 25.29%**	

The findings from the two HLM analyses confirmed Proposition 4, because there were associations among students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom learning environments and student outcomes (students' critical thinking skills and students' attitudes toward ICT) in relation to teacher factors (teachers' critical thinking skills and teachers' attitudes toward ICT). In the case of only three outcome variables, however, these associations were at the significant level.

2.5 CONCLUSION TO PART 2

Part 2 of the portfolio outlined the validation of the adapted Thai versions of the research instruments used to gather the quantitative data (NCEI, CCTT, and TAT). The selection of the respondents and the collection of data from 150 students and 16 teachers from eight schools in the ICT schools pilot project in Thailand were then discussed. The various statistical techniques (t-test, simple regression, multiple regression and multilevel analysis), which were used to analyse the questionnaire data, were explained and the results presented. From the analysis of the quantitative data, it was possible to draw the following conclusions, for those involved in the ICT schools pilot project in Thailand, concerning the associations and interaction effects among teacher and student background variables, students' perceptions of ICT classroom environments and student outcomes.

(a) There were differences between students' perceptions of their actual and preferred classroom learning environments with ICT.

(b) Students' perceptions of classroom learning environments with ICT and student outcomes differed according to students' individual background characteristics (student gender, academic background, computer experience, and computer usage).

(c) Two student critical thinking outcomes (a deduction-assumption and induction-credibility reasoning thinking skill outcomes) were statistically significantly correlated with two individual characteristics (subject areas and school levels) and two classroom environment scales (Co-Operation and Teacher Support). Therefore, there was partial support for the relationships between student' individual background characteristics, students' perceptions of classroom learning environments with ICT and two critical thinking skills.

(d) Students' individual background and all classroom predictors were related to three student attitudes toward ICT use (Email for Classroom, ICT Involvement, and Email Use). In addition, students' individual characteristics (gender, academic background, computer experience, and computer usage) and their perceptions of ICT classroom environments combined to have small associations with students' attitude towards ICT, although these were not statistically significant for all six-attitude outcomes. These results represent only partial support for proposition 3.

(e) There were associations among students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom environments and student outcomes (students' critical thinking skills and students' attitudes towards ICT) in relation to teachers' critical thinking skills and teachers' attitudes toward ICT. For most variables, the associations were not statistically significant.

Overall, the results supported the research model in which students' perceptions of classroom learning environments with ICT constituted a variable in its own right, rather than mediating the relationships between individual characteristics and student outcomes.

PART 3

A QUALITATIVE INVESTIGATION OF THE ICT SCHOOLS PILOT PROJECT IN THAILAND

3.0 INTRODUCTION

Part 3 of the Research Portfolio represents a qualitative investigation of the ICT schools pilot project in Thailand. The study sought to focus on the project's outcomes at two levels – the School/Teacher Level and the Student Level. As with most qualitative research, the main perspective adopted for data gathering and the interpretation of data was that of the participants involved in the phenomenon being investigated (Creswell, 2003, p.182). In the case of this study, the outcomes of the ICT schools pilot project in Thailand were being investigated through the eyes of the students and teachers who were interviewed and the teachers, principals, and university supervisors who carried out the on-going reporting and evaluation of the project. The third strand of qualitative data used in this study was the researcher's observation of ICT classrooms in the pilot project schools. In this case the perspective adopted was the complementary one of a Thai university based ICT education specialist.

The first section of Part 3 presents the qualitative analysis of school based reports and evaluation documents gathered over the course of the project and used by the researcher for a thematic analysis of the project's outcomes. The second section discusses the two qualitative methods used to collect data. In relation to interviews with participants, the procedures and sampling used are outlined, as well as the structure and management of the interviews and the questions asked. The procedures used in the other major data collection, classroom lesson observation, are also explained, together with the method of analysis used for the observational data. Section 3 provides an analysis of both the interview and classroom observation data in terms of students' perceptions of their ICT classroom learning environments and student outcomes.

3.1 SCHOOL LEVEL

The first section of the qualitative investigation focussed on the experiences of the ICT model schools, as recorded in documents prepared over the course of the pilot project. These provided important insights into how the introduction of ICT as a teaching and learning tool affected the operation of the school and the extent to which it impacted on the role and effectiveness of teachers. Creswell (2003, pp. 187-190) has argued that such documents directly express the participants' points of view, in their own words, and represent data which have not been influenced by the researcher.

3.1.1 The Role of the Participating Institutions

As outlined in the introduction to the Portfolio, three groups of institutions were involved in the ICT schools pilot project in Thailand. Further details of the participants and their particular roles in the project are given below.

(a) The Office of the Basic Education Commission (OBEC)

OBEC and Office of the Permanent Secretary (OPS) under the Ministry of Education worked together in allocating money to all the ICT schools. They were also responsible for monitoring and evaluating, involving the achievements of the model ICT schools continuously and systematically over the three year operating period. The other main responsibility of the OBEC was to coordinate and conduct the Research Development (R&D) with the three major parties together with other relevant government or private institutions. Overall OBEC was the major coordinator of the project, seeking specific and helpful participation from relevant government or private organisations, such as the Ministry of Information and Communication Technology, National Science and Technology Institution, National ICT Learning Centre, and ICT software companies who provided the computer equipment, software, ICT Network, and Multimedia for all model ICT schools.

(b) The Supervising Universities

The seven supervising universities were important parties. They supported the human resource development of students, teachers, and school staffs in model ICT schools through providing training in basic and advanced ICT knowledge and technological skills, which were necessary to enable the subject or ICT teachers to integrate ICT in their classrooms. In addition, each model ICT school incorporated the use of ICT into teaching and learning among classroom learning environments with ICT by teaching their students basic ICT knowledge and skills according to the methods the teachers knowledge had learned through the professional development provided by the universities. A particular focus of the formal guidance of each supervising university was the promotion of learners' development activities for individual learners.

(c) The Model ICT Schools

The model ICT schools had the role of practical implementation of the project. They introduced the ICT-integration into the teaching and learning process, self-learner development, and school managements in their schools. The model ICT schools also agreed to implement school policies to persuade all subject teachers to use ICT as an instructive tool through various classroom learning activities. In addition, the leading ICT teachers had the role of transferring basic and advanced ICT knowledge and technological skills to school teachers who taught in any of the eight groups of basic subjects.

3.1.2 Sources of Data

As mentioned above, OBEC was responsible for the on-going evaluation of the ICT schools project. This was based on a range of documents collected over the total period of the project. These are outlined below.

- preliminary reports of each pilot school's ICT needs;
- Each school's ICT strategic plans, including lesson plans, learning activities and professional development plans;

- The reports of meeting at each model school between principals, administrators, teachers, and staff from supervising universities, in order to share their views and exchange experience;
- School assessment reports, both internal and those of the external assessment committee made up of university staff, ICT consultants and school principals.

These documents were used as the basis of *Summary report of school model of excellence in learning with ICT: Pilot Study in 12 schools* (Bureau for Innovative Development in Education, 2006b) and *Research and Development (R&D) for the ICT Schools Pilot Project in Thailand* (Bureau for Innovative Development in Education, 2006a), published by the Bureau for Innovative Development in Education, part of the Ministry of Education in Thailand. Copies of the actual documents were included as the appendices to these reports. The reports were available to interested members of the public.

In this part of the Portfolio, focussed on qualitative analysis, the reports included in the appendices were treated as original documents from the participating schools and supporting institutions of the Thai government's ICT schools pilot project. They represent important data concerning the history of the project's development and implementation, as well as the nature and extent of its achievements. In this sense, they can be used as primary data for qualitative analysis (Creswell, 2003, p. 190).

3.1.3 School Outcomes from Project Documents

After an initial reading of all the reports, it was possible to identify five themes, which could be used to analyse and categorise the data. As far as possible, these were related to the school and student outcome variables, used in the quantitative analysis. However, one school outcome which emerged in these data was unexpected, or unintended, in the sense that it had not specifically been planned for.

3.1.3.1 The Effects on School Administration

Most of the model ICT schools reported major changes in school administration and management, through the use of ICT as an administrative tool. This was a positive outcome evident in the report documents (particularly the schools' strategic plan and the reports of school/ university meetings), which had not been specifically anticipated in the planning. The administrative improvements can be categorised in the following ways.

(a) The model ICT schools developed and improved a database system by using ICT for school networking. This enabled school administrators to accelerate school efficiency and effectiveness through reducing school time management, more efficient managing of personnel, controlling the over-use of school materials, and arranging better resource utilisation. In addition, the Office of the Basic Education Commission (OBEC) provided database systems, which organised student-teacher database systems through online schooling. This was able to assist school teachers, personnel and other staff to manage and arrange database which led to a reduction in school time management and increasing school budgeting efficiency. However, all model ICT schools had to set up one, or more than one, team of teachers to enter and update the databases, for student personal data (e.g. study enrolment, school and service fees) and student performance data (e.g. student scores, school grades, and students' performance results).

(b) All schools began to use ICT to communicate with students and their parents. The school's website and online networking posted news about school activities and information about students' scores and their performance results. Moreover, the school website was used as a means for students to receive messages from school continuously, involving timetable changes, school enrolments, appointments with students and their parents, and announcements of student parent meetings.

(c) In particular, school guidance teacher maintained public relations and made announcements about academic and school services through school's website through digital or online material resources, such as Electronic-classroom (E-classroom), Digital Library, and Resource Centre, and other relevant ICT resources.

(d) School teachers used ICT-related technologies that included online network, the school's intranet which provided real time and asynchronous online learning opportunities for students. They also used the Internet to demonstrate students' and teachers' achievements by posting examples of their students' work and learning outcomes on the school website.

(e) Students' and teachers' outputs were presented on the school's webpage, which enabled schools to promote their reputation not only to stakeholders, such as students, teachers, school staff, students' parents, but also to the general public. ICT thus became the means of making the community proud of their school's achievement and the students' performances.

3.1.3.2 The Effects on Human Resource Development

Each model ICT school needed to train groups of subject teachers, staff and educational personnel who were interested in integrating ICT into teaching and learning process and incorporating ICT into school management. Importantly, teachers were given a basic and advanced understanding of knowledge and technological skills concerning ICT and the use of ICT applications for classroom teaching. The schools' strategic plans and the records of the schools' meetings with university supervisors provided evidence of the procedures adopted for the professional development of teachers and school administrative staff. These are outlined below.

(a) Each model ICT school established an individual or a small group, drawn from subject teachers, school administrative staff, or other relevant personnel, with responsibility to monitor, evaluate, and assess the school performance results. These people received training in the use of computer and ICT through the supervising university, OBEC, or relevant government or private organisations.

(b) Each model ICT school set up one or two teams of leading ICT teachers who were given the chance to receive specialist training in computer and ICT application skills from the supervising university.

(c) Each model ICT school expanded the integration of ICT usage into teaching and learning process among classroom learning environments with ICT for subject teachers who taught in eight groups of basic subjects. In this process, the leading ICT teachers transferred basic technological knowledge and basic application skills to other teachers in all subject areas. This represented a process of continuous professional upgrading through participating in a variety of personal computer or ICT course training.

3.1.3.3 The Effects on the Teaching and Learning Process

The strategic plans submitted by each school and the reports of the meetings between each school' staff and the supervising universities provided many examples of the way the incorporation of ICT into the classroom helped to transform the teaching and learning process. These are discussed below.

(a) The specialist ICT teachers from the Art, Career and Technology-related Education grouping, worked with teachers from other subject areas to develop more interesting instructional materials. As well, some ICT classroom teachers in all subject areas prepared various assignments that included working tasks, homework, school projects, and other relevant class activities for their students, in order to encourage them to generate attractive and professional products through the use of ICT. In addition, the school ICT or subject teachers discovered a variety of students' learning sources to motivate individual students' self-developed learning and students' individual interests to achieve a higher standard of students' performance results, such as good grade scorings for students.

(b) Perhaps the most innovative outcome was development of activities to promote students' individual learning potential through making available learning opportunities to follow their own interests in a variety of environments outside the immediate classroom. Examples of such students' self learning opportunities included ICT Camps, and ICT Clubs. Specific examples are described below.

> School E formed a computer laboratory ('lab'), which was called "Public Net for Child". This lab gave students a chance to prepare and conduct their own research reports by using the internet. Children were permitted to access computer or ICT in the school lab to complete their assignments before or after normal study hours. Student took advantage of this opportunity to spend time, searching, organising, analysing information from the internet, presenting ideas, and discussing and evaluating results with others, through online communication tools such as email.

Most of students completed their various school task projects or activities by spending time in this room.

School B gave their students, as well as other interested learners who were not in the school, a chance to access computers or the internet in a computer laboratory ‘lab’ anytime, so long as it was outside class hours. In addition, the school operated and provided a variety of computer training courses for their students, or other learners who were interested in attending, during school weekends or school breaks.

School H trained some leading ICT students who acted as computer or ICT tutors to introduce or assist students’ parents who desired to spend some time in the school computer ‘lab’, searching for information, reading online newspapers from the internet, or other activities before or after study hours.

(c) Throughout the course of the project, leading ICT teachers in all model ICT schools continued to work together with the subject teachers, assisting and guiding them in integrating ICT into their teaching and learning process. In this way a number of advanced ICT applications and technological techniques were introduced into classroom teaching and learning. Most model ICT schools divided teachers into two groups, each with a leading ICT teacher to work with the subject teachers. As the subject teachers constructed lesson plans, subject content, work activities, instructional materials, learning assessments and evaluations, they were being trained and facilitated by the leading ICT teacher in their team to use computer software and hardware in their teaching and learning processes.

(d) School students were also stimulated to learn through external electronic learning sources, that included their school website, and other relevant websites. They were able to gain the benefit of gathering real world experiences in visiting natural learning sources such as the community learning centre, the National ICT Learning Centre, the Thai Knowledge Park (TK Park), and other relevant external learning sources.

3.1.3.4 The Effects on ICT Learning Sources

The strategic plans and reports of school meetings with university supervisors showed clearly that all model ICT schools sought to construct and generate electronic learning sources, which particularly integrated ICT or computers into teaching and learning process in a variety of classroom environments with ICT. They began to make use of database computer software, such as websites for learning, Web-Based Instruction, online lessons and digital contents. From such computerised learning sources, staff, as well as students were able to access basic knowledge, lesson contents, computerised or technological theories, ICT or educational technological researches, and innovative explorations in the use of ICT.

Details of electronic learning sources they used are described in the following section.

(a) ***Websites for Learning***: Some of the model schools set up websites for incorporating ICT into teaching and learning process. These were established by some of ICT teachers who taught in subjects in eight groups of teams of ICT specialist and subject teachers. These websites were used within the school as computerised learning sources for supporting and promoting students' development learning, through school website or other relevant websites. These Websites for Learning or Web-Based Instruction were mostly incorporated into the website of the school or the Ministry of Education.

(b) ***Online Lessons and Digital Contents***: In particular, subject and ICT teacher teams worked together to create online lessons, or digital contents, on their school website. In the first step, the subject teachers designed, and prepared lesson plans, lesson materials, learning activities, pre-tests (used before instruction), post-tests (used after instruction), and other relevant learning and instructing process to post on the school website. Then, these online lessons and digital contents were guided and co-established by ICT teachers or school ICT coordinators by using the various ICT techniques, such as interactive classroom environments with video clips, sound files, and other relevant advanced techniques to create an attractive variety of online lessons and digital contents. In addition, some model ICT schools gathered student reports, school projects, and student or teacher outputs or products to post on the school webpage, in electronic forms such as Flip Album, PDF files, and E-Library, Electronic-book (E-Book).

3.1.3.5 The Effects on Self-Development of Learners

One of the major aims of model ICT schools under the Thai ICT schools pilot project was to enable students to develop at their own pace and to maximise their individual potential through the possibilities made available by ICT-integration into their classroom learning environments. Students in these model schools were given a chance to use ICT or computers as a learning tool in different ways in the different subjects. The extent and the effectiveness of these self learning opportunities both inside and outside the classroom depended on the particular the school context and on individual teacher background characteristics. Specific examples of the opportunities for students are provided in the following sections.

In most schools, however, the strategic plans and meeting reports provided evidence that the schools' efforts to integrate ICT into classroom learning and teaching processes resulted in students being able to apply and use a greater body of knowledge. They had learned to increase and promote their own learning interests and develop their capabilities through accessing instructional materials for themselves. Moreover, some model ICT schools maximised these opportunities by permitting their students to access computer hardware and software and the internet in the pursuit of their own interests.

In these student initiated activities, however, school teachers were no longer able to control or limit the scope of their students' imaginations. Most students formed school activities such as computer clubs, ICT clubs, ICT camps, and other relevant clubs, with their subject or ICT teachers, in response to students' individual learning interests. There was one interesting example, where students conducted mass media projects, working in a team as professional TV directors, DJs, VDOs, photographers, as well as creating and controlling robot-by-robot programming to handle this project. This project directly supported the self-development of different students' interests through the use of ICT. Since those model ICT schools were linked by a common cabled computer and media network, students were able to write, produce, and present their own television programs that were broadcast on the school network. However, that school teachers were required to facilitate their students in creating and constructing these new ideas or projects, rather than to control or guide them as teachers.

3.1.4 Overview

The analysis of school level qualitative data has provided important insights into the achievements of the ICT schools pilot from the teachers' and supervisors' perspective. The positive outcomes most clearly evident in the documents included in the official Ministry of Education reports on the project, can be summarised as:

- improvements to school administration;
- the professional development of teachers in ICT skills and knowledge;
- incorporating of ICT technology into the day to day teaching of all subjects in the curriculum;
- development of ICT-based learning resources; and
- the provision of ICT technology and resources for individual students to use in their own self-development.

The next section presents a qualitative investigation of the project's achievements from the students' perspective.

3.2 STUDENT LEVEL

In the section that follows the methods used for analysis and the collection of qualitative data are discussed. The focus of this part of this study was understanding the achievements and limitations of the project at the level of students' outcomes – both in terms of their critical thinking skills and their attitudes to ICT.

3.2.1 Qualitative Methods

For the qualitative investigation of student level outcomes, I explored participants' perceptions of their classroom learning environments with ICT through interviews with individual students and a few teachers. The purpose was to examine their attitudes toward ICT more deeply in order to provide data to supplement, expand, and support the quantitative results in Part 2 in this Portfolio. The interviews were particularly important because open-ended and in-depth questions were used which encouraged students and teachers not only to talk about the advantages and disadvantages of their classroom learning environments with ICT, but also to discuss the incentives and disincentives in the use of ICT in classroom learning environments to develop students' critical thinking skills. The opinions expressed by students and teachers directly reflected their observations and interpretations, derived from their experiences of being involved in the pilot project for introducing ICT into all subjects in all schools in Thailand.

Moreover, as a researcher, I had the opportunity to observe students' learning processes in classrooms where ICT was being integrated into students' activities, assignments, and individual tasks or work in their ICT classroom environments. The classrooms observed covered the five subject areas of science, mathematics, computer or IT, social studies, and English languages. Each lesson was classified for teaching and learning levels by the researcher, according to Bloom's Taxonomy (Woo, 1999, September 17) of six categories of critical thinking processes to be explained more fully in 3.2.1.3.

3.2.1.1 Ethical Considerations

The proposal for this research was submitted to the University of Adelaide's Ethics Committee which gave approval to the methods and ethical safeguards outlined. Confidentiality was a major ethical issue in the qualitative investigation. Assurances were given to all those participating in interviews and classroom observations that their privacy would be respected.

- Individuals or schools would not be identified in published results arising from the study.
- Participants could withdraw themselves or any information they provided, at any time.
- Interview participants would be asked whether they would allow the interview to be audio-taped.
- Permission would be sought from classroom observation participants before video recordings were made.

- Only I, as the researcher, would complete the transcriptions of all interviews and observations, and no names would be used to maintain confidentiality.

Ethical approval for the research was sought and given by the 13 ICT school principals, the chief of the curriculum subject teachers, the ICT teachers, and the staff member of the Bureau for Innovative Development in Education in the Office of the Basic Education Commission under the Ministry of Education who was the project coordinator of the ICT schools pilot project in Thailand.

3.2.1.2 Interviewee Respondents, Procedure and Analysis

Students and subject or ICT teachers from the 13 model ICT schools were approached and asked if they would be willing to be involved in an open-ended in-depth interview. Out of these, 30 students and five teachers from 10 of the schools agreed to participate in the qualitative interview approach. Fortunately, students and teachers who volunteered to participate in the interviews in this study came from the same ICT schools (School A, B, C, D, E, F, and H) who joined in the questionnaire surveys, together with three model ICT schools (School G_a, I, and J) who joined the project later.

I explained my interview process to the participants before proceeding. The students and teachers were assured of confidentiality and strict anonymity. I also gave some details about the definition of critical thinking skills by providing some sample behaviours to them, because there were some interview questions concerning critical thinking skills. I interviewed all participants personally. The teachers were interviewed individually, and the students in small groups of two or three. All of them gave permission for me to record the interview on tape. Each interview took approximately 30 minutes to complete with the individual or small group involved.

The open-ended interview questions encouraged the students to talk about the advantages and disadvantages of their classroom learning environments with ICT in their schools and those characteristics of their teachers that supported or prevented their critical thinking skills. In addition, the teacher interviews included questions concerning teachers' attitudes toward the use of ICT and aspects of teachers' personalities, which stimulated or obstructed their students' critical thinking skills. Teachers and students were encouraged to explore a range of related factors and associated issues that motivated or inhibited them from using ICT through ICT-integration into teaching and learning processes in the classroom.

The interview schedules were as follows:

For students

1. What benefits or advantages do you get from the use of ICT in your classroom learning environment?
2. What costs, losses or disadvantages are there for you arising from the use of ICT in your classroom learning environment?
3. Are there any problems using ICT and network facilities for your subjects? If yes, what strategies did you use to solve the problem?
4. What kind of learning support do you expect from your teacher to assist you with ICT?
5. What are the skills and attributes of teachers who support you effectively in improving your critical thinking skills?
6. What are the attributes and personality traits of teachers who discourage or obstruct your critical thinking skills?
7. How do you think the use of ICT improves your critical thinking processes?
8. The government wants to introduce ICT with all schools for all subjects. Is this a good idea? Are there limitations? What do you think?

For teachers

1. How do you apply the use of ICT to support students' critical thinking skills?
2. How is student-self learning applied using ICT in your classroom environment?
3. How could you better design your subject or course to develop your students' critical thinking skills?
4. How could you better support students' critical thinking skills?
5. What is your opinion about the use of ICT? What are the advantages and disadvantages?

6. What are the needs of teachers as facilitators of ICT in classroom learning environments?
7. What are the main roles of teachers in classroom learning environments with ICT?
8. What are the particular skills and attributes of teachers who stimulate students' critical thinking skills?
9. What are the specific attributes and personality traits of teachers who impede students' critical thinking skills?
10. The government wants to introduce ICT into all schools for all subjects. Is this a good idea? Are there limitations? What do you think?

All students' and teachers' interviews were recorded by audio-tape recorder and then were transcribed by the researcher. To provide realistic insights, data from the interviews were not edited for grammatical accuracy, but rather presented in verbatim form. However, the interviews, which were all in Thai, had to be translated into English by the researcher who tried to ensure, as far as possible, that the original meanings were not lost.

The interview responses were manually coded into descriptive or interpretable categories by the researcher (Miles & Huberman, 1994). I started the analysis with the longest and most complex interview, following the advice to "categorise richly and to code liberally" (Richards & Richards, 1995). The categorised data were then entered into a spreadsheet in computer data files. The six categories used were as follows:

(a) The positive attitudes toward the use of ICT (Advantages of the use of ICT)
(b) The negative attitudes toward the use of ICT (Disadvantages of the use of ICT)
(c) Problems concerning the use of ICT
(d) Teachers' characteristics that encourage or discourage students' critical thinking skills
(e) Effect of ICT-integration into teaching and learning process on the development of students' critical thinking skills
(f) Desirability of the introduction of ICT-integration into teaching and learning for all subjects in all schools in Thailand.

The categorised responses were then coded into a frequency table. The interview data, analysed in this way, were mainly used for descriptive purposes and to assist in interpreting the results of other data (questionnaire surveys and observations).

3.2.1.3 Classroom Observation, Selection, Procedure and Analysis

When I approached all the model ICT schools, fortunately I received confirmation from 22 subject or ICT teachers from all 13 model ICT schools (school A, B, C, D, E, F, G, H, I, J, K, L, and M) that they would participate in my study. I contacted them immediately to agree on a time to discuss my data collection process through classroom observations in their class. I explained my classroom observation process for collecting data to each ICT teacher to confirm what I would do during their class hours (about 50-60 minutes). I told them that because I needed to understand their lesson plan thoroughly, all classroom observations needed to be recorded by video camera. Furthermore, it would be helpful if I were provided with their lesson plans in advance. All the teachers complied with this request to facilitate my observations of their classrooms.

Following these procedures, I observed 22 classrooms, which integrated ICT into teaching and learning among classroom learning environments with ICT in all model ICT schools under this pilot project in Thailand. These classes included all five subject areas – science, mathematics, computer or IT, social studies and English languages.

The observation field notes of the classroom lessons proved to be more useful than the video-recording in the analysis and interpretation of the lessons. I used the learning levels from Bloom’s Taxonomy (Paul, 1989; Paul & Willsen, 1995; Woo, 1999, September 17) to provide a six-tiered classification framework of student learning outcomes. Benjamin S. Bloom is a recognised name in educational research of the twentieth century. Together with his colleagues, he undertook the challenging task of creating a taxonomy of educational objectives. Instead of examining how to teach, what to teach, or when to teach it, Bloom focused his research on outcomes. Thus, Bloom’s research “focused educators on students’ learning outcomes… what students should know and be able to do” (Woo, 1999, p.22). The taxonomy provided a six-tiered framework of educational learning outcomes, with each learning level clearly defined. These learning levels form a hierarchy that is organised by cognitive complexity, in that the lower level abilities are also needed for proficiency at each successive level.

Bloom's classification could be applied to the observations of the Thai ICT classrooms and the different instruction used in the various subject areas. The six-tiered classification framework of students' learning outcomes represented an organised hierarchy of students' learning levels and critical thinking processes from the lowest to the highest: gathering knowledge, comprehension, application, analysis, synthesis, and evaluation. The criteria for these learning levels were summarised by the researcher, and used to categorised students' classroom activities or assignments such as task activities, work, and other relevant work in each classroom lesson. Each lesson was assigned an overall classification based on the categorisation summarised in Table PF3-1.

Table PF3- 1: The Six Learning Categories of Bloom's Taxonomy for Teaching and Learning Processes

Learning Levels	Definition	Sample cues
Knowledge (Level I)	Student recalls or recognises information, ideas, and principles in the approximate form in which they were learned.	write, list, state, define, label, quote, name, who, when, where
Comprehension (Level II)	Student translates, comprehends, or interprets information based on prior learning.	Explain, summarise, paraphrase, describe, illustrate
Application (Level III)	Student selects, transfers, uses data and principles to complete a problem or task with a minimum of direction.	Use, compute, solve, demonstrate, apply, construct
Analysis (Level IV)	Student distinguishes, classifies, and relates the assumptions, hypotheses, evidence, or structure of a statement or question.	Analyse, categorise, compare, contrast, separate
Synthesis (Level V)	Student originates, integrates, and combines ideas into a product, plan or proposal that is new to him or her.	Create, design, hypothesise, invent, develop
Evaluation (Level VI)	Student appraises, assesses, or critiques on a basis of specific standards and criteria.	Judge, recommend, critique, justify

A more detailed description of Bloom's six learning levels as applied to the Thai ICT classroom observations is given below.

- **Level I - Knowledge**

The knowledge objective is primarily concerned with the recall or remembering of facts and information (processes, directions, criteria, methodology), as well as the use of cues to retrieve information from the students' mind file. Therefore, at this level the student is able to recall, restate and remember learned information.

- **Level II - Comprehension**

This is considered the lowest level of understanding and involves interpreting the materials. "The emphasis is on the ability to grasp the meaning and intent of the material." (Bloom, 1956, p.89) Therefore, the student can show his or her comprehension of the meaning of information by interpreting and translating what has been learned.

- **Level III - Application**

"A demonstration of comprehension shows that a student can use an abstraction when the use is specified. A demonstration of application shows that he or she will use it correctly, given an appropriate situation, without prompting" (Bloom, 1956, p.120). In other words, the student has ability to apply information or concepts in another familiar situation, or in problem-solving by using the information in a context different from the one in which it was learned.

- **Level IV - Analysis**

This outcome involves the learners being able to sort through the elements, relationships, or organisational principles of the material, in order to understand its organisational structure. Therefore, the student can break learned information into parts to explore better understanding and relationships.

- **Level V - Synthesis**

Synthesis requires "… the putting together of elements and parts so as to form a new whole… the students must draw upon elements from many sources and put these together into a structure or pattern not clearly there before" (Bloom, 1956, p.162). This can be thought of as using previous knowledge to create new concepts, relating knowledge to several areas, predicting, drawing conclusions and hypothesising. The student can therefore create new products, ideas, information, or ways of viewing things, by using what has been previously learned.

- **Level VI - Evaluation**

This level is defined as “the making of judgments about the material. It involves the use of criteria as well as standards for evaluating” (Bloom, 1956, p.185). It can be both qualitative and quantitative and the criteria can be given, or determined by the evaluator. Learning outcomes are at the highest level here because they contain elements of all other categories. Therefore, the student can make decision or embark on a particular course of action based on in-depth reflection, criticism, and assessment.

Example behaviours from classroom observations, which highlight the difference in student outcomes at each learning level, are presented below.

- **Knowledge Level:** The student <u>defined</u> the 6 levels of Bloom’s Taxonomy of the cognitive domain.
- **Comprehensive Level:** The student <u>explained</u> the purpose of Bloom’s Taxonomy of the cognitive domain.
- **Application Level:** The student <u>wrote</u> an instructional objective for each level of Bloom’s Taxonomy.
- **Analysis Level:** The student <u>compared</u> and <u>contrasted</u> the cognitive and affective domains.
- **Synthesis Level:** The student <u>designed</u> a classification scheme for writing educational objectives that combined the cognitive, affective, and psychomotor domain.
- **Evaluation Level:** The student <u>judged</u> the effectiveness of writing objectives using Bloom’s Taxonomy.

Bloom’s six-tier model can usefully seen to fall into two levels. These are summarised below, in themes of observable behaviour of students in classrooms.

Basic-Understanding Learning Skills

Level 1: Knowledge
(e.g. the student is able to recall, restate, and remember learned information)

Level 2: Comprehension
(e.g. the student has the ability to grasp the meaning of information by interpreting and translating what has been learned)

Level 3: Application
(e.g. the student can use the information in another familiar situation)

Critical Thinking or Higher-order Thinking Skills

Level 4: Analysis
(e.g. the student can break learned information into parts to explore better understanding and relationships)

Level 5: Synthesis
(e.g. the student can generate new products, ideas, ways of viewing things or information, using what has been previously learned)

Level 6: Evaluation
(e.g. the student can make decisions based on in-depth reflection, criticism, and assessment)

Results from the classroom observations, analysed by applying six learning levels of Bloom's Taxonomy, can be regarded as relevant qualitative data for understanding any improvement in students' critical thinking skills through ICT-integration into teaching and learning process in classroom learning environments with ICT.

3.3 QUALITATIVE FINDINGS FROM INTERVIEWS AND CLASSROOM OBSERVATIONS

From the analysis of the interview and classroom observation data, I attempted to identify qualitative results, which would be useful in answering Research Question 7: What are students' perceptions of the classroom learning environments in ICT? and Research Question 8: How do students make use of classroom learning environment with ICT to improve their thinking skills?.

3.3.1 Participants' Background

Table PF 3-2 shows the details of student and teacher interviewees who come from 10 model ICT schools (School A, B, C, D, E, F, G_a, H, I, and J) under the Thai ICT schools pilot project. There were 30 volunteer students and 5 teachers who agreed to participate in the interview section in my study. In the analysis of interview data, that follows, the comments of the participants (Thai teachers and students) from each school are presented together.

Table PF3- 2: **Details of Interview Participants**

School	Grade Level	Student and teacher Label	Participant Label
School A	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3) *Teacher no. 1 (T1)*	AS1(student no.1 from school A) AS2(student no.2 from school A) AS3(student no.3 from school A) *AT1(teacher no.1 from school A)*
School B	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3) *Teacher no. 1 (T1)*	BS1(student no.1 from school B) BS2(student no.2 from school B) BS3(student no.3 from school B) *BT1(Teacher no.1 from school B)*
School C	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3)	CS1(student no.1 from school C) CS2(student no.2 from school C) CS3(student no.3 from school C)
School D	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3) *Teacher no. 1 (T1)*	DS1(student no.1 from school D) DS2(student no.2 from school D) DS3(student no.3 from school D) *DT1(Teacher no.1 from school D)*
School E	9	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3) *Teacher no. 1 (T1)*	ES1(student no.1 from school E) ES2(student no.2 from school E) ES3(student no.3 from school E) *ET1(Teacher no.1 from school E)*

continued

School	Grade Level	Student and teacher Label	Participant Label
School F	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3)	FS1(student no.1 from school F) FS2(student no.2 from school F) FS3(student no.3 from school F)
School G_a	9	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3)	$_{GaS1}$(student no.1 from school G_a) $_{GaS2}$(student no.2 from school G_a) $_{GaS3}$(student no.3 from school G_a)
School H	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3) *Teacher no. 1 (T1)*	HS1(student no.1 from school H) HS2(student no.2 from school H) HS3(student no.3 from school H) *HT1(Teacher no.1 from school H)*
School I	6	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3)	IS1(student no.1 from school I) IS2(student no.2 from school I) IS3(student no.3 from school I)
School J	9	Student no. 1 (S1) Student no. 2 (S2) Student no. 3 (S3)	JS1(student no.1 from school J) JS2(student no.2 from school J) JS3(student no.3 from school J)

3.3.2 Interview Findings

At the beginning of each of the six themes discussed below, a table summarising the types of comments made and the respondents into who expressed these views is presented. This is followed by a discussion of the theme, making extensive use of the actual words of the respondents. These have been translated by the researcher from the original Thai, but every attempt has been made to retain the spirit and tone of the original comments.

(a) Advantages of using ICT in the classroom

Table PF 3-3 shows a summary of the respondents who gave salient comments about the advantages of using ICT in their classroom environments. The main benefits perceived concerned enjoyment, searching for information, and gaining new knowledge from the use of ICT in the classroom learning environments.

Table PF3- 3: Advantages of Using ICT in the Classroom

ADVANTAGES	RESPONDENTS (Thai students and teachers)	TOTAL RESPONDENTS
1. INCREASING ENJOYMENT	AS1, AS2, BS2, CS3, DS2, ES3, FS3, GS1, HS2, IS3, HT1	10 students and 1 teacher
2. SEARCHING FOR INFORMATION	CS2, FS3, GS3, HS3, IS1, BT1	5 students and 1 teacher
3. OBTAINING NEW KNOWLEDGE	BS1, DS1, FS1, FS3, GS3, IS2	6 students
4. CLARIFYING UNDERSTANDING OF LESSONS	AS3, ES2, GS2, IS1, AT1	4 students and 1 teacher
5. USING A RANGE OF MULTIMEDIA IN THE CLASSROOM	BS2, ES2, HS2, HS3, JS1	5 students
6. ENCOURAGING PROFESSIONAL PRESENTATION OF REPORTS AND PAPERS	FS2, FS3, HS1,HS2, GS2	5 students
7. FACILITATING REPORT WRITING	AS1, AS2, IS1	3 students
8. BECOMING FAMILIAR WITH MODERN TECHNOLOGY	BS3, CS1, GS1	3 students
9. MOTIVATING STUDENTS' SCHOOL ATTENDANCE	FS1, GS1, JS2	3 students
10. FAMILIARISING STUDENTS WITH THEIR FUTURE ENVIRONMENTS	AS1, IS3	2 students
11. SUPPORTING SELF – STUDY	DS3, IS2	2 students
12. OFFERING CONVENIENT ACCESS TO STUDY MATERIALS	GS2, IS1	2 students
13. OFFERING VARIED WAYS TO LEARN	BS3	1 student
14. PROVIDING STIMULATION OF NEW IDEAS AND INNOVATIONS	HS3	1 student
15. OBTAINING GOOD EXPERIENCES	IS3	1 student

Details of data analysis for interviewee responses regarding the advantages of the use of ICT are provided in Appendix "F".

When the interviewees were asked for their feelings about the benefits or advantages of using ICT in their model ICT classroom environments, the responses were generally positive. The most frequent response (from about a third of respondents) was that the ICT classroom environment increased their enjoyment in learning.

- **Increasing enjoyment**

There was a general opinion among participants that the use of ICT in the classroom, particularly for teaching and learning, was enjoyable.

> *I always feel very happy every time, when I sit in front of my computer.*

> *I do not feel worried when the ICT or computing class hour is coming, I experience pleasure and joy.*

> *I have never been nervous, and I usually feel familiar when using the computer.*

Most of the interviewees perceived that one benefit of the use of ICT in their classroom was that it made students and teachers feel positive about their topic, or doing research in their topic. Such views were illustrated by two of the student participants:

> *I feel very happy and have a great time during studying in ICT classroom in all school subjects, including science, mathematics, computer, foreign language and so on.*
> *Some teachers teach their students in different subjects by using CD-ROM and interactive games from the internet in their class, these make studying science or English enjoyable.*

These ideas seemed to indicate that the integration of ICT into teaching and learning in classrooms could be a motivating factor for students to attend and to participate in their class work, activities, and homework which was assigned via electronic instructional medias such as CD-ROM or online lessons.

Among teachers, there was generally a positive feeling about integrating ICT to their teaching. One teacher, from School H, talked about this positive personal effect, in the following way:

I am very excited and enthusiastic when I use computer or ICT equipments, including CD ROM, instruction and teaching software, and other electronic equipments in my class.

- **Searching for information**

About a fifth of the interview participants considered that the use of ICT in searching for information in the education field was an important benefit. Some data from the internet were more detailed than textbooks or classroom documents and/or handouts. This was demonstrated by some expressions such as:

I am very curious to search information from the internet. For me, I always use Sanook.com, Google.com, and Yahoo.com, these are my favourite search engine websites.

Some teachers permit their students to search information from the Internet in their class hour, for example, Science subject and Mathematics Subject and so on.

In addition, teachers said that researching on the Internet was a useful tool in lesson preparation. A number of responses obtained indicated that teachers found computers to be excellent tools for making up worksheets and tests, and "handy for doing all sorts of things". For example, teacher respondent from School B commented that:

I am always searching for information from the www to prepare my instructional materials such as texts, world maps, pictures, figures, diagrams, and so on.

- **Obtaining new knowledge and information**

Another fifth of the respondents acknowledged that the use of computers in teaching and learning supported students in gaining new knowledge, ideas, and information from modern software programs through electronic lessons. Two of the interview participants stated that:

It helps me know some new and modern computer software programs, so I can apply these programs to my tasks in both individual and group work.

> *I have never known the HTML or Dream Weaver program before, until my ICT or computing teacher used each program to teach me to create my personal homepage and webpage. Of course, it is an absolutely amazing program because it gathers and shows my personal data concerning personal profile background, extra activity such as my favourite sport, food or television program through personal webpage.*

Four other interviewees expressed the idea that demand for the use of computers in education might result in students handing up class or homework that was absolutely correct, by the use of computer programs.

> *When I do some work or homework through searching information from the internet, it gives me new knowledge and I can accept appealing and innovative ideas.*

- **Clarifying understanding of lessons**

About a sixth of the interviewees considered that ICT in the classroom could help them during their private study time to easily clarify their understanding of lessons given earlier. Their comments included, for instance,

> *I get new knowledge about subject topics from my subject or ICT teachers quite fast because they provide all of their instructional material lessons by the integration of ICT or computer into their teaching and learning process.*

> *It helps me to clearly understand when my teacher provides his/her documents by using word processing or PowerPoint presentation.*

Another teacher's suggestion was to facilitate their students' understanding into each of the teaching classroom lessons. He claimed:

> *When I use ICT-integration into teaching and learning process to teach our students, it is much easier to explain subject contents than other classroom environments (e.g. whiteboard classroom).*

- **Using a range of multimedia in the classroom**

There was a strong opinion among about a sixth of the interview participants that the use of ICT in teaching was attractive, interesting, and efficient when teachers used ICT or computer to conduct a lesson with a range of multimedia instructional materials for their students. Some comments which illustrated this are given below:

> *Most students prefer to learn in ICT classroom environments, especially if teachers use several multimedia instructive tools such as television, video, video camera, slide, and other media in their teaching and learning process for their own students.*

> *I perceive the ICT classroom environment positively through a variety of multimedia in my learning process, including listening through headphones, speakers, and looking at the monitor as well.*

- **Encouraging the professional presentation of reports and papers**

For another sixth of the students, the use of computers in the classroom for class work, group presentations, or project homework was very helpful, enabling them to make their work professional in presentation.

> *I am a professional because I start from searching information by using the internet (www), conducting report by word processing, and preparing handouts until presenting my work through PowerPoint presentation.*

> *I always do my school projects which were assigned to me by using the PowerPoint program, because it assists me to complete my projects like a professional.*

> *I and my group had the opportunity to present my project in front of the class by PowerPoint presentation. We do it like a professional presentation.*

> *I admire my teacher who constructs an advance presentation program (PowerPoint), which uses flash and animation to do her teaching document.*

Another nine specific advantages were mentioned by the interview respondents, but each of these was limited to three or less citations. These are listed below, but are not further discussed here.

- facilitate students' report writing;
- make students familiar with modern technology;
- motivate students to attend class;
- familiarise students with their future work environments;
- support students' self-study or independent learning;
- offer students convenient access to study materials;
- offer students varied ways to learn;
- provide students with the stimulation of new ideas and creative innovation; and
- allow students to obtain good experiences.

(b) Disadvantages in using ICT in the classroom

The interview schedule sought to find out students' and teachers' perceptions of what factors had hindered the effective use of ICT, or particularly computers, the teaching in and learning process in ICT schools. Table PF3-4 summarises the categories of disadvantages mentioned by the interviewees in relation to studying and teaching in their ICT classroom environments.

Table PF3- 4: Disadvantages in Using ICT in the Classrooms

DISADVANTAGES	RESPONDENTS (Thai students and teachers)	TOTAL RESPONDENTS
1 ANXIETY	AS1, BS1, FS2, FS3, ET1	4 students and 1 teacher
2.TAKES TIME	AT1, BT1, DT1, ET1, HT1	5 teachers
3. LACK OF CLASS ATTENTION DURING CLASS HOUR	DS1, BT1, HT1	1 student and 2 teachers
4. LACK OF STUDENT-TEACHER INTERACTION	FS2	1 student

Details of data analysis for interviewee responses regarding disadvantages in the use of ICT are provided in Appendix "G".

- **Anxiety**

The most frequent disadvantage cited by a sixth of the participants referred to negative attitudes, such as anxiety, which could pose a hindrance to the effective integration of computer technology in education. Phrases and words which the students mentioned, such as “scare factor”, “afraid”, “frightening”, “daunting”, “intimidated”, “terrify”, “not confident”, and “uncomfortable” all illustrated this anxiety factor. More detailed negative comments are given below.

> *I feel scared. I do not know how I can use this program because it is too complicated.*

> *I am afraid, I cannot control how I am doing to finish my assignment in my class Period.*

> *It is very difficult to follow the contents on the teacher’s handouts which are prepared by PowerPoint presentation…Sometimes my teacher focuses on the subject contents of a PowerPoint presentation to occupy the class hour (50 minutes) rather than concentrating on students’ understanding…It is too fast to catch… It prevents me from understanding the lesson.*

> *I am apprehensive about using computers in the class, maybe because I have not done enough of it by myself…So I’m not strongly confident.*

The problem of the lack of computer training, understanding of computer and computer-based skills among subject or ICT teachers usually related to the lack of experience and familiarity with the educational technology for classroom instruction. Related to that, one teacher participant reported that:

> *I have a desire to use computers in teaching, but sometimes I feel helpless because I am not sure how to do it…A PowerPoint presentation was attempted during one class,…but somehow, something did not work.*

The teacher's anxiety over the possibility of another computer failure was reflected in the further comment:

> *…you have to plan another alternative lesson along with the computer-based lesson…just in case something goes wrong, or something's not wired properly.*

- **Takes Time**

All five teacher interviewees from model ICT schools (School A, School B, School D, School E, and School H) perceived the problem of time to be factor inhibiting the effective ICT-integration into teaching and learning. Some examples of their comments follow:

> *Planning of a lesson using computers or ICT requires more time, as specificity is necessary.*

> *…a lesson incorporating computers or ICT takes more time to set up with respect to instructional equipment and classroom organisation.*

> *The pressure of time already exists in trying to complete coverage of subject contents, thus not allowing for experimentation with new technologies during curriculum time.*

- **Lack of class attention during class hour**

Problems with classroom management in computer-based lessons were another disadvantage factor cited by two teachers and one student.

The student interviewee observed that:

> *Most students do not follow the teacher's instruction and assignments because they are playing games and surfing the internet, not attending to the teachers' instruction.*

Two teacher participants highlighted the difficulty of delivering instructions, because of the computer being a competing attraction for their students.

When I attempted to conduct a computer based lesson during my teaching, it made me very disappointed. When I was giving instructions, my students were not listening; they were busy doing things on the computer screen. I had to go around to everywhere to get the instruction across the classroom.

(c) Practical Problems in the use of ICT and network facilities in ICT classroom learning environments

Table PF3-5 summarises the categories of practical problems that, in the views of the participants, hindered the use of ICT and network facilities in ICT classroom environments.

Table PF3- 5: **Practical Problems in the Use of ICT and Network Facilities in ICT Classroom Learning Environments**

PROBLEMS	RESPONDENTS (Thai students and teachers)	TOTAL RESPONDENTS
1. PROBLEMS OF RESOURCES/EQUIPMENT/ ACCESS	AS1, CS1, ES2, CS2, DS1, ES2, AS3, CS3, GS1, GS2, GS3, JS1, JS2, AT1, DT1, ET1,	13 students and 3 teacher
2. POOR SCHOOL ENVIRONMENT	AS1, CS2, DS3, ES1, ES2, FS1, GS1,GS2,GS3, JS1, AT1, ET1,DT1	10 students and 3 teachers
3. CLASSROOM MANAGEMENT	JS1	1 student

Details of data analysis for interviewee responses regarding problems in the use of ICT are provided in Appendix “H”.

- **Problems of resources, equipment and access**

Over half the interviewees perceived the lack of proper resources, equipment and access to be a problem that inhibited the effective use of ICT for studying and teaching in their schools. Such a view was iterated through student comments, such as:

There is some outdated hardware and soft ware in the resources of my school.

Computer provision and access (to the number of functioning computers) in my school are not enough for the number of students in each classroom.

The internet in our schools is not high speed. So it is very difficult and too slow to access electronic information.

In my classroom learning environments with ICT, the infrastructure layout was not conducive for classroom instruction. Because some friends do not attend to studying, they are watching the computer screen rather than attending to instruction.

There are not enough computer complements such as printers, LCD projectors, LCD screens, and other relevant computer equipment.

Teacher comments (from four out of the five interviewees) reflected the same difficulties.

We think that we are not comfortable using ICT instructional material resources for preparing our classroom instruction materials…our schools have not enough computers for all of the ICT or subject teachers…In addition, the school's computer laboratory was often booked out.

(d) Teacher characteristics encouraging students' critical thinking skills

The interview schedules tried to find out which teacher personality characteristics supported or encouraged students' critical thinking skills, compared to those that did not.

Table PF3-6 provides a summary of the categories of teacher characteristics which were seen as factors encouraging students' critical thinking skills.

Table PF3- 6: Teacher Characteristics Encouraging Students' Critical Thinking Skills

CHARATERISTICS	RESPONDENTS (Thai students and teachers)	TOTAL RESPONDENTS
1. Good listener	AS2,HS1, HS3 FS2, FS3, HS2, HS3 AS1, BS2, JS1, ES1, ES2, ES3, JS2, JS3, IS2	16 students
2. Professional teacher	AS1,AS2,AS3, CS2, DS1, FS2, HS2, JS2, BS2, CS3, ES1, JS1 ES1, ES2, ES3	15 students
3. Logical thinker	BS3, ES3 AS1, ES1, ES2, HS2, GS1, GS2, GS3	9 students
4. Teamwork approach teacher	AS1, AS2, AS3, CS2, ES1, FS3, ES2	7 students
5. Reasonable thinker	BS1,BS2	2 students

Details of the data analysis for interviewee responses regarding teachers' characteristics, which encouraged students' critical thinking skills, are provided in Appendix "I".

- **Good listener**

Over half the student interviewees perceived that there was a relationship between their teachers' personality characteristics and their interpersonal behaviour in both general and classroom environments with ICT. The particular quality, they emphasised was the ability to be a patient and a good listener, reflected in teachers being friendly, helpful, and giving time for personal discussion in and out class. These views were illustrated through excerpts taken from the participant interviews, as following:

> *When my teacher asks some questions of my classmates, and me she patiently waits for our answers…Although, sometimes it takes a long time to find out the correct answer… Particularly, the most significant reason involved the use of computer in the classroom learning environments with ICT, I prefer more open-ended answers and suggestions rather than closed answers, or exact final answers concerning the difference in the way of thinking… It means that teachers need to give a wide latitude to their students' ideas and views…*

> *My teacher always spends her busy time talking and listening with me and my friends about our technical or ICT practical problems in and out of the class, although she is busy with her own work. So my favourite teacher is friendly and gives time to me anytime, and is very flexible.*

> *In science subjects, during their class hours, our teachers allow us to experiment with the process until we have finished, without interrupting. They encouraged a relaxed type of classroom environment, particularly where we felt comfortable studying in a variety of different types of situations, particularly the classroom environment with ICT.*

> *In the sound lab and English language laboratory, sometimes I cannot recall new vocabulary which was taught in the beginning of the class, but my teacher keeps*

repeating those words again and again, even though some of my friends remember these words, but I don't.

My Mathematics teachers have never blamed, looked down, complained or criticised me when I spend a long time proving the Square Root by using the formula on the whiteboard or on the monitor screen. In contrast, they guided me to do the short or easy way. In addition, they provided supporting material resources or electronic instructing resources to clarify our understanding of subject contents.

My teachers who teach in social studies subjects allow me and my peers to present our group work with PowerPoint presentation until we finish, although our presentation is not good enough, if it is compared with other group works. Finally, at the end of the class, they give some helpful advice and useful suggestions and a recommendation for improving our presentation for the next time.

- **Professional Teacher**

There was acknowledgement by half the student interviewees, that teachers who established a supportive classroom environment, achieved higher student progress, by being more professional in regard to improving their students' critical thinking skills within their learning and teaching process. Some quite extensive comments related to this effect are given below.

In my personal eyes, the best teachers' characteristics to develop critical thinking skills for their students needs to have high understanding of skills and knowledge to teach their students in several ways of teaching and learning process, to actively search for new information from various learning sources such as the internet, books, articles, and other learning sources, and to provide interesting and attractive electronic lesson materials… Particularly, there is a need for teachers to develop technological literacy, including basic computer operations, professional use of technology, applications of technology in instruction, and so on….

Teachers must use a variety of teaching skills that change from the complex to the simple contents of their subject lesson. I strongly agree that it is the most important factor. Because all teachers should try to teach their students with the easiest method to clarify their students' understanding of subject contents among classroom learning environments with or without ICT.

I think that if all teachers spend a long time preparing supportive and helpful resources and lesson materials, using both electronic and paper materials, these materials will attract their students' attention during class periods (about 50-60 minutes). This process is quite a large amount of teacher's work, and adds to their teaching experience also…. In addition, the influence of the teachers' enthusiasm for using computers supports their students' learning process during the class period in their ICT classroom environments with ICT.…

In the preferred classroom environment, the ideal teacher for me must develop their skills and knowledge through reading many books, get new information from the internet, get continuous training in professional knowledge which leads to the development of their teaching experiences…For subject or ICT teachers, they need to apply this modern technology in their classroom. They must address their lack of training, their limited teaching experience, insufficient time to prepare, as well as their lack of computer access. In addition, they need to increase positively high perceptions of technology skills and levels of computer competence and reduce the fear of the use of computer equipment also….

- **Logical teacher**

Nearly a third of the student interviewees mentioned that logical teachers were more effective in developing students' thinking abilities and skills. Some examples of the comments were:

In Mathematics and Science subjects, during the class time, both of our teachers usually ask many questions to stimulate their students to think logically…

Particularly students using ICT were strongly motivated to develop new strategies for establishing logical thinking skills by using a variety of computer software….

It made me understand easily, when my teacher handed out lesson materials before, she started teaching. Because I follow the steps of Math calculations by following step-by step in paper sheet.

I love a teacher who teaches me how to apply the contents of the lesson rather than memorise them in all subjects. This method helps me to understand clearly my subject lessons.

- **Teamwork approach style teacher**

Just over a quarter of the respondents pointed to the importance of teachers with collaborative learning styles, not only between student and peers, but also between teacher and students. These were seen to affect the development of students' critical thinking skills, in the use of ICT. In particular, they saw the need for teachers to develop their students' critical thinking skills by collaborative group working in class.

I like my teachers who usually assign us to do group work, because it gives me an opportunity to share and discuss any different ideas with others. It leads me to work effectively with others and develop better understanding in their classroom learning environment.

When we work as a team, we can help to support each other in relation to reducing our weaknesses, and increase my depth of knowledge and understanding.

Every time we do group work with our team, I practise dividing and joining work responsibilities among the individuals to bring out their skills.

- **Reasonable teacher**

According to a few students, a reasonable teacher is one who systematically uses a sensible and reasonable, rather than emotional, approach to solving study problems. Their comments were:

> *All students prefer to study with teachers who use more systematic reason than emotion to solve our study's problems…Particularly in our ICT classroom environment, we think that the effectiveness of using ICT to learn and study in any subject content needs to focus on scientific skills step by step….*

(e) Effect of ICT-integration into teaching and learning process on the development of students' critical thinking skills

Table PF3-7 shows a summary of interviewees' comments on the influence of ICT on the development of students' critical thinking skills. On this topic, all the comments came from the teacher interviewees.

Table PF3- 7: The Use of ICT in Developing Students' Critical Thinking Skills

The use of ICT helps to develop students' critical thinking skills	RESPONDENTS (Thai students and teachers)	TOTAL RESPONDENTS
1. ICT for study skills development	AT1, BT1, DT1, ET1, and HT1	5 teachers
2. ICT for scientific skills development	AT1, BT1, DT1, ET1, and HT1	5 teachers
3. ICT for meaning making	AT1, BT1, and HT1	3 teachers

Details of the data analysis of the interviewee responses regarding the influence of ICT on the development of students' critical thinking skills are provided in Appendix "J".

In relation to using ICT for developing students' critical thinking skills, the teacher interviewees made the following comments:

If we familiarise ourselves positively with ICT or computers, it will develop other important skills and competencies such as self-study learning, thinking analytically and logically, synthesising ideas and concepts, and so on.

ICT use can improve a number of scientific skills or researching process, including reading data, interpreting graphs, manipulating variables, constructing hypotheses, conducting experiments, generating creative questions, drawing conclusions and so on.

The use of ICT can facilitate the process of meaning-making. It means that I use ICT to help students gather, organise, remember, retrieve information, and make decisions.

(f) Views on the desirability of the introduction of ICT-integration into teaching and learning process for all subjects in all schools

Table PF3-8 summarises the views expressed concerning the desirability of introducing ICT into all subjects in all schools.

Table PF3- 8: Views of the Desirability of Introducing ICT into All Subjects in All Schools

Views of the desirability Introduction of ICT for all subjects in all schools	RESPONDENTS (Thai students and teachers)	TOTAL RESPONDENTS
1. Human Resources	AS2, AS3, BS3, DS2, CS1, HS2, GS1, GS2, GS3, JS1, ES1, ES3, FS3, AT1, BT1, DT1, ET1, HT1	13 students and 5 teachers
2. Materials and Environments	AS1, EF2, FS1, GS1, GS2, GS3, AS1, EF2, FS1, JS2, CS2, ES2, FS2, JS2, FS2, CS1, FS2, CS1	18 students
3. Management	FS1, GS1, GS2, GS3, DT1, ET1	4 students and 2 teachers

Details of the data analysis of the interviewee responses regarding the introduction of ICT-integration into teaching and learning process for all subjects in all schools are provided in Appendix “K”.

On this topic, most of those interviewed appeared to take for granted that this would be a good more, but expressed their concerns about the difficulties of doing it. The three areas of their concern are discussed below.

- **Human Resources**

The need for professional development of teachers and school administrative staff in ICT skills and knowledge was mentioned by more than half the respondents, including all the teachers interviewed.

> *Some teachers think that we are too old to learn and get new information and knowledge through technology. So they have been thinking that modern technology might confuse them, so they cannot accept new technology to improve their teaching process.*

> *Some teachers, who have long experience in teaching in traditional classroom environments, do not open their minds to accept modern educational technology for use in education areas.*

> *Some teachers lack ICT understanding of skills and knowledge of modern technology knowledge concerning the use of ICT and other electronic equipment. So, they lack confidence to teach their students through the use of ICT or computers to assign homework or group activities.*

> *Due to high teachers' workloads, some teachers do not have enough time to get training courses such as the basic or advance computer usage like the Microsoft Office program, Micro Worlds, Paint Program, Photo Shop, Flash Animation, Flip Album, and Webpage Creation (Dream Weaver and HTML programs), which were provided by their schools or computer training institutions. These programs can help teachers to generate their electronic lessons to teach their own students.*

> *There are not enough leading ICT teachers or ICT teachers who can teach their students through ICT-integration into teaching and learning process in ICT classroom environments in all eight groups of basic subjects.*

- **Materials and Environments**

Of equal concern to student respondents was the lack of ICT resources and equipment in schools.

> *There is not enough ICT equipment or computers to provide for all subject teachers in all schools across the country.*

> *The quality of computers and computer equipment such as CPUs, printers, microphones, headphones, speakerphones, monitors and other devices, including T.V., LCD projectors, and slides is low and inefficient. Most of it is out-dated equipment.*

> *Our ICT classroom environment is quite uncomfortable, because some schools do not have ICT laboratories or computing rooms with good quality of physical layout of classrooms such as good quality of air conditioning and providing sets of sufficient learning tools.*

- **School Management**

A fifth of the respondents, including two of the teachers, mentioned the issue of school managements and their failure to support teachers in integrating ICT into their classrooms.

> *Some school administrators, particularly school principals do not support their school teachers to incorporate ICT into their teaching and learning process to teach their students in their ICT classroom environments. Because these administrators feel more confident with supporting and teaching in the traditional classroom environments than the ICT classroom environment.*

> *Some principals do not allocate budget or distribute money for setting up ICT classroom environments. In addition, some schools do not have a policy to support the budget for ICT teachers to integrate ICT into their teaching and learning process in any subject and to provide continuous course training regarding new*

computer programs such as Micro World, PhotoShop, Animation, Flash, Dream Weaver, HTML, and so on for subject or ICT teachers.

Overall the analyses of the qualitative interview data provided a deeper level of understanding of students' positive and negative attitudes toward ICT, and also the effects of teachers' different personalities and teaching styles on the actual experience of using of ICT in the classroom to promote critical thinking skills. Some of the most revealing and useful comments related to practical difficulties that were hindering the effective integration of ICT into classroom learning.

3.3.3 Classroom Observation

3.3.3.1 Introduction

This section presents findings from the researchers' classroom observations, which relate directly to Research Question 8: How do students make use of classroom learning environment with ICT to improve their thinking skills? For each classroom observed, the researcher kept hand-written field-note documentation of essential events, the students' behaviour and conversations, and the phases of the classroom lesson. This included data on teachers' use of ICT or computers to assist students in developing their critical thinking skills through the topic being taught, for example mathematics, science or language. On some occasions, the researcher moved around the classroom and talked with students about what they were doing during their class hour. As explained in 3.2.1.3, the data from each lesson observation was classified by the researcher according to the six learning levels of Bloom's Taxonomy, which comprised gathering knowledge, comprehension, application, analysis, synthesis, and evaluation.

3.3.3.2 Participants' Background

Table PF 3-9 shows the details of classroom observation participants from 13 model ICT schools in Bangkok and surrounding districts. I had the opportunity to observe 22 classrooms, in which I was able to see ICT being incorporated into the teaching and learning process of five different subjects, science, mathematics, computer, social studies, and English language.

Table PF3- 9: Details of Classroom Observation Participants

	School	Class Subject	Class Label
1	School A	1.1 English (Eng) 1.2 Mathematics (Math) 1.3 Computer (Comp)	1.1 AEng 1.2 AMath 1.3 AComp
2	School B	2.1 English (Eng) 2.2 Science (Sci)	2.1 BEng 2.2 BSci
3	School C	3.1 English Language (Eng)	3.1 CEng
4	School D	4.1 English Language (Eng)	4.1 DEng
5	School E	5.1 Mathematics (Math)	5.1 EMath
6	School F	6.1 Mathematics (Math) 6.2 Science (Science) 6.3 Computer (Comp)	6.2 FMath 6.2 FSci 6.3 FComp
7	School G	7.1 Computer (Comp)	7.1 GComp
8	School H	8.1 Mathematics (Math) 8.2 Science (Sci)	8.1 HMath 8.2 HSci
9	School I	9.1 Mathematics (Math)	9.1 IMath
10	School J	10.1 Mathematics (Math) 10.2 Social Studies (Social)	10.1 JMath 10.2 JSocial
11	School K	11.1 Science (Sci)	11.1 KSci
12	School L	12.1 Science (Sci) 12.3 computer (Comp)	12.1 LSci 12.3 LComp
13	School M	13.1 Social Studies (Social) 13.2 English Language (Eng)	13.1 MSocial 13.1 MEng

3.3.3.3 Classroom Observation Findings

The results of the classroom observations are presented below, with a description of each lesson's classroom context, followed by examples of the levels of learning outcomes used in the lesson.

School A

- English Language Class (AEng)

(a) Description of the classroom context and the lesson

The English teacher (AEng) prepared a lesson plan and content regarding "The Use of Articles (a, an, the) with different nouns". She used the Flip Album program, which explained the definitions of the articles (a, an, the), and suggested a method to use the articles with different nouns, and so on. This program comprised a pre-test (before instruction), lesson contents, and a post-test (after instruction). Each student took the pre-test and recorded their scores in their books, using the Flip Album program. Then, each student read the contents of the articles and worked through the examples from the Flip Album, from the first page to the last, during the English class hour (50 minutes). Each student needed to take the post-test to check their understanding, and kept their scores, enabling a comparison between the pre-test and post-test scores. Most of the students in this class had higher scores on the post-test than the pre-test, which indicated that they had made progress in their understanding of the lesson content. There were only a few students who had scores at the same level on both the pre-test and the post-test.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students defined the definition of Articles (a, an, the).
Comprehension	Students explained the use of Articles with different nouns.
Application	Using the Articles in pre-test and post-test questions, students applied the Articles in each question.
Analysis	Students compared and contrasted the use of Articles (a, an, the) with the different nouns in different sentences.
Synthesis	Students created sentences by selecting Articles to be used correctly with various nouns.
Evaluation	Each student evaluated their pre-test and post-test scores and recorded their own scores in their books after they finished class.

- Mathematics Class (AMath)

(a) Description of the classroom context and the lesson

The Mathematics teacher (AMath) used a PowerPoint presentation to teach her students how to set goals for their Mathematics group project, which was integrated with other basic subjects. Groups of 5-6 students worked together on their project during their Mathematics class hour. The teacher demonstrated how students were to use the

PowerPoint Program to create their Mathematics project slides. During the class hour, each group prepared 5-6 slides to present their ideas about their project in the following week.

For their study projects, one group of students integrated three basic subjects that included (a) mathematics, (b) arts, career, and technology related education, and (c) foreign languages. Students tried to find out which brand name cars were most popular among the parents in their class. Students prepared a few interview questions to interview their parents. In addition, they showed pictures of the brand name cars, which were popular among their parents with 2-3 slides. Finally, this project concluded by presenting the various percentages of the different brands of cars in pie and bar graphs on several slides. On the last slide, students illustrated the major reasons that their parents chose their preferred brand of car for their family.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	The students listed the project questions, which were of interest to their group.
Comprehension	The students from each group project described the process that they would use to solve the project question.
Application	The students illustrated appropriate ways to answer a project question with surveys or interviews. For example, students constructed 2-3 interview questions to ask their parents.
Analysis	Students categorised quantitative and qualitative results after using surveys or interviews to collect data.
Synthesis	Students invented their project ideas or proposals and initiated 5-6 slides of a PowerPoint presentation to demonstrate their project ideas and propose their proposal for each group.
Evaluation	Students evaluated how well integrating mathematics with other groups of basic subjects worked in group projects in mathematics classes using PowerPoint presentations.

- Computer Class (Acomp)

(a) Description of the classroom context and the lesson

The Computer teacher (AComp) started her class by teaching the students to use the Dream Weaver program to put data and information and create a new webpage that was formed and posted on school website. The teacher provided the topic title and data outline, which were on a piece of paper with the title "My Lovely Pet Dog". The teacher gave the piece of paper, which included details of topic contents in three parts, including introduction, body, and conclusion, respectively, to her students, and each student put the data on a new webpage to their school website by typing texts during the class hour. All the students selected different texts (fonts, colours, styles, and size), and pictures to illustrate their webpage on school website.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students filled in information in different types of texts and pictures by typing the data on their individual personal webpage on their school website.
Comprehension	Students explained how particular texts or pictures with different font, colour, size, and style texts might be used to organise information.
Application	Students applied the font, colour, size or style type to their texts by using the toolbar menu in the Dream Weaver program for their personal student webpage on their school website.
Analysis	Students classified data, which were on a piece of paper, into the types of contents in the different parts of the introduction, body, and conclusion of the text. They separated each part of data by using a variety of text styles, colour, and pictures on the individual webpage.
Synthesis	-
Evaluation	-

School B

- English Language Class (BEng)

(a) Description of the classroom context and the lesson

The English teacher (BEng) taught her students by using the software on the CD-Rom on the topic “Using adjectives with nouns”. This software introduced the definition of adjectives, the use of a variety of adjectives with nouns, and the pronunciation of each adjective. Students placed adjectives in front of nouns in the incomplete sentences provided to clarify their understanding about using different adjectives with various nouns. In addition, each student practiced pronouncing each adjective by using microphones and headphones.

(b) Examples of the Levels of Bloom’s Taxonomy used

Knowledge	Students recalled the meaning of different adjectives and told the class how to choose and put adjectives in front of different nouns.
Comprehension	Students described how to choose adjectives to fill in the incomplete sentences.
Application	Students gave some examples of adjectives which were chosen to put in the incomplete sentences.
Analysis	Students listened to their peers’ pronunciation and analysed which adjectives they found correctly pronounced.
Synthesis	-
Evaluation	-

- Science Class (BSci)

(a) Description of the classroom context and the lesson

The Science teacher (BSci) permitted his students to search for information from the Internet on the topic “Water Filtration”. The students were permitted to find out relevant information from their computers for about 15-20 minutes during the class hour in answer to four scientific questions, which were provided by the classroom teacher. These questions comprised the definition of a water filter, the types of water filter, the purpose of the water filter, the possible water filtering processes to remove something that was not wanted. The students then worked in groups to discuss their answers and brainstorm about the benefits of water filtration. Students wrote all their answers on paper and prepared to present them before the time ran out. The teacher selected a few students at random to present their information.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students recalled the steps for the water filtration process and listed them.
Comprehension	Students explained the process of water filtration and reviewed the filtration process aloud in class.
Application	Students applied the principles of water filtration to their daily lives.
Analysis	Students brainstormed about the benefits of water filtration in working groups.
Synthesis	Students searched for information and printed out the charts of filtration process to exhibit to their classmates during group presentations.
Evaluation	-

School C

- English Language Class (CEng)

(a) Description of the classroom context and the less

During the previous class hour, the English teacher (CEng) had assigned to groups of 3 to 4 students a task to prepare a PowerPoint presentation (approximately 7-10 slides) on the topic "Christmas Day", after searching for information from the internet. Each group was assigned to do their homework on different aspects of Christmas Day. There were several interesting topics, including the history of Christmas Day, Holy Activities on Christmas Day, Special Dinner Menu on Christmas Day, and Well-known Christmas Carols, and so on. Each group chose they found most interesting topic from these activities. After they had finished preparing their topic, they had an opportunity to present their work during the class hour by PowerPoint presentation, which took about 10-15 minutes for each group.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students collected words and pictures that described the interesting events on Christmas Day to make PowerPoint presentations.
Comprehension	Students summarised relevant themes concerning what happened on Christmas Day, and illustrated significant themes in PowerPoint presentations.
Application	-
Analysis	-
Synthesis	-
Evaluation	-

School D

- English Language Class (DEng)

(a) Description of the classroom context and the lesson

The English Teacher (DEng) used teaching software on CD-Rom in a topic "Parts of the Human Body". The teacher handed out pre-test and post-test papers to her students. She assigned her students to take a pre-test before the class started. During the class hour, she used the CD-Rom software to teach her students about new vocabulary such as forehead, eyebrows, hands, legs, and so on. After her class had finished, she gave her students 10 minutes to take a post-test. The teacher recorded her students' scores to compare the pre-test and post-test scores.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students matched the vocabulary words of parts of the human body in the pictures in pre-test and post-tests sheets.
Comprehension	Students explained at least five new vocabulary words of parts of the human body by pointing to the picture and spelling their words aloud.
Application	-

Analysis	-
Synthesis	-
Evaluation	-

<u>School E</u>

- Mathematics Class (EMath)

(a) Description of the classroom context and the lesson

The Mathematics teacher (EMath) taught her students by preparing a PowerPoint presentation on the topic "How is the Square Root Equation solved by using a Mathematical formula". During the class hour, the teacher used several teaching materials and resources, both paper and electronic handouts, to provide information and details about the content of this topic. These comprised sets of knowledge sheets, working sheets, and reviewing sheets to confirm the students' understanding of the topic rather than just memorising it.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students <u>recalled</u> the steps of a calculation by using the formula, following from slides of a PowerPoint presentation and <u>listed</u> them on a piece of paper.
Comprehension	Students <u>explained</u> step-by-step a solution to the class on how to use the formula to calculate an equation.
Application	Each student <u>solved</u> the equation by doing an example from an exercise sheet.
Analysis	Students <u>compared and contrasted</u> solving the equation by using the formula and by other ways.
Synthesis	-
Evaluation	-

School F

- Mathematics Class (FMath)

(a) Description of the classroom context and the lesson

The Mathematics teacher (FMath) taught students the topic “Adding and Subtracting four digits of whole numbers in two ways (Horizontal and Vertical)” with a PowerPoint presentation. The teacher assigned electronic class work to her students during the class hour of the PowerPoint Presentation. Students did class work in groups of 4-5 students. All students learned from the first slide to the next slide, concerning lesson contents, exercise, review and conclusion. All students from each group had done a class activity completely before their time ran out. The teacher used exercise questions on the PowerPoint presentation. The students solved mathematics questions by discussing them together during their group work.

(b) Examples of the Levels of Bloom’s Taxonomy used

Knowledge	Students recalled the steps for adding and deleting four digits of whole numbers and listed them.
Comprehension	Students explained a step-by-step solution to the class concerning how to add and subtract by vertical and horizontal calculation methods.
Application	Each student solved the equation by doing a task from the exercise sheet such as find the sum of 3457 and 2578 by using vertical and horizontal calculation methods and showed the work to the class.
Analysis	Students compared and contrasted solving the calculation by vertical and horizontal methods.
Synthesis	-
Evaluation	-

- Science Class (FSci)

(a) Description of the classroom context and the lesson

The Science teachers in this school laid out one room for searching, exhibiting and analysing information about how to conserve water, fuel, or energy in daily life. This room was named the “Green Classroom”. This room was set up with six learning units to give information relevant to “Energy Conservation as a Real Life Activity”. I had the opportunity to observe one of several science teachers who had been teaching his students in the Green Classroom during the science class hour. The Science teacher assigned his students into five groups. Each group had six students working together as a team. Each team found out the possible correct answers for each learning unit, and they needed to talk and discuss to choose the best solution to conserve energy efficiently. Finally, the students wrote or filled in their answers on a piece of paper to prepare for each team’s presentation of their answers.

(b) Examples of the Levels of Bloom’s Taxonomy used

Knowledge	Students got information and knowledge from six learning units. They defined terms for Energy Conservation, including electrical, water, and fuel energy conservation.
Comprehension	Six groups of students reported on the efficiency, and summarised positive effects on the environment, of a chosen energy source.
Application	Students within a small group collaborated to determine the possible and suitable ways to conserve energy in their real lives.
Analysis	Students analysed information, which was gathered from six learning units regarding electrical energy conservation. For example, if they wanted to buy a refrigerator, they needed to think about brand name, size, temperature of inside or outside, area, electrical running costs, in order to find out the extent of energy conservation.
Synthesis	Students collected information from members of their team and wrote a brief paragraph on paper comparing their results and a possible explanation for the difference.

Evaluation Students recommended the best ways that people could save energy.

- Computer Class (FComp)

(a) Description of the classroom context and the lesson

The Computer teacher (FComp) taught her students to draw a picture by using the Micro World program on the topic “Natural Resources and Environment Conservation”. Students talked about and discussed their ideas together in small group (3-4 students) before starting their drawing. A few student groups focused on air conservation, and how to reduce air pollution in the city and Central Business District (CBD) areas. Most student groups concentrated on nature and water conservation in the conservation parks and natural forests. Finally, each group had the opportunity to show their pictures in front of the class by using an LCD projector and explained the ideas which were being illustrated.

(b) Examples of the Levels of Bloom’s Taxonomy used

Knowledge Students discussed with their partners about the lists of types of natural resources and environment conservation, which they were interested in.

Comprehension Students discussed with their group how particular natural resources might be conserved to provide good environments for people and drew one picture on their computer screen by using the Micro World program.

Application On their picture, the students applied the principles of environmental and natural resource conservation to their real lives, to explain the importance of conserving natural resources.

Analysis During their presentations, students analysed how natural resources might be useful to all living things in the world.

Synthesis -

Evaluation -

School G

- Computer Class (GComp)

(a) Description of the classroom context and the lesson

The Computer teacher (GComp) instructed her students to adjust their individual photos by using the Photo Shop program. Students completed their work during the class hour.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Each student recalled the steps for adjusting individual photos by using the PhotoShop program.
Comprehension	Students illustrated the procedure for using the PhotoShop software that adjusted and decorated their photos to show their classmates.
Application	Students applied the principle of this software to integrate with other programs such as PowerPoint, Word Processing, and other relevant software.
Analysis	Each student compared and contrasted the PhotoShop program with the other software, which was used for the same purpose, such as Arcsoft.
Synthesis	-
Evaluation	-

School H

- Mathematics Class (HMath)

(a) Description of the classroom context and the lesson

The Mathematics teacher (HMath) instructed each student to review the contents of the mathematics lessons during the whole semester by using a PowerPoint presentation during the class hour. Each student could select any part of a lesson from the semester to review.

After they had finished, they needed to present their work by themselves to the rest of the class.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Each student memorised one part of the curriculum contents, which was taught during a whole semester.
Comprehension	Each student summarised each part of the lesson on a piece of paper. They then put it into a PowerPoint presentation of 7-10 slides.
Application	Each student demonstrated some examples of mathematical calculations. For example, how to calculate square areas and find out the easiest and best solutions to the problems step-by-step.
Analysis	Each student determined what was the best way to calculate and find out the correct answer. For example, most students found out the area of a square by using a formula rather than by using other measurements.
Synthesis	Students created and designed the easiest method of calculation to present to the class with a PowerPoint presentation.
Evaluation	Students evaluated each method to find out which was the best measurement to use.

- Science Class (HScience)

(a) Description of the classroom context and the lesson

The Science teacher (HScience) taught her students about the "Static and Dynamic Electricity Cycle" by CD-ROM. At the beginning of the class hour, the teacher asked many questions of her students, and encouraged them to find out the correct answers by following CD-ROM presentation.

(b) Examples of the Levels of Bloom's Taxonomy used in each class

Knowledge	Students defined two kinds of electricity (static and dynamic electricity) and memorised the processes of two cycles from the PowerPoint presentation.
Comprehension	Students described to the class what the differences were between static and dynamic electricity.
Application	Students inventoried and gathered a list of examples of the occurrence of static and dynamic electricity.
Analysis	Students compared and contrasted static and dynamic electricity.
Synthesis	-
Evaluation	-

School I

- Mathematics Class (IMath)

(a) Description of the classroom context and the lesson

The Mathematics teacher (IMath) divided her students into five groups for teamwork. She assigned each group to review the contents of the mathematics lessons over the semester by using a PowerPoint presentation during the class hour. Each group could select any parts of the semester (18 weeks) lesson contents. When they had finished, they needed to present their work to the rest of the class.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Each group memorised one part of the lesson contents, which they had learnt during the previous semester.
Comprehension	Each group summarised each part of the lesson to note on paper. They then put their ideas into a PowerPoint presentation of seven to ten slides.
Application	Each group demonstrated some examples of mathematical calculation. For example, how to calculate the area of a circle and find out the easiest and best solution step-by-step.

Analysis Each group determined the best way to calculate the solution. For example, most students found out the area of a square by using the formula rather than other methods.

Synthesis Students in each group created and designed the easiest calculation method to present to class by a PowerPoint presentation.

Evaluation Students in each group evaluated each method to find out which was the best.

School J

- Mathematics Class (JMath)

(a) Description of the classroom context and the lesson

The Mathematics teacher (JMath) taught students about "Basic Statistics" by using a PowerPoint presentation. During her class hour, she always asked students many questions to encourage them to concentrate on the teaching content. Most students could understand clearly what statistics meant, how many kinds of statistics there were, how to find out statistical terms such as standard deviation, means, modes, and examples of applying statistical knowledge in any area. In addition, the teacher guided her students to interpret the value of statistics to describe the quantitative results applied to real situations in the real world. For example, she taught her students to interpret the average students' scores for the midterm test for that semester, which would affect the final grade (Grade A, B, C, or D) given in the subject.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge Having referred to several sources such as books, the Internet, background knowledge, and so on, students identified the definition of statistics.

Comprehension Students described how to calculate some terms of statistics by using formula and the applications of statistical terms in real life.

Application From the exercise sheet, students computed the average and standard deviation from raw data.

Analysis Students analysed the difference of the value of statistical terms, which were calculated, and compared the results of each quantitative finding with the implication and application to real circumstances in the real world.

Synthesis -
Evaluation -

- Social Studies (JSocial)

(a) Description of the classroom context and the lesson

The Social Studies (JSocial) teacher divided his students into six groups to do group work. One of the six groups was assigned to find out information on the topic "The Highlights of 14 October 1973" (the year of a Thai people coup in Thailand to overcame a military government) by searching the internet. They had the opportunity to present their work by using a PowerPoint presentation. After they had presented, the teacher suggested some interesting points, including the following:
(1) What was the important information that was searched from the Internet to put into the PowerPoint presentation?
(2) How do you make an attractive and professional PowerPoint presentation? and
(3) What are the essential characteristics of professional presenters who motivate an audience to concentrate on their presentations?

(b) Example of the Levels of Bloom's Taxonomy used

Knowledge Students recalled the history of an event for "The Highlights of 14 October 1973" that have told about the claims of democracy from the government by Thai people dictator (dictatorship).

Comprehension Searching information concerning this main event from the internet (in group of five students), students summarised the highlights and explained what was learned about this event.

Application -
Analysis -
Synthesis -
Evaluation -

<u>School K</u>

- Science Class (KSci)

(a) Description of the classroom context and the lesson

The Science teacher (KSci) started her teaching by giving details of the contents of a CD-ROM, “The Movements of the Earth’s Surface”. Firstly, each student needed to take a pre-test that related to this topic. Next, all the students started to gather a body of knowledge and information to classify their understanding about the movements of the Earth’s Surface. Finally, everyone had an opportunity to check his or her knowledge and comprehension by taking a post-test at the end of the class. All the students recorded their scores for comparison.

(b) Examples of the Levels of Bloom’s Taxonomy used

Knowledge	Reading and gathering information from the CD-ROM, students <u>recollected</u> knowledge, <u>memorised</u>, and <u>quoted</u> the main parts of the contents on paper.
Comprehension	Students <u>summarised</u> how the earth’s surface was moved or changed by drawing a diagram or chart, or by mind mapping, to further illustrate their understanding.
Application	Each student <u>displayed</u> some interesting features of the earth’s surface by explaining them to the class while the teacher supported them in answering questions from the rest of the class.
Analysis	Students <u>compared</u> the movement of the earth’s surface from the past to the present and analysed cracking and the amount of erosion.
Synthesis	-
Evaluation	-

School L

- Science Class (LSci)

(a) Description of the classroom context and the lesson

The Science teacher (LSci) taught students about "Electrical Current (Direct and Alternator current) by using a PowerPoint presentation. During the class hour, the teacher asked some questions to encourage students to apply the lesson contents to their daily lives.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students told the class about the definition of Direct Current (DC) and Alternator Current (AC).
Comprehension	Students described how the electrical current worked.
Application	Students gave some examples of electrical appliances, which used Direct Current (DC) or Alternating Current (AC) power.
Analysis	Students compared and contrasted the two kinds of Electrical Current, the processes to generate power, and made lists of electrical appliances that we use in our daily lives.
Synthesis	-
Evaluation	-

- Computer Class (LComp)

(a) Description of the classroom context and the lesson

The Computer teacher (LComp) set his class a task to make a New Year Card using a computer program. Each student selected and placed essential and interesting short statements or words on his or her New Year card.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Students knew and memorised the step-by-step procedure to use the computer software to decorate and create their greeting cards (New Year Cards) by different texts (font, styles, and colour), picture, diagram, figures, and graphics.

Comprehension Students described the procedure for using the software by which they created and decorated their New Year cards.

Application Students applied the font, colour, size or style type to their texts by using the toolbar menu in the specific program for decorating and creating their New Year Card.

Analysis Each student classified and differentiated between a variety of particular cards such as post card, birthday card, thank you card and the New Year Card by the different procedures which were used. Students separated each card by using a variety of texts (sizes, fonts, styles, and colour) and pictures on these cards.

Synthesis -
Evaluation -

School M

- Social Studies Class (MSocial)

(a) Description of the classroom context and the lesson

During the final class of the semester, the Social Studies teacher (MSocial) divided her students into five groups. The teacher assigned each group to review the lesson contents of the social studies course and present their findings using PowerPoint during the class hour. Each student group could select any part of the semester's lessons for review.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge Students worked with group members to list the topics, which were the most interesting to them.

Comprehension Students summarised the details of the contents, which were put in PowerPoint presentations of seven to ten slides.

Application -
Analysis -
Synthesis -
Evaluation -

- English Language Class (MEng)

(a) Description of the classroom context and the lesson

The English teacher (MEng) prepared her class for a "General conversation" topic with a PowerPoint presentation. Most students were interested in the teacher's presentation because she used attractive graphics and sound effects to create her presentation. She taught conversation topics relevant to general real life, speaking from the first slide to the last slide, including (a) how to answer the phone at the office, (b) how to book a room at a hotel, and (c) how to reserve a table at a restaurant. Students practised in pairs using basic conversation following from these topics. Most of the students felt very happy to practise conversation by speaking with each other.

(b) Examples of the Levels of Bloom's Taxonomy used

Knowledge	Each student chose a partner to practise conversation with. They memorised some conversation chunks for repetition by speaking them with each other, not by reading from the slides on presentation.
Comprehension	Students learned what these conversation chunks meant.
Application	Students understood the appropriate context, and when to use the subjects. Students described how to maintain a longer conversation and change the topic, practising in pairs. Students gave a few examples of longer conversations while they were practising with each other or with their teacher.
Analysis	Students listened to conversations on a PowerPoint presentation and compared it to their speaking.
Synthesis	Each student created novel subjects using previous memorised lexical items and grammar. Students designed events, which used English conversations in real life situations.
Evaluation	The students discussed and compared each other's learning experience.

3.3.4 Overview

The observation findings showed that the classrooms in which science, mathematics and computing were being taught gave the students a greater opportunity to reach the higher learning levels in Bloom's Taxonomy than classrooms where other subjects were being taught. It could be argued that these subjects, by the very nature of their content, were more oriented to the higher order thinking skills. The fundamental importance of teacher characteristics was also apparent. Variations in teaching styles and methods, choice of instructional materials and the level of teachers' professional and development, in terms of both ICT knowledge and skills and their understanding of levels of critical thinking, meant the difference between well managed and effective ICT classrooms where students reached the higher levels of critical thinking skills and those classrooms where ICT use was minimal and ineffective and students' learning remained at basic levels of thinking.

It showed also be noted that in the analysis of the classroom observations, a lesson was classified as having achieved Bloom's higher order critical thinking skills if it gave evidence of students carrying out activities involving analysis only. It was not necessary for the learning process to include synthesis and evaluation as well. In practice, these last two levels of higher order thinking skills were not observed very often.

3.4 QUALITATIVE INSIGHTS INTO THE ICT SCHOOLS PILOT PROJECT IN THAILAND

The documentation from the model schools, as well as the interview and observation data, indicated overall that the professional development model of training a trainer to upgrade teachers and school administrative staff in ICT knowledge and skills had worked effectively in most of the schools. The team of leading ICT teachers and administrative staff from the model schools, attended regular computer training courses provided by the supervising universities and OBEC. These leading ICT teachers and staff then transferred the technological knowledge and techniques they had learned to other subject teachers throughout school individually or in small groups. Finally, these subject teachers integrated ICT into the teaching and learning processes in their classrooms. In this way, the training process increased the number of teachers who were successfully integrating ICT into their teaching and learning processes in the model schools.

The school documentation from the project provides examples of how each teacher in the ICT model schools constructed electronic instructional material resources, such as electronic lessons (E-Lessons), lesson plans (E-lesson plans), subject contents (E-contents), which included online lessons and digital contents, and other electronic information and products. The teachers used a variety of teaching methods to assign work projects and activities through the integrating ICT into the teaching and learning process during class hours. From the documentation it was clear that most of the model ICT schools had developed various electronic learning resources, such as electronic-book (E-Book), learning web pages, digital contents as well as Web Based Instruction. Some teachers collected subject lessons, lesson plans, instructional material, and other content in the forms of digital contents or online lessons through Learning Management System (LMS), Flip Album, and CD-ROMs. In addition, schools and other relevant institutions provided innovative learning materials for subject teachers in their own and other ICT schools. As well, all teachers could access available teaching and learning resources through electronic-library (E-Library), which was set up for all subject areas under the ICT schools pilot project in Thailand.

The school documentation and interviews also demonstrated how effective some model ICT schools were in motivating their students' self learning through students' work activities or school work both in and out of classrooms. Students were being encouraged to construct their own meaning from their learning by organising their own authentic learning activities, including such activities as ICT Camps and ICT Clubs. These activities helped students to get involved in a variety things in the real world and apply their ICT skills in an immediate and direct way. Moreover, these learning activities stimulated students' individual interests, which derived from existing interests, previously untapped potential, available opportunities, community needs, supportive environments, or other sources of knowledge. In addition, these activities generated a wider opportunity for students to access ICT at school; this was particularly important for students who could not access the internet or a computer at their home. However, as one of the identifying principles of the project made clear, these activities needed to supervised carefully and controlled closely by ICT teachers or subject teachers to ensure that students searched for beneficial information through appropriate websites. All ICT teachers were required to support students critically in using ICT in the correct manner and not allow any break of copyright.

From the researcher's observation, as well as teacher and student comments, it was apparent that many of the students who had been studying in the model ICT schools were developing at their own pace and maximising their potential by the use of ICT as a tool for different ways of learning. This self-learning was illustrated most clearly in the way many students combined their new ICT knowledge with their traditional learning experiences to generate various innovative ideas and create some imaginative projects and products, synthesised through the use of ICT. Examples included producing their own TV program, DJs, VDO directors, attractive drawings using Micro World program, as well as the creation and control of robot-by-robot programming.

The data from the school-based meetings provided evidence of the way all the model ICT schools tried to take advantage of their access to ICT by using it as an administrative tool in schools. This included setting up a database, collecting data for personal student profiles and recording student performance results (study and grade scores) during semester periods. OBEC provided a database management system (Learning Management System: LMS), which was used to help and organise student-teacher database systems through the online school network. This program helped ICT teachers, computer personnel or staff to manage and arrange the database effectively, with considerable saving in time and cost for the ICT school budget.

The most frequent pattern was for one or more teams of teachers to enter and update the database, with students' personal data (e.g. study enrolment, school and service fees) and student performance data (e.g. student scores, school grades, and students' performance results). These computer or ICT staff included the ICT teachers or anyone who could understand, apply, and use the school management system's software. However, the leading ICT teachers had a much higher responsibility in overseeing the school management system. They had to construct the basic infrastructure for the teaching and learning with ICT by developing and updating the school websites, through posting significant information regarding school administration, school contexts for school stakeholders, such as students, teachers, staff, parents, communities, and other relevant participants. In addition, some model ICT schools employed additional school staff to assist the model ICT teachers and help solve the practical problems, which arose in managing the ICT system and its applications for classroom and school management use.

The qualitative investigation was also useful in pointing to critical constraints which had acted as barriers to applying or integrating ICT into teaching and learning process. There was evidence that insufficient funds, lack of teachers and support staff who were experienced and qualified in ICT usage, and the negative attitudes of some school principals had obstructed the effective integration of ICT into the teaching and learning process in those classrooms which had access to ICT through the Thai ICT school pilot project.

All the teaching staff interviewed and many of the students pointed to insufficient equipment and resources, which had prevented the effective integration of ICT into the classroom teaching and learning process. There were specific complaints about the low speed of the internet, the low quality and lack of computers and ICT equipment which made the incorporation of ICT into the learning and teaching process for students during the class hour inconvenient and uncomfortable. The lack of appropriate resources was certainly one of the factors explaining why some of the model ICT schools were less successful in stimulating students' self-learning. Other reasons related to non-supportive school contexts and lack of community resources.

The other major factor hindering the full implementation of the aims of the ICT model schools program, was revealed most clearly in the classroom observation. In over a quarter of the classrooms observed, the ICT based teaching and learning activities reached only the lower levels of Bloom's learning outcomes. These classrooms were in contrast to the majority observed where the teachers concerned were able to give their students' opportunities for learning with ICT at the higher level of Bloom's scale. These findings point to the need for more professional training, which specifically links the integration of ICT into classroom learning and teaching with Bloom's Taxonomy of learning outcomes. There was evidence that this was particularly needed in the social studies and language areas. Examples of lessons from this study and the appendices of the official project reports (Bureau for Innovative Development in Education, 2006a, 2006b) could be used to give teachers practical experience of teaching approaches and student activities that lead to the three higher learning outcomes. Such professional development would seem to be critical for those schools in which the ICT pilot project was not proving to be as effective as had been hoped. It seems likely that among the teachers who did not volunteer to be observed, the proportion of those failing to teach to Bloom's higher levels of learning could be greater.

In relation to the key student outcomes being investigated in this study, the interview and observation data provided some very useful evidence. In the student interviews the number of comments positive to ICT in the classroom were more than three times greater than the disadvantages named. In addition, almost all the disadvantages they mentioned related to the constraints in the effective implementation of the ICT pilot study and not to the idea of ICT integration into the classroom per se. This was true also of their responses to the proposal of introducing ICT into all Thai classrooms, where the doubts and reluctance expressed related always to practical issues of how this could be done. The overall picture was of students favorable to ICT integration into classroom learning environments, although it is worth noting that students who had access the ICT at home tended to be rather less positive than those for whom the school classroom represented their only access to computer and ICT.

The classroom observation data were most useful in pinpointing the development of critical thinking levels in the ICT based classrooms of the pilot project. Three quarters of the classrooms observed gave evidence of teaching and learning activities at the higher level of Bloom's Taxonomy. This finding reflects very positively on the teacher characteristics of those who volunteered to be observed, as seen in their teaching methods and approaches, and their development of appropriate and challenging ICT resource and activity materials.

The finding on classroom teaching at the higher level of Bloom's Taxonomy and the evidence of students' self-learning and development, are the two most promising outcomes of the Thai ICT schools pilot project revealed in the qualitative analysis.

CONCLUSION TO PORTFOLIO

Introduction

The major purpose of the current study was to investigate how effectively Information and Communication Technology (ICT) was being integrated into teaching and learning in grade six at elementary and in grade nine at secondary schools involved in the ICT schools pilot project in Thailand. A research model was designed to examine possible associations among students' individual background characteristics (student gender, academic background, computer experience, and computer usage), student perceptions of classroom environment with ICT, and student outcomes (students' critical thinking skills and students' attitudes toward ICT), and the extent to which these were influenced by teachers' characteristics (teachers' critical thinking skills and teachers' attitudes towards ICT). I used both quantitative and qualitative research methods to examine four research propositions, which were constructed from the research model developed.

This conclusion to the Portfolio synthesises the major results of the analyses of data which focused on the four major factors investigated: in relation to (a) classroom learning environment with ICT, (b) students' attitudes toward the use of ICT, (c) students' critical thinking skills, and (d) teachers' characteristics to support two student outcomes (students' critical thinking skill and their attitudes toward ICT). The research results are discussed in relation to examining the associations among variables, proposed in Proposition 1 to Proposition 4. After considering some limitations of the research, the study ends with a discussion of implications and recommendations for teachers and school management, followed by a proposal for the direction of the future research.

Synthesis of Findings

The results from both the quantitative and qualitative investigations provided evidence that many students improved their levels of critical thinking and developed positive attitudes to ICT. However, the findings pointed also to the fact that these positive outcomes were not evident for all classrooms of the Thai ICT schools pilot project. The discussion of the results that follows seeks to pinpoint the factors, which led to positive outcomes for many, while identifying the factors that limited or hindered other students from achieving the desired outcomes.

The key quantitative and qualitative findings of the study are synthesised in the following sections, which discuss the associations between the key factors, as postulated in the four Research Propositions:

Proposition 1: There are differences between students' perceptions of their actual and preferred classroom learning environments with ICT. The ways in which these differences were made apparent in the various analyses are outlined below.

When students' perceptions of classroom learning environments with ICT were investigated in terms of both actual and preferred environments, the quantitative analysis found that most students had more favourable perceptions on co-operation, teacher support, student involvement, and competition and would prefer more group work, teacher-student relationships, and order-organisation, in terms of the scales of classroom learning environment. Therefore, most students would be happy with an ICT classroom atmosphere that allowed them to work together in groups through assignments and classroom tasks or activities.

Moreover, students were satisfied in their ICT classrooms where they were taught by teachers who helped, supported, and were interested to encourage a better understanding of the lesson content, basic knowledge, and theoretical concepts. This was consistent with the previous study of Capel et al (2001). Similarly, Ramsay's (2001) research found that the use of ICT, particularly in terms of computers in schools, involved a change in the relationship between students and teachers, resulting in students having greater power. The fact that computers cannot easily be integrated into classrooms without a better understanding of the interaction between teachers and students, and between students and their peers, was also documented in other prior studies (Fulton, 1998; Olson, 1992).

An interesting finding was that students did not feel pressured to complete their assignments in competition with their peers or classmates. In contrast, student-peer interaction tended to make them satisfied to achieve higher study performances (study or grade scores) by comparing themselves with others. In addition, most students would pay attention to studying and doing class activities, provided that the classroom had definite rules to control student behaviour. Students who had had less opportunity for computer training and access to computer or internet at home preferred a group work learning environment with ICT. Because they had less opportunity to become familiar with ICT at home, they tended to have higher expectations of help and support from working in groups through collaborative achievements or cooperative assignments. Those students who had access to ICT facilities at home often preferred individual work and self-development activities, which they could finish by themselves at home.

Proposition 2: The students' perceptions of ICT classroom learning environments and student outcomes differ because of students' individual background characteristics (gender, academic background, computer experience, and computer usage). In comparing students' individual background characteristics, the data analysis showed differences in student gender, academic background, computer experiences, and home computer usage in relation to student perceptions of in both actual and preferred classroom environments with ICT.

Gender Differences

The quantitative analysis indicated that, normally, girl students seemed to have more favourable perceptions than boy students did of both actual and preferred classroom environments with ICT. This finding was supported by the studies of Raaflaub and Fraser (2002). The girl students also perceived more competition with one other than did boy students, perhaps because the girls' achievements in terms of good grade scores were higher. It is possible that girls focused on how to get good grade scores in comparison with others in their ICT classroom more often than boys.

When the two student outcomes were examined, however, there were no significant differences between boys and girls on students' critical thinking skills. On the other hand, girls had more positive overall attitudes toward ICT than boys. This is consistent with previous research by Almahboub (2000) who showed that girl students had significantly more positive attitudes toward computers than did boy students. Additionally, girls had significantly more positive attitudes toward ICT in terms of ICT Feeling, ICT Involvement, and Using Email than did boys, as has been documented in prior studies (Crump & Rennie, 2004; Raaflaub & Fraser, 2002). Therefore, findings from the analyses of the present study provide partial support for differences between perceptions of ICT classroom environments and student outcomes influenced by student gender.

School Level Differences

Quantitative results showed that secondary school students (ninth graders) preferred more group work, better teacher-student relationships, and more competitive ICT classroom environments than primary school students (sixth graders). The older students appreciated that computer technology provided more opportunity to learn through working with others. Class activities which involved working in groups appeared to motivate students to achieve and to exchange knowledge with one another. Similarly, Barak's (2004) study concluded that using computers, particularly the internet, for teaching and learning in electronics studies in Israeli high schools, was likely to increase motivation, promote deeper learning, encourage co-operation and knowledge exchange between students, and foster the joint development of ideas.

In relation to the two student outcomes, the older students tended to have higher scores in critical thinking skills than the younger students. Perhaps this is due to the fact that the older grade nine students possessed more theoretical concepts and knowledge to understand the lesson content and were able to use their thinking skills to analyse or apply the concepts in solving problems or answering questions. In the case of students' attitudes toward ICT, however, younger students seemed to have more positive attitudes toward ICT than older students. In the researcher's observation, the primary school teachers in the ICT schools pilot project appeared generally to have more technological skills and be more confident in integrating ICT into their teaching then the secondary teachers did. Perhaps this fact helps to explain school level difference in students' attitudes to the use of ICT in their classroom, since teachers very often act as a role models for student in attitudes toward ICT. Bramald and Higgins (1999) supported this evidence that teacher perceptions of technological skills could be related to student outcomes.

Although the analyses of the present study supported the proposition of school level differences influencing student perceptions and outcomes, it should be noted that the difference in mean scores on attitudes toward ICT between primary and secondary school students was not significant.

Subject Area Differences

The quantitative analysis indicated that students who were studying in the Social Studies-Arts area considered that they had more opportunities for group work in ICT classroom learning environments than did students in the Science-Technology subject areas. Students who studied in Social Studies-Arts subjects were allowed to access ICT to work collectively in gathering and organising information from the internet for preparing their project reports or completing group tasks and activities. Both the classroom and interview data supported this finding, although there was evidence that Science-Technology teachers aimed at higher levels of critical thinking skills when integrating ICT into their teaching and learning process.

For ideal classroom environments also, students in the Social Studies-Arts subject areas preferred more group work, co-operation, teacher support, and student involvement than students who were in Science-Technology subjects.

When student outcomes were examined, the differences between subject areas were not statistically significant for either critical thinking skills or attitudes toward ICT, although the attitudes of students who studied in the Social Studies-Arts area were more positive toward ICT than those of students in the Science-Technology subject. In the case of students' critical thinking skills, the results of the present study are consistent with Mucherah's (2003, pp. 50-54) study which suggested that students who studied in the Science-Technology subjects seemed to have higher scores of deduction and assumption reasoning skills than students who studied in the Social Studies-Arts subjects. The school observation data in the present study indicated that teachers in the Science-Technology area more often organised lessons that involved higher level learning outcomes than the Social Studies-Arts teachers. Three outstanding examples of this were discussed in Part 3, section 3.3.3.3. Therefore, the findings of the present study gave support to Proposition 2 in relation to differences between perceptions of ICT classroom environments and student outcomes being influenced by subject area differences.

Computer Experience Differences

While there were no significant differences between students, based on the length of their computer experience, on any of the seven scales of classroom environments with ICT, there was evidence that students with longer computer experience (more than 5 years) had more favourable perceptions of ICT classroom environments than students with shorter computer experiences (equal or less than 5 years). In relation to perceptions of ideal classroom learning environments, the results of the present study indicated that students who lacked computer experience more often favoured student involvement in the classroom than those students with computer experience. This was the only classroom variable that was statistically significant. Perhaps, students with more computer experience felt they could do additional work on their own and still enjoy themselves in their ICT classroom environments. Students who lacked computer experience, however, hoped that their peers would motivate them to participate more effectively in class activities. The comments made by students in the interviews supported this interpretation. A number claimed that when they worked as a team, students could help support one other, reduce their weaknesses and increase their depth of knowledge and understanding. In addition, many students expressed the view that students liked subject teachers who assigned them group work to do, because this gave them an opportunity to share the work and discuss different ideas with others.

There were no significant differences on the two student outcomes (attitudes toward ICT and critical thinking skills) between students who had long and short computer experiences. Therefore, the findings in relation to differences in computer experience students’ perceptions of ICT classroom environments and student outcomes provided only partial confirmation of Proposition 2.

Computer Training Differences

In general, students who had previously attended courses for computer training seemed to have more favourable scores on the two student outcomes (critical thinking skills and attitudes toward ICT) than those who did not. However, the differences between the two groups of students on the two outcomes were not significant.

In the case of actual classroom learning environments, students who had received computer training favoured more teacher support in their classroom learning environments with ICT than students who had had no training. When the preferred classroom environments were considered, there were no statistically significant differences for all seven scales, but students who had received training in computer courses seemed to prefer student involvement and teacher-student relationships more than those who did not. The interviewees' responses demonstrated that students would have liked more guidance and instruction from their subject teachers, since this encouraged a better understanding of the concepts connected with computer applications and their use.

Therefore, the findings partially support Proposition 2 in that were some differences between perceptions of ICT classroom environments and student outcomes which were influenced by computer training differences.

Computer Home Usage Differences

In the investigation of differences based on students' computer home usage, there were no statistically significant difference for any of the seven scales of both actual and preferred ICT classroom environments. However, students who used a computer at home tended to have more favourable perceptions than students who did not, for both actual and preferred ICT classroom environments.

When the outcomes of students' critical thinking skills and attitudes toward ICT were examined, there was evidence that students who used a computer at home seemed to have higher critical thinking scores than students who did not. The response from the interviews showed that when students were able to familiarise themselves with ICT or computer use at home, it developed other important skills and competencies, such as self-study learning, thinking analytically and logically, synthesising ideas and concepts, and so on. Nevertheless, there was no significant difference in mean scores for students who used a computer at their home and those who did not on students' critical thinking skills.

In relation to students' attitudes to ICT, however, students who used a computer at home had statistically lower scores on the two scales of ICT Importance and Computer Usage. This finding could imply that students who could access computer at their home paid lower attention during study hours and were not interested in using a computer at their schools for doing their assignments. They preferred to complete school assignments through using the computer at their home. This is compatible with previous research by Jedeskog and Nissen (2004), who found that some students worked successfully on their own by using a computer at home, and preferred to work at home, rather than during class hours.

The findings confirm Proposition 2 in that there were some differences in perceptions of ICT classroom environments and student outcomes, which were influenced by differences in computer home usage.

The Internet Home Usage Differences

Although, there were no statistically significant differences for all seven scales of both actual and preferred classroom environment with ICT, students who accessed the internet at their home had more positive scores than students who did not.

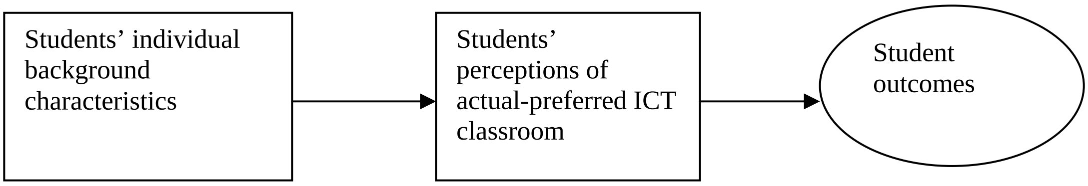
In the preferred environments, however, the scores of students who were able to access the internet at home tended to be lower on some scales than students who could not. Students who were able to access the internet at home seemed to prefer to search information from the internet at their home rather than at their school, due to it being more convenient or comfortable to access. Their preferences might also reflect the practical problems of using ICT and network facilities in some ICT classroom environments. The responses from the interviews provided support in the students' frequent mention of problems with computer or internet access at their schools. There were complaints of low internet speed, outdated hardware and software, low numbers of functioning computers or ICT equipment, which could have obstructed some students, so that they paid less attention and did not focus on their work during study hours.

When the two student outcomes (students' critical thinking skills and their attitudes toward ICT) were examined, a statistically significant difference in student outcomes was found only in students' attitudes toward ICT (ICT feeling). As with computer home usage, students who could access the internet at their home had less motivation about using it at school than those who had no internet access at home. The students considered that accessing the internet at home was a more convenient and comfortable way of completing their school work. On the other hand, there was no significant difference in the mean scores for students who accessed the internet at their home and those who did not, on the outcome of students' critical thinking skills. However, students who accessed the internet at home had higher critical thinking scores than students who had no internet access at home.

Therefore, findings from the analyses of the present study provided partial support for Proposition 2, because there were some differences in student attitudes to ICT, which were influenced by differences in internet home usage.

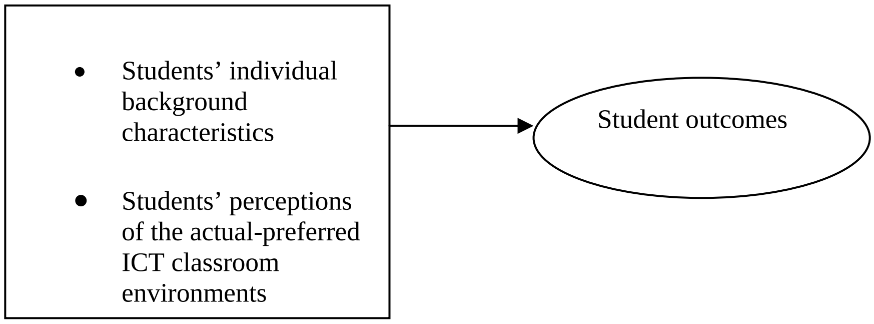
Proposition 3: There are relationships between students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom learning environments, and student outcomes (attitudes toward ICT and critical thinking skills).

The associations put forward in Proposition 3 were tested in two stages. Firstly, it was necessary to formally exclude the possibility that students' perceptions of ICT classroom learning environments directly mediated the relationship between students' individual characteristics and student outcomes, as in the form below.



I used Hierarchical Multiple Regression Analysis to test the above model. The results supported the proposition that students' perceptions of ICT classroom environments did not mediate the relationships between students' individual characteristics and student outcomes.

In consequence, the appropriate research model for further consideration was of the following form where students' perceptions were treated as a separate variable.



Here students' individual background characteristics are seen as combining with students' perceptions of ICT classroom to have associations with student outcomes.

The Multiple Regression Analysis, used to test this second model, found that some of the student background characteristic variables and some of the scales of the student perceptions of ICT classroom environments combined to have small associations with three student attitude outcomes: (a) students' attitudes toward email for classroom use; (b) attitudes toward ICT involvement; and (c) attitudes toward the use of email in the classroom. There were some individual characteristic variables and some classroom perception scales that directly, rather than in combination (indirectly) proved to have some association with critical thinking outcomes. School level related positively to both critical thinking outcomes; Subject area was negatively associated with deductive-assumption reasoning skills; and Student perceptions of classroom co-operation and teacher support were linked to deduction-assumption reasoning skills. Each of the positive relationships identified in Proposition 3 is discussed below. Findings from the qualitative analysis are included where they were relevant.

The statistical analysis showed that the school level and students' perceptions on the classroom group work predictor combined to have a small association with students' attitudes toward email for classroom use. Where students preferred to work by themselves rather than in groups, they seemed to recognise the importance of getting help or sharing their ideas or opinions with their teacher by using online communication tools such as email. Thus email was seen as a way of helping students to learn more by themselves or to do extra work on their own without face-to-face teacher discussions, while allowing better access to their subject teacher, as an information disseminator, both in and out of study hours.

In the case of students' attitudes toward ICT involvement, the student characteristic variables of gender and computer training and the students' perceptions of five classroom predictors (Teacher Support, Student Involvement, Teacher-Student Relationships, Competition, and Order-Organisation) combined to provide a small association with students' attitudes toward ICT Involvement.

The finding concerning gender as a significant variable, is consistent with previous research. Specifically, Knezek and Christensen's research concluded that girl students had significantly more positive attitudes toward ICT than boy students in the areas of study habits and empathy in their classrooms (which was compatible to the student involvement with ICT variables in the present study) and indicated the importance of these aspects in the development of a successful ICT classroom (Knezek & Christensen, 1997; Knezek et al., 1998; Knezek & Christensen, 1995). As might be anticipated, the variable of student training proved to be related positively to the outcome of ICT involvement.

For the classroom predictors of Teacher Support, Student Involvement, and Competition, the relationships with students' attitudes in ICT Involvement were positive. However, for Order-Organisation and Teacher-Student Relationships, the relationship to students' attitudes toward ICT Involvement was negative – an unexpected result. It is possible that students who enjoyed using computers during class hours preferred less teacher control and more peer interaction in their learning. The finding on the teacher support predictor replicated previous research (Levy et al., 2003), in that some students who had less confidence or more anxiety in the use of the computer in their classrooms than others needed a subject teacher who was extremely supportive to guide them to achieve their task rather than working on their own. Moreover, Newhouse's (2001a) research similarly found that teachers needed to establish a variety of ICT technological environments and provide supportive instructional resources relevant to their particular students.

In the case of attitudes toward email in general, the student variable of gender together with the classroom predictors of teacher-student relationships and student involvement combined to have a small association with student attitudes towards the use of email.

Students who favoured teacher attention and friendly interest had more positive attitudes to the use of email, because subject teachers could discuss issues through using online communication tools such as email. It could be implied that the use of email provided better access to the subject teacher and made students feel more involved with students and with teachers.

Three of the outcome factors related to student attitudes to ICT were shown to have associations with individual variables and classroom predictors. Although these links did not prove to be significant in the present study, they are discussed below because of their links with earlier research.

In relation to the outcome of attitudes toward ICT importance, the quantitative findings indicated that students who received training in a computer course had higher perceptions on students' attitudes toward ICT importance than those who did not. This finding appeared to be consistent with an investigation by Pope-Davis and Walter (1993) who recognised that students who received computer training had less anxiety, more confidence and more interest in using computer or ICT than those who did not.

With regards to students' positive feelings on the use of ICT, the findings of the present study asserted that student gender differences and the use of internet at home had positive associations with their attitudes toward ICT feeling. Girls had more positive feelings on the use of ICT than boys, as has been documented in previous studies (Sacks et al., 1993-1994). Furthermore, this finding appeared to support the argument by Alamhaboub (2000) who stated that girls had significantly more positive attitudes toward computers than did boys. The more positive attitudes toward ICT among students who had no internet access at home, reflected the situation that students who could access the internet at their home tended to lack motivation to use ICT during study hours, due to the fact that internet accessibility at home was more convenient and more comfortable. The majority response from the student interviews also indicated that the internet at school was usually not high speed. Many students recognised that it was very difficult and slow to access electronic information from any websites at school. They were not comfortable accessing the internet or using the computer at their schools when preparing or conducting reports, and preferred to use the computer or access the internet at their homes.

In the case of students' attitudes toward computer usage outcome, the quantitative analysis found that the Teacher Support classroom predictor was related positively to students' attitudes toward the use of computer. This result highlighted again the importance of supportive teaching in the ICT classroom environments.

When critical thinking outcomes were considered, the multiple regression analysis indicated that no combinations of individual variables and classroom predictors were significantly related to either the deduction-assumption reasoning skill or the induction-credibility reasoning skills. However, there were a number of individual background variables and classroom predictors, which singly had associations with critical thinking outcomes. These are discussed in the paragraphs that follow.

The quantitative analysis found that the school level variable was related positively to both critical thinking skill outcomes. This finding implied that students who came from grade nine in secondary schools had higher scores on both deduction-assumption and induction-credibility reasoning skills than students who were in grade six at primary schools. Almost certainly this was due to the age of the students and their additional two years of schooling. The older students had more knowledge to analyse and apply, a better understanding of theoretical concepts and were able to perform better on critical thinking skills than the younger students.

In addition, the subject area variable was related negatively to the deduction-assumption reasoning skill outcome. This indicated that students who studied science, mathematics, and computer or Information Technology (IT) subjects had higher scores in the deduction-assumption reasoning skills in comparison to those who studied in social studies-art subjects. This is consistent with the studies of Thomson, Simonson, and Hargrave (1992) and Thornburg (1991) which reported the way mathematics teachers used technology, including a computer in the class, as a tool to increase students' mathematics achievement, as well as, to assist students in solving problems. Part 3 (3.3.3.3) of this study reported the observations of one mathematics teacher who gave students the opportunity to use critical thinking skills during class hours in a mathematics class.

Thomson, Simonson, and Hargrave (1992) also considered that instructional technique in mathematics could create a positive ICT classroom learning environment to support students' higher study achievements. This approach was also supported by a research on high school physics students in a Spanish classroom, which was conducted by Sierra-Fernandez and Perales-Palacios (2003). The study suggested that the process of learning computer simulation helped a student to think about how to solve a problem and indicated further that the interactions among students, software, and teachers in the activities-based science learning framework encouraged the development of problem-solving skills and conceptual understanding in the students.

There were two classroom predictors that proved to have statistically significant relations with students' critical thinking skills. Students with high scores on co-operation and teacher support in the classroom had higher scores in critical thinking skills. The responses from the interview provided further support that some mathematics or science teachers spent a long time preparing supportive and helpful instructional resources through using both electronic and paper materials. These materials could attract their students' attention to focus on their study during study hours, and made students clarify their understanding. The interview participants also suggested that they preferred teachers who asked questions to stimulate their students to think logically or systematically. The classroom observation and interview responses singled out teachers who asked questions, and then patiently waited for answers. Several examples of this teacher behaviour were reported in Part 3 in section 3.3.3.3.

In relation to the second critical thinking outcome, the variable of computer training was related negatively to induction-credibility thinking skill. This implied that students who received computer training had higher scores on the induction-credibility thinking skill.

Overall, the analysis of Proposition 3 revealed that students' perceptions of classroom environments did not mediate the relationship between student individual characteristics and student outcomes. However, the multiple regression analyses conducted subsequently showed a number of individual characteristic variables and a number of classroom predictors did combine to have statistically significant associations with the attitudes to ICT outcomes. In the case of the critical thinking outcome, there were some individual characteristic variables and some classroom scales, which singly had statistical association with one or both critical thinking skill outcomes. These findings provided partial support for Proposition 3.

Proposition 4: There are associations between students' individual characteristics (gender, academic background, computer experience, and computer usage), students' perceptions of ICT classroom learning environments, and student outcomes (students' critical thinking skills and students' attitudes towards ICT) in relation to teachers' critical thinking skills and teachers' attitudes toward ICT.

The results of the HLM analysis indicated that three of the outcome variables (Deduction-Assumption Reasoning Skills, Students' Use of Email and students' Use of Email in the Classroom). These are discussed in turn below, beginning with critical thinking skills.

Students who had high perception scores on co-operation between students and their peers to achieve assignments and class work tended to have higher scores on the deduction-assumption reasoning skill. This points to the way using technology in the classroom can improve problem solving, decision-making, collaborative and higher-order thinking skills for students (Thompson, et al.,1992; Thornburg, 1991; Papert, 1993). This is also consistent with the previous study by Hopson, Simms, and Knezek (2001-2002) who found that a collaborative computing classroom environment was able to create a new teaching and learning environment. However, the observation data from this study indicated that it was essential for teachers to make a conscious link between ICT in the classroom and increasing higher-order or critical thinking skills. Without this, it was possible for co-operative learning in the ICT classroom to focus only on lower learning thinking skills.

There was evidence that both teacher characteristics (critical thinking skills and attitudes to use of computer) interacted with the co-operation classroom predictor to impact on students' deduction-assumption thinking skills. This meant that students' deduction-assumption thinking skills were higher where they had teachers with high critical thinking skills and positive attitudes to the use of computer in classrooms using co-operative learning approaches. The responses from the teacher interviews confirmed that where subject teachers familiarised themselves positively with ICT, in particular the computer, in order to incorporate ICT into their teaching and learning, their students were able to develop more effectively in skills such as thinking critically, analytically and logically, and synthesising knowledge and theoretical concepts. These teacher participants also indicated that the use of ICT could facilitate students to organise, remember, retrieve information, and make decisions. This finding is consistent with the previous study by Marjanovic

(1999, p.129) who found that collaborative learning methods had the potential to improve students' problem solving, critical thinking skills, and communicative skills.

In the case of using ICT equipment other than a computer, the results of the present study found that where students were taught by teachers who were very interested in integrating other instructional materials such as television, video, camera, slide, multimedia into their teaching and learning process, students' deduction-assumption reasoning skills were higher. The interviews also supported this finding in that most student interviewees preferred to learn in classroom environments, which incorporated ICT into teaching and learning, especially when subject teachers used a variety of multimedia such as television, video, digital camera, slides, and other media to provide attractive lesson materials in a supportive and interesting environment. They further expressed the opinion that the best teacher to develop critical thinking skills had high technological skills and knowledge and used these to teach their students actively. They strongly agreed that the most important factor was that all teachers ought to try to teach their students through the use of a variety of ICT equipment which could help to make complex content more simple and understandable.

The quantitative analysis also showed that students' deduction-assumption skills were also affected by teachers' computer experiences and home internet accessibility, although in an unexpected way. Teachers who did not have long computer experience, appeared to be providing opportunities to their students to share learning resources and work together, using the students' own technological knowledge and skills, material resources and sharing computer experience with one other in a way which enhanced students' critical thinking skills during the class periods. The qualitative results provisionally suggested that the ideal teachers, according to students, were those who developed their professional understanding of skills and knowledge through reading many books, gathering and organising new information from the internet or incorporating internet research strategies into their teaching and learning. The teacher interviews pointed to the need for continuous training in professional knowledge, which would lead to the improvement of their teaching experiences, even if they did not have long periods of computer experience. Moreover, students preferred teachers who could establish positive and supportive environments and increase students' technology skills and levels of computer competency and thus reduce the fear of using computer equipment.

Similarly teachers who could not access the internet at their home, were able to generate learning and instructing material resources with their own students through internet usage during class hours. This method appeared to attract their students' attention and help them focus on the lesson content. According to the participant students' views, the ideal teacher to develop students' critical thinking skills needed to have a high understanding of skills and knowledge to teach their students to actively search for new information, from any sources such as the internet, books, articles, and other resources, and to provide attractive lesson materials to apply this modern technology in their classroom. Particularly, there was seen to be a need for teachers to develop students' critical thinking skills through the use of the internet in the actual classroom environment in any subject. This is consistent with prior research of Admiraal et al's (1998) who found that the use of technology in the classroom, through computer conferencing, and in particular the use of the internet, could support and develop collaborative learning among students and between students and teachers. Moreover, watching the teachers construct an understanding of ICT skills and knowledge enabled the students to reach higher quality learning outcomes, as reflected in their critical thinking skills.

The HLM analysis indicated that the home internet accessibility of teachers influenced students' attitudes toward the use of email either through a direct or interaction effect. One direct effect was that students who were taught by teachers who could access the internet at their home demonstrated more positive attitudes toward the use of email. Churach and Fisher's (1999) research similarly found that the teacher plays an important role in increasing internet usage among their students. Internet usage was seen to be an instrument of teaching and learning which enabled students to focus on the school task, through gathering, organising, analysing data and information from the internet. Forgasz's (2002) and Meredyth et al's (1999) research also identified factors that facilitated or prevented teachers from integrating ICT, particularly the computer, into their teaching and learning process. These factors included computer ownership, level of technological skills and knowledge, teachers' individual background characteristics, teachers' beliefs about teaching and learning with ICT, and their perceptions of their own level of basic and advanced technological skills.

The quantitative analysis also showed that girl students and students who favoured teacher-student relationships tended to have more positive attitudes to email use. In summary, students who had positive attitudes toward email were more likely to be girl students and to emphasise teacher-student relationships in their ICT classroom environments. Both of these factors were documented in prior studies by Raaflaub and Fraser (2002).

The quantitative analysis further indicated an interaction effect between teachers with high deductive reasoning skills and the classroom predictor of student-teacher relations, impacting on students' attitudes to the use of email in general. It could be implied that students who favoured classroom environments with positive student-teacher relationships, and who were taught by teachers who had high levels of deductive reasoning skills had more positive attitudes toward email generally. Comments from the interviews indicated that online communication tools, such as email, enabled students to get help or share discussions with their subject teacher.

A negative direct effect was evident in relation to student attitudes to the use of email in the classroom. Students who were not in favour of group work, but preferred to work by themselves, tended to have more positive attitudes towards the use of email in the classroom. Such students were supported in their autonomous learning through the dissemination of class information using email or using other online communication tools. Email provided students with better access, supportive help, or shared discussions with those subject teachers who allowed their students to learn at their own rate and made them feel free to contact them without face-to-face communication. This is consistent with previous research by Alessi and Trollip (2001) who asserted that computer based instruction in classroom learning environment with ICT could motivate and stimulate students to work at their own pace, while offering students' the opportunity to learn more by themselves. Therefore, the use of ICT, in particular email, was considered to be an effective way of nurturing meaningful communication between teacher and their students, and fostering creative learning, and problem solving (Ramsay, 2001).

There were also a series of teacher characteristics, which had direct effects on student attitudes to email use in the classroom. Where teachers were female, had long computer experience, positive attitudes towards the use of email for the classroom and could access the Internet at their home, students had more positive attitudes to using email in the classroom. Forgasz's (2002) research similarly found that there were differences in technological skills, at both basic and advanced levels among teachers in relation to school types (private, public, or Catholic school), teacher gender (female or male), and school educational levels (primary or secondary school level). All of these influenced students' attitudes regarding using the computer. The finding was also consistent with previous research by Churach and Fisher (1999) who found that teachers played a vital role in student attitudes to the use of ICT and the internet in particular.

Meredyth et al (1999) concluded from their study that teachers' characteristics, such as gender, computer ownership, computer experience, and school educational level, as well as beliefs about teaching and learning with computers, perceptions of their technological skills were all significant influences on the ICT classroom environment. .

The teacher interviewees also expressed the opinion that there were a number of teacher background characteristics that could prevent or stimulate teachers' enthusiasm for incorporating ICT into the teaching and learning process. Some subject teachers were not confident in using computers in their classroom due to the lack of confidence in the use of the computer, lack of computer experience, lack of computer training, lack in of time to prepare or conduct instructional technological materials as well as lack of computer accessibility, as was documented in prior studies (Ktoridou, 2002; Russell & Bradley, 1997; Stokes, 2001). Therefore, they did not actually apply the technology, in particular the computer, in their classroom.

Moreover, there was evidence in the students' comments that teachers' computer anxiety could negatively influence their students in classroom learning environments with ICT. This is consistent with previous research by Rosen and Weil (1990) who found that if teachers felt negatively about the use of the computer and were therefore reluctant to use it, their negative attitudes could be passed on to their students.

Based on the analysis of interview data, some teachers lacked technological understanding of skills and knowledge and they did not have enough time to receive training in computer courses. As a result, they lacked the confidence to teach their students effectively through incorporating ICT or computer into the teaching and learning process. Some interview participants further recognised that some teachers thought that modern technology might confuse them or their students by applying ICT or computer into teaching and learning with ICT. This was seen to apply also to school leaders, in particular principals, who might not feel confident to incorporate ICT in their schools. As a result, they did not allocate any budget or distribute money for setting up ICT in the classroom. In addition, they did not provide support or budget funding for teachers' technological or computer training regarding integrating ICT or the computer into the classroom.

Another interaction effect identified in the quantitative analysis involved teachers' attitudes to computer and the classroom group work predictor. Where teachers' attitudes to the computers were negative and students preferred group work in the classroom, the attitudes of students to email use in the classroom were more positive. Riel (1994) confirmed in his research that subject teachers could choose to change the classroom environment and that the use of the computer could be part of the motivation to do so. It certainly would appear that even when classroom environments were not changed by integrating the computer or ICT into teaching and learning, changes did occur in the interaction between students and teachers.

In contrast, Bramald and Higgins (1999, p. 97) made a detailed argument that "effective teachers who use ICT were confident and comfortable with it as an enabling addition to their pedagogical understanding of skills and knowledge". This is consistent with the quantitative findings of this study, which indicated that in classroom environments not involving group work, but with teachers who had high positive attitudes toward the use of email, students' attitudes toward email for classroom were also positive. It could be implied that where students were in classes with teachers who approved the use of email in the classroom, students came to be proficient in, and positive toward, the use of email in the classroom. In this context, the use of face to face group work declined in favoured of email communication. This is consistent with a previous study by Jedeskog and Nissen (2004, p.44) who found that "if the pupils are occupied in front of the computer, there always is a chance that they might manage their own learning process by themselves".

Another interaction effect involved subject area differences. In group work oriented classroom environments, students who studied in science, mathematics, and computer or Information Technology (IT) subjects tended to report higher levels of positive attitudes toward email or other online communication tools, than students who studied in social studies subjects. This is in line with, Barak's study (2004) which investigated the impact of introducing computerised communication, mainly simulation and the internet on teaching and learning in electronics studies in Israeli high schools. The results concluded that using computer and communication technologies was likely to encourage cooperation and knowledge exchange between students, and support joint development of ideas.

The responses from the student interviews also provided support to the idea that the use of computers in the classroom for student group work, group presentation, or project work was very helpful for the students who wanted to do their work as professionals. There was an interesting example concerning working in groups in science subjects among the ICT classroom environments observed. Group work seemed to increase the level of students' positive attitudes toward ICT, mainly computer use. The example of a science class discussed in Part 3 in section 3.3.3.3 illustrated this well.

Overall, findings from both quantitative and qualitative analyses supported Proposition 4 which indicates that there are relationships between students' individual background, students' perception of ICT classroom learning environment, and three student learning outcomes (deduction-assumption thinking skills, attitudes towards email in general, and attitudes towards email for classroom) in relation to certain teacher characteristics (teachers' individual background, teachers' critical thinking skills, and teachers' attitudes toward ICT).

Limitations of the Study

The present study developed a mediation model to provide an initial framework to investigate the associations between students' individual characteristics, perceptions of classroom learning environments with ICT, and student outcomes in relation to certain teacher characteristics (teachers' critical thinking skills, and teachers' attitudes towards ICT). Generally, students' individual backgrounds and perceptions of classroom learning environments were associated with only small amounts of variance in student outcomes. The study also provided substantial insights into the quality of learning through interviews and classroom lesson observations in ICT schools under the Thai ICT schools pilot project. The final results concluded that students could be assisted to learn critical thinking skills and their attitudes toward ICT could be enriched in ICT classrooms where teachers have the necessary ICT knowledge and skills, and the positive attitudes to provide a supportive learning environment.

However, several considerations need to be taken into account when interpreting the findings of the current study. These limitations are discussed below.

Population and Sample Scale

(a) Populations

In terms of questionnaire surveys, the study population consisted of students and teachers who were in grade six at primary and grade nine at secondary schools in 13 model ICT schools under Thai ICT schools pilot project. This fact limits the generalisability of the results. It would generally be assumed that sixth graders in primary and ninth graders at secondary schools from the 13 model ICT schools were too small a population to allow the results to be representative of all students and teachers in all the different educational levels across primary and secondary schools. Thus, it is recommended that this study should be replicated by extending the target population to include other participants from grades one to grade twelve in the 13 model ICT schools under the Thai ICT schools pilot project.

(b) Samples

The sample included only the participating 150 students and 16 teachers who were in grade six at primary school and grade nine at secondary school in eight model ICT schools. Only eight model ICT schools were involved in the study, which limited the generalisability of the findings to other model ICT schools. In addition, the sample size in the quantitative studies was typically too small to allow the results to be representative of the entire population in 13 model ICT schools in all educational school levels. Therefore, extending the sample size to include students and teachers who came from all educational levels could provide richer data.

In addition, the sample of this study was relatively small (n=150 students, n= 16 teachers), although it was considered adequate for the statistical procedures used to test comparisons and associations. Therefore, further research should involve a larger, more diverse sample, which includes a larger number of student and teacher participants from all grades in primary and secondary schools. In particular, there should be inclusion of students and teachers from all 13 model ICT schools under the ICT schools pilot project in Thailand.

While there is a risk about generalising the findings because of the limitations discussed above, my quantitative and qualitative research design involving four sources of data was intended to overcome, to some extent, some of these problems. In the quantitative part, data collection was based student and teacher surveys. For the qualitative part of this study, three methods of data collection were chosen to provide a triangulation of methods and perspectives. School documents, written by the participants in the ICT school pilot project, provided data which were independent of the researcher's influence. Classroom lesson observations, on the other hand, were carried out by the researcher herself and represented her observation and interpretation of the teaching and learning processes in the classroom involved. Interviewing was chosen as the third data collection method, because it provided the best opportunity to access directly the experiences and views of student and teacher participants.

The questionnaires were used to measure important dimensions of the classroom learning environments with ICT related to students' critical thinking skills and students' attitudes toward ICT, which were influenced by certain teacher factors. But, there was a possibility that these questionnaire surveys were not sensitive enough to address the research intentions adequately. Therefore, the quantitative analysis was complemented and supplemented by school documents, student interviews and classroom observations, to identify additional themes not possible with quantitative findings alone. While the qualitative investigations provided a fuller and more detailed picture of information given by the students and teachers, they also enhanced the statistical findings, thus giving a more comprehensive understanding of teaching and learning with ICT among ICT classroom learning environments at the ICT schools pilot project in Thailand.

Limited Resources

It was impossible for one researcher alone to encompass an entire year in ICT classroom environments in all 13 model ICT schools, because of school privacy factors and the small research budget available for undertaking this study. In addition, because there was only one researcher involved, significant biases could have developed, which could invalidate the findings of the study.

However, the researcher tried to avoid these potential problems by attempting to gain multiple perspectives from a variety of data sources and using a variety of already validated questionnaire instruments, the Thai versions of which were given to school teachers (ICT teachers and subject teachers), school administrators, school staff, and academic colleagues for checking.

Validity and Reliability Quantitative Instruments

The present study has adapted and translated the quantitative instruments into a Thai version. The three instruments for students comprised the adapted form of the New Classroom Environment Instrument (NCEI), the adapted form of the Cornell Critical Thinking Skills Test (CCTT), the adapted form of the teachers' Attitudes Toward Information Technology (TAT) for students. The two teachers' instruments used to measure teachers' attitudes toward ICT and teachers' critical thinking skills comprised the adapted form of the teachers' Attitudes toward Information Technology (TAT) and the adapted form of the California Critical Thinking Skill Test (CCTST), respectively.

For this study, a panel of students verified the adapted Thai instruments for students. Moreover, teacher participants from all 13 model ICT schools under the Thai ICT schools pilot project together checked the contents and validated each item of the teachers' and students' instruments. A process back translation into English for confirming the meaning consistency by the researcher and student and teacher participants, also occurred simultaneously.

To check and examine the cross-validity of these questionnaires, there needs to be a replication of the study, using the instruments with a larger sample selected from all grade levels throughout all 13 model ICT schools under the Thai ICT schools pilot project. The results could then be projected to a wider population.

Overall then, the current study used several different kinds of data-collection instruments such as surveys, interviews, and classroom observations, in an approach, which can be called ‘triangulation of data collection method or multimethods’. This study enhanced the understanding of the complex reality being investigated by using triangulation of methodology (Borg & Gall, 1989). Carter (1990) argued that this method would not only increase internal validity but also reduce bias.

Implications of the Study

The findings from both the quantitative and qualitative investigation indicated that students could be assisted to learn critical thinking and their attitudes toward ICT might be enriched through integrating ICT into teaching and learning. The results have major implications for school teachers through their teaching roles in the following aspects:
(a) promoting active and autonomous learning;
(b) increasing more cooperative learning and assignments; and
(c) assisting students to construct their own knowledge and share it with other students.

There are also important implications for school management, in regard to:
(a) the allocation of school budgets for ICT;
(b) the use of classrooms’ ICT infrastructure; and
(c) the establishment of schools’ organisational structures.

These implications are presented in the following sections.

Implications for Students’ Learning

Based on the findings that technology-enhanced learning could serve as a catalyst for speeding up the move toward student learning among classroom learning environments with ICT, my recommendations to improve students’ learning through teaching and learning process with ICT are:

(a) Promote active and autonomous learning in students.

Generally, the quantitative findings of the present study indicated that students who favoured working by themselves tended to have positive attitudes toward ICT. To promote active and autonomous learning in students through incorporating ICT into the teaching and learning process, teachers need to give assistance, advice, suggestions or pose questions in a way that enables students to make decisions and to find out the information they need to complete particular tasks by themselves. Moreover, teachers need to recognise the need to give students a great deal more autonomy, and encouragement to take more responsibility for their own learning. There are substantial learning strategies that promote student autonomous learning through incorporating ICT into teaching and learning. There are two main strategies, which can support this.

Students may become more autonomous, independent, self-motivated managers of their own time, if subject teachers encourage students' self-direction through the use of ICT during class hours. In particular, the computer can be used to support students' active learning, peer interaction, and students' learning creativity. Therefore, teachers ought to design, plan, organise, and provide instructional lesson materials, resources, and courses which effectively integrate technology in their classroom teaching. For example, a teacher can initially sequence and structure a lesson to explain important concepts and theories, followed by explanations that can show the relationship of what they are learning to real life situations.

This is consistent with the previous study by Marjanovic (1999, p. 129) who stated that teachers needed to transform their teaching roles from 'information delivery specialists' into 'guides and facilitators of learning'. Teachers should not limit students' rights to learn, but help them to link new information to prior knowledge, to refine their problem-solving strategies, and to learn how to learn. Specifically, teachers must play the important role of facilitator, to provide rich environments, experiences, and activities for learning by incorporating opportunities for problem solving, authentic tasks, and shared knowledge and responsibility with their students in their classroom environments with ICT. This means that teachers' roles must be changed from lecturer to consultant, guide, and resources provider. At best, the subject teacher is required to be a designer, director-actor, facilitator, or manager of student learning.

As part of an increasing emphasis on learner development activities, the teacher needs to enable students to learn more by themselves through their individual self interest. Teachers should not limit the scope of their students' imaginations or learning creativities, but encourage them in various forms through individual developmental learning during school activities. Students should have the opportunity to perform activities by themselves, within the context of an ICT Camp, an ICT Club, and other relevant activity related to their interests. The most important thing is that teachers should make greater efforts to facilitate their students in these activities, by supporting their ideas or creating projects, rather than by controlling them. A good example of this sort of accommodation to learner development activities was School E's creation of a computer lab "Public Net for Child" for out of class student use.

(b) Increase more collaborative/cooperative learning and assignments with students.

The quantitative data showed that in the case of the communicative process, sharing experiences, and co-operative work, students who lacked computer experiences would prefer more student involvement through class activities or more participation in class discussions. These students could understand better what they had learned through sharing or exchanging their computer experiences with others. Moreover, students who lacked computer experience hoped to be involved with their peers during class hours to motivate each other to participate in class activities. In particular, students who had less opportunity to obtain computer training and to be involved with the computer or the internet at their home preferred a group work learning environment, because they had higher expectations of getting helpful and supportive contributions through collaborative or cooperative assignments by working in groups with their classmates.

The quantitative results also showed that secondary school students (ninth graders) had more favourable perceptions of group work and peer co-operation in classroom learning environments with ICT than did primary school students (sixth graders). Computer-based classroom learning environments can therefore be seen as particularly valuable for students in class by motivating students' interest through group class activities. This collaborative or cooperative learning with others among the classroom learning with ICT enables students to exchange knowledge and share experience between classmates during study hours. Subject teachers can work as managers of collaborative learning through brain storming sessions, group discussions, and other team-related activities during class hours.

On the other hand, taking students' age or school level differences into consideration, it might be implied that younger students could benefit from the older students who have had more ICT experience. It could be explained that older students (higher graders) possessed enough theoretical concepts and knowledge to understand the lesson contents and were able to use their thinking skills to analyse or apply theoretical concepts to solve problems or answer questions for the younger students.

The responses from the student interviews pointed to the need for professional teachers to develop their students' critical thinking skills through collaborative group work in their class. When students worked as a team, they could help to support each other in relation to reducing their weaknesses, and increasing their depth of knowledge and understanding of skills. Statements from several students strongly expressed the view that they liked teachers who always assigned them to do group work, because it gave an opportunity to share and discuss different ideas with others. It led them to work effectively with others and develop better understanding during study hours. In addition, several participants identified the use of computers in the classroom for student group working, group presentation, or project work as being very helpful in presenting their work professionally. They started from gathering information through internet use, organising and analysing data to conduct a project report by word-processing and preparing handouts and sharing their work with others through Power Point presentation. They enjoyed the sense of having achieved a professional presentation.

One of the quantitative research findings asserted that students who preferred a cooperative classroom atmosphere, with co-operation between students and their peers through teacher supported environments, had higher scores in critical thinking skills. The implication is that teachers should be willing to learn together with their students in the quest for knowledge and that they must be more open-minded with regard to the learning process, by encouragingly interactions between students and the subject teacher. Indeed, through incorporating ICT into teaching and learning in classroom environments, students may become the teachers, as teachers become the learners.

Using technology in the classroom can be the start of improving problem solving, decision-making, collaborative and higher-order thinking skills for students (Thornburg, 1991). This is consistent with the previous study by Hopson, Simms, and Knezek (2001-2002) who found that a computing collaborative classroom environment was able to create a new teaching and learning environment. This study found associations among professional teachers and educators using technology in the classroom, students' attitudes toward learning, and increased higher-order thinking skills.

There were two implications from the quantitative findings on the use of email. On the one hand, students working by themselves reported that they could get help or share discussions with their subject teacher through online communication tools such as email. In this way students could get better access, supportive help, or discussion with the subject teacher. Using email, a teacher could allow his or her students to learn more at their own rate and make them feel more free and involved to contact their subject teacher without face-to-face communication.

On the other hand, students could be facilitated by their subject teachers to use online communication hardware and software tools, such as email or bulletin board. They could work a team with their peers, or with their teachers, to send messages, share ideas or opinions for discussions and get help between themselves and teachers through the use of email. This is consistent with prior research (Barak, 2004) and that conducted by Admiraal et al. (1998[a]). This study similarly found that using technology in the classroom through computer conferencing, in particular internet use, supported and developed collaborative learning between students and between students and teachers. Moreover, the constructive understanding of skills and knowledge enabled students to reach a higher level learning outcome, in relation to critical thinking skills and school achievements.

Online-communication, however, depends on schools providing students with an email account that enables them to deliver data or news and to exchange information with team members and subject teachers. Additionally, schools need to set up intranet applications that support the exchange of documents between students and between students and subject teachers. New developments, such as, wikis and blogs, could also be explored for their relevance.

(c) Assist students to construct their own knowledge and share with students

The findings showed how integrating ICT into teaching and learning enabled students to develop some competencies and technological skills that allowed them to search for, organise, and analyse information, and then to communicate and share their ideas in a variety of media forms. The most effective way for students to develop these skills is to see them modeled by their teachers. The interviews of the current study supported the fact that most student participants preferred to learn in classroom environments where teachers used a variety of multimedia such as television, video, video camera, slide, and other media to provide attractive lesson materials. They further expressed the view that the professional teacher needed to have high technological skills and knowledge to teach them to act and think critically. Therefore, there is a need for all teachers in ICT classrooms to have the opportunity to develop technological skills, including basic or advanced computer operation, professional use of technology, applications of technology instruction, and other relevant technological applications. Many interview participants also strongly agreed that the most important factor was that all subject teachers ought to try to teach their students by using various teaching skills with a variety of ICT instructional material resources to clarify their students' understanding.

Where subject teachers have the necessary ICT skills, they can give students a great deal of autonomy to take responsibility for their own learning. Students can be given access to various stores of information, either on the internet or CD-ROM. In addition, they can be shown a variety of tools, such as search engines, data analysis packages, word processors, spreadsheets, graphing and graphics packages, and presentation and web development software. With the teachers' active encouragement, students can turn this information into personal knowledge.

Based on the study findings, there are a number of specific strategies that I would recommend to help students construct their own learning and share it with others.

There is a need for teachers to increase their technology skills and levels of computer competency and to reduce the fear of using computer equipment, as well. One possible strategy is for subject teachers and students to work together to generate a 'Reading Circulation' or 'Website for Learning', where others could find new information from learning sources such as the internet, other computerised learning resources, as well as books or articles. They can then spend time in discussion through online communication hardware or software tools, such as email or bulletin boards. Nevertheless, teachers must be conscious that face-to-face discussions are still very valuable to complement online communications. Traditional classroom environments, which permit students to spend time discussing, asking significant questions and exchanging different kinds of knowledge, theoretical concepts, and experiences, which have been gathered, from online communications, are most important both before and after online discussions.

Some model ICT schools under the ICT school pilot project in Thailand have been using online digital content as a means of incorporating ICT into the teaching and learning process. Subject teachers have designed learning activities, pretest (used before instruction) and post-test (used after instruction), teaching-learning objectives, and lesson materials, including course syllabus, course planning, exercise, and other lesson contents, which were then formatted and placed on the school's webpage. Typically, online digital content was guided and co-established by ICT or IT teachers (ICT or IT coordinators), particularly where it involved complex techniques, so as to make it attractive and interactive, with video clips, sound files, and other relevant techniques. The success of these efforts points to the value of other subject teachers and ICT teachers organising themselves to create online lessons or digital content and placing them on school websites.

Several model ICT schools under the Thai ICT schools pilot project constructed ICT learning sources or ICT learning centres, which provided different kinds of digital or online material resources. There are advantages in subject teachers and students working together to develop a range of electronic and digital lesson material resources and facilities in the form of Electronic-book (E-Book), Flip Album, PDF files, E-Library, and other relevant electronic resources which may be called a 'digital library' or 'resource centre'. Moreover, library and resource centres can include a range of electronic and digital lesson material resources and facilities to promote students' learning and to achieve student outcomes. Although, the role of teacher librarians was not mentioned by interview participants in the current study, generally, subject teachers and teacher librarians can work together to generate resource centres or libraries, such as those which have been growing in several model ICT schools under the Thai ICT schools pilot project. In addition, libraries and resource centres could be renamed with labels such as the 'Learning and Thinking Centres' or the 'Learning Centres for Solutions'. Such name changes can be used as symbols to highlight the changing nature of learning in schools and to recognise the emerging digital roles of the library or resource centre.

The quantitative results of the present study indicated that students who received training in computer courses tended to have more favourable perceptions of student learning outcomes than students without this training. The students with training also perceived more teacher support in their classroom learning environments with ICT than the students without. Moreover, students with training seemed to prefer student involvement and teacher-student relationships more than students without training. Therefore, it may be a useful strategy for subject teachers to train some students through one-on-one, or small, or large training groups. These can then act as computer tutors to introduce or assist students without prior training to develop technological skills and competencies and increase the ICT application skills that they require, such as word processing, Excel, Power Point presentation and spreadsheet software. This is one important way of reducing the fear of some students, who have had no prior ICT experience and help them to gain the ICT skills they need.

Implications for School Management

The results of the study suggest that the success of incorporating ICT into teaching and learning is fundamentally dependent not only on teaching roles but also school management. Allocating school budgets for ICT, setting up classroom ICT infrastructure, and establishing school ICT support structures were all vital prerequisites for the effective incorporation of ICT into classroom teaching and learning in the ICT model schools project. Following from these findings, my recommendations are discussed below.

(a) Allocating school budgets for ICT in teaching and learning process

The issue of school budget constraints was raised as central to support the integration of ICT into teaching and learning process. The interview participants recognised that not only did budgets for ICT vary across ICT schools, depending on the size and wealth of each ICT school, but also the extent to which school principals were prepared to provide an appropriate funding to support the effective integration of ICT into classrooms, differed greatly. In some cases, this was a reflection of the fact that financial resources available to, for example, the two private schools in the project were more substantial than those available to the government schools. Several interview participants indicated that some principals were reluctant to incorporate ICT in their schools. As a result, they did not allocate budget or distribute money for introducing, setting up, or using ICT as a teaching and learning process in classroom environments. Moreover, some interviewees strongly commented that some subject teachers were not provided with funding for technological or computer training and support for their role in integrating ICT into teaching and learning. Therefore, the importance of including sufficient funds within school budgets for regular review and replacement of equipment, technical support, and ICT professional development of teachers and staff, has to be recognised in the budgeting and planning of each ICT school.

Interestingly, the issue of allocating school budgets for ICT in teaching and learning was highlighted in a study by Moyle (2006) of over 400 of Australia's educational leaders in 2005. Her recommendations included:

(a) ICT budgets need to accompany a strategic plan and approach that should form a part of the overall school budget;
(b) Budgetary processes need to ensure shared understanding by the school community of all processes;
(c) The cost of keeping abreast of technological changes must be budgeted by the school; and
(d) ICT budgets need to be specific but allow for growth (Moyle, 2006, p.35).

Moyle's (2006) study further suggested that in relation to school budgets for ICT, school leaders:

(a) must have a commitment to allocating resources to ICT;
(b) need to have a vision which guides their decision in ICT budgets, yet maintain the standards in all areas of the curriculum; and
(c) *must establish recurrent financial models that underpin sustainable budget approaches for schools' ICT infrastructure (Moyle, 2006, p.35).*

(b) Setting up classrooms' ICT Infrastructure

The infrastructure for ICT schools involves the provision of the hardware, software, internet services, networking and connectivity requirements which are necessary for the teaching and learning process, and school administration. Specifically, classroom learning environments have changed from traditional classroom tools e.g. blackboard, whiteboards, pens, books, and so on to technological instructional equipment e.g. computer laboratories, computers, laptop computers, ICT equipment, and so on which are used in classroom learning. Several subject teachers in ICT schools were still having to use computer laboratories to cover their subject teaching rather than having computer access for their students in the normal classroom. There were other participants who expressed the view that there was not enough ICT equipment or computers in 'labs' to provide for all subject teachers throughout the school to include ICT in their teaching and learning processes in the classroom. Moreover, some interviewees further emphasised that in their schools the quality and quantity of computer and computer equipment, such as CPUs, printers, microphones, headphones, speakerphones, monitors and other ICT devices, as well as television, LCD projectors, and slides, were quite low and inefficient. In addition, many were using out-dated computers or ICT equipment. For these reasons, subject teachers in some model ICT schools developed their ICT classroom environments by choosing portable or computer laptop and wireless technologies, as they were convenient tools for the job. The principals of the two private schools and some government schools in the project had provided funds for these initiatives.

Incorporating ICT into all classroom environments means more than just providing the necessary computer equipment and software. Changing the physical layout of classrooms is not a rapid or inexpensive process. It involves careful school planning, thoughtful consultations, and cooperative collaboration with schools' stakeholders (e.g., parents, community, and other ICT schools). Hence, school leaders, in particular principals, need to understand and interpret issues in their school, concerning the relationships between pedagogy, technology, school budgets for ICT and the physical layout of classrooms with ICT that are appropriate to their local context.

(c) Establishing school organisational structures to support teaching and learning with ICT

The school principals in the project had the power to employ school staff to assist subject or ICT teachers, with or provide the necessary technological ICT knowledge and capabilities to effectively incorporate ICT into classroom teaching and learning. Some interview participants in the current study indicated that support staff such as technical support officers, library assistants, IT systems or Information Systems Manager, or other relevant had important specific roles in supporting teaching and learning with ICT. This is in line with the recommendations of Moyle (2006) in relation the specific responsibilities of various staff. She set out in detail what was required at each level. Her recommendations are quoted at length because of their particular relevance to the Thai ICT schools project.

According to Moyle, the school principal should:

- *provide organisational leadership in relation to ICT;*
- *facilitate in-school processes to establish and maintain the school culture and pedagogical directions of the school;*
- *articulate a school vision;*
- *be a curriculum leader with and understanding of the roles ICT can play in fostering teaching and learning;*
- *model good ICT practice;*
- *foster in-school ICT leaders;*
- *be a risk taker innovative and courageous;*
- *foster risk-taking and innovation in others;*
- *understand the change processes required that incorporate ICT into the life of the school community;*
- *drive change and remove barriers to change;*
- *manage conflict;*
- *ensure budgets have funds for hardware, software, professional learning, and technical time;*
- *secure ICT expertise; and*
- *mediate system accountability demands with school programs (Moyle, 2006, p.43).*

The role of the curriculum coordinator should be to:

- *assist teachers with curriculum development incorporating ICT;*
- *help teachers embed ICT into their teaching and learning;*
- *support teachers to actually include online instructional materials in their teaching and learning; and*
- *conduct in-house professional development sessions (Moyle, 2006, p.43).*

The various subject and IT teachers need to:

- *lead at the classroom level and within faculties;*
- *utilise the skills of students; and*
- *participate in school and out of school professional learning activities (Moyle, 2006, p.44).*

The role of the teacher-librarian is important to:

- *source and make recommendations about online and other digital media resources;*
- *support professional learning of teachers and staff by sourcing suitable journal articles and books; and*
- *support students to research using the internet and other digital resources (Moyle, 2006, p.44).*

The technical support officers are vital to:

- *provide troubleshooting support both on a just in time and longer term basis;*
- *install upgrades and patching of software across the school;*
- *install new software packages as required;*
- *un-install obsolete software;*
- *contribute to the upgrade of hardware;*
- *ensure plug-ins are installed as required;*
- *ensure virus checks are undertaken across the system;*
- *ensure processes are undertaken to maintain the backup systems and keep disaster recovery processes up to date; and*
- *contribute to the development and maintenance of the school's website and intranet (Moyle, 2006, p.44).*

In addition, Moyle recommends that schools should appoint an IT systems manager to ensure technical support is provided across the school for activities such as file management, network management, data transfers, intranet maintenance, troubleshooting, and so on (Moyle, 2006, p.43). Some schools in the Thai project appointed such a person from the private sector a short-term contract.

The time needed to develop effective ICT based teaching and learning was seen to be an organisational concern. Based on the analysis of interview data, some teachers who lacked ICT technological skills and knowledge did not have enough time to receive training in computer courses, due to their workloads. Such teachers lacked the confidence to incorporate ICT or computers into the teaching and learning process in their classrooms. Some interview participants further recognised the negative attitudes of a few such teachers who thought that ICT technology would confuse them or their students. Similarly, the use of ICT was also seen to increase teachers' workloads, because of the need to respond to email, reports online, and especially to prepare ICT lessons. Several teachers commented that planning and preparing of an ICT lesson required more time. Each ICT lesson, which was integrated into the teaching and learning process during class hours, took additional time to set up the computer or ICT equipment and classroom organisation, as has been documented also in previous studies (Moyle, 2006). On the other hand, Moyle (2006) found that the advantages of ICT would eventually enable school teachers to decrease their workloads, once teachers were confident and familiar with the software and/or the hardware involved. It is strongly contended that teachers should be provided with the necessary professional learning to support and improve their proficiency and confidence, to enable them to plan and conduct effective lessons including ICT during study hours.

Another issue at the organisational level was ensuring equity of access to ICT at school. On the one hand, the quantitative data showed that students who used computers at home seemed to have higher critical thinking scores than students who did not. On the other hand, they seemed to pay less attention during class hours and were not interested in using the computer to do their school assignments at school, because they knew that they could complete school assignments at home. This is compatible with previous research by Jedeskog and Nissen (2004) who found that some students worked successfully on their own, by using the computer at their home, and preferred to work at home rather than at school. Similarly, students who were able to access the internet at home seemed to prefer to search information from the internet at their home rather than at their school (during study hours), due to the fact that it was more convenient or comfortable to access.

In addition, the interview data also demonstrated that there were some problems with computer or internet access at school. These included low internet speed, outdated hardware and software for teaching and learning in school computer laboratories ‘labs’, low number of functioning computers or ICT equipment, and other relevant problems with ICT devices. These practical or technical problems obstructed some students from paying attention or showing interests, so that they did not focus on their work during study hours.

The study revealed that there were many students in the model ICT schools project, who could not access the computer or the internet at their home, due to budget constraints or the limitation of family support. This was consistent with the previous research by Moyle (2006), which found that school principals needed to focus on ensuring equity of access to computing equipment at school and to face the dilemma of how to provide students with access to ICT at school, without exception, especially in areas where the rate of home ownership of ICT was lower than elsewhere, or where the required software and hardware were too expensive for the students’ families.

Directions for Future Research

The discussion on the limitation of the current study has already made some suggestions for future research. The most important of these was to extend the present study, by using students and teacher participants across all primary and secondary grade levels in the schools of the Thai ICT pilot project. This section considers other qualitative and quantitative investigations, which could be useful in following up the results of this study.

Firstly, I would propose the carrying out of a longitudinal study, grounded in the ethnographic research tradition and using interpretative methodologies, to investigate how far teacher characteristics, such as levels of critical thinking skills and attitudes to ICT, influence student outcomes in these same two areas. This research approach, which is most useful for analysing classroom behaviour and the role of the teacher, (Jacob, 1987), would be most useful for a deeper understanding of the possible links among the predictor and outcome variables used in this study.

Secondly, attempts could be made to extend the study to students studying in elementary and secondary schools (grade one to grade twelve) in mainstream schools, which have been integrating ICT into all subjects, even though they were not in the ICT schools pilot project. As far as possible, this should include schools from different regions across Thailand.

Finally, it would be very valuable to do studies based on gathering qualitative data from focus groups of students and teachers. Such data may provide insights into what teachers had experienced and how they felt about using ICT in the teaching and learning process. It also may provide additional data regarding how students felt about using ICT or the computers during class hours. This information would provide a clearer picture not only about what actual learning was occurring in the classroom, but also concerning what the respondents would like to see happening in their ideal ICT classroom environments.

Overview

Over recent years, Thailand has placed an emphasis on the use of ICT technologies in education to facilitate the improvement of teaching and learning processes (Office of the National Education Commission, 2002). It was anticipated that the adoption of new technologies would also enhance higher-order learning outcomes, critical thinking skills, and systematic thinking skills for all students in ICT classroom learning environments (Office of the National Education Commission, 2004).

The purpose of the present study was to investigate how effectively ICT was being used to support positive student outcomes in the ICT schools pilot project in Thailand. The overall findings showed that students were assisted to learned critical thinking skills and their attitudes toward ICT were made more positive through integrating ICT into the classroom teaching and learning process.

The present study concluded that successfully incorporating ICT into teaching and learning can only take place when school management provides the underlying resources and support through principals allocating school budgets for ICT, providing classroom ICT infrastructure and establishing supportive school organisational structures.

The other vital factor demonstrated in the study was the importance of all teachers involved in the integration of ICT into classroom teaching and learning being thoroughly prepared for their role. At the most basic level, they needed to have knowledge of how to use computers and other equipment, so that they felt confident and positive toward ICT and integrating it into their teaching. The findings showed, however, that teachers also needed the opportunity to develop high levels of critical thinking skills and be able to relate this to the way they organised the teaching and learning process. Only then were teachers able to structure ICT learning situations to encourage higher levels of learning, as well as positive attitudes to ICT in their students. Appropriate professional development is thus essential for achieving this level of teacher effectiveness.

The study's results also point to the importance of teachers taking into account student differences in gender, academic background and previous experience in using computer and internet, when planning teaching and learning activities in the ICT classroom. The ICT teaching approaches favoured by the students, as most effective in their experience, included opportunities for co-operative learning and group class activities, as well as the chance for autonomous learning and self-development through greater access to computers, ICT networks and learning resources outside class hours.

I hope that the findings of my study will provide useful guidelines that will help to make the integration of ICT into classroom teaching and learning at all school levels throughout Thailand more effective and worth while for all students.

APPENDICES

Appendix A: New Classroom Environment Instrument (NCEI) and the Adapted NCEI in Thai Version for Students

NOTE: Appendix A (pages 311 – 324) is included in the print copy of the thesis held in the University of Adelaide Library.

Appendix B: Modified Teachers' Attitudes towards Information Technology (TAT) Questionnaire for Students and the Adapted TAT for Students in Thai Version

General Information

1. How long have you been starting use computer?

………0-1 years ……..2-5 years …….6-10 years

……..11-15 years……..15+ years

2. Do you have access at home:

a computer?	........Yes……..No
the World Wide Web(www)?	........Yes……..No

3. At my home, I use the computer approximately……..hours per week.

4. Currently, I use the computer approximately……..hours per week in my classroom.

5. If you do use computers, what type of training have you received?

……..No training

……..Basic Computer Literacy (on/off operations, how to run programs)

……..Computer applications:

- ……..Microsoft office(word, excel,power point)
- ……..Autoware
- ……..Dream Weaver
- ……..Internet
- ……..E-Mail
- ……..Other-please specify……………………………………….

6. Where did you receive your training?

- ……..Self-taught
- ……..School district
- ……..College or University
- ……..Other-please specify…………………………………………

7. Gender: ……..Male ……..Female

8. Age: ……..7-9 ……..10-12 ……..13-15 ……..16-18

This questionnaire is adapted from Teachers' Attitudes Toward Information Technology (TAT) developed by Christensen, R. & Knezek, G. (1996). As you take the questionnaire, you are expected to indicated that how you feel about the use of computers, Electronic Mail(E-Mail), and the Instrument.

Instructions: Please read each statement and then circle the number which best shows how you feel.

SD=Strongly Disagree D=Disagree U=Undecided

A=Agree SA=Strongly Agree

	SD	**D**	**U**	**A**	**SA**
1. I enjoy doing thing on a computer.	1	2	3	4	5
2. I am tired of using a computer.	1	2	3	4	5
3. I concentrate on a computer when I use one.	1	2	3	4	5
4. I enjoy computer games very much.	1	2	3	4	5
5. I know that computers give me opportunities to learn many new things.	1	2	3	4	5
6. I can learn many things when I use a computer.	1	2	3	4	5
7. I enjoy lessons on the computer.	1	2	3	4	5
8. I believe that it is very important for me to learn how to use a computer.	1	2	3	4	5
9. I think that computers are very easy to use.	1	2	3	4	5
10. I feel comfortable working with a computer.	1	2	3	4	5
11. Working with a computer makes me nervous.	1	2	3	4	5
12. Using a computer is very frustrating.	1	2	3	4	5
13. Computers are difficult to use.	1	2	3	4	5
14. Computers do not scare me at all.	1	2	3	4	5

Instructions: Place an ‘x’ between each adjective pair to indicate how you feel about the object.

Computers are:

15.Unlikable								Likable
16. Unhappy								Happy
17. Bad								Good
18. Unpleasant								Pleasant
19. Tense								Calm
20. Uncomfortable								Comfortable
21. Artificial								Natural
22. Empty								Full
23. Dull								Exciting
24. Suffocating								Fresh

Instructions: Please read each statement and then circle the number which best shows how you feel about that statement.

1 = Strongly Disagree (SD)
2 = Disagree (D)
3 = Undecided (U)
4 = Agree (A)
5 = Strongly Agree (SA)

	SD	D	U	A	SA
25. Computers do not scare me at all.	1	2	3	4	5
26. I would like working with computers.	1	2	3	4	5
27. I don't understand how some people can spend so much time working with computers and seem to enjoy it.	1	2	3	4	5
28. Computer lessons are a favourite subject for me.	1	2	3	4	5
29. I want to learn a lot about computers.	1	2	3	4	5
30. A computer test would scare me.	1	2	3	4	5
31. Our country relies too much on computers.	1	2	3	4	5
32. I feel apprehensive about using a computer.	1	2	3	4	5
33. Computers are changing the world too rapidly.	1	2	3	4	5
34. Computers isolate people by inhibiting normal social interactions among users.	1	2	3	4	5
35. If there was a computer in my classroom it would help me to be a better teacher.	1	2	3	4	5
36. Someday I will have a computer in my home.	1	2	3	4	5
37. Learning about computers is boring to me.	1	2	3	4	5
38. I like learning on a computer.	1	2	3	4	5
39. Working with a computer would make me very nervous.	1	2	3	4	5
40. I think working with computers would be enjoyable and stimulating.	1	2	3	4	5
41. Computers are not exciting.	1	2	3	4	5
42. Studying about computers is a waste of time.	1	2	3	4	5
43. I enjoy learning how computers are used in our daily lives.	1	2	3	4	5
44. Computers would help me learn.	1	2	3	4	5
45. The challenge of learning about computers is exciting.	1	2	3	4	5

46. Learning to operate computers is like learning any new skill – the more you practice, the better you become.	1	2	3	4	5
47. I am afraid that if I begin to use computers I will become dependent upon them and lose some of my reasoning skills.	1	2	3	4	5
48. I dislike working with machines that are smarted than I am.	1	2	3	4	5
49. If given the opportunity, I would like to learn about and use computer.	1	2	3	4	5
50. Computers intimidate and threaten me.	1	2	3	4	5
51. Working with a computer makes me feel tense and uncomfortable.	1	2	3	4	5
52. Computers are difficult to understand.	1	2	3	4	5
53. I would like to learn more about computers.	1	2	3	4	5
54. Working with computers means working on your own, without contact with others.	1	2	3	4	5
55. Using a computer prevents me from being creative.	1	2	3	4	5
56. You have to be a “brain” to work with computers.	1	2	3	4	5
57. Computers frustrate me.	1	2	3	4	5
58. I will use a computer as soon as possible.	1	2	3	4	5
59. I enjoy computer work.	1	2	3	4	5
60. Electronic mail (E-mail) is an effective means of disseminating class information and assignments.	1	2	3	4	5
61. I prefer E-mail to traditional class handouts as an information disseminator.	1	2	3	4	5
62. E-mail provides better access to the instructor.	1	2	3	4	5
63. The use of E-mail increases motivation for the course.	1	2	3	4	5
64. The use of E-mail makes the course more interesting.	1	2	3	4	5
65. The use of E-mail makes the students feel more involve.	1	2	3	4	5
66. The use of E-mail helps the students to learn more.	1	2	3	4	5
67. The use of E-mail helps provide a better learning experience.	1	2	3	4	5

Instructions: Place an ‘x’ between each adjective pair to indicate how you feel about the object.

To me, Electronic mail **(E-mail)** is:

1. important								unimportant
2. boring								interesting
3. relevant								irrelevant
4. exciting								unexciting
5 means nothing								means a lot
6. appealing								unappealing
7. fascinating								mundane
8. worthless								valuable
9. involving								uninvolving
10. not needed								needed

To me, **using the World- Wide Web (www)** is:

1. important								unimportant
2. boring								interesting
3. relevant								irrelevant
4. exciting								unexciting
5 means nothing								means a lot
6. appealing								unappealing
7. fascinating								mundane
8. worthless								valuable
9. involving								uninvolving
10. not needed								needed

Instructions: Place an 'x' between each adjective pair to indicate how you feel about the object.

To me, **multimedia** is:

1. important								unimportant
2. boring								interesting
3. relevant								irrelevant
4. exciting								unexciting
5 means nothing								means a lot
6. appealing								unappealing
7. fascinating								mundane
8. worthless								valuable
9. involving								uninvolving
10. not needed								needed

To me, **using computers for my productivity** is:

1. important								unimportant
2. boring								interesting
3. relevant								irrelevant
4. exciting								unexciting
5 means nothing								means a lot
6. appealing								unappealing
7. fascinating								mundane
8. worthless								valuable
9. involving								uninvolving
10. not needed								needed

NOTE: Pages 330 – 333 are included in the print copy of the thesis held in the University of Adelaide Library.

Appendix C: Cornell Critical Thinking Test (CCTT) Level X and the Adapted CCTT in Thai Version

Cornell Critical Thinking Test Level X is a standardized test which developed by Ennis and Millman (1971). It contains 76 multiple-choice items. They include inductive inference, credibility of sources, deductive, and assumption identification.

NOTE: Appendix C (pages 335 – 364) is included in the print copy of the thesis held in the University of Adelaide Library.

Appendix D: California Critical Thinking Skills Test (CCTST) and the Adapted CCTST in Thai Version

The California Critical Thinking Skill Test (CCTST) is a standardized test, which developed by Peter A. Facione (1990). It is comprised of 34 multiple-choice questions. It measures in five skill areas, which are analysis, inference, evaluation, induction, and deduction.

NOTE: Appendix D (pages 366 – 384) is included in the print copy of the thesis held in the University of Adelaide Library.

Appendix E: Teachers' Attitudes toward Information Technology (TAT) Questionnaire for Teacher and the Adapted TAT for Teacher in Thai Version

NOTE: Appendix E (pages 385 – 395) is included in the print copy of the thesis held in the University of Adelaide Library.

Appendix F: Advantages of the Use of ICT

The main in-depth interviews - Benefits or advantages from the use of ICT

Benefits	**Interview Respondents**					
ENJOYMENT	AS1 said that "I feel very happy and have a great time during studying in ICT class in all subjects, including Science, Mathematics, Computer, Foreign Language and so on"	BS2 said that "Some teachers teach their students in different subjects by using CD ROM and interactive games from the Internet in their class; these make learning of Science and English enjoyable time."	CS3 said that "I always feel very happy every time, when I sit in front of my computer"	GS1 said that "I do not feel worried when the ICT class hour is coming, I experience pleasure and joy."	IS3 said that "I have never been nervous, and I usually feel familiar with using computers."	HT1 said that "I am very excited and enthusiastic when I use computers and ICT equipment including CD ROM, instruction and teaching software etc in my class."
SEARCH INFORMATION	CS2 said that "I am very curious to search information from the Internet. For me, I always use Sanook.com, Google.com and Yahoo.com, these are my favourite search engine websites."	FS3 said that "Some teachers permit their students to search information from the Internet in his/her class hour, for example, Science subject and Mathematics Subject and so on."	HS3 said that "Most of the data from the Internet is more detailed than our textbooks or our classroom documents and/or handouts."	BT1 said "I am always searching for information from www to prepare my instructional materials such as world maps, pictures, diagrams and so on "		

Benefits	**Interview Respondents**					
NEW KNOWLEDGE	DS1 said that "It helps me know some new and modern computer software programs, so I can apply these programs to both individual and group work."	FS1, FS3, GS3, and IS2 said that "When I do some work or homework about searching information from the Internet, it gives me new knowledge and can accept appealing innovative ideas"	BS1 said that "I have never known HTML or Dream Weaver program before; until my ICT teacher used each program to teach me to create my personal homepage and webpage. Of course, it is absolutely amazing program because it gathers and shows my personal data concerning personal profile background, extra activity, and my favourite sport, food or television program.			
EASY TO UNDERSTAND/ EASY TO TEACH	AT1 said that "When I use ICT to teach our students, I find it easier to explain the subject contents than with other classroom environments such as using a whiteboard classroom."	ES2 and IS1 said that "I get new knowledge about subject topics from my ICT teachers quite fast because they provide all of their instruction by ICT or computer."	GS2 and AS3 said that "It helps me to clearly understand when my teacher provides his or her documents by word processing or PowerPoint."			

Benefits	Interview Respondents					
USING VARIETY OF MULTIMEDIA	BS2, HS2 and HS3 said that “students prefer to learn in ICT classes, especially if teachers use interesting multimedia to teach their students.”	JS1 and ES2 said that “I perceive ICT classroom environment positively with computers through a variety of multimedia, including listening through headphones, speakers, and looking at the monitor as well.”				
PROFESSIONAL REPORT OR PAPER	FS2 said that “I handed in assignments using word processing, some even with pictures”	HS2 said that “I always do my school projects which were assigned to me by my teacher by using the PowerPoint program, because it assists me complete my projects like a professional.”	HS1 said that “I and my group had opportunity to present my project in front of the class by PowerPoint presentation, we do like professional presentation”	GS2 said that “I am as a professional because I start from searching information pass the Internet (www), conducting report by word processing, and preparing handouts until presenting my work through PowerPoint.”	FS3 said that “I admire my teacher who construct advance presentation program (PowerPoint) which use flash and animation to do his/her teaching document.”	
EASY FOR WRITING	AS1 said that “When I use word processing to do my report, it is very easy to type, edit, and check my English grammar, and to add figures, charts or graphics to my report.”	AS2 said that “The Word processing program helps me to submit my work confidently, it will be tidier than my hand writing.”				

Benefits	Interview Respondents					
MODERN TECHNOLOGY	BS3 said that “The ICT classroom helps me to gain knowledge better than a general classroom.”	CS1 said that “I get more basic skills such as switching off and on the computer by myself, and use Microsoft Office Programs such as Words, Excel, and PowerPoint.	GS1 said that “During ICT class, I do not fascinate too much in modern technology.”			
ATTRACT TO ATTEND THE CLASS	FS1 said “when I was surfing the Internet at school, my feeling is happy and I am not bored by spending a long time in my computer room”	GS1 said that “I do not feel bored or sleepy, when I study in ICT classroom, so I am never absent in classes which were taught through ICT.”	JS2 said that “My maths teacher used interesting new software to apply topics such as quantitative statistics in Maths to find out the best answer. It is very stimulating to learn this way”			
GOOD ENVIRONMENTS	AS1 said that “Yeah, I think it’s very good. Every other environment in the working world requires it.	IS3 said that “It is a good experience that I have an ICT environment”				
SELF-STUDY LEARNING	DS3 said that “I like to study by using computer in my class, because I can learn and study by myself.”	IS2 said that “Sometimes I cannot follow all of the contents which are prepared by subject teachers, however, I can learn and get more understanding by myself through ICT learning.”				

Benefits	**Interview Respondents**					
CONVENIENT IN LEARNING	GS2 said that “Touching the key board and clicking the mouse is the easies way to study, for example, I have just put an CD Rom application in my computer, and then I can do pretests and posttests by myself.”					
VARIETY WAYS TO LEARN	ES2 said that “My teacher downloads interesting pictures from the www to show in his classroom, it helps me to understand clearly.”					
INNOVATIVE IDEAS	HS3 said that “ICT opens a new world through the Internet surfing”					
GOOD EXPERIENCES	IS3 said that “I had an excellent opportunity to study and learn in an ICT classroom environment.”					

Appendix G: Disadvantages of the Use of ICT

The main in-depth interviews - Loses or disadvantages from the use of ICT

Disadvantages	**Interview Respondents**					
ANXIETY ABOUT USING COMPUTER	AS1 and BS1 said that "I feel scare. I do not know enough how can I use this program because it is too complicated"	FS3 said that "I am afraid. I can not control to complete/ finish my assignment in my class period"	FS3 said that "It is difficult to follow contents on teacher handouts which were prepared by PowerPoint presentation"	FS2 said that "I am not apprehensive about using computers in the class. Maybe because I have not done well enough of it myself…so I'm not so confident"	ET1 said that "I have a desire to use computers in teaching but sometimes I feel helpless because I am not sure how to do it."	
TAKE TIME	AT1 and DT1 noted that "Planning of a lesson using computers and ICT required more time, as specificity is necessary"	HT1 confirmed that "a lesson incorporating computers and ICT takes more time to set up with respect to equipment and classroom organization"	BT1 and ET1 said that "the pressure of time already exists in trying to complete coverage of subject content, thus not allowing for experimentation with new technologies during curriculum time."			
LACK OF CLASS ATTENTION DURING STUDYING TIME	DS1 said that "Most students do not follow teacher assignment because they are playing games and surfing the Internet, not attend to teachers' instruction"	HT1 and BT1 said that "I attempted to conduct a comp based lesson during my teaching, It made me very disappointed. When I was giving instructions, my students were not listening; they were busy doing things on the comp screen. I had to go around to every other to go the instruction."				

Disadvantages	Interview Respondents					
LACK OF STUDENT-TEACHER INTER ACTION	FS2 said that “I feel lack of student-teacher interaction during my studying in ICT classroom environment with computer. Sometimes I would like to ask/ interrupt my teacher, but I couldn’t.”					

Appendix H: Practical Problems in the Use of ICT

The main in-depth interviews - Problems/barriers to the use of ICT and network facilities for studying and teaching

Problems	**Interview Respondents**					
PROBLEMS OF RESOURCES/ EQUIPMENT/ ACCESS	AS1, GS1, GS2 and GS3 said that "There is some outdate hard ware and soft ware in resources of my school."	ES2, GS1, GS2 and GS3 said that "Computer provision and access (number of qualified computers) in my school are not enough for students in each classroom."	AS1, CS2, DS1, ES2, GS1, GS2 and GS3 said that "The internet in our schools is not high speed. So it is very difficult and too slow to access electronic information. "	AT1, ET1, DT1 and HT1 said that "We think that we do not comfortable to use ICT resources for preparing our classroom instruction materials. Because my school has not enough number of computers for all of ICT teachers. In addition, the school's computer laboratory was often booked out."	CS1, JS1 and JS2 said that "In my ICT classroom environment, the infrastructure layout was not conducive for classroom instruction. Because some friends do not attend studying, they are watching on the computer screen rather than attend to instruction. "	AS1, DS2, ES3, GS1, GS2, GS3 and TS1, said that "There are not enough in computer complements such as Printer, LCD Projector, LCD screen, etc."

Problems	**Interview Respondents**					
POOR SCHOOL ENVIRONMENT	AS1, CS2, ES1,ES2,GS1,GS2, GS3, AT1 and ET1 said that "…the number of computers is not enough for the number of students…there was not a good computer in computing room…there were not high quality of computer equipments (headphone and speaker phone) during class hour of foreign subjects."	GS1, GS2 and GS3 revealed that "In computing room, quite hot…there are many computers which are out of order…the computers were collecting dust. Nobody cared about them."	CS2, DS3,FS1, GS1,GS2,GS3 and JS1 confirmed that "..we cannot search information from the internet at the same time (30-40 students) during class hours…lacks of the Internet high speeds…"			
CLASSROOM MANAGEMENT	DT1, ET1, and HT1 said that "Sometimes I have to plan an alternative lesson along with the computer-based lesson. Just in case something goes wrong, or something's not wired up properly."					

Appendix I: Teachers' Characteristics which Encouraged Students' Critical Thinking Skills

The main in-depth interviews - Teachers' characteristics encourage their students' critical thinking skills

Teachers' characteristics	**Interview Respondents**					
Good Listener	AS2, HS1, and HS3 said that "When my teacher ask some questions to me and my classmates, she patient to wait for our answers."	FS2, FS3, HS2, and HS3 said that "My teacher always spend her busy time to talk and listen with me and my friends concerning about my study's problems, although she is busy with her work."	AS1, BS2, and HS2 said that "In science subject, during her class hours, my teacher support us to explain or describe the process of lesson science subjects until we finish without her interruption."	JS1 and HS2 said that "In sound lab class, sometimes I cannot recall new vocabularies which were taught in the beginning of my class, but my teacher keeps continue to repeat those words again and again. Even though some friends still remember these words, except me only."	ES1, ES2 and ES3 said that "Math teacher never blame or complain me when I spend a long time to prove Square Root by using formula on whiteboard. In the other hand, she guided me how did I do the short way to be done."	JS1, JS2, JS3 and IS2 said that "My social study teacher allow me and my team to present our work by PowerPoint presentation until finish. Though our presentation is not good enough compared with other teams. "
Logical Teacher	BS3 and ES3 said that "In Math and Science subject. During class hour, both of our teachers usually ask many questions to stimulate their students to think logically."	AS1, ES1,ES2, ES3 and HS2 said that "It made me understand easily, when my teacher hand in lesson materials before start teaching. Because I can catch steps of Math calculations follow from step-by step in paper."	GS1, GS2, GS3 and HS2 said that "I love teacher who taught me by application rather than memorization in all subjects. Because it make me understanding clearly longer. "			

Teachers' characteristics	Interview Respondents					
Professional	AS1,AS2,AS3, CS2, ES2, DS1, FS2, HS2 and JS2 said that "In my personal eyes, the best teacher to develop critical thinking skills for their students, need to have high skills and knowledge to teach their students, be active to search new information from any sources, and provide lesson materials interestingly and attractively. "	AS1, BS2, CS3, ES1, and JS1 said that "teacher must use a variety of teaching skills that change from the complex contents to simple contents in her/his subject."	ES1, ES2 and ES3 said that "I think that if all teachers spend a long time to prepare lesson materials, including electronic and paper materials, these materials will attract their students' attention during class hours (about 50-60 minutes)."	AS2 and HS2 said that "Ideal teacher for me, must develop their skills and knowledge through reading many books, get new information from the Internet, get continuously training in professional knowledge."		
Reasonable person	BS1 and BS2, said that "All students prefer to study with teachers who have more reason than emotion to solve our study's problems."					
Teamwork Approach teacher	AS1, AS2, AS3, CS2, ES1 and FS3 said that "I like my teachers who usually assign us to do group working. Because it makes opportunity to share and discuss any different ideas with others."	ES1, ES2 and FS3 said that "When we works as team work, we can help to support each other in relation to reduce my weakness and increase my strength of knowledge."	AS1, AS2, AS3, CS2 and ES2 said that "Every time when we do my work with our team, I practices to divide work responsibilities by individual skill."			

Appendix J: The Influence of ICT-Integration into Teaching and Learning Process on the Development of Students' Critical Thinking Skills

The main in-depth interviews - The influence of ICT on the development of students' critical thinking skills

ICT helps to develop students' critical thinking skills	**Interview Respondents**					
ICT FOR MEANING MAKING	AT1, BT1, and HT1 that "ICT can facilitate the process of meaning-making. It means that I use ICT helps students organize, remember, retrieve information, and making decision "					
ICT FOR STUDY SKILLS DEVELOPMENT	AT1, BT1, DT1, ET1, and HT1 said that "If we familiarises with ICT or computers positively, it will develop other important skills and competencies, such as self-study learning, thinking analytically and logically, synthesizing ideas and concepts, and so on."					

ICT helps to develop students' critical thinking skills	**Interview Respondents**					
ICT for SCIENTIFIC SKILLS DEVELOPEMNT	AT1, BT1, DT1, ET1, and HT1 said that "ICT can improve in a number of science skills, including reading data, interpreting graphs, manipulating variables, constructing hypothesis, ability to conduct experiments, generate creative questions, draw conclusion and so on."					

Appendix K: The Introduction of ICT-Integration into Teaching and Learning Process for All Subjects in All Schools

The main in-depth interviews - Views of the desirability of the introduction of ICT for all subjects in all schoo**ls**

Limitations	**Interview Respondents**					
HUMAN RESOURCE (PEOPLE)	AS2, AS3, CS1, HS2, GS3, and ES2 said that "Some teachers think that we are too old to learn and get new information technology and knowledge. So they have been thinking that modern technology might make them confuse to accept new technology to improve their teaching process."	GS1, GS2, GS3, JS1, and ES2 said that "Some teachers lack of ICT skills and modern technology knowledge concerning the use of ICT and other equipments. So, they lack of confidence to teach their students by the use ICT or computers to assign homework or group activities."	said that DT1, AT1, and HT1"Some teaches do not have enough time to get training courses such as basic computer usage, Microsoft Office program, Micro Worlds, paint program, Photo Shop, Flash Animation, Flip Album, and Webpage Creation (Dream Weaver and HTML program), which were provided by their schools or computer training institutions. These programs can help teachers to generate their electronic lesson by themselves."	ES1, ET1, AS2, AT1, BS3, DS2, and FS3 that "Some teachers, who got long experience in teaching in traditional classroom environments, do not open their minds to accept modern educational technology for using in education areas."	AT1, BT1, DT1, ET1, and HT1 said that "There are not enough the number of ICT teachers or teachers who can teach their students by ICT in ICT classroom environments in all eight groups of subjects."	AT1 and ET1 Said "lack of support staff such as technical support officer, IT systems or Information systems manager"

Limitations	Interview Respondents					
Materials and environments	AS1, EF2, FS1, JS2, GS1, GS2, and GS3 said that “There are not enough the number of ICT equipments or computers to provide for all subject teachers in all schools across the country.”	CS2, ES2, FS2, GS1, GS2, GS3, and JS2 said that “Quality of computers , computer equipments such as CPU, printers, microphones, headphones, speakerphones, monitor and other devices, including T.V., LCD projector, Slide are low and inefficient. Most of them are out-dated equipments.”	FS1, FS2, CS1, GS2, GS3, and CS2 said that “Our ICT classroom environments are quite uncomfortable, because some schools have not ICT rooms with high quality air condition.”			
Management	GS1, GS2, GS3 said that “Some school administrators or headmasters do not support their teachers to teach their students in their ICT classroom environments. Because administrators feel more confident in the traditional classroom environments than ICT classroom environments.”	FS1, GS1, GS2, GS3, DT1, and ET1 said that “Some principals do not allocate budget or distribute a few money for forming ICT classroom environments. In addition some schools do not support budget for teacher training regarding new programs.”				

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