Is School-Wide Adoption of ICT Change for the Better?

Katherine L. Dix

FLINDERS UNIVERSITY INSTITUTE OF INTERNATIONAL EDUCATION
RESEARCH COLLECTION
NUMBER 17

STUDIES IN COMPARATIVE AND INTERNATIONAL EDUCATION

Number 17

Is School-Wide Adoption of ICT Change for the Better?

KATHERINE L. DIX

FLINDERS UNIVERSITY
INSTITUTE OF INTERNATIONAL EDUCATION

Produced by the Flinders University Institute of International Education
Sturt Road, Bedford Park, Adelaide SA 5000

Designed by Katherine L. Dix
Published by Shannon Research Press, South Australia
ISBN: 978-1-920736-30-9

Preface

The use of information and communication technologies (ICT) in schools is now an intrinsic part of students' learning, both inside and outside the classroom. The adoption and impact of ICT on teaching practice and learning outcomes has been a source of keen interest among government policy makers, school leaders, teachers and researchers worldwide. Research in this field has principally centred on pseudo-scientific comparative studies conducted mainly in the United States and the United Kingdom, with a focus on academic achievement. Few empirical studies have been conducted in Australia, or worldwide, that focus on student attitudinal outcomes framed within a design-based paradigm that spans several years.

The overarching purpose of this study is to investigate longitudinal change in school climate through its influence on students and teachers, during a period of school-wide transition as ICT were embedded throughout mainstream curricula. An assessment of the impact of ICT on student attitudinal outcomes, in particular, changes in self-esteem over a three-year period of school-wide ICT adoption, is provided through the examination of factors affecting teaching practice and students' attitudes towards computers and school. A feature of this study is the development of a theoretical and practical framework, DBRIEF (Design-Based Research in Innovative Education Framework), which underpins the design and conduct of the research, and addresses technical issues involved in specifying appropriate methods of analysis, taking full advantage of the hierarchical and longitudinal nature of the data.

A total of 219 teachers and 2560 students from six metropolitan public primary and secondary schools in South Australia participated in the study. The main method of data collection involves the use of online questionnaires suitable for repeated administration over the three-year lifespan of the study, and appropriate for all teachers and those students in Years 5 to 7 in primary school and Years 8 to 10 in secondary school. The principal analytical strategies employed in this study use structural equation modelling and hierarchical linear modelling in order to develop models to assess the influence of potential student, teacher and school factors on student attitudinal outcomes in a climate of change.

School-wide integration of ICT is found to promote significant change in teaching practice and has benefits for students, particularly those with low self-esteem. Moreover, it also appears to benefit girls, by reducing the gender gap in which boys traditionally maintain higher self-esteem. Students' self-esteem and their attitudes towards computers are found to improve significantly in an increasingly ICT-rich learning environment. However, as computers became the norm rather than a perceived highlight in daily school life, the influence of technology on students' attitudes towards school becomes less important. Students are extended through word-processing, drawing and presentation software to edit, revise, and ultimately produce higher quality work in a wider variety of formats, and these efforts are further enhanced in schools with good technical support and the experienced guidance of ICT specialist teachers. Furthermore, ICT-rich homework appears to enhance students' attitudes towards school, but particularly among primary students, drawing attention to the importance of equitable home computer access.

This study posed many challenges in the collection and analysis of hierarchical longitudinal data where appropriate methods of analysis are not widely applied or well established. The management of these challenges, together with the practical and theoretical implications of the study, should re-inform original theory and design, with the underlying premise that change is sustainable and that innovation in classroom practice should be ever evolving. In this way, this project makes a significant contribution to the field of educational innovation.

Acknowledgments

I would like to express my deepest thanks and appreciation to all those who helped and guided me during the course of my research. In particular, I am indebted to Emeritus Professor Jonathan Anderson, Emeritus Professor John P. Keeves, and Dr I Gusti Ngurah Damawan, for their advice in analysing the data and for their valuable comments, support and friendship.

Contents

Figures

Tables

1

Introduction

Because IT changes the way we interact with the world, IT changes us.
(Anderson, 2005, p.3)

The use of information and communication technologies (ICT) in school has become an intrinsic part of students' learning, both inside and outside the classroom. With millions of dollars now being spent on ICT in schools, the adoption and impact of ICT on teaching practice and learning outcomes is of critical concern among government policy makers, school leaders, teachers and researchers worldwide. The prolific number of studies in this field over the last two decades has mainly focused on pseudo-scientific comparative studies, which take as a starting point that the introduction of technology brings improvement. The majority of early research studies concentrated on students' cognitive outcomes, that is, on academic achievement. Only relatively recently have studies been conducted that focus on students' affective outcomes, their attitudinal development in an ICT-rich environment. For example, in a review of findings from research, Ringstaff and Kelley (2002) concluded that technology has a positive effect on student motivation, attitudes toward learning, self-confidence, and self-esteem. However, these researchers and others (Coley, 1997; Mandinach and Cline, 1997; Russell, 1997) contend that due to difficulties resulting from rapid changes in technology and inadequate measures, many of the results from "studies examining the impact of students learning 'with' technology are far from conclusive" (Ringstaff and Kelley, 2002, p.7). What is clear is that few studies have been conducted that are empirical in design and undertaken in Australia.

The call for research to inform policy and support schools in creating a more diverse and inclusive ICT-rich curriculum that views the development of students holistically, and recognises individual need and capacity, is increasingly widespread. Mandinach and Cline (1997) were among the first to recognise the need for research to focus on longitudinal design, multiple methods, and multiple levels of analysis. In a report to Education Network Australia (EdNA), the need for further research was implicit in the suggestion from Moran et al. (1999):

> It is often asserted rather simplistically that ICTs can improve learning outcomes. Yes, they can, but the conditions for success need to be understood more widely by policy makers and teachers alike. (Moran et al., 1999, p.10)

The Department of Education, Training and Employment gave the following more specific directive under their directions for research:

> To contextualise the national and international research to South Australian public education, what is now required is a longitudinal study to establish structures and processes through which clear and useful advice and support relating to curriculum applications of learning technologies can be provided to department schools. (DETE, 1999, p.15)

The Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA, 2003) report listed in its priority areas for ICT research: the changing nature of schooling, student learning, equity issues, teacher development, and monitoring progress. In a report to the Bill and Melinda Gates Foundation, Fouts (2000, p.ii) argued that "More research is needed to answer several critical questions as technology is thoughtfully deployed throughout our schools". Fout went on to list 10 critical questions for further study, two of which include:

- How does the use of computers affect classroom climate and student attitudes?
- What are the conditions that must be in place for technology to effectively improve student learning and especially the achievement of "at-risk" students? (Fouts, 2000, p.ii).

In a recent review of research into the effect of ICT on learning, Eng (2005) concluded that, increasingly, there is a worldwide call for large-scale longitudinal studies examining ICT and how ICT changes learning.

The desire to understand how individuals change in an increasingly ICT-rich world is echoed in a UNESCO report (2005), *ICT in Schools: A Handbook for Teachers or How ICT Can Create New, Open Learning Environments*:

> With the need for more independence, creativity, as well as the ability to engage in teamwork, the role of the individual in society is becoming more and more important. Today, it is natural to wish to design a school that is oriented towards developing these attributes, which can be done for all age groups, based on ICT. (UNESCO, 2005, p.187)

The emphasis on approaching the education of an individual holistically, by balancing cognitive as well as affective and behavioural aspects of development, is now a common directive in many educational systems. For example, *Learning in an Online World*, produced by Education Network Australia (EdNA, 2000), advises the following goals across all schools for education in the information economy:

> 1. All students will leave school as confident, creative and productive users of new technologies, including information and communication technologies, and understand the impact of those technologies on society.
> 2. All schools will seek to integrate information and communication technologies into their operations, to improve student learning, to offer flexible learning opportunities and to improve the efficiency of their business practices. (EdNA, 2000, p.3)

In summary, the current themes and recommendations emerging from the literature, both in Australia and abroad, call for empirical studies capable of informing policy, which embrace longitudinal, multi-level, and multi-method design, conducted in authentic contexts undergoing change that holistically examine teachers' practice and students' learning with, and not from, ICT. At the heart of such research, and the cornerstone of this study, is the human desire to understand change.

In order to understand change further, a discussion about planning for technological change provides a useful contextual precursor to the setting of the study. However, before commencing either of these discussions it is necessary to clarify terms that are frequently referred to throughout this study.

ICT Adoption and Student Learning Outcomes

Central to the focus of this study are the terms 'ICT adoption' and 'student learning outcomes'. Over the years, both terms have come to mean many things, and so it is necessary at the outset to clarify and explicitly define how these terms are used in this research.

Information and communication technologies

The phrase 'information and communication technologies' (ICT) was originally coined by Stevenson (1997) in his report to the United Kingdom government, and promoted by the new National Curriculum documents for the United Kingdom in 2000. Stevenson (1997) described ICT in the context of education as the study of the technology used to handle information and aid communication. Since then, other definitions have emerged that describe ICT as traditional computer applications with the addition of communication tools such as e-mail, chat-rooms and other internet resources. For example, UNESCO provides the following definitions to serve as a guide:

> Information technology (IT) is the term used to describe the items of equipment (hardware) and computer programmes (software) that allow us to access, retrieve, store, organise, manipulate and present information by electronic means. Personal computers, scanners and digital cameras fit into the hardware category. Database storage programmes and multimedia programmes fit into the software category.
>
> Communication technology (CT) is the term used to describe telecommunications equipment, through which information can be sought and accessed, for example, phones, faxes, modems and computers. (UNESCO, 2003, p.7)

In Australia, the Department of Education, Training and Youth Affairs (DETYA) defines information and communication technology as relating to:

> those technologies that are used for accessing, gathering, manipulating and presenting or communicating information. The technologies could include hardware (eg computers and other devices); software applications; and connectivity (eg access to the Internet, local networking infrastructure, videoconferencing). What is most significant about ICT is the increasing convergence of computer-based, multimedia and communications technologies and the rapid rate of change that characterises both the technologies and their use. (DETYA, 2001, p.1)

The recent addition of 'communication' to previous terms such as information technology (IT) emphasises the growing importance placed on the communication aspects of new technologies (Anderson et al., 2002).

In this study, ICT is extended to include mass penetration technologies, such as television, video, tape recorders, CD music, radio and mobile phones. Accordingly, the working definition adopted in this study defines ICT as any form of technology, be it analogue or digital, used as an educational tool for information or communication purposes. What it does not include are traditional learning tools like pencil and paper, blackboards or whiteboards, although electronic whiteboards would be included in this definition.

Prior to the widespread use of the term ICT, the phrase ‘learning technologies’ was commonly used to refer to computer-based learning environments, but could include any resources, such as methods, tools, or processes that are used for handling any activities involved in education (Pea, 1998). In the current study, the terms ‘ICT’ and ‘learning technologies’ are used more or less interchangeably.

ICT adoption

The adoption of learning technologies “refers to the process of determining which *electronic tools* and which methods of implementation are appropriate for given classroom situations and problems” (Roblyer and Edwards, 2000, p.8). However, throughout the literature this and other terms are used interchangeably. The term ‘implementation’, used by Roblyer and Edwards (2000), was also used by Rowe (1996) when describing the adoption of information technology in the classroom. Other terms such as ‘integrating’ and ‘embedding’ technology are also featured frequently. The Department of Education Training and Employment (1999) provides one such example in their goal that technology “is able to be an embedded, integrated part of learning activities (DETE 1999, p.1).

Strict definitions of these terms refer to a) ‘adoption’ as dealing with the transfer between an old system to a new system that is more effective, b) ‘integration’ as combining software or hardware components or both into an overall system, c) ‘implementation’ as the carrying out or physical realisation of something like the installation of new hardware and system software, and d) ‘embedding’ as causing something, in this case, technology, to be an integral part of a surrounding whole, like the curriculum, for example. Although there are subtle differences between these terms, in the current study they are used more or less synonymously.

Student learning outcomes

‘Outcomes’ as a term has long been used to encompass a wide range of activities. More recently though, the phrase ‘student learning outcomes’ has gained a specific meaning in the education community, where developmental wellbeing (for example, student confidence and motivation) are emphasised. Spady (2001) provides a definition of:

> Outcomes are clear observable demonstrations of student learning that occur at or after the end of a significant set of learning experiences. They are not values, attitudes, feelings, beliefs, activities, assignments, goals, scores marks or averages. Typically these demonstrations, or performances, will reflect three key things:
>
> - What the student knows,
> - What the students can actually do with what he or she knows, and
> - The student’s confidence and motivation in carrying out the demonstration.
>
> (Spady, 2001, p.3)

Yet other curriculum documents like the *South Australian Curriculum, Standards and Accountability (SACSA) Framework*, includes as one of five essential learning outcomes, the notion of identity, where students are to “develop a positive sense of self and group, accept individual and group responsibilities and respect individual and group differences" (DETE, 2001, p.46). This focus on the individual presents a clear shift towards student-centered learning and a holistic approach to education.

Accordingly, in this study the term 'student learning outcomes' is taken to include attitudes and beliefs, and in particular, student attitudes towards self, more commonly termed self-esteem. Moreover, the term 'student outcomes' only refers to attitudinal development in this study. Students, their attitudes, and ICT are discussed more fully in Chapter 2.

Planning for Technological Change

The nature of change undertaken by many schools when integrating ICT is usually that of a top-down approach, initiated by school leaders and administrators. Although top-down approaches may ensure adequate support, funding and resources, such approaches risk involving the teacher in a superficial or even an oppositional capacity (Aaron, et al., 2004). Since teachers determine to a large extent what happens in the classroom, their cooperation and willingness to employ ICT-rich teaching practices plays a critical role in the successful use of ICT with their students (Fuller, 2000; Hooper and Rieber, 1995). The schools involved in this study and discussed further in the following section, adopted the top-down approach.

As Dooley (1999, p.5) puts it, "Teachers teach in the manner in which they themselves were taught". In order to overcome potential resistance from teachers, the method by which schools prepared an application to 'win' the honour of being selected for inclusion in this study, generated considerable enthusiasm within the successful schools to engender teachers' active commitment, support and a willingness to change. Sustaining teachers' support, however, requires ongoing effective planning by combining top-down and bottom-up approaches, where school leaders provide the mandate, the resources, and the coordination, yet at the same time recognise the importance of local acceptance, autonomy and empowerment (Aaron, et al., 2004). Teachers, therefore, are very much the active component of such reform, where government and school leaders provide the structure, but teachers determine the detail of day-to-day teaching practice.

Research has shown that the most effective way to embed ICT curriculum-wide is through whole school engagement in a democratic and structured process of planned change (Becker and Riel, 1999; Becta, 2003a; Becta, 2004; Clarkson, 1998; Collins, 1991; Crichton and Kinsel, 2000; Czerniak et al., 1999; Dirksen and Tharp, 1997; Dexter et al., 1999; Downes et al., 2001; Fisher and Dove, 1999; Fullan, 1991; Riel and Fulton, 1998). By dictating general guidelines for technology adoption, but leaving the detail to each school, many governments, both nationally and internationally, have successfully followed this type of planning (Brush, 1999; DETE, 1999; Indiana Department of Education, 2002; California Department of Education, 2004). The success and effectiveness of such implementation strategies, is therefore moderated by teachers' beliefs and attitudes toward these technologies and their ability to readily use them successfully. Teachers' beliefs, their teaching practice, and ICT are discussed in Chapter 2.

The Study Setting and School Selection Process

Clearly, the introduction of any technology into classrooms, changes the learning environment – what is being learned, why and how it is learned, social interaction, and more. Thus evaluative research into the impact of ICT on learning must encompass the total system. To do so, usually requires research initiatives driven from the government level. If schools are to embed learning technologies effectively into their curriculum, research must resolve a complex array of school-wide interrelated issues. Governments the world over are aware of the need for such research and the DECS*tech* Project, conceived by the South Australian Department of Education Training and Employment (DETE, 1999), is one such initiative. At the core of the project are six so-called ‘Discovery Schools’, and it is these schools that constitute the setting for this study. The schools are described in detail in Chapter 7, while the study sample is discussed in Chapter 4.

Six co-education public schools in the metropolitan suburbs of Adelaide, South Australia, were selected from among many applicants. The selection of the Discovery Schools was a government driven process involving a committee consisting of members from the Department of Education Training and Employment. Schools were chosen on several factors, which included the quality of their application, their level of enthusiasm and commitment to participate in a longitudinal study, their preparedness to undergo a school-wide process of change, and in order to represent a diverse spectrum of learning environments. The schools were not selected on the degree to which ICT was already embedded in their curriculum or the extent of their ICT resources. The result of being selected, however, afforded them opportunities to undergo a school-wide process of change, and as such, is of interest to research.

In further describing the setting of this study, a brief discussion of the DECS*tech* Project outlining the program of structured change within each school is useful. Over a three-year period the schools are to undertake an intensive process of development and change by embedding ICT throughout mainstream curricula. The first year is an establishment year where the schools identify their needs, and plan and initiate strategies to build a curriculum more widely enriched by ICT. During the following two years, students and teachers continue to experience changes in the learning environment as strategies are implemented and ICT are increasingly taken out of specialised subjects and adopted across all areas of learning. Assistance in the form of a dedicated ICT manager and funding is available to the schools for the three-year period (Filsell and Barnes, 2002; MCEETYA and EdNA, 2001). How resources are allocated and strategies are formulated and implemented, is ultimately driven by the informed decisions of each school’s leaders. Although the common objective is to increase students learning outcomes, it is expected that each school will arrive at a different solution, governed by its existing resources and the unique needs of its students.

Purpose of the Study

In a survey of ICT adoption studies, Russell (1997) argued that it did not matter what delivery system was used, since results obtained in these studies yielded “no significant difference”. In most instances, these ICT adoption studies examined by Russell contain major flaws in terms of poor research design, weak statistical analysis or small sample size. Furthermore, those studies that do purport to measure student learning as an outcome variable often measure the lowest levels on Bloom’s Taxonomy (Bloom, 1956). Only at high levels of understanding does the learning process become sensitive to the method of instruction, and the clearest evidence of the effectiveness of that methodology is revealed (Russell, 1997).

The current study is not about presenting implementation strategies and solutions arrived at by the schools; these are to be documented and reported elsewhere (for example, see Filsell and Barnes, 2002). Neither is this study about informing or guiding the change process; the schools are autonomous in their decisions, and any research undertaken in the schools is aimed at recording the change process without interfering with that process.

Instead, the purpose of this study is to measure longitudinal change in school climate through its influence on students and teachers, during a period of school-wide transition as ICT are embedded throughout mainstream curricula by assessing the influence of potential student, teacher and school factors on student attitudinal outcomes.

Rather than strive to measure the effects of ICT adoption on student achievement as much previous research has done, the focus of this study recognises that student learning outcomes encompass the growth of the person not just in terms of their academic performance. Research in this field is beginning to emerge (Alexiou-Ray et al., 2003; Deaudelin et al., 2003; Leonard et al., 2004). In their review of research on the affective and social aspects of human-computer interaction, Deaudelin et al. (2003) advocate the need for such research:

> The advent of computers in schools should prompt educational researchers to scrutinize the affective and social aspects of student-computer interactions since they play an important role in learning. (Deaudelin et al., 2003, p.1)

This focus in the current study is further extended by the absence of an empirical measure of ICT adoption, since implementation processes vary from school to school. The notion of ICT adoption as an ongoing process, therefore, is measured through student and teacher attitudes and beliefs as they respond to a changing environment. Put simply, the purpose of this study is to investigate longitudinally the effects on students and teachers caused by a changing school climate, but not the cause of the change of school climate itself.

Aims of the Study

If schools are to embed learning technologies effectively into their curriculum, research must resolve a complex array of interrelated factors, recognising that the teacher is a central element within the main context of improving student learning outcomes. In recognition of this complexity, the aims of this study can be conceptualised as school, teacher and student-level influences sub-divided into a series of overarching inquiries that are of central concern to both researchers and educational leaders in the field of incorporating ICT into the curriculum.

1. How does a changing school climate, due to the adoption of ICT across the curriculum, influence teacher beliefs about ICT and student learning outcomes? How do primary and secondary schools change over time and how do they differ?
2. How do teacher factors, such as background, current and planned use of ICT, in addition to beliefs about support and confidence in using ICT, influence their use of ICT in their teaching practice and in turn, influence student outcomes?
3. How do student factors, such as background, practical aspects of ICT use, and their attitudes towards school and computers, influence student self-esteem, and how do they change over time? Are there differences in the factors that influence student self-esteem in primary and secondary schools, and are there gender differences?

Through the use of online survey instruments suitable for repeated administration over the three-year lifespan of the study, the specific aims are to:

1. assess teacher factors, such as background, current and planned use of ICT, in addition to beliefs about support and confidence in using ICT;
2. investigate the factors that influence teachers' adoption of ICT in teaching practice;
3. assess student factors, such as background, practical aspects of ICT use, and attitudes towards school, computers and self;
4. investigate the factors that influence students' self-esteem, and how these change over time;
5. examine differences in students and teachers regarding ICT in primary and secondary settings;
6. examine differences in male and female students' ICT beliefs and skills, in addition to their attitudes towards school, computers and self-esteem; and
7. examine how student, teacher and school factors influence how students, their self-esteem in particular, and schools change over a three-year period due to the ICT adoption process.

Delimitations of the Study

Research into the impact of embedding ICT into mainstream curricula on students and teachers, may well form the basis for several doctoral studies. However, for the purposes of a single study, a number of delimitations are necessary to provide focus and define the boundaries of manageability.

Although there may be value in studying all year levels within primary and secondary school, this study is limited to those students in middle school. Accordingly, students in Years 5 to 10 are selected for several reasons. Firstly, only one instrument appropriate for the age range is required. Secondly, the risk of disruption to students in senior school during a crucial time in their studies and formal examinations is considered too great a priority over their involvement in the study. Thirdly, by targeting public sector middle school students, both primary and secondary settings are involved in the study in a co-educational environment, maximising the transferability of results.

In order to maintain focus and not introduce undue complexity in this study, a number of other specifications are considered necessary. The study is confined to metropolitan public schools in Adelaide, South Australia. The focus of the study is restricted to student and teacher attitudes, beliefs and practical issue regarding ICT. No measures are taken of the academic achievement or the ability of students. Likewise, no direct links are made between teachers and students at the classroom level, although periodic informal observations are made in order to provide further contextual understanding about school demographics. In addition, on the basis of manageability, specific methods of ICT use and processes of adoption in each curriculum area are not measured. A final delimitation in this comparative study provides only a relative and not an absolute measure of change, since no control group measures (schools not involved in the DECS*tech* Project) are used. Rather, by surveying the study schools at the planning stage in the first year prior to ICT being actively embedding in curricula, a baseline measure for each school provides a point of comparison.

Limitations of the Study

A number of constraints served as limitations in this study. These chiefly include the duration of the study, the degree of change, the response rates and the sample size. However, where possible steps were taken to minimise these effects.

The three-year duration of the study was predetermined by the lifespan of the DECS*tech* Project, which provided funding and expertise. School leaders clearly felt that there was a symbiotic commitment to the project and to this research study.

Since each school participating in the study was autonomous in its decisions about undertaking the process of embedding ICT throughout the curriculum, the paths that each school took to achieving this end was different. Furthermore, each school was to conduct its own action research into these processes, rather than face scrutiny by an external body. Consequently, the degree and success of this adoption process could not be measured directly or in absolute terms, and it may be that some schools changed very little at all.

The response rates of teachers in most schools were lower than hoped, for two reasons. First, schools clearly put a great deal of effort into scheduling for classes to use computer labs and complete the student survey. For schools to provide this opportunity for over half its student population, in the four-week survey administration period each year, was a considerable challenge. However, teachers were not afforded a similar allocation of time and access, and thus the onus was on teachers themselves to complete the survey. Second, unlike the student survey, the administration of the teacher survey was conducted by other researchers and therefore problems arising from technical failure and data management were out of the researcher's direct control. As a consequence of the incomplete data, longitudinal analysis was not appropriate for the teacher responses.

A final limitation of this study was that only four primary and two secondary metropolitan schools are selected to participate in this study. It should also be stated that the inclusion of all students going through Years 5 to 10 and all teachers in these schools over the three-year period forms a sample of convenience rather than a random sample. Fortunately, there are adequate numbers of teachers and students in the sample to not restrict or prevent the use of the statistical and modelling procedures employed.

Significance of the Study

The significance of this research results from the combination of several features into one comprehensive study, which involve the time frame, the magnitude, the complexity, and the methodological approach.

The longitudinal nature of this study, over a three-year period, is rarely achieved in doctoral studies because of time constraints. While it results in the study taking longer than the minimum three-and-a-half years to complete, the benefit of this decision is apparent. It allows for comparison over a useful and meaningful period of time. Many studies that undertake similar longitudinal designs generally use, for convenience, shorter intervals between measurement points, sometimes only a month apart. Such intervals can be too short to measure any significant change in participants (Russell, 1997). Institutional change is a slow process and measuring any significant difference takes time. Therefore, within student comparison is conducted in this study (that is how students change within themselves over time) by examining how the increasing use of ICT in learning influences them, with the realistic expectation that if there is any change, it will be measurable and significant.

The scale of the study using multiple schools and multiple year-levels across the primary and secondary public school sector, results in findings that have broad application. Undertakings of such magnitude, using thousands of students and their teachers from a number of schools, are uncommon in educational research (Forbes, 2005). The use of common instruments across multiple contexts optimises analysis, and the focus on attitudinal rather than achievement-based outcomes further assists in yielding results that are more likely to be transferable and generalisable to similar contexts. Any school has the ability to implement a process of change and undertake a similar study to assess the attitudinal outcomes of their students.

In addition, the use of multiple schools introduces further complexity arising from the hierarchical nature of the environments in which this study is conducted. Analysis is conducted that takes into consideration the multi-level structure of the data, where occasions are nested within students who are nested within schools.

Possibly the greatest contribution that this study brings is in its approach to remain relevant and withstand the rapid changes of technology. Many previous studies examining the adoption of ICT into mainstream learning have focused on what is done with technology rather than on its effect. Consequently, when the specific technology becomes obsolete, the research risks becoming obsolete and its findings lose relevance. It is hoped that this study will stand the test of time by focusing on a process of change rather than a process of implementation. The distinction here is that change concerns the personnel involved, whereas, implementation concerns the technology involved.

The findings of this study are expected also to contribute to theoretical and methodological knowledge, in addition to informing school managers and policy developers, on "clear and useful advice and support relating to curriculum applications of information and learning technologies" (DETE 1999, p.15). The theoretical framework and models developed for this study, which examine the environmental factors that influence student attitudes, are tested empirically in the context of public primary and secondary schools in a metropolitan city. The complex sample design, as well as the issues of the hierarchical and longitudinal nature of the data, involve innovative use of various data analysis methods to examine the proposed models. As a result, this study identifies student, teacher and school related factors that optimise student learning outcomes in an ICT-rich learning environment. In doing so, it is expected that educational leaders, nationally and internationally, can better formulate strategies for developing ICT-embedded curricula that support student learning from a holistic approach.

Overview

The major objectives of this study involve the longitudinal assessment of change in school climate due to an increased use of ICT in learning and the impact on student learning outcomes. Discussion in this chapter includes a broad statement of the research questions addressed, the delimitations and limitations faced, information about the setting and the significance of the study. This chapter provides an introductory foundation on which the following chapters are developed.

The next chapter reviews and summarises the major research findings relating to the adoption of technology in schools and the measurement of beliefs and attitudes. Chapter 3 presents the theoretical research framework, built from the discussions of the previous chapter and modelled on design-based research methods. The research propositions are also restated in more detail.

The research design, presented in Chapter 4, provides information about the samples of students and teachers, and details the questionnaire instruments employed, together with the procedures used for data collection in this longitudinal study.

Methodological considerations are addressed in Chapter 5. Examination is made of the analytic techniques and the software tools selected for the data analyses.

Chapter 6 describes the complex steps involved in preparing the raw data for subsequent analyses, from matching and coding responses to imputing missing data, testing validity and reliability, to the development of factors that form the basis from which the student and teacher models are constructed. In order to give meaning to the underlying concepts of these factors, Chapters 7, 8, and 9 respectively, profile the schools, through general demographical information, and the teachers and students, through their responses to the questionnaires.

In Chapter 10, the teacher- and student-level factors are examined by testing two models using path analysis. Since single-level path analysis is able to show interaction effects between factors within levels, but is unable to show the interaction effects between factors across levels, Chapter 11 presents the across-level factors influencing student learning outcomes using three-level hierarchical linear modelling procedures. The final chapter draws together the results of the preceding analyses, and presents concluding remarks, implications and recommendations for future research.

2

Measuring the Impact of ICT in Teaching and Learning

While Chapter 1 provides an introduction and overview to this study, this chapter presents a synthesis of previous research into the adoption of ICT in learning and the implications on students, teachers and schools. The importance of conducting such a review establishes the current boundaries of knowledge and understanding in the field, and in doing so, provides the research context in which this study is rooted and from which those boundaries can be extended in the subsequent chapters.

The review of literature conducted in this chapter is organised into three sections. The first section discusses trends in educational technology and its integration; the second section discusses teachers, their teaching practice and ICT; and the third section addresses students, their attitudes and ICT. A short summary concludes the chapter.

Trends in Educational ICT and its Integration

In Plato's *Phaedrus*, a story is told of the god Theuth who presents to King Thamus of Upper Egypt his inventions including number, dice, and writing:

> Thamus inquired into the use of each of them, and as Theuth went through them expressed approval or disapproval, according as he judged Theuth's claims to be well or ill founded...When it came to writing, Theuth declared: "Here is an accomplishment, my lord the king, which will improve both the wisdom and the memory of Egyptians. I have discovered a sure receipt for memory and wisdom". "Theuth, my paragon of inventors," replied the king, "the discoverer of an art is not the best judge of the good or harm which will accrue to those who practise it. So it is in this case; you, who are the father of writing, have out of fondness for your offspring attributed to it quite the opposite of its real function. Those who acquire it will cease to exercise their memory and become forgetful; they will rely on writing to bring things to their remembrance by external signs instead of their own internal resources. What you have discovered is a receipt for collection, not for memory. And as for wisdom, your pupils will have the reputation for it without the reality: they will receive a quantity of information without proper instruction, and in consequence be thought very

> knowledgeable when they are for the most part quite ignorant. And because they are filled with the conceit of wisdom instead of real wisdom they will be a burden to society."

Since the invention of writing, there has been an ongoing parade of new technologies that each claim to revolutionise learning and improve educational outcomes. The intense interest and excitement surrounding the emergence of each new technology is often followed by disappointment when expected learning gains are not realised. The introduction of computers to learning has been no different.

During the 1950s to 1970s in the era before microcomputers, computers were described as teaching machines and imbued with their ability as tireless examiners of students (Alexander, 1998). Microcomputers were introduced in the late 1970s (Anderson, 1984), marked by the publication of *Mindstorms* (Papert, 1980) and the beginnings of the computer literacy movement (Roblyer and Edwards, 2000). The term 'computer aided learning' was widely adopted and computers were viewed as "patient tutors, scrupulous examiners and tireless schedulers of instruction" (Alexander, 1995). Furthermore, the expected benefits to students included the freedom of self-directed learning, with richer resources and automatic feedback. Computers would free teachers from their role as instructor allowing them to devote more individual time to students and less time to administrative tasks (Kulik et al., 1983).

During the 1980s and into the 1990s interactive multimedia came into prominence, with further claims of facilitating immediate student feedback, individualising instruction, and enhancing learning by combining text, sound, graphics and animation to create video segments, so that learning need not be reliant on language and text alone. Clark and Craig (1992) challenged these claims with a survey of interactive videodisc and multimedia research, concluding that multimedia are not the factors that influence learning and that any measured gains in learning are more likely due to the instructional methods rather than to the technology used. By 1996, widespread use of the internet renewed expectations of improved learning outcomes with the emergence of internet-based teaching and learning. Again, claims where made that teaching and learning would be richer, more effective and flexible, with improved communication in a more motivating online environment (Anderson, 1997; Budin, 1999; Education Information Center, 1998; Glennan, 1998; Harasim et al., 1995).

With the new century came new hopes in the potential of the information superhighway, adaptive testing, virtual reality systems, and other emerging technologies. However, little seems to have changed. Technology is increasingly accessible, intuitive, reliable, and diverse in its application, and yet, has fallen short in delivering similar gains in education. As Alexander (1995) states, "It seems surprisingly obvious that there is no reason to expect the quality of learning to improve if we simply transfer a learning experience from one medium to another". Reynolds (2001) presents an appropriate summary of the situation:

> … we are trapped in a cycle of classic innovation failure – a low quality implementation of a not very powerful new technology of practice produces poor or no improvement in outcomes, which in turn produces low commitment to the innovation and a reluctance to further implement more advanced stages of the innovation (like the new communities of learning now possible with 'second wave' ICT) that are more likely to generate the improvement in outcomes that would produce the commitment to ICT utilisation. (Reynolds, 2001, pp.2-3)

However, Godfrey (2001b) presents a more optimistic view:

> More recently, there has been a shift in the way computer-based tools are perceived in the classroom, with an emphasis on the quality of learning experiences for students rather than just quantifiable outcomes. (Godfrey, 2001b, p.15)

What does appear to be clear from the most recent literature is that current trends in educational technology and its integration are encouraging. Anderson (2005) addresses how trends in ICT are impacting and changing our lives and, from necessity, changing the nature of schools brought about by the integration of ICT in teaching and learning. Focusing on technologies that directly relate to the delivery and enhancement of teaching and learning, Millea et al. (2005) reports:

> Predicting the likely adoption and evolution of emerging technology is, of course, a best guess scenario, given the rapid state of change in the digital world. Nevertheless, there is considerable agreement in the literature, and in education policies framing commitments to ICT, on general trends. These emphasise mobility; interoperability; convergence; divergence; integration; richness of content; security; creativity, interactivity and collaboration; and utilisation of open source software as a potential alternative. (Millea et al., 2005, p.1)

In order to affect development and change in teachers and students, it is the design of the learning experience, the method of intervention, and not the technology, that has the greatest potential. A report by Goddard (2002) further advocates a progression of technology adoption that leads to a judicious use of technology in classrooms:

> It is time to step away from this technology-centered focus and promote classroom learning activities in which students work in small groups rather than in isolation or as a whole class. The technology should be designed to support models of teaching that incorporate real-world applications, using research, design, analysis, composition, and communication. (Goddard, 2002, p.25)

In order to measure such change, research needs to adopt a holistic approach that focuses on the context and culture, the intervention process, and the individual, as sets of interrelated systems, rather than the technology used (Rowe, 1996; DBRC, 2003; Dooley, 1999). According to Jones and Paolucci (1997), less than five per cent of published research is sufficiently empirical, quantitative and valid to support conclusions with respect to the effectiveness of technology in educational learning outcomes. These authors further argue that the influence of technology, while substantial, is largely unfounded.

So what impact have learning technologies had on teachers and students and what factors support effective integration and promote positive learning outcomes? The following sections address these questions.

Teachers, their Teaching Practice and ICT

Over the past two decades, many aspects of teachers and teaching have been measured and scrutinised in an effort to determine and understand what factors influence the effective use of ICT in classroom practice. In this section, a review of literature mainly confined educational research undertaken since 1990, focuses on teacher characteristics, ICT access, institutional support, confidence using ICT, and beliefs about student learning and teaching practice.

Teacher characteristics

Personal characteristics of teachers have been identified in research on predictors of exemplary teaching practice and computer use. Factors common to many studies examining predictors of teachers' ability to implement computer-based instruction, include teacher gender, grades taught, years of teaching experience, training and experience in teaching with ICT, and computer ownership (Becker, 1994; Marcinkiewicz, 1994; Ross et al., 1999; Smeets and Mooij, 2001).

There is consistent evidence that males are more confident about their ICT skills than females (Becker, 1994; Dix, 1999; Siann et al., 1990). According to Chalmers and Price (2000), a number of inequities are faced by female teachers with regards to ICT use, and include gender stereotype, lower self-efficacy, software and games that are more appealing to males, and lack of experience.

The lack of experienced ICT-using teachers, both male and female, however, is a common theme throughout the literature locally and abroad (Barrette, 2000; Clarke, 2001; Crook, 2001; Czerniak et al., 1999; Czernezkyj et al., 2001; Pan, 1998). In Norton's (1999) study examining secondary mathematics teachers' responses to computers and their beliefs about the role of computers in their teaching, "only teachers with special expertise used computers regularly" (p.404). Other literature supports the notion that early-career teachers have more positive views towards ICT, tending to abdicate agency to the technology, and are trained in student-centred constructivist learning theories and ways of teaching (Carr-Chellman and Dyer, 2000).

Little research exists that considers the impact of the permanency of teaching position and teaching load on teachers' use of ICT in their teaching practice. However, in her review of research, Brand (1997, p.3) noted that "remuneration and teacher recognition" were important factors, by providing teachers with incentives and recognition in order to motivate them to acquire new skills.

Access and use of common ICT

Cox, Preston and Cox (1999a) found that teachers placed great importance on computer ownership and access to ICT for personal use as a factor that influenced their adoption of ICT in teaching practice. Lupton (1996) reported similar findings. Dawson (1998) identified teachers' use of ICT for non-instructional activities that were not directly related to classroom instruction, and included, most commonly, word-processing and graphics, and least frequently, databases and spreadsheets. In a keynote address, Reynolds (2001) stated that:

> ICT can provide the means of storing and analysing a wide range of data on the progress of pupils over time in different subjects, so that one can also see which pupils are performing well in which subjects. Teachers therefore may be more likely to use with their pupils something that they get benefit out of themselves - hints that this thesis is accurate come from some of the studies that show teacher home ICT usage correlated with effective classroom usage. We need more research in this area too. (Reynolds, 2001, pp.6-7)

Becker's (2000) report of findings from the *Teaching, Learning and Computing Survey* (Becker, Ravitz and Wong, 1999), indicated that classroom access to local computer clusters or hubs were more frequently used in teaching and learning than computing laboratories. Another factor influencing computer use, reported by Becker (2000) and Czerniak et al. (1999), is the structural difference between primary and secondary school lessons. Primary school teachers have their students for most of the day, allowing opportunity to provide frequent access to ICT. However, at the secondary school level, where 50-minute instructional periods are the norm, regular access is less likely, particularly if computers are located in a separate computer room.

Confidence using ICT

A growing number of studies have been conducted on teachers' confidence in their use of computers, either for personal work or in their teaching practice. Several studies (Lynch, 1999; Macmillan, Timmons and Liu, 1997; Bandura, 1997; Sandholtz, Ringstaff and Dwyer, 1997) reported that teachers were reluctant to reveal their level of computer knowledge to students and were unwilling to use computers in regular teaching practice until they felt comfortable and competent in using the technology. Teachers with more computer experience had greater confidence in their ability to use computers effectively (Galloway, 1997; Nash and Moroz, 1997).

In a world-wide study of the use of computers in 19 educational systems, Pelgrum and Plomp (1991, 1993) emphasised the relationship between teachers' ICT knowledge, skills, and training. Their discussion of the difficulties faced when integrating computers into the curriculum included the needs of teachers "to overcome their (initial) problems of uncertainty and their concerns about changing teacher/student relationships and about accountability" (Pelgrum and Plomp, 1993, p.5). Overall, Russell and Bradley (1997, p.18) argue, "teachers' lack of confidence in their ability to use computers in the classroom is likely to be related, at least in part, to their training and professional development".

In their review of literature, Ross, Hogaboam-Gray and Hannay (1999) located no studies that identified the antecedents of teachers' confidence in their ability to teach with computers. However, they did report extensive evidence that "teachers with stronger beliefs about their abilities are more likely to set higher goals for students and themselves, persist through obstacles, and be more successful" in achieving planned learning outcomes (Ross, Hogaboam-Gray and Hannay, 1999, p.76).

Computer experience was found to increase confidence in using computers, particularly in male teachers, and correlated positively with attitudes towards computers. This evidence is further supported by Cox, Preston and Cox (1999a; 1999b), who reported that teachers who regularly used ICT, were more confident using ICT, perceived it to be useful in their teaching practice, and were more motivated to use it.

School support and ICT teaching issues, challenges and obstacles

Although whole school engagement in a democratic and structured process of adoption has been shown to be the most effective way to embed ICT curriculum-wide, research has revealed many barriers that hinder progress. Cox, Preston and Cox (1999a) discovered that teachers' perceptions of their school's technical support influenced their uptake of ICT in their teaching practice. Hannay and Ross (1997) identified a number of school and cultural factors, which included support for collaboration, access to professional learning resources, and leadership for change, among others. As one of many key findings, Education Victoria (1998) identified the need for:

> Enhancement of a collegiate culture, which stimulates reflective practice, provides a continual context for formal and informal learning. Teachers need emotional, technical and pedagogical support in the integration of learning technologies. Support should include: routine access to computers and appropriate software at school and at home, and ongoing professional development programs. (Education Victoria, 1998, p.16)

Undermining teachers' willingness to change is their strongly held beliefs that the adoption of any sort of innovation in the classroom will threaten their priority to maintain order and control in the learning environment (Akbaba and Kurubacak, 1998; Christensen, 1998; Cox, Preston and Cox, 1999a; Godfrey, 2001a; Lynch, 1999). In a comparative discourse analysis of primary and secondary school teachers and promoters of ICT integration, Sasseville (2004) concluded that:

> Teachers are adapting their practice to the use of information technology but only to a certain extent. They are not willing to put aside or throw away years of precious experience simply to adopt a tool that is generally perceived as ill - fitted to the framework of their craft. Teachers are also refusing the very popular conception of professional merit by technological means. They do not want their competence as educational professionals evaluated merely by their ability to use the technology in the classroom. (Sasseville, 2004, p.5)

School-wide strategies must involve all teachers in the decision to adopt ICT, by providing supportive environments where teachers' feel more prepared to attend training and change their teaching practice. According to Czerniak et al., (1999), teachers shared the belief that:

> educational technology enhances student learning and that the integration of technology into their teaching is both desirable and needed. Yet, they do not perceive that sufficient support structures are in place to enable them to achieve the outlined technology education standards. (Czerniak et al., 1999, p.12)

Further challenges, identified in the research literature on ICT and pedagogy, to teachers adopting ICT in their practice, are a lack of school resources and insufficient time to undertake planned cycles of, development, enactment, reflection and further planning, in order to effectively integrate technology in teaching and learning (Becker and Riel, 1999; Cox et al., 2003; Edwards, 2000; Hennessy and Deaney, 2004; Ringstaff et al., 1996; Sasseville, 2004). This sentiment is reiterated by Hennessy and Deaney (2004) who state that:

> Innovation and adaptation are costly in terms of time; in particular, developing effective pedagogy around ICT involves significant input in terms of planning, preparation and follow-up of lessons. (Hennessy and Deaney, 2004, p.5)

Research by Ballard (2001), Dawes (2001), and Schofield (1995) also identify other contextual factors that can act as barriers, including a lack of confidence, teaching experience, training opportunities, and access to reliable technology resources. According to Akbaba and Kurubacak (1998), teachers' attitudes and beliefs about technology are directly related to their training and comfort level, and so in identifying factors that affect the integration of ICT in teaching practice, expertise and support are pivotal. Leggett and Persichitte (1998) and others have also identified sets of factors that reportedly have influenced the adoption of learning technology. These were defined as TEARS: Time, Expertise, Access, Resources and Support. Meanwhile, in summarising research on attempts to introduce teaching technologies in schools, Aaron (2001) modified this to the acronym, SPECTRA (Support, Perceived need, Expertise, Communication, Time, Resources, Access), by adding the key ingredient, communication (Aaron et al., 2004).

Mumtaz (2000) distinguished between 'school level' and 'teacher level' barriers but emphasised the interdependence between them, arguing that institution, resources and teachers were the three main factors affecting uptake of ICT. Of greater influence, however, were 'teacher level' factors such as pedagogical beliefs, technical skill, and confidence. Akbaba and Kurubacak (1998) identified several salient beliefs held by teachers, which involved teachers' fears about their changing role in the classroom, concerns about workload, and loss of status in being the main information provider.

Indeed, the literature on change and innovation emphasises the crucial role that teachers play as both agents of change and also as adopters of the innovation (Cavanagh et al., 2004; Vaughan, 2002).

Williams et al. (2000) emphasised the importance of ‘school level’ factors and identified the need for school leaders to create a supportive organisational culture that was “forward looking and dynamic but also sympathetic to the stage which teachers are at in their own ICT skills and knowledge development” (p.318). More recently, Tearle (2003) supported these findings by concluding that much broader issues of teachers’ mindsets, assumptions, beliefs and values, in addition to whole school characteristics, culture and ethos, are highly influential in the uptake of ICT in teaching and learning.

Beliefs about students work and effort using ICT

Many years of research into school improvement and effectiveness have shown that improving the educational outcomes of students requires changing belief and value systems of teachers throughout the school (Bennett et al., 2000; Harris and Bennett, 2001). Teachers’ educational beliefs are strong indicators of their planning, instructional decisions and classroom practices (Dwyer et al., 1991; 1992a; 1992b; Moseley et al., 1999; Pajares, 1992). Indeed, according to Pajares (1992, p.311), teachers’ beliefs are “far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behaviour”.

Cox, Preston and Cox (1999a) concluded that those teachers who believed that computers made lessons more interesting, easier and fun for them and their students and provided diversity and motivation, were more likely to use computers in their teaching practice. They also argued that improving the presentation of material was an important consideration. Dawson (1998) investigated teachers’ instructional computer use and found that motivating students’ interest in school work was an important factor. According to Kimble (1999, p.3), “When technology is properly implemented in the classroom, according to research results, it can result in increased student self-confidence and eagerness to learn”.

The importance that teachers place on student effort is complemented by a growing body of research evidence of increased student work output resulting from ICT use. Recent studies (Smeets and Mooij, 2001; Tolmie, 2002; Zandvliet, 1999) have noted marked student productivity improvements as a direct result of ICT usage. Riel and Becker (2000, p.34) found that experienced ICT-using teachers were more likely to “expect their students to contribute new insights and provide an atmosphere of respect for divergent innovative thinking.” In other words, they taught students in ways that support students, and not their own, understanding of learning.

Planned learning objectives and outcomes

Akbaba and Kurubacak (1998) identified in their review of research, a number of indicators of teacher’s attitudes towards technology. These included teachers’ planned use of technology in the classroom and the encouragement of their students to use technology. Cavanagh, Reynolds and Romanoski (2004) developed a model of classroom ICT learning culture that examined, among other factors, teachers’ negotiation of ICT use, recognition of student ICT ability, and encouragement of students using ICT.

Barnes et al. (2001) concluded that teachers were encouraged to employ technology in their teaching when they saw clear opportunities to extend students' learning outcomes, that is "when students were able to achieve outcomes that were either not possible or more difficult using traditional technologies" (Barnes et al., 2001, p.11). Moreover, they found that the flexibility of ICT encouraged teachers to plan less, allowing student experiences of the learning process to evolve and shape the learning outcomes.

Learning outcomes that utilise open-ended software, such as presentation, multimedia authoring, and word-processing programs, are more likely to encourage deeper learning and extend learning beyond the classroom and into the home (Becker et al., 1999). Teachers who planned such learning objectives, which resulted in student engagement and thoughtful effort, were identified as exemplary computer-using teachers:

> Across the academic subjects at both elementary and secondary levels, the most common objectives that teachers have for their students' use of computers no longer are "practicing skills just taught" or "learning computer skills." Instead, the objectives most often named have to do with students gaining access to information and improving their writing. Moreover, the kinds of software that teachers report using most often with their students—word processing programs, CD-ROM reference materials, and World Wide Web browser software—confirm that what students do most often on school computers involves searching for information and ideas through electronic media and expressing themselves in writing; not practicing math and grammar drills, playing games, or learning computer skills as isolated skills. (Becker et al., 1999, p.47)

Teaching practice

Over nearly two decades, research has closely examined teachers' attitudes, beliefs and practices relating to learning technologies as ICT has become an increasingly stable part of educational settings (Bigatel, 2004; Cox et al., 1999b; Passey and Samways, 1997). As Stevenson (2004) suggests:

> These studies point to a number of factors, including the processes of change, school contexts, and training, as being significant in shaping teachers' approaches to the integration of ICT into pedagogical activity. (Stevenson, 2004, p.11)

Teachers' beliefs and attitudes towards ICT can influence their teaching practice and in turn, influence students' attitudes towards technology (Akbaba and Kurubacak, 1998; Clarke, 1997; Fulton and Torney-Purta, 2000). According to Becker (2000, p.7), "computer-using teachers … are distinctly more constructivist than non-using teachers", particularly in secondary school. This shift in teaching practice from teacher-centred to student-centred constructivist practice is prolifically reported in the literature and indicates that embedding technology into the curriculum influences and changes teaching practice (Barnes et al., 2001; Confrey et al., 1990; Connell, 1997; Deacon, 1999; Housego and Freeman, 2000; MacDonald, 2005; Newhouse, 1998; Rowe, 1996; Sheingold and Hadley, 1990; Smeets and Mooij, 2001). Moreover, teaching practice has to change in order to optimise student learning outcomes in an ICT-rich environment (Sheingold, 1991; Amarasinghe and Lambdin, 2000). Other literature (Machnaik, 2002) supports the notion that in order for teachers to adopt ICT-rich teaching practice, teachers "must be allowed, encouraged, and supported to risk becoming learners themselves" (Crichton and Kinsel, 2000, p.5). Reflecting on previous research, Fulton and Torney-Purta (2000) also support this view:

> Comprehensive use of technology, when combined with access, training, and support, encouraged teachers to change their views about teaching, from instruction to construction. (Fulton and Torney-Purta, 2000, p.3)

Taking a contrary viewpoint, Dexter et al. (1999) challenge this view of computers as a catalyst for change in instructional practice:

> A simplistic view of computers as catalyst of instructional change is misleading because it disregards what we have learned about teacher development and the change process. Specifically, it underestimates the impact teachers' beliefs have on how they teach, it simplifies the process of how teachers develop and learn professional knowledge, and it diverts the examination of how social norms and structures might support or contradict a proposed change. (Dexter et al., 1999, p.237)

Transforming the culture of a school requires teachers to develop new beliefs, attitudes and values about instructional processes that will lead to change in classroom practice and improved student educational outcomes (Halsall, 1998). In their diffusion of innovation study, Dooley et al. (1999) recommend that:

> Through formal training and professional development, individuals gain the skills, knowledge and attitude to be successful with the innovation. Individuals must not only have training on the use of the technology, but on how the innovation can become a part of their training or teaching repertoire. (Dooley et al., 1999, p.10)

In a study by the *Australian Department of Science, Education and Training,* educational change is needed to "… affect the practices, culture and structure of schools by restructuring roles and re-organising responsibilities, including those of students and parents" (Cuttance, 2001, p.2). The study also revealed that successful innovation implementation focused on "creating learning environments that could meet the learning needs of individual students, which, in most cases, involved a more student-centred approach" (Cuttance, 2001, p.20). In a three-year project, the Victorian Department of Eduction ascertained that the adoption of learning technologies challenged teachers to "reflect on their teaching philosophy and practices" (Education Victoria, 1998, p.12). They also established that:

> Computer networks provide the infrastructure to enhance student learning and improve administrative practice by enabling the efficient management, organisation and distribution of information, and facilitating communication and collaboration locally and globally. (Education Victoria, 1998, p.8)

From these previous findings into teachers and their teaching practice, a set of factors considered to be important in influencing ICT-rich teaching practice can be distilled and formalised into a representation of the real world. But this is only half the picture. A similar review of literature considering student-related aspects of the learning environment must first be conducted.

Students, their Attitudes and ICT

In addition to the many school and teacher related influences on the formation of students' beliefs, behaviours and attitudes in an ICT-rich learning environment, research has endeavoured to determine what other factors at the student level influence their attitudes. Petty and Cacioppo (1986, p.127) provide a general definition:

> Attitudes are general evaluations people hold in regard to themselves, other people, objects, and issues. These general evaluations can be based on variety of

> behavioural, affective, and cognitive experiences, and are capable of influencing or guiding behavioural, affective, and cognitive processes.

In this section, a review of research literature focuses on student antecedent characteristics, ICT access including use both inside and outside of school, students' skills and confidence in using ICT, students' attitudes towards computers and towards school, and self-esteem.

Student characteristics

Under much investigation in educational research are the influences of antecedent factors, those of student gender, age and language background. A key finding of a review of literature conducted by the Victorian Curriculum and Assessment Authority (2002) stated:

> There are many factors that impact on a student's ICT skill level, including: gender, indigeneity, enrolment across different school sectors, location in terms of urban and rural, enrolment in small and large schools, and family income. (VCAA, 2002, p.80)

Many studies have found that female students maintain a more positive attitude towards school than male students, but both decline with age (Christensen, 1998; Dix, 1999; Dix, 2005; Keeves, 1986). On the other hand, it appears likely that female students do not approach computers with the same enthusiasm as male students (Dix, 1999; Dix, 2005; Liao, 1999; OECD, 2006). A paper discussing issues and challenges in information technology education in Australian schools noted that:

> Schools are still reporting significant gender imbalance in Computer Studies classes and courses, and it need hardly be stated that while this continues, the country is missing out on large numbers of potential information technology professionals, and girls are missing out on a wide variety of exciting and worthwhile career opportunities. (McDougall, 2001, p.19)

Schofield (1995) reported that there were clear differences between boys and girls, both in the age they began to use computers and in the nature and degree of exposure to computers at home. Adding further support to the concerns of many educational practitioners about gender equity, Janssen-Reinen and Plomp (1997) concluded that, in comparison to male students, female students knew less about ICT, enjoyed using the computer less, and perceived more software problems. They attributed these gender inequities to "differences in parental support, access to computers (in terms of availability and use), amount of female role models and activities carried out with the computer at school" (Janssen-Reinen and Plomp, 1997, p.77).

A significant research focus on gender and ICT in the areas of literacy and numeracy was identified by Blackmore et al. (2003) in a wide-ranging review of literature on disadvantage, ICT and learning. These authors found little research and few case studies that considered the issue of "How ICT works for different groups of NESB students disaggregated by gender and location, e.g. How does English as a second language impact on their attitudes and use of computers?" (Blackmore et al., 2003, p.71).

How students' language background, age and gender influence their self-esteem in a changing learning environment is clearly an area of research requiring further investigation.

Home ICT access and use

Although the importance of home environment has been empirically associated with positive attitudes towards ICT use at school, research has struggled to identify plausible explanations for this association. Cavanagh et al. (2004) developed a model of classroom ICT learning culture that examined, among other factors, the importance of ICT in the home, and homework using ICT. They concluded that student attitudes towards school was highly dependent on the home ICT environment, and this environment also mediated the dependency on student ICT learning behaviours. Based on their findings, Cavanagh et al. (2004) argued:

> … it might be more appropriate to view the congruency between positive home and school ICT attitudes as an attribute of the individual student - some students have a general positive disposition towards ICT and this will be evidence both at home and school. (Cavanagh et al., 2004, p.13)

Research also revealed the importance of home access to computers and the so-called ‘digital divide’ (Alexiou-Ray et al., 2003; Becta, 2001; Becta, 2002; Farell and Wachholz, 2003; OECD, 2006; Rudd, 2002; Spender and Stewart, 2002; Wartella et al., 2000; Williamson, 2003). Although, the digital divide can be one of unavoidable circumstance, it can also be one of choice, as Spender and Stewart (2002, p.18) contended:

> Just as access to books was no guarantee that people would learn to read and write, so access to the internet is no guarantee that people will become computer competent. ... In these circumstances the need is to change the mindsets rather than to simply promote keyboard skills.

In terms of how long students have been using computers at home, the OECD (2006, p.18) concluded that “students who first use computers in their mid-teens are less likely to be comfortable in using them than those whose experience dates back to their primary or early secondary school years”. Moreover, of all the OECD countries participating in the PISA 2003 study, Australia ranked first by having the greatest majority of 15-year-old students with at least five years of computer experience (OECD, 2006). Further supporting the importance of access to computers at home, a study undertaken by the Victorian Education Department showed that:

> Electronic links between the home and school have a marked impact on the learning environment. Students gain substantial benefits from being able to work from home by accessing electronic files, software, CD-ROMs, the Internet, the school intranet, e-mail and a variety of collaborative tools. (Education Victoria, 1998, p.18)

More recently, Somekh et al. (2003) reported that students used ICT at home for leisure, to improve the presentation of work, conduct internet-based research and revise websites, concluding that students were developing good skills at home. Moreover, they stated that students without access to ICT at home were disadvantaged and that students’ home use of ICT and their home-developed skills were often ignored by schools.

School access to ICT and ICT literacy

Lattimore (1999) argued that in order for students to become proficient in using technology, they needed more access time than a few minutes a week. Many studies claim that students get only one lesson a week to use computers and that this is insufficient for their skill development. Lynch (1999, p.7) reported that “scarcity of equipment is the most obvious contributor to difficulties gaining [whole class] access to technology”, and emphasised the importance of individual student access.

Fuchs and Wößmann's (2005) investigation into computers and student learning using multivariate evidence on the availability and use of computers at home and at school concluded that having a computer at home and using it at school would improve some computer skills, but possibly at the expense of other skills. The importance of computer access at school was further stressed by the OECD:

> This tendency for more students to have computers available at school than at home is especially important in countries with comparatively low levels of access to computers at home, for which the availability of a computer at school may help to compensate. (OECD, 2006, p.21)

In Australia, nearly all students participating in the PISA 2003 study reported that they had access to computers in school, and over 95 per cent reported having access to a computer at home (OECD, 2006). In addition, a high level of confidence in using computers reflected this high level of access. Of the OECD countries, students in Australia were the most confident in performing routine tasks such as opening files or playing computer game, and were only slightly less confident moving or copying files on a computer (OECD, 2006).

Attitudes towards computers

Several research studies have reported that students like computers and are positively motivated to use them (Christensen, 1998; Dix, 1999; Shade, 1994). There is also clear evidence in the literature that suggests increased exposure to ICT positively influences students' attitudes towards computer (Levine and Donitsa-Schmidt, 1998; Meredyth, 1999).

In a meta-analysis using 106 research studies examining gender differences on attitudes toward computers, Liao (1999) concluded that female students were more likely to hold lower attitudes toward computers. The PISA 2003 study posed the question "To what extent can students' gender be used to predict their attitudes to computers, compared to other factors such as the availability of computers at home, how frequently students use computers or whether students have taught themselves to use computers?" (OECD, 2006, p.43). It found that while students' attitudes to computers were associated with their gender to some extent, their attitudes were mainly determined by other factors. In Australia, the strongest factor was whether students taught themselves to use computers.

A computer attitude scale for secondary students was developed by Jones and Clarke (1994). They posited that "For many students, particularly for girls, attitudes towards computers are a primary predictor of choices to engage in computing activities and of achievement in these activities" (Jones and Clarke, 1994, p.315). A comprehensive measure of attitudes towards computers was achieved, they argued, by formulating the scale within a tripartite framework of attitudes, identifying the affective, behavioural, and cognitive aspects (Jones and Clarke, 1994).

Galbraith and Haines (1998) developed a computer attitude scale that considered computer confidence and computer motivation. Students who demonstrated high computer confidence felt self assured in operating computers, believed they could master computer procedures, were more sure of their answers when supported by a computer, and were confident in correcting mistakes made on a computer. Those students who demonstrated low computer confidence felt disadvantaged when using a computer, nervous about learning new computer procedures, did not trust computers, and panicked when errors occurred. High computer motivation was demonstrated in students who found learning more enjoyable, liked the freedom to experiment, and enjoyed using and exploring the computer. In contrast, low computer motivation was demonstrated by students who avoided using computers, felt their freedom was eroded by program constraints, believed that computers made them mentally lazy, and did not understand others' interest in computers.

In a study where ICT use was integrated and practised in classroom settings, Johnson-Gentile et al. (2000) measured students' self-perceptions of their ICT skills development. The results showed "remarkable gains in confidence using the instructional skills" (Johnson-Gentile et al., 2000, p.105). A previous study, by Levine and Donitsa-Schmidt (1998), linked measures of computer experience, computer-related attitudes, computer-related confidence, and perceived computer-based knowledge, and confirmed that beliefs lead to attitudes, and that attitudes were an important precursor to behaviour. Their causal model suggests, "computer use has a positive effect on perceived computer self-confidence, as well as on computer-related attitudes" (Levine and Donitsa-Schmidt, 1998, p.125). This is further supported by a review of the literature which generally concurs that students learn more quickly and with greater retention when learning with the aid of computers, particularly low achieving and at-risk students (Noeth and Volkov, 2004).

Attitudes towards school

A number of studies claim to show improvements in students' attitudes towards learning and school due to the use of ICT (Belanger, 2000; Christensen, 1998; Coley, 1997; Fisher and Stolarchuk, 1998; Kulik, 1994; Moundridou and Virvou, 2002). In particular, younger students seem to develop more positive attitudes towards learning as a result of using ICT (Dix, 2005; Volman and van Eck, 1997). The vast majority of studies reviewed by Fouts (2000) reached positive conclusions about the efficacy of the use of computers, generally agreeing that "Students like learning with computers and their attitudes toward learning and school are positively affected by computer use" (Fouts, 2000, p.8). In an extensive summary of research and evaluation findings on technology in education, Cradler (1994, p.1) reported that ICT was found to improve student "attitude and confidence – especially for "at risk" students". Moran et al. (1999) reported similar outcomes in their review of literature, stating that:

- Technology can have positive effects on student attitudes towards learning and on student self-concept
- ICTs in the classroom can help level the playing field for students of different socio-economic background and reduce the divide between information 'haves' and 'have nots' (Moran et al. (1999, p.10)

However, Cavanagh et al. (2004) tested these assertions by examining student attitudes towards school, which focused on improving schoolwork and increasing engagement in learning, and argued that the use of computers for motivational purposes may be an ineffective classroom incentive or reward. Christensen (1998) concluded that declines in attitudes towards computers as students grow older are not necessarily due to the so-called 'novelty effect' towards computers, but rather are a part of a larger decline in attitude towards learning in school.

Self-esteem

Self-esteem is a widely applied concept in social research that refers to an individual's sense of value or worth and is assumed, under normal circumstances, to be stable across time. According to Coopersmith (1967), self-esteem, which involves an attitude of approval or disapproval:

> indicates the extent to which the individual believes himself to be capable, significant, successful, and worth. In short, self-esteem is a personal judgment

> of worthiness that is expressed in the attitudes the individual holds toward himself. (Coopersmith, 1967, pp.4-5)

Blascovich and Tomaka (1991) go further and describe self-esteem as the evaluative component of self-concept, a broader representation of the self that includes cognitive and behavioural aspects as well as evaluative or affective ones.

Many studies have established a strong link between students' beliefs about themselves and their success as learners (Beresford, 2000; Marsh, 1986; Meece and Miller, 1996; OECD, 1994; Pajares and Schunk, 2001). Research suggests that autonomous learners form views about their own competences and learning characteristics, and these views influence their judgment of the difficulty of a task and their ability to accomplish it. These views have been shown to have considerable impact on goal setting, strategies used, and academic performance. Bandura (1986, p.410) notes that self-esteem is partly determined by "how well one's behaviour matches personal standards of worthiness". In support of Bandura, further evidence is reported by the PISA 2003 study:

> Students' academic self-concept is both an important outcome of education and a powerful predictor of student success. Belief in one's own abilities is highly relevant to successful learning (Marsh, 1986). It can also affect other factors such as well-being and personality development, factors that are especially important for students from less advantaged backgrounds. (OECD, 1994, p.132)

Pajares and Schunk (2001, p.24) note that "assessing students' self-beliefs can provide schools with important insights about their pupils' academic motivation, behavior, and future choices". Moreover, unrealistically low self-esteem, and not lack of capacity, can lead to a lack of confidence and contribute towards maladaptive academic behaviours and diminishing school interest and achievement. They go further:

> Given the generally lower confidence of most girls related to boys in the areas of mathematics and computer technology, it seems that young women may be especially vulnerable in these areas. (Pajares and Schunk, 2001, p.25)

Although there is a wealth of research reporting the relationship between self-esteem and learning, how computers impact on students' self-esteem as learners is not as widely reported in the literature. In their review of research, Cuttance and Stokes (2000, p.11) reported that "effective ICT-based learning environments can have an impact on a range of non-cognitive learning outcomes, including … affective development, such as self-esteem, motivation and a sense of purpose". In the same year, researchers commissioned by the Software and Information Industry Association (SIIA) examined 311 research reviews and reports from published and unpublished sources. The authors concluded that technology has a positive effect on student attitudes toward learning, self-confidence, and self-esteem (Sivin-Kachala and Bialo, 2000).

However, although much of the research claims benefits for the use of ICT, some studies are less optimistic. Concerns about the effects of student computer use on their social development were voiced by teachers in Lynch's (1999) study, particularly when the access was unmonitored. Beresford (2000) noted that where students were less clear about how they learnt, they were more inclined to highlight personal shortcomings for their lack of success, which could impact upon both their motivation and their self-esteem as learners. Placing students in a new learning situation that used unfamiliar ICT might cause them to question how they learn.

Summary

This chapter presents a synthesis of previous research into the adoption of ICT in education by considering three major aspects. The first section discusses trends in educational technology and its integration, concluding that now, more than ever before, the potential for ICT to affect positive change is possible with the shift from teacher-centred to learner-focused classrooms. In the second section, aspects of teaching practice and ICT are considered by examining the influences on teaching practice of teacher characteristics, ICT access, institutional support, confidence using ICT, and beliefs about student learning in an ICT-rich environment. The third section addresses students, their attitudes and ICT. Similar in structure to the previous section, it considers students' antecedent characteristics, ICT access including use both inside and outside of school, students' skills and confidence in using ICT, students' attitudes towards computers and towards school, and self-esteem.

Conducting such a review of the literature provides a basis for the research and supports the development of the theoretical paradigm underpinning this study, discussed in the next chapter.

3

A Research Paradigm

The concerns of educational leaders and researchers that educational research is often divorced from the problems and issues of everyday teaching practice, resulting in “unusable knowledge” (Lagemann, 2002, p.1), is strongly influenced by the chosen paradigm in which the research is framed (Bauder et al., 1997). The United Kingdom’s leading agency for ICT research in education raised this issue:

> A common framework should be developed for evaluating ICT in schools which incorporates a core set of measures, which can serve the needs of schools themselves as well as policy-makers and researchers. (Becta, 2003b, p.2)

In order to produce professional knowledge that can be applied in practice, Haertel and Means (2004) called for a) research that addresses the questions that educational leaders and teachers care about, b) integration of local understanding driven by researcher-policymaker partnerships with disciplinary knowledge, and c) the use of research findings to inform and transform practice. In response to the concern to produce usable findings, this study was born out of the collaborative partnership between researchers and policymakers focused around inquiry that is of interest to educational leaders and teachers with the intention of informing practice. Moreover, the study needs to be framed in an appropriate paradigm that furthers the understanding of how and why an innovation works within and across settings over time (Bauder et al., 1997; Brown and Campione, 1996; Terashima et al., 2003). The challenge faced in this study, therefore, is to develop a theory-driven design to accommodate complex interventions that can be informed and improved through empirical study.

The recent emergence of an important research method, called design-based research (Design-Based Research Collective, 2003), meets the challenges of this study and is one focus of discussion in this chapter. Within a design-based research framework, this chapter also reviews theories into factors that influence educational innovation and their impact, in order to develop hypothesised school, teacher and student models of influence that will inform the development of more complex causal models (Keeves, 1988; Noonan and Wold, 1988; Raudenbush and Bryk, 1994; 2002; Sellin and Keeves, 1997).

Design-Based Research

The premise of design-based research, to promote, sustain and understand innovation in the world, particularly in an educational context, has maintained a close synergy with the development and adoption of ICT in educational practice. Design-experimentation has become, over the past decade, an increasingly accepted mode of scholarly inquiry appropriate for the theoretical and empirical study of change in everyday educational settings brought about by complex educational interventions (Bell, 2004; Cobb et al., 2003). In particular, Bell (2004) states:

> Scholars came to engage in design-based research in order to better understand how to orchestrate innovative learning experiences among children in their everyday educational contexts as well as to simultaneously develop new theoretical insights about the nature of learning. (Bell, 2004, p.244)

Design-based research brings together research on educational practice and its effects by employing the scientific processes of discovery, exploration, confirmation and dissemination (Kelly, 2003). This interconnection of research and practice complements the fundamentally interventionist nature of education and provides practical and theoretical progress in the field by conducting empirical research in naturalistic settings. Cobb et al. (2003) suggest:

> Design experiments ideally result in greater understanding of a *learning ecology*—a complex, interacting system involving multiple elements of different types and levels—by designing its elements and by anticipating how these elements function together to support learning. Design experiments therefore constitute a means of addressing the complexity that is a hallmark of educational settings. (Cobb et al., 2003, p.9)

The importance that context and local interpretation plays in successful adoption of ICT becomes salient when examining cases in which teachers develop different strategies to achieve similar learning outcomes. Just as there are many guiding principles when it comes to effective teaching and learning, there is no single right approach when it comes to embedding ICT into the curriculum successfully. The differences brought about by school, teacher, and student characteristics result in many models of successful implementation that yield positive outcomes. The very nature of this study, by not externally imposing a set of instructional methods of embedding ICT into teaching practice, is underpinned by this philosophy and reflective of design-based research.

In order to explain the context and conditions associated with change in educational practice, design-based research should exhibit the following five characteristics (DBRC, 2003).

1. The design of learning environments and learning experiences are intertwined with theories of learning.
2. Development and research take place through a continuous cycle of design, enactment, evaluation and redesign.
3. Research on design leads to sharable knowledge and practice that can be communicated to practitioners and other designers.
4. Research must account for how and why designs work in authentic settings.
5. Accounts of research must describe and connect processes of enactment with outcomes of interest.

However, because of these characteristics, there are a number of challenges faced by design-based research, centred around the issue of credibility and arising from unscientific research approaches in educational research (NRC, 2002), and the detachment of research from practice (Lagemann, 2002). Providing further clarification, Robinson (1998) argues that educational research is detached from practice when it does not account for the influence of contexts, the emergent and complex nature of outcomes, and the lack of understanding about which factors are relevant for prediction. In order to promote credibility and generalisability, the effective use of ICT in learning requires that the effects of ICT need to be studied across a number of contexts over time (DBRC, 2003). Furthermore, the research design needs to view educational innovation holistically. The design process is enacted as a product of the context in which the innovation is adopted and emergent as one of the outcomes. By doing so, the disparity between well-designed research and that of unscientific detached research that is unable to claim credibly success or failure of an innovation in context is lessened.

Typically, design-based research relies on techniques used in other research paradigms in order to maintain objectivity, reliability and validity. Triangulation of multiple sources of data to connect intended and unintended outcomes to the innovative practice is commonly employed. When data are collected using standardised instruments repeated on a number of occasions, validity can be tested. Since it is not logistically possible to pursue all possible factors equally that may contribute to the outcomes, particularly in complex longitudinal studies such as this that span multiple settings over a number of years, the reliability of findings depends on the triangulation of data and repeated use of standardised instruments (DBRC, 2003).

A further logistical problem in design-based research results from the need to maintain a productive collaborative partnership between researcher and participants over a long period of time (Cobb et al., 2003). This study is no exception. In maintaining these relationships, by the negotiation of a shared enterprise, regular opportunities for debriefing and further planning are necessary. Moreover, because a single line of research investigates multiple cycles of design, enactment and research, the study often spans years and potentially challenges teachers' and researchers' closely held beliefs. Successful examples of design-based research (for example, Linn and Hsi, 2000) minimise the potential tension between researcher and teacher to sustain a cooperative partnership. This tension is best summarised by the Design-Based Research Collective:

> The challenge for design-based research is in flexibly developing research trajectories that meet our dual goals of refining locally valuable innovations and developing more globally usable knowledge for the field. (Design-Based Research Collective, 2003, p.7)

Furthermore, the success of design-based research should be measured by its ability to inform and improve educational practice. Its choice as a paradigm for this study, lies in its potential to explore novel learning and teaching environments that support and promote the adoption of ICT in real settings, and to increase human capacity for innovation through the exchange of ideas and expertise across academic and educational communities.

Towards a Research Framework for ICT Adoption

In developing a research framework for this study that positions design research as a socially constructed, contextualised process resulting in educationally effective outcomes that can inform teaching practice, a review of existing theoretical models on the teaching and learning process and emerging frameworks used in design-based research was conducted. However, during the review process, it was evident that the terms 'framework' and 'model' were generally not defined and were often used interchangeably, resulting in a need for clarification.

Frameworks and models

Dictionaries generally define a framework as a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality. Smyth (2004) reflected on the purpose of a framework as a:

> … research tool intended to assist a researcher to develop awareness and understanding of the situation under scrutiny and to communicate this. As with all investigation in the social world, the framework itself forms part of the agenda for negotiation to be scrutinised and tested, reviewed and reformed as a result of investigation. (Smyth, 2004, p.168)

For the purposes of this study, a framework provides a fundamental structure and a practical instrument that enables a researcher to think through ways of doing things. Frameworks are commonly presented as structured tables with clearly defined interrelated concepts. However, frameworks are also portrayed in diagrammatic form and are often referred to as models.

Keeves (1997, p.386) defines a model as a hypothetical structure, which "is used in the investigation of interrelations between the elements". In investigating such interrelations, a set of hypotheses, "developed from intuition, from earlier studies, and from theoretical considerations" are proposed, tested and confirmed or rejected (Keeves, 1997, p.386).

A distinction can then be drawn between a framework, as a general structure that provides an overarching set of concepts and processes, and a model, as a specific structure of interrelated factors hypothesised to be tested. Indeed, a framework may include or reflect a model, or guide the development of a model or number of models. Such a distinction is necessary, particularly with the emergence of design-based research, where interrelated processes are represented alongside concepts and factors.

A review of educational research frameworks and models

Of the many models reviewed (for example, Jones and Paolucci, 1998), those of Carroll (1963), Biggs (1989), and Huitt (1993), in addition to the frameworks of Orrill (2001), Keeves (2003), Bannan-Ritland (2003) and Sandoval's (2004), are considered pertinent to the development of the framework and subsequent models used in this study.

Carroll introduced a model of school learning in 1963 that still has currency in educational research, some four decades later. The original model, presented in Figure 3.1, is formal and quasi-mathematical in design (Reeves, 1997). Carroll's (1963) model explains variance in school achievement through three time-related variables, namely aptitude, opportunity to learn and perseverance, and two classes of variables that focus on a student's ability to understand instruction and the quality of instructional events.

Biggs (1989) proposed the 3-P model, which posits presage, process and product as the main features of a learning system. Figure 3.2 presents the 3-P model and the paths of influence. The overarching assumption is that learning outcomes are a result of the interactions of teaching and learning contexts with student approaches to learning. Presage, what comes before the learning situation, involves student learning characteristics and teacher characteristics, which are embedded in the context of the learning environment, set by teacher and school. Both student and teaching presage factors interact to produce an approach to learning that produces characteristic outcomes. In the process phase, what happens in the learning situation, particular approaches to learning result in either deep or surface learning (Entwistle and Ramsden, 1983). Accordingly, processes used in learning are not simply a fixed attribute of the learner, but a function of both learner characteristics and teaching factors. The product phase of the 3-P model, the outcome of learning, suggests that study approaches influence qualitative differences in learning outcomes. Deep approaches to learning produce high quality learning outcomes, while surface approaches result in lower quality outcomes.

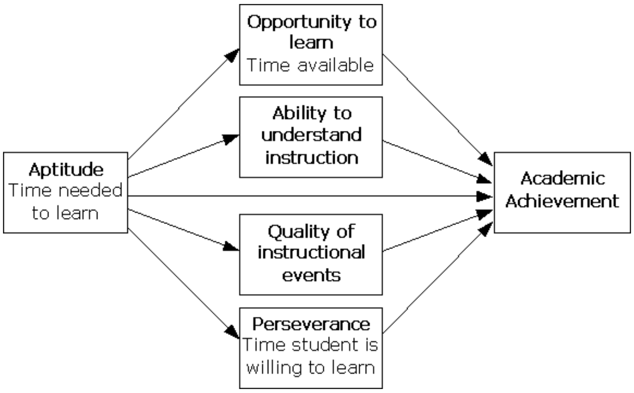


Figure 3.1 Carroll's (1963) model of school learning to explain school achievement

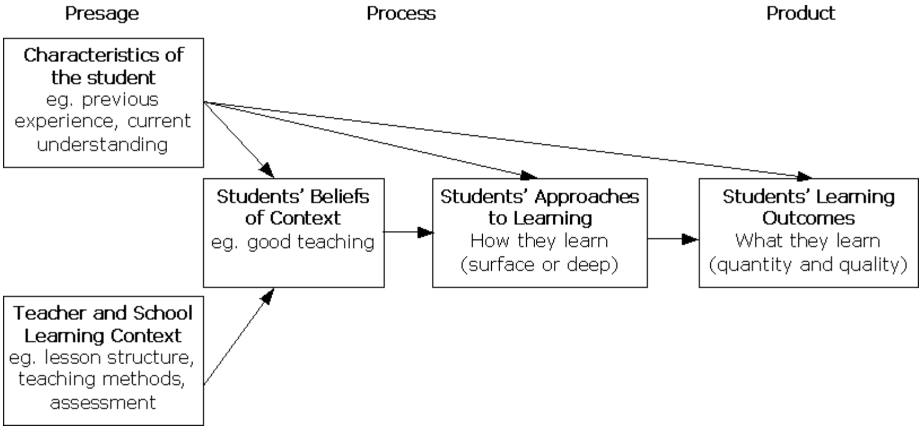


Figure 3.2 Biggs' (1989) 3-P model of the learning process consisting of presage, process, and product features

A useful review of models (including Carroll, 1963; Proctor, 1984; Cruickshank, 1985; Gage and Berliner, 1992) on the teaching and learning process, culminated in the development of Huitt's (1993) transactional model of the teaching and learning process, shown in Figure 3.3 as reported in McIlrath and Huitt (1995). The transactional model was developed to categorise factors that influence variance in student learning and academic achievement in the context of classroom and school. According to the model, the factors are classified under four categories: context, input, classroom processes and output. Context includes all those factors outside the classroom that might influence teaching and learning. Input is defined as those qualities or characteristics of teachers and students that they bring with them to the classroom experience. Classroom processes examine what is going on in the classroom and involves teacher and student behaviours as well as other variables such as classroom climate and interpersonal relationships. The last category, output, measures student learning separate from the classroom learning process (Huitt, 1993).

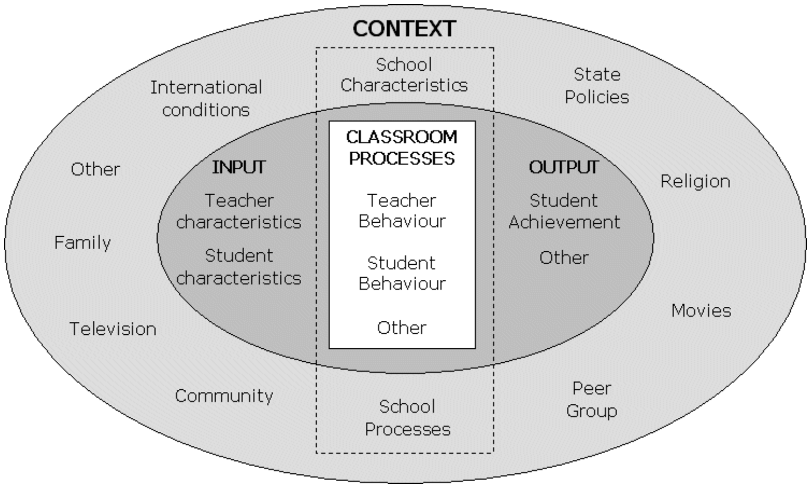


Figure 3.3 The transactional model of the teaching and learning process (McIlrath and Huitt, 1995)

Orrill's (2001) professional development framework centres around a context-based three-way interaction between the processes of enactment, reflection and goal setting. The objective of the framework was to support middle-school teachers to become more learner centred when implementing computer-based instruction in their classrooms, and was grounded in the belief that "change is individual and needs to be supported in context and over time" (Orrill, 2001, p.15). The five key aspects of the framework, presented in Figure 3.4, include reflection, proximal goals, collegial support groups, one-to-one feedback, and support materials for the teacher.

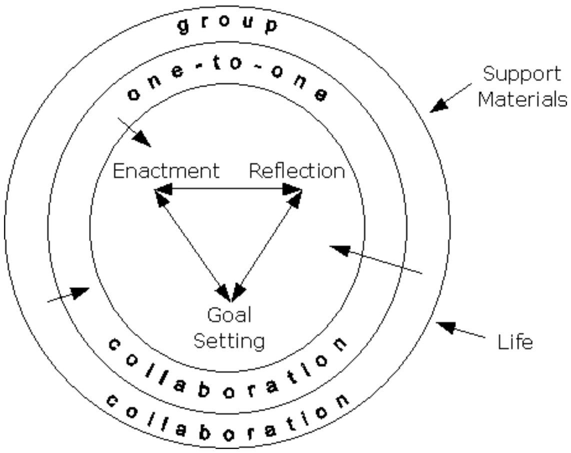


Figure 3.4 The Professional Development Framework (Orrill, 2001)

Applying the ideas presented by Cobb et al. (2003) and the Design-Based Research Collective (2003) to extend the work of Turner's (1991) analysis of Giddens' (1984) theory of structuration, Keeves (2003) developed a design-based research framework, presented in Figure 3.5. The framework consists of inter-linked but discrete concepts that proceed through five phases of design. Reading the diagram from right to left, the phases move through an exploratory mode of operation with structural freedom, to a confirmatory mode with imposed structure reflecting good design.

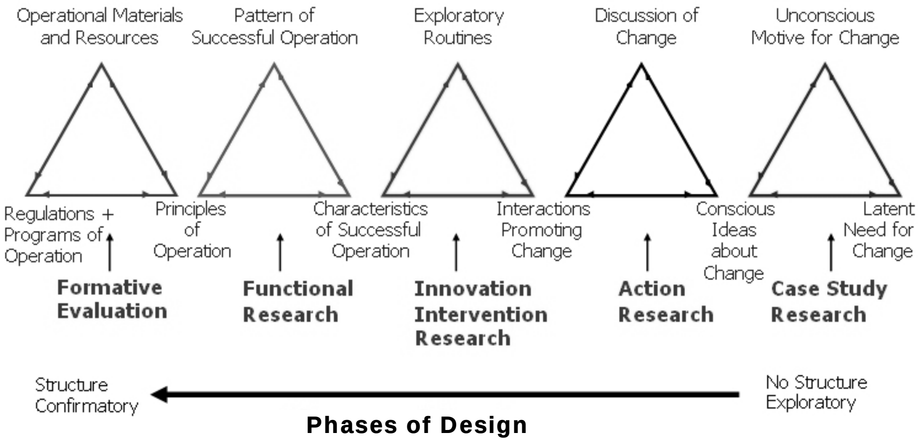


Figure 3.5 Design-based research phases of design (Keeves, 2003)

During the case study phase, in Keeves' (2003) framework, the researcher examines the unapparent needs for change and helps to make conscious the underlying reasons and motivations for the desired change by identifying and specifying the nature and the purpose of the innovation. The action research phase collects evidence that will further assist in identifying the appropriate processes of change by promoting discourse about planning and designing the change. During the intervention research phase, the researcher and practitioners explore the different possible modes of change and seek to identify and introduce successful types of change. At this stage, the intervention is designed and detailed, and the nature of implementation is planned. The functional research phase examines the operation of change and relates the context and conditions of enactment to the outcomes achieved. In the final stage, the formative evaluation phase, iterative cycles of innovation and intervention allow the researcher to examine how and why the changes introduced succeed or fail to deliver the desired outcomes. Informed decisions guide modification of the subsequent cycle in ways that leads to better design.

Bannan-Ritland (2003) proposed the integrative learning design framework. This model emphasises the stage of sensitivity of a) research questions, b) data and methods, and c) the need for researchers to conduct analyses at earlier stages in the research that can then be profitably used to inform later stages. The framework draws from product design (Ulrich and Eppinger, 2000), usage-centered design (Constantine and Lockwood, 1999), instructional research (Dick and Carey, 1990), and diffusion of innovation (Rogers, 1995), in addition to established educational research methods (Isaac and Michael, 1990; Keeves, 1988b). The integrative learning design framework consists of four broad phases: a) informed exploration, b) enactment, c) evaluation – local impact, and d) evaluation – broader impact. The first phase provides the foundations of the research by undertaking the fundamental processes of problem identification, literature review and development of research questions, supplemented by the identification of contextual factors through needs analysis and stakeholder perceptions. These activities are informed by the views of the researcher, school leaders and teachers, but also by school and classroom observation. Based on these findings, appropriate methods of intervention emerge. The enactment phase is an iterative process, where the intervention is conducted, reviewed and refined, and may involve multiple cycles of design. At the evaluation phase, the local impact is assessed through data collection and analysis using an iterative process of formative and summative evaluation, and may well necessitate revisiting the enactment phase. The final phase, that of evaluation on a broader scale, extends the dissemination stage of educational research, which typically sees publication of findings as an end-point, by promoting ongoing research practices and interventions.

In Sandoval's (2004) framework of design-based research, presented in Figure 3.6, learning theory is developed through an iterative process of refining conjectures embodied in educational designs. Theoretical principles or conjectures are embodied in tools and materials, and structures of tasks and participants. These predictors of intermediate outcomes, which are embedded in the learning context, inform and modify the theory and the nature of the intervention in a micro-cyclical process. The refined intervention then leads to the prediction of outcomes, which might, for example, examine the effects on learning motivation. These outcomes, in turn, re-inform the original conjectures and the intervention in a macro-cyclical process.

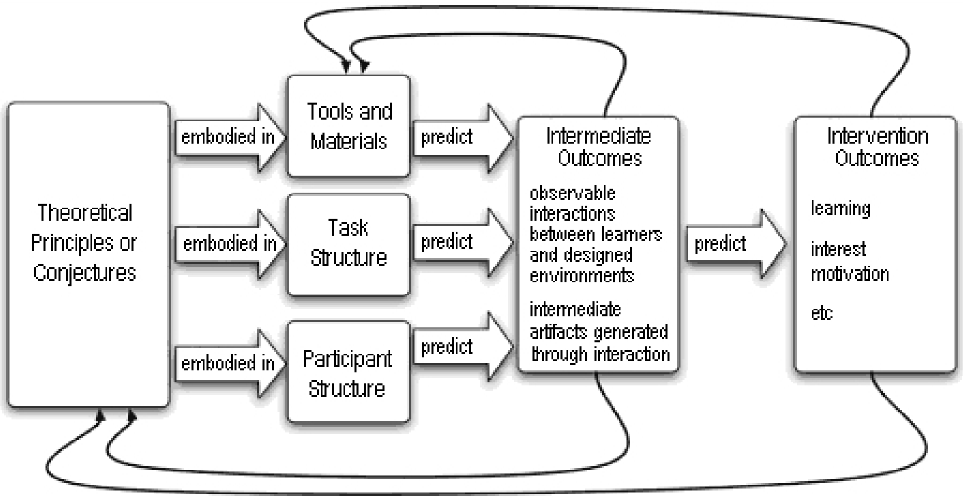


Figure 3.6 Design-based research embodied conjectures of learning (Sandoval, 2004)

In undertaking a review of educational research frameworks and models, similarities and differences emerge. The similarities exist because the frameworks and models have been born out of the same field of research, that of the educational sciences. The differences exist because each framework or model considers a particular aspect or has been designed to serve a specific purpose. They can be considered as part of a greater whole, or rather, the pieces of jigsaw puzzle, where the different pieces interlock at similar edges. It follows then that any new aspect of educational research potentially requires the development of a new framework or model, another piece of the puzzle.

This study is no different to other studies in finding that previous frameworks or models, while informative, are insufficiently able to embody the unique features, and drives the development of a new educational research framework. Rather than just develop another piece of the puzzle however, the question begs, are there enough pieces to anticipate the greater picture and develop a framework with general application? This researcher contends that there are enough pieces, and through the synthesis of previous frameworks and models, presents the resulting 'picture' of educational research in the following section.

DBRIEF: Design-Based Research in Innovative Education Framework

In order to provide a theoretical foundation to guide the development of this study, in addition to encapsulating the major features of the research design, a general framework was developed. Influenced by previously developed educational research models and frameworks, detailed in the previous section and touched on in Chapter 2, the resulting framework builds upon the emerging field of design-based research but remains firmly grounded in existing theory about the factors that influence teaching and learning in an innovative environment. This section presents the new framework developed for this study and details its features.

The Design-Based Research in Innovative Education Framework (DBRIEF) is presented in Figure 3.7, and combines influential elements from previous research in the field of education (Carroll, 1963; Biggs, 1989; Huitt, 1993; Orrill, 2001; Keeves, 2003; Bannan-Ritland, 2003; Sandoval, 2004). For example, the stages of presage, process, and product are attributable to Biggs (1989), while the concept of moving from unstructured exploratory analysis through to structured confirmatory analysis originates from Keeves (1993). In fact each feature, discussed in detail further below, can, in one form or another, be attributed to a previous model or framework, but it is their presentation as an integrated whole, that offers new worth.

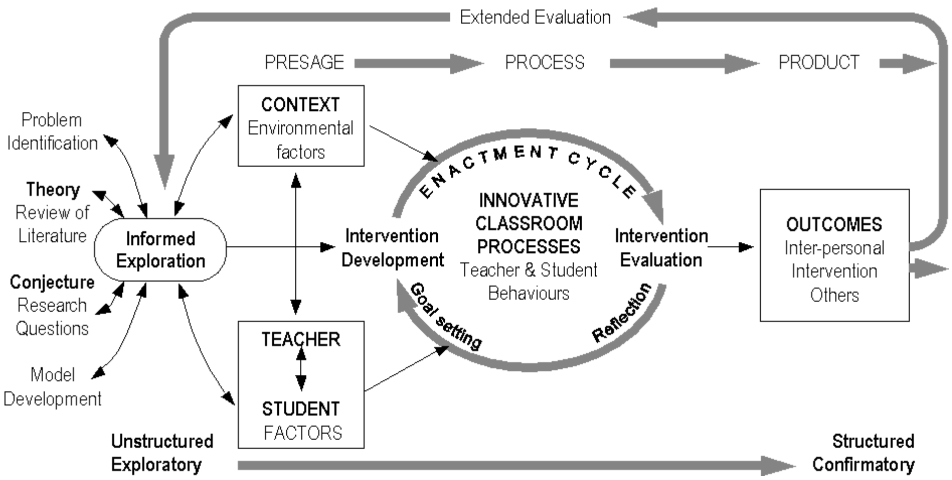


Figure 3.7 The *Design-Based Research in Innovative Education Framework* (DBRIEF) developed for this study

More importantly, DBRIEF attempts to provide a visual representation of a research paradigm that embodies what is currently considered good research design. Gage and Berliner (1992) argue that diagrammatic models make the process of understanding a domain of knowledge easier because it is a visual expression of the content. They found that students who studied models recalled as much as 57 per cent more conceptual information than students who received instruction without the benefit of seeing and discussing models. In accordance with Gage and Berliner's (1992) findings, the presentation of DBRIEF in diagrammatic form is chosen in order to, as the acronym implies, share knowledge.

DBRIEF proceeds through five main phases: a) informed exploration, b) presage, c) process, d) product, and e) extended evaluation. The elegance and power of DBRIEF is realised when an entire study, such as this, can be mapped upon its main features.

Informed Exploration. Most educational research studies follow a standard format. Figuratively speaking, they begin in an unstructured exploratory mode by identifying the problem, usually presented in the first chapter, followed in the next by a review of related literature. In the following chapter, conjecture, informed by contextual factors derived from school and classroom observation, and stakeholder perceptions, leads to the development of research questions and model hypothesis (Bannan-Ritland, 2003; Keeves, 2003; Sandoval, 2004). All of this activity, conducted as an intuitive and iterative process and represented in Figure 3.7 by curved two-way arrows, is conceptualised under the banner of 'informed exploration'.

Presage. Reflecting Carroll's (1963), Bigg's (1989), and Huitt's (1993) models of the learning environment, the interrelationship between the presage factors of context, teacher and student are presented in a causal model defined by straight arrows or paths of influence. From these basic components, combined with process and product factors, detailed models are hypothesised for subsequent testing, and by doing so, more structure is imposed. Chapters containing rich descriptions of context and participants are presented along with discussion about data collection methods and instruments used.

Process. At the heart of DBRIEF is the 'enactment cycle', where innovative programs of classroom intervention, such as the adoption of ICT in learning, are developed and evaluated in an iterative process of micro-cycles. Contextual factors along with teacher and student behaviours are measured to provide intermediate outcomes that support reflection and further development of proximal goals, and refinement of the intervention (Orrill, 2001). The complexity of studying such activity is best represented by Keeves' (2003) framework of educational change through the use of multiple research strategies. Such a framework is too complex to embed in DBRIEF but does provide an example of one of many suitable methodological approaches. Related chapters would contain observation, descriptions of interventions and intermediate outcomes generated through interaction and data collection.

Product. During the product phase of research, quantitative longitudinal data are rigorously analysed and hypothesised models, informed by qualitative data, are tested. By this stage, analysis takes a highly structured form and is confirmatory in nature. Other outcomes, such as intervention programs and implications, are prepared for dissemination and evaluation to the broader educational research community. But rather than viewing the publication of findings as the end-point of the research, a final macro-cycle phase is necessary and fundamental to the design-based research method.

Extended Evaluation. Similar to those models of Bannan-Ritland (2003) and Sandoval (2004), this final stage is designed to promote ongoing research and development of further theory and interventions. Accordingly, the outcomes, findings and implications feed back into and re-inform the original theory and conjectures with the underlying premise that change is sustainable and that innovation in classroom practice should be ever evolving. With this outlook, long-term relationships between practitioners and researchers better ensures that educational research does inform teaching practice.

Clearly, in developing DBRIEF, it is desirable not only to provide a practical instrument for this study, but also to provide an adaptable instrument with the potential to find applicability, currency, and promote the 'sharing of knowledge' in the wider educational research community. With a research framework to guide this study, now in place, the development and hypothesis of testable models, can proceed.

Conceptualising Models of Change

All models are wrong, but some are useful. (George Box, 1976)

Rowe (1996) states that studying changes in individuals within a changing learning environment poses two main issues. The first issue is one of validity based on information sourced from the researcher as an outsider to the learning environment or from the perceptions of teachers and students as insiders. On theoretical and methodological grounds, data obtained from teachers and students holds greater validity in accurately reflecting change, both in the environment and in the individual. The second issue, epistemological in nature, addresses the need to measure the whole learning environment and the individuals within it as a complex system of interdependent factors. The emphasis is how the learning environment, conceived as a set of relationships among sets of factors, is structured and changes over time. Burnham et al. (2000) discussed the challenge of 'putting the pieces together' and argued that:

> Since technology can not be separated from the other educational pieces, the measure of its impact needs to be multifaceted to ensure a clearer picture of the entire teaching/learning environment. (Burnham et al., 2000, p.2)

As the current study is concerned with understanding changes in teachers and students brought about by the adoption of ICT in the learning environment, the development of models that represent simplified real-world influences on teachers and students in a changing environment are necessary.

Model building in design-based research

According to Sloane and Gorard (2003):

> The purpose of model building is to construct a model that is consistent not only with the data but also with existing knowledge and assumptions about the processes that produces the data. In fact, it may be useful to construct more than one model using a variety of plausible assumptions about the "true" model and about what the future may hold. (Sloane and Gorard, 2003, p.30)

Sloane and Gorard (2003) go on to suggest three main stages in model building, which include, model formulation, estimation or fit, and model validation. The challenge, they say, for any researcher "is to construct or select a model of the appropriate form and complexity" (Sloane and Gorard, 2003, p.29).

In formulating a model, it should: a) provide a parsimonious description of the aspects under investigation, b) provide a basis for comparing multiple sets of data, c) confirm or refute conjectured theoretical relationships, d) account for the properties of residual variation or error, e) provide proximal predictions, and f) provide empirical insight into the underlying relationships. At the estimation stage, statistical modelling techniques are employed. However, despite the sophistication of many statistical computer packages, the formulation of sensible models is still a challenge (Maruyama, 1998). Just because a model appears to fit the data well, does not necessarily result in a sensible and meaningful model. Underlying assumptions need to be checked and the model modified as required. More importantly, in the validation stage, the model should be generalisable to more than one data set. Longitudinal studies, such as in this study, where multiple sets of data are collected over a period of time, overcome the philosophical problems of constructing and validating models using the same data.

A conceptual model for this study

Following the general principles for model formulation described by Sloane and Gorard (2003), an evaluation was conducted of existing theory and qualitative knowledge about factors that influence students and teachers in a changing environment. Of particular interest, were those factors that pertain to student attitudes and teaching practice. It was found that the factors for potential inclusion in the models can be structured under four categories, that of context, presage, process and product, reflecting the work of Carroll (1963), Biggs (1989) and Huitt (1993). Presented as a conceptual causal model in Figure 3.8, the three hypothesised sets of factors are inter-related to each other and to the outcomes.

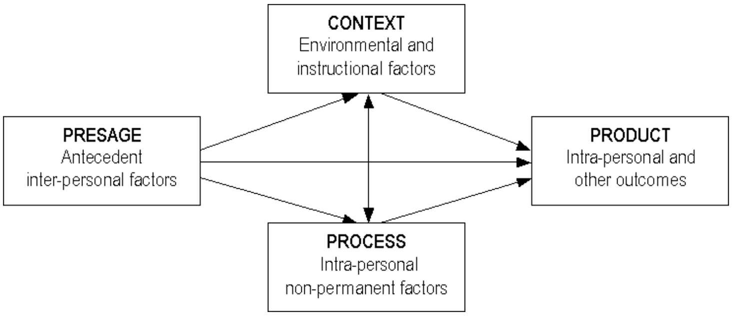


Figure 3.8 Hypothesised conceptual model for investigating interdependant factors in a complex changing learning environment

Presage factors include variables that are antecedent latent factors that are inter-personal characteristics brought to the learning environment. They include personal qualities that are fixed in time, such as gender and language background, in addition to other characteristics, like teaching experience and age, which change with time. The exogenous or antecedent nature of this set of factors means that they are not influenced by any other factor.

Context factors identify those variables that inform properties of the changing learning environment and are typically observed in the type of school setting and the way in which schools structure their lessons, support ICT use in classroom practice and arrange ICT resources. This set of factors also includes the influence of factors external to the school environment, such as home access to computers, use of ICT outside of school, and exposure to other forms of electronic media.

Process factors comprise those variables that reside and change within the individual over time, influenced by the changing learning environment around them. Such factors are attitudinal, motivational, belief based and reflective. This set of factors includes, for example, confidence in using ICT, beliefs about level of ICT literacy, attitudes towards school and computers, and beliefs about teaching and learning with ICT.

Product factors are those outcomes selected as important to the focus of the study. Although design-based research typically focuses on the intervention as the main outcome (Bannan-Ritland, 2003; Cobb et al., 2003), the interests of this study follow the direction taken by others (Rowe, 1996; Sandoval, 2004) and focus on change in the individual, specifically that of student self-esteem and teaching practice, brought about by the intervention process.

The research model hypothesises that an individual’s antecedent characteristics impact on environmental factors such as the school they attend, access to technology, their use of ICT and other influences outside of school. In addition, inter-personal factors might also impact upon an individual's intra-personal beliefs, attitudes and motivations, which might influence and be influenced by, contextual factors. These sets of factors, in turn, might affect intra-personal outcomes, such as student self-esteem and teaching practice, both directly or indirectly through the mediation of context and process factors.

Models Hypothesised for this Study

The simplicity of the conceptual model presented above in Figure 3.8 conceals the true complexity of a learning environment and the characteristics and behaviours of the individuals within it (Rowe, 1996). Since the focus of this study is concerned with understanding changes in teachers and students brought about by a school-wide ICT adoption process (Dooley, 1999), the development of a single model would be too complex to be feasible or testable. Rather, this study conceives the complex nature of change in a learning environment as a set of inter-related systems or layers, separated into student, teacher and school. This section details the development of the three hypothetical models suitable for testing.

Development of a teacher path model

Derived from the conceptual model, shown above in Figure 3.8, and informed from theory and research findings on factors relating to teachers' beliefs about the adoption of ICT in their planning, administrative and teaching duties that influence their teaching practice, a hypothetical teacher path model is developed for this study. The resulting hypothesised teacher-level path model of factors influencing teaching practice is presented in Figure 3.9. A general discussion of the variables broadly described under the categories of presage, context, process and product follows.

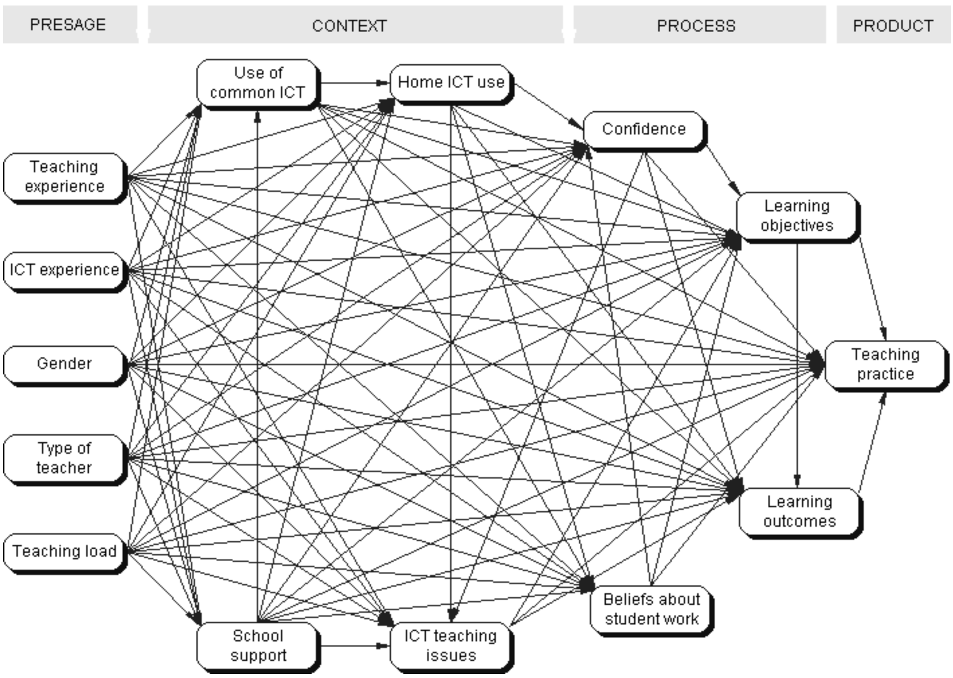


Figure 3.9 Hypothesised teacher-level path model of factors influencing teaching practice

Presage Factors. Antecedent factors considered important in influencing teaching practice and included in the teacher model involve such teacher characteristics as years of teaching experience, ICT teaching experience or specialisation, gender of the teacher, the type of teaching position in terms of permanency, and teaching load. Appropriate questions in the background section of a questionnaire elicits such details. Indicated by the causal path relationships, it is hypothesised that these presage factors influence directly or indirectly all other factors in the teacher model.

Context Factors. Four aspects of the learning environment and teacher behaviour that purport to influence teaching practice are selected for inclusion in the teacher model. These factors include level of school support in implementing ICT-rich practice, school and teaching issues in adopting ICT, teachers' use of common forms and mass-penetration electronic media (like television and CD players), and their access to and use of computers at home. In an increasingly ICT-rich school environment, it is anticipated that these variables provide a broad indication of contextual change.

Process Factors. In order to understand intra-personal aspects of teachers in a school environment undergoing a process of change, four factors are considered to contribute, directly or indirectly, to the influences on teaching practice. Teachers' confidence in using technology is an important variable, in that teachers are placed in a potentially confronting situation where they are expected to move toward ICT-rich teaching practice. It is hypothesised, then, that teachers' levels of ICT confidence influence the types of learning objectives and learning outcomes planned for their students. Another important variable in influencing teaching practice considers aspects of the learning process and teachers' beliefs about how this impacts on the quality of students' work and the effort they give. Again, the measurements of all these variables are suitable for posing as questions in a survey.

Product Factor. The teacher-related outcome considered important in this study as a measure of the adoption of ICT in the curriculum, is that of teaching practice. In order to target broadly the multifaceted aspects of teaching practice, several questions are formulated that address teachers' use of the internet, their choice of software when planning lessons, the types of activities and intended use of ICT, along with direct question on their teaching practice and beliefs about teaching with ICT.

Development of a student path model

Based on the conceptual model (see Figure 3.8 above) and informed from theory and research findings on factors relating to students' beliefs and use of ICT in learning that might influence change in self-esteem, a hypothetical student path model is developed for this study. However, an additional consideration in selecting factors, both in the student model and the teacher model, is influenced by their measurement feasibility. Clearly, if a potential factor is considered difficult to measure, then for reasons of practicality it is not included in the model.

A common data collection method employed by many studies is the self-administered questionnaire. In constructing a questionnaire, the use of self-developed or pre-existing items and tools pertaining to each factor can be formulated or found. A detailed description of the questionnaires developed for this study are presented in the following chapter. Figure 3.10 presents the resulting hypothesised student-level path model of factors influencing self-esteem. A general discussion of the variables included in the model follows.

Presage Factors. The antecedent factors selected for inclusion in the student model are a student's non-English speaking background (NESB), their age, and their gender. Measurement of these factors can readily be gained through several simple questions in the background section of a questionnaire. It is hypothesised that these factors might influence directly or indirectly all other factors in the student model.

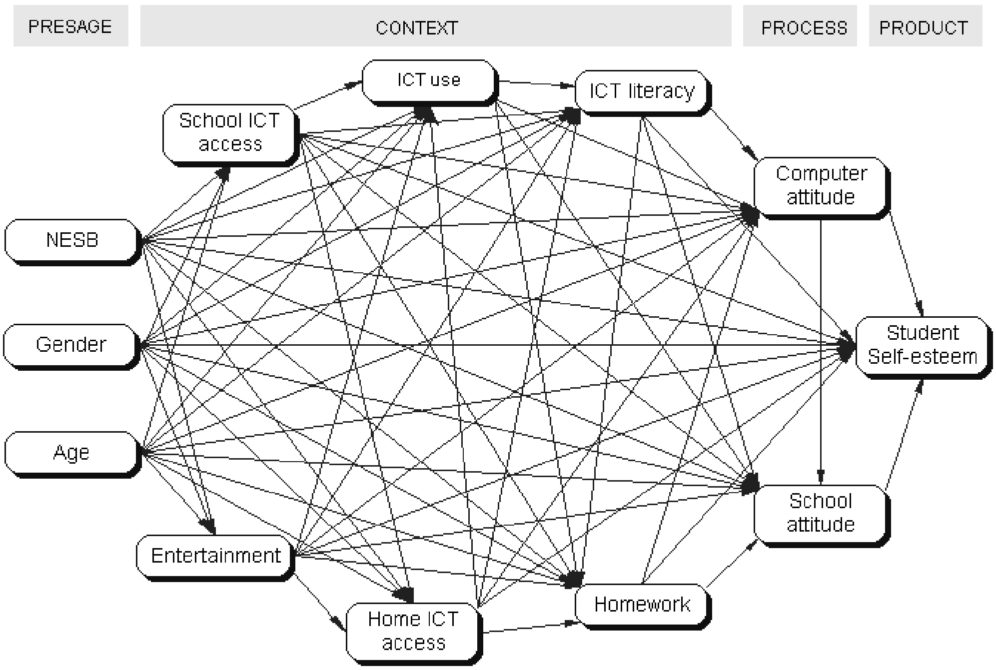


Figure 3.10 Hypothesised student-level path model of factors influencing self-esteem

Context Factors. There are six aspects of the learning environment, be it at school or in the home, that are considered to influence student self-esteem and warrant inclusion in the student model. In an increasingly ICT-rich school environment, an important measure of change is students' access to ICT at school. Although a student to computer ratio would provide one indication of student access, students do not generally know such details about their school and its reliability and validity as a measure of access is therefore questionable. A more accurate measure of ICT access may involve a number of questions that ask students, for example, if their school has enough computers. Possibly influenced by an increase in school ICT access and use, is students' access to computers at home, measured by home ownership. To further understand the home context, two factors, that of ICT use and homework, canvas students' general use of computers at home and for homework purposes. Another context factor, entertainment, considers students' exposure to mass-penetration electronic media like television and radio. The last factor selected as a measure of changing context, is ICT literacy, which investigates students' levels of computer skill, knowledge and enjoyment.

Process Factors. As a measure of the process of deep change within students due to school-wide adoption of ICT in the curriculum, measures of attitudes towards computers and school are selected for this study on the basis that attitude is a relatively stable attribute. The existence of reliable survey tools also make this a feasible undertaking (Jones and Clarke, 1994; Keeves, 1974). It is hypothesised that change in students' attitude towards computers and towards school, affected by contextual factors, influences, directly or indirectly, their self-esteem.

Product Factors. The assessment of learning outcomes in the past has generally referred to scholastic achievement and cognition but has done little to further the understanding of how intervention and change in the learning environment impacts on the affective attributes of a student. This study takes a more holistic approach and argues the need to broaden the concept of learning outcomes to include self-esteem as an important aspect of student development. This aspect alone, is the focus of this study. Moreover, Coopersmith's (1986) *Self-esteem Inventory* supports the longitudinal measure of student self-esteem and is therefore employed for use in this study.

In both cases, the hypothesised teacher and student models, shown in Figure 3.9 and Figure 3.10 respectively, are a partial representation of a full path model, in that only the inner model latent variables and relationships are presented. In order to achieve the aims of this study, full path models, complete with outer model relationships between manifest and latent variables, are developed for testing and analysis, and constitute the focus of Chapter 11.

Development of multi-level school models

The design of this study includes students, measured on three occasions, their teachers, measured once over the three years, and demographic information from the participating schools. The major impetus undertaken in these schools over the three-year period is to embed learning technologies throughout the curriculum. The broad aim of this study, therefore, is to measure the impact of the adoption process on students, and in particular, their self-esteem.

The complex nature of the data provides an opportunity to combine all aspects of the learning environment, derived from quantitative and qualitative data from students, their teachers and the schools, into a single multi-level model. By doing so, the hierarchical structure of the data can be taken into account, in that occasions are nested in students, which are nested in schools. Moreover, the development of a multi-level model allows the testing of across-level influences, so that student, teacher and school factors, detailed in previous sections of this chapter, are not examined in isolation, but tested as a whole inter-related system.

In order to achieve this end, not one but two, three-level models, are proposed for testing in this study. Both hypothesised models place student self-esteem as the outcome but each model differs in its approach. The first model examines change in students over time by nesting occasions within students within schools. The second model examines change in schools over time by nesting students within occasions within schools. Figure 3.11 presents the hypothesised three-level student and school models.

Change in students over time. In the student model, the occasion level (Level 1 or micro-level) contains within-student variables that change over the three occasions. The student level (Level 2 or meso-level) contains static between-student variables, which include among others, the within-student variables aggregated to the student. The school level (Level 3 or macro-level) contains school variables, which include among others, between-student variables and between-teacher variables aggregated to the school.

Change in schools over time. In the school model, the student level (Level 1 or micro-level) is the same as in the student model, except that it is sorted so that the student is nested within the occasion. The occasion level (Level 2 or meso-level) also changes over time and contains the within-student variables aggregated to the occasion. Effectively, this gives a measure of the school as it changes over time. The school level (Level 3 or macro-level) contains the static school variables, which include among others, between-teacher variables aggregated to the school.

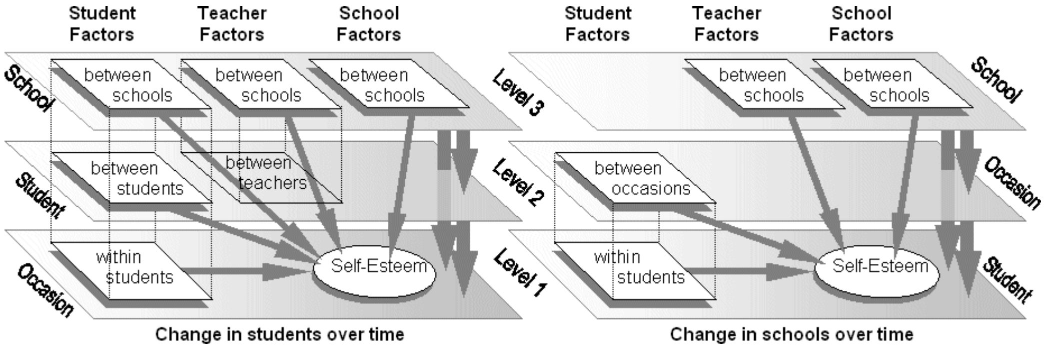


Figure 3.11 Hypothesised three-level student and school models

It is hypothesised that in both the student and teacher models all factors at each of the three levels have a direct influence on the criterion variable, namely student self-esteem. In addition, there may also be indirect influences due to across-level interactions of higher-level variables with lower-level variables. Testing of the student and school three-level models requires the use of hierarchical linear modelling (HLM) procedures, the details of which are presented in Chapter 12.

Given the complexity of the three-level school models and the student and teacher path models, testing needs to be guided through the investigation of clearly defined statements of hypothesis. The following section addresses the propositions or hypotheses to be tested for this study.

Research Questions: Propositions to be Tested

Previous research examining the uptake of ICT in teaching and learning and its effects on student and teacher beliefs and attitudes are reviewed in Chapter 2. These studies indicate that there are a variety of factors that influence the effects of technology adoption on teachers and students, and in particular teaching practice and student self-esteem. The conceptual models proposed in the previous section suggest that in each model, factors are hypothesised to have direct influences on the criterion variable. In the teacher path model (see Figure 3.9 above), the criterion variable is teaching practice. In the student path model (see Figure 3.10 above) and the three-level school models (see Figure 3.11 above), this variable is student self-esteem. It is further hypothesised that in each model, there exists either a direct or indirect, or both direct and indirect relationship between factors. Accordingly, the models proposed in this study need to be tested.

Therefore, the major issues to be addressed in this study are the investigation of factors influencing teaching practice and change in student self-esteem due to a school-wide ICT adoption process. Conceptualised as a set of testable propositional statements and framed in the research paradigm underpinning this study, the propositions under investigation are sensitive to a) the aims of the study and the broad research questions posed in Chapter 1, b) concerns arising from the findings of previous research presented in Chapter 2, c) the design-based research framework, DBRIEF, structuring this research, d) the issues arising from the conceptual models proposed in this chapter, and e) the methods of data analysis discussed in Chapter 6. Accordingly, 10 major propositions are formulated for testing in this study.

Proposition 1: School-wide adoption of ICT across the curriculum influences teachers' ICT-rich teaching.

Proposition 2: School-wide adoption of ICT across the curriculum influences students' self-esteem and the extent to which it changes.

Proposition 3: ICT-rich teaching practice influences students' self-esteem.

Proposition 4: Teachers' planned use of ICT influences their adoption of ICT in teaching practice.

Proposition 5: An emphasis on ICT use in school influences students' access and use of ICT both inside and outside of school.

Proposition 6: Teacher and Student presage characteristics influence students' self-esteem.

Proposition 7: Students' presage characteristics influence their attitudes towards school and computers in different ways.

Proposition 8: Teachers' presage characteristics influence their adoption of ICT in teaching practice.

Proposition 9: Schools differ in how effectively they integrate ICT into the curriculum and how this, in turn, influences students.

Proposition 10: School-wide adoption of ICT leads to beneficial changes.

Summary

This chapter presents the research paradigm underpinning this study. The Design-Based Research in Innovative Education Framework (DBRIEF) is developed and derives from the early works of Carroll (1963) and Biggs (1989), and more recently from the works of Huitt (1993), Orrill (2001), Keeves (2003) and members of the Design Based Research Collective (2003).

Informed by previous research and observation, elements of DBRIEF are extended in order to develop conceptual models of interdependent factors that examine student, teacher and school level processes. The student and teacher path models hypothesise, respectively, how student-related factors influence student self-esteem and how teacher-related factors influence teaching practice, and are the focus of Chapter 10. Finally, the three-level models, discussed in detail in Chapter 11, which examined change in schools and students over time, hypothesise how school, teacher and student factors influence student self-esteem.

In order to test the proposed models and fulfil the aims of the study and general research questions presented in Chapter 1, propositions to be tested are advanced. These propositional statements serve to the guide the research design, presented in the following chapter, and subsequent analyses with the ultimate intention, as guided by DBRIEF, to inform educational practice and promote ongoing research and development in the field of learning technologies.

4

Research Design and Data Collection

The major purpose of this study is to measure longitudinal change in school climate in order to understand the impact on student self-esteem and ICT-rich teaching practice due to the increased adoption of ICT across the curriculum. In order to achieve these purposes, four primary schools and two secondary schools were selected and appropriate methods of data collection were investigated and designed.

Shavelson et al. (2003) argue that in designing a study, scientific research should endeavour to a) pose significant questions suitable for empirical investigation, b) link research to relevant theory, c) use methods that promote direct investigation, d) provide a coherent and explicit chain of reasoning, e) attempt to yield findings that replicate and generalise across studies, and f) disclose data and methods to promote professional scrutiny and critique.

With this in mind, the resulting design of this study is shaped by two areas of need raised in the DECS*tech* Report (DETE, 1999). The first is in response to measuring changes in student learning outcomes attributable to the use of learning technologies, and the second is in recognition of the need for longitudinal research, as highlighted in the report, under directions for research:

> … what is now required is a longitudinal study to establish structures and processes through which clear and useful advice and support relating to curriculum applications of learning technologies can be provided to department schools. (DETE, 1999, p.15)

Shavelson et al. (2003) reinforce the importance of a longitudinal design.

> In recognition of the complex, multivariate, multilevel, iterative, and interventionist nature of design studies, those working in this research mode have argued for intensive, longitudinal studies that trace the design process and capture meaning constructed by individual subjects over time. (Shavelson et al., 2003, p.27)

The focus of this chapter, therefore, is to provide information about the samples of students and teachers who participated in the study, and to detail the instruments employed, in addition to detailing the procedures used for data collection in this longitudinal study.

The Study Sample

The sample involved teachers and students from six South Australian metropolitan public schools. The schools were selected through a non-random process of evaluating submissions based on set criteria, rather than selection based on a random process. The importance of engaging schools that were committed to the study over the three-year duration required their active involvement and cooperation and hence the method of selection.

During the three years of the study, the schools were intensively involved in a process of development and change, primarily focused around embedding ICT into the curriculum. The first year was an establishment year where the schools identified their needs, and planned and initiated strategies to build curriculum more widely enriched by ICT. Over the following two years, students and teachers continued to experience changes in the learning environment as ICT were increasingly embedded throughout the curriculum, with the objective of improving student learning outcomes. The study sample was selected to take full advantage of this unique undertaking by maximising the opportunity for comparative analysis. Therefore, the subjects selected and surveyed for this study were all students in upper primary school, from Years 5 to 7, and those in lower secondary school, from Years 8 to 10, in addition to all teachers in the four primary and two secondary settings, during the three-year duration of the study.

In order to maximise transferability of results across a broad range of educational settings, a common set of survey instruments was used across the primary and secondary school settings that were age-appropriate for students in the middle schooling years. Accordingly, those students from Years 5 to 10 and all teachers in the selected primary and secondary schools, were invited to participate in the study by completing the respective student or teacher questionnaire, which is detailed in the next section.

Data Collection Methods and Procedures

Since almost all methods of data collection have some bias associated with them, triangulation is often employed to contribute to the verification and validation of the data collected. Burns (1998, p.324) defines triangulation as “the use of two or more methods of data collection in the study of some aspect of human behaviour”. In this study, triangulation is achieved through the use of primary data sources, involving questionnaires and informal observation and interviews, and secondary data sources, in the form of publicly available school context statements and school websites. Very little of the informal observations and interviews or secondary-source data are used in a quantitative sense. This includes the responses to a number of questions in the teacher survey that invited open comment. However, teachers did provide invaluable insight into the contexts in which to interpret the quantitative data. Though specific mention of the qualitative methods and resulting data are not generally given, they are intrinsically employed throughout later discussions by contextualising the findings that result from the quantitative data analysis (Patton, 1990; Wolcott, 1988). Metaphorically speaking, if the quantitative data is the skeleton, then the qualitative data provides the flesh.

Thus, the predominant method of data collection employed in this study is by way of questionnaire, designed to obtain information on human factors at the student and teacher levels. Accordingly, a student and a teacher survey are developed for this study, and are detailed in the remaining sections of this chapter.

Online questionnaires

In light of the technology focus of the study, it was appropriate that the administration of the student and teacher surveys be conducted online via the internet. The size of the student and teacher samples also requires a more efficient means of data collection than the traditional pencil-and-paper type format. Accordingly, the use of the online survey, a method only recently employed in educational research (Dix and Anderson, 1999; Gould et al., 1998), is undertaken in this study.

Online surveys offer a number of advantages. First, the participating schools have sufficient and reliable access to the internet. Where difficulties were experienced in one school in the first year of the study, the equivalent paper-based survey was administered. Second, the items comprising the student and teacher surveys, predominantly multiple-choice Likert scales, are easily representable in an online environment through the use of radio buttons. Other items like short response and listed selections are similarly achieved, and all have the advantage of allowing respondents to change their mind easily by re-selecting or typing their response. Third, the key benefits of an online environment are time and cost. Instantaneous electronic distribution of survey materials and subsequent electronic return of completed surveys give the fastest possible opportunity for responses to be collected and automatically compiled into an electronic database. The time and cost incurred from survey distribution by hand or mail and the manual entry of responses to form a database were minimised in the first year of the study and were nonexistent in the subsequent years. Fourth, the use of colour in the online environment, for backgrounds and images, makes the surveys appealing and engaging. Fifth, and most important, the automatic compilation of responses removes any possibility of input errors that can occur during manual data entry due to lapses in concentration or fatigue.

Development of the surveys

The entire procedure of design, coding, server management, trialling and administration of the student survey was undertaken by the researcher, as detailed by Dix and Anderson (1999). While the researcher was instrumental in the design of the teacher survey, personnel from the University of South Australia undertook its development and management in a cooperative endeavour. The form-mailing surveys were constructed and formatted using hypertext markup language (HTML). Server-sided common-gateway-interface (CGI) programming enabled the interactive online administration process. The submitted data were collected by design-specific in-house servers and stored in tab-delimited text files that were easily transferable to database and statistics software packages. The collection of data for this study through online administration, and the scale on which it was conducted, was unprecedented in Australia at the time of the study.

Administration in schools

The ICT managers and Principals in the six schools were encouraged to allow all middle school students, Years 5 to 7 in the primary sector, and Years 8 to 10 in the secondary sector, to participate in the online student survey, while all teachers across both settings were encouraged to participate in the online teacher survey. In planning such an ambitious study and ensuring its success, the researcher developed a close working relationship with each school. Regular school visits and formal meetings with school leaders were conducted to facilitate initial support and preparation in the undertaking, and to report ongoing progress. Formal presentations by the researcher at after-school staff meetings informed staff and gained their initial support. Subsequent to each administration period, further presentations were given, tailored to each school, in order to report progress and preliminary findings, present them with their school's interim report, and reaffirm their commitment to the three-year study. In addition to all of this, informal contact via email, phone, fax and in-person, were necessary to clarify any other issues raised and to maintain the ongoing support of the schools to the study.

Administration of the student survey was conducted during the third and fourth terms of each of the three years. This usually took place in designated class periods, planned for by each school, where students were taken to the school's computer laboratory and completed the survey under supervised conditions. It was expected that most students should be able to complete the entire survey in a standard 50-minute lesson. However, if more time was required, then additional class periods were allowed for. If students encountered technical difficulties completing the online survey, the school's ICT manager or the researcher was on hand to support students and overcome access issues. Given the nature of the study, it was imperative that a student's experience in completing the survey was as problem-free as possible, so that the process itself of collecting the data had minimal influence on a student's responses. If students had difficulties understanding an item, support staff were available to assist them, but were instructed not to influence students' decisions. Those students with learning or physical disabilities required additional support. A school service officer or the researcher, but not the student's teacher, sat with the student and assisted in entering responses for the entire survey. In some cases, when students were absent when their classes completed the survey, and where support staff were available, these students were released from their regular lesson to complete the survey under supervised conditions. So that students felt that their responses were confidential, staff remained accessible to students if needed, but were primarily there in an unobtrusive role to oversee that students were not discussing items and were staying on task.

Administration of the teacher survey was conducted during the same period but teachers were only required to respond once over the duration of the study, even though they were encouraged to respond on all three occasions. This design catered for the possibility of a transient teacher population, due to teachers leaving or commencing a school mid-way through the study period. Furthermore, unlike students, teachers were not required to identify themselves by name so that their assurance of complete anonymity would allow them to express their views freely and respond without bias to the survey. Although teachers were asked to provide and remember another form of traceable identification from one year to the next, it was considered unreliable. Rather than risk poor response rates and an incomplete data set, it was considered of greater importance to gain a comprehensive and complete 'snapshot' of teachers at the start. By doing so, it overcame difficulties associated in tracking teachers across the three years and encouraged them to respond, since they only had to do it once. Where enthusiastic teachers volunteered to respond more than once, their responses on each occasion were averaged to a single snapshot. Teachers usually completed the survey at computers stationed in the staff-room or in their office in their own time during staff breaks or after school. Some schools gave teachers time to complete the survey by providing a replacement teacher during one of their teaching periods or counting it towards their professional training and development. ICT managers were well known to all members of staff and were usually available if staff needed technical assistance.

Ultimately, the resulting number of students and teachers responding to their respective surveys, detailed in the next section, depended on each school's success in administering the online instruments and encouraging staff and students to participate.

The Instruments

The instruments employed to collect the data necessary in order to achieve the purpose of gauging longitudinal change in school climate comprise a combination of self-developed and pre-existing tools, assembled into eight questionnaires. The teacher survey involved four questionnaires: a) teacher background, b) current ICT use, c) planning and implementing ICT in student learning, and d) confidence and support in using ICT in teaching practice. The student survey also consisted of four questionnaires: a) student background, b) attitudes towards school, c) self-esteem and d) ICT use and attitudes towards computers. In many cases, these scales required participants to respond to statements using a three-point or five-point Likert scale. The Likert scale was used because it is generally considered to be the most useful type of scale for use in a group-testing situation (Burns, 1998) and is easy to administer. The items in these scales were programmed in HTML as radio buttons so that only one choice could be selected. Other items, developed to measure background information and practical aspects of ICT use, rather than attitudes and beliefs, employed response systems that were dichotomous or allowed for multiple selection, and some required open response comment. Depending on the type of response system required, radio buttons, check-boxes, drop-down lists, or text-fields were used (Dix, 2007). The following sections detail the development of each of the questionnaires employed in the collection of data for this study.

Teacher background

General information about teachers' backgrounds was collected from all teachers participating in the study, using the background section of the teacher survey. The items requested information about the school they were at, their gender and teacher identification number. Other background characteristics that were also measured include the type of teaching position they held, their number of years teaching, areas of specialisation, the year levels and subject areas they taught, and their teaching load. The teacher background questions and the associated coding are summarised in Table 4.1.

Teachers' current use of ICT

In order to gain a measure of teachers' use of technology during the study, the extent of which may influence both student and teacher attitudes, several questions were developed specifically that addressed teachers frequency and type of ICT use, student learning objectives, and encouragement to use ICT. A detailed description of teachers' current ICT usage follows.

Opportunities for students to gain experience in using computers and software applications in the classroom, beyond that of normal access issues, generally depend on a teacher's efforts in purposefully planning the use of ICT in lessons and on the importance of ICT use as a learning objective. Of additional interest is whether the teacher encourages students to use ICT. In order to examine teachers' planned computer use, intended objectives and levels of encouragement, two questions were developed with the expectation that students would be directly influenced.

Table 4.1 Items comprising the teacher background questionnaire and how these are coded

Item	Description of Characteristics
School	Select from: Primary School 1 (P1), Primary School 2 (P2), Primary School 3 (P3), Primary School 4 (P4), Secondary School 1 (S1), Secondary School 2 (S2)
ID number	Teacher identification number
Gender	Sex of individual: Male (0), Female (1)
Type of teacher	Type of teaching position held: Teacher (1), Permanent against temporary (2), School Services Officer (3)
Experience	Indicate the number of years of full time equivalent teaching: less than one year (0) incrementally to 17 plus years (17)
Load	Describe your teaching load: 0.4 incrementally to 1.0
Year level	Describe your teaching year level (you can nominate more than one): Reception (R) incrementally to Year 12 (12)
Subject area	Subjects (you can nominate more than one): Aboriginal Education (1), Mathematics (2), Health & Physical Education (3), Technology (4), The Arts (5), SOSE (6), Science (7), Computing (8), Special Education (9), English (10), LOTE (11)
Specialisation	Select your area of specialisation (you can nominate more than one): Pre-school (1), Junior primary (2), Primary (3), Middle (4), Senior (5), Gifted & talented (6), Resource based learning (7), Vocational education and training (8), Information technology (9), Teacher librarian (10), Non-English speaking background students (11), Work experience (12), Aboriginal and /or Anangu (13), Augmentative communication (14), Counselling (15)

In planning for their teaching and students' learning, teachers were asked to indicate how many lessons they purposefully planned for their students to use a variety of software applications in the classroom during a term, which, according to Koper (2000), broadly encompasses open-ended learning packages and communication environments. A four point logarithmic scale was adopted, allowing teachers to response with either 'no lessons' (1), '1 to 2 lessons' (2), '3 to 9 lessons' (3) or '10 or more lessons' (4). The 10 items are given below.

F1. Games for practising skills
F2. Simulations for exploration environments
F3. Encyclopaedias and other reference materials on CD-ROM
F4. Word processing
F5. Software for making presentations
F6. Graphics oriented printing
F7. Spreadsheets or database programs
F8. Multimedia authoring environments
F9. World wide web browser
F10. Electronic mail

Teachers' frequency of ICT use for preparing teaching programs and for reporting purposes may indicate their level of ICT competence and indirectly influence student attitudes towards technology. Accordingly, teachers were asked to identify how often they used computers when preparing lessons or reporting on students' work. Eight items, presented below, were included and required teachers to respond on a five-point Likert scale of 'never', 'rarely', 'occasionally', 'frequently', or 'always', which were scored 1 to 5 respectively.

G1. Get information from the internet for use in lessons
G2. Write lesson plans or related notes

G3. Use video cameras, digital cameras, scanners to prepare lessons
G4. Record or calculate student grades
G5. Make handouts for students
G6. Exchange computer files with other teachers/students
G7. Post student work, ideas, resources on the WWW
G8. Report on students use of learning technologies

In order to gauge teachers' current learning objectives for their students when using computers, a list of 10 items were developed, framed around behavioural and cognitive aspects of learning outcomes. Teachers were invited to select as many or as few as were applicable. If a learning objective was selected, then it was given a score of one, while those that remained unselected were scored zero. The list of 10 items that were among teachers' objectives for student computer use were:
H1. For mastery
H2. For remediation
H3. Finding out about ideas and information
H4. Communicating electronically with other people
H5. Analysing information
H6. Synthesising and presenting information
H7. Improving computer skills
H8. Learning to work collaboratively
H9. Learning to work independently
H10. Evaluating and selecting the most appropriate resource for the intended audience

Teachers' encouragement of students' ICT use was included in the items that explored influences on teaching practice. Item I asked teachers: Do you encourage your students to use learning technologies? It required teachers to respond on a four-point Likert scale of 'never', 'occasionally', 'most days', or 'virtually every day', with responses scored 1 to 4 respectively.

The next item (Item J) asked teachers to what extent they incorporated students' use of ICTs in reporting. A four-point Likert scale was again used but with responses of 'never' (scored 1), 'occasionally' (2), 'frequently' (3), and 'always' (4).

To understand the classroom environment further and how they were influenced by ICT, teachers were asked how learning technologies had influenced their teaching practice. Five different aspects, listed below, required teachers to respond on a four-point Likert scale of 'no influence' (scored 1), 'minimal influence' (2), 'medium influence' (3), and 'strong influence' (4).
K1. The way you organise space in your classroom
K2. The way you break your class period into activities
K3. Your beliefs about curriculum priorities
K4. Your teaching methods
K5. Your teaching goals

Planning and implementing ICT in student learning

The values that teachers placed on various forms of ICT when planning learning activities for their students is also of interest in this study. A five-point Likert scale was adopted, asking teachers to rate the 10 forms of ICT as either 'don't know' (scored 1), 'not needed' (2), 'some value' (3), 'valuable' (4), or 'essential' (5). The question read: In planning for the use of learning technologies with your students, rate the value of the following equipment and software. The list included:
L1. Teacher computer with internet connection
L2. 5+ computers in the vicinity

L3. WWW access in the classroom
L4. Scanner for photos and graphics
L5. Video camera
L6. A telephone in you classroom
L7. A class presentation system (large TV, data-show)
L8. Digital encyclopaedia's and reference works
L9. Presentation software (Powerpoint)
L10. Multimedia authoring software (Hyperstudio)

Teachers' beliefs about factors influencing students' learning outcomes are another aspect of interest in this study. Eleven items were developed that gauged teachers' beliefs about the importance of ICT in influencing issues of teaching practice and student behaviour. Teachers were asked to respond about their beliefs, which were answered on a three-point Likert scale of 'true' (3), 'no opinion' (2), or 'false' (1). The statements are listed below.

M1. Students create better looking products than they could do with just writing and other traditional media
M2. Average students are communicating and producing in ways only gifted ones did before
M3. Computers provide a welcome break for students from more routine learning activities
M4. Students help one another more while doing computer work
M5. A teacher has to give up too much instructional responsibility to the computer software; I feel I am not really teaching
M6. Students take more initiatives outside of the class time – doing extra research or polishing their work
M7. Students writing quality is better when they use word processing
M8. Students work harder at their assignments when they use computers
M9. Students are more willing to do second drafts
M10. It is difficult to integrate computer activities into most of my regular lesson plans
M11. Too many students need my help at the same time

Confidence and support in using ICT in teaching practice

A series of questions was developed to gauge teachers' confidence in using ICT in teaching practice and beliefs about the level of ICT support teachers received within their school. The first question asked teachers to indicate their level of confidence in doing the tasks, listed below, with their students. The seven tasks were scored as either 'no confidence' (scored 1), 'little confidence' (2), 'unsure' (3), 'some confidence' (4), or 'high confidence' (5).

N1. Manage files
N2. Create a new database
N3. Prepare a slide show
N4. Use a WWW search engine
N5. Develop a multimedia document
N6. Manipulate graphics
N7. Author web pages

Generally, the more experience people have with different computing platforms, the more confident they feel in using computers. Accordingly, the next question presented five different operating environments, listed below, and asked teachers to rate their level of confidence in using them. Similar to the previous question, teachers could choose from ‘no confidence’ (1), ‘little confidence’ (2), ‘unsure’ (3), ‘some confidence’ (4), or ‘high confidence’ (5).

O1. MS-DOS
O4. Macintosh
O5. Unix/Linux
O2. Windows 3/95/98
O3. Windows NT

The next two questions used the same response system of ‘no confidence’ (1), ‘little confidence’ (2), ‘unsure’ (3), ‘some confidence’ (4), or ‘high confidence’ (5). Statement P asked teachers to rate their level of confidence in implementing learning technologies in the classroom, and Item Q presented a similar statement by asking teachers to rate their level of confidence in introducing an unfamiliar learning technology application to your students.

Further examination of teachers’ confidence included an additional statement (Item R): Rate your competence for applying learning technologies with your class. For this item, teachers responded on a five-point Likert scale of ‘recruit’ (1), ‘novice’ (2), ‘fairly competent’ (3), ‘highly competent’ (4), or ‘expert’ (5).

Several questions were developed for this study, to gauge teachers’ beliefs about the level of support they received, and gave, in their school. The first question was presented as a three-pronged statement, which asked teachers to rate the level of support within their school in the following areas:

S1. Technical/hardware
S2. Adoption of LT
S3. Staff training and PD from other staff

A four-point response system of ‘no support’ (1), ‘little support’ (2), ‘good support’ (3), or ‘excellent support’ (4), was provided.

The next question (Item T), which also related to confidence, asked teachers: To what extent do you actively support other teaching staff in the use of learning technologies, their needs and problems? Teachers responded on a five-point Likert scale of ‘never’, ‘rarely’, ‘occasionally’, ‘frequently’, or ‘always’, scored 1 to 5 respectively.

The last question (Item U) related to collegial support, where teachers were asked how often they sought advice from others in the use of learning technologies. For this item, a four-point scale was adopted with possible responses of ‘never’ (1), ‘occasionally’ (2), ‘frequently’ (3), or ‘always’ (4).

A very straightforward question: Do you use a computer at home? was presented next and comprised Item V. Rather than just using a standard dichotomous scale of ‘yes’ or ‘no’, teachers could select from, ‘never’ (1), ‘rarely’ (2), ‘occasionally’ (3), ‘frequently’ (4), or ‘always’ (5).

The final question in the teacher survey, presented once again as an indication of confidence, asked teachers to list any peripheral technologies they were confident in using within their teaching programs. Teachers were invited to select as many or as few as were applicable. If an item was selected, then it was given a score of one, while those unselected were scored zero. The list of 15 peripheral technologies, both common and uncommon, include:

W1. Hand helds/Palm tops
W2. Digital whiteboard
W3. Video conferencing
W4. Digital video conferencing
W5. Digital camera
W6. Data shows
W7. Television
W8. Radio
W9. Fax machine
W10. CD or cassette player
W11. Video player
W12. Video camera
W13. CD-burner
W14. Modem
W15. Scanner

Clearly, the teacher survey was developed to gather a wide variety of information on aspects related to teachers, their beliefs about their teaching practice, and their confidence in using ICT. Such a tool provides, a 'snap-shot' of the teachers, in order to better inform the analysis of the data obtained from the student survey, which is presented next.

Student background

General information about student background was collected in each year of the study using the background section of the student survey. The items comprising this part of the survey requested name, date of birth, gender, and language spoken at home. Unlike other variables in the student survey, these items remained fixed for each student over the three-year period. The year-level or grade of the student on each occasion was also recorded. The student background questions and the associated coding are summarised in Table 4.2.

Table 4.2 Items and coding comprising the student background questionnaire

Item	Description of Characteristics
School	Select from: Primary School 1 (P1), Primary School 2 (P2), Primary School 3 (P3), Primary School 4 (P4), Secondary School 1 (S1), Secondary School 2 (S2)
Name	Identification so that individual can be tracked over 1, 2 or 3 occasions
Gender	Sex of individual: Male (0), Female (1)
Date of birth	Age of individual in years
NESB	What language is spoken at home: NESB (1), English (0)
Year-level	Year-level of student which will vary over 3 occasions

Students' attitudes towards school

A questionnaire to measure students' attitudes towards school and academic motivation was constructed by modifying an instrument used by Keeves (1974). The first 17 items (8 of which were negatively worded) were designed to assess attitudes towards school and school learning and comprised one instrument, while the remaining 20 items (9 of which were scored negatively) measured motivation to achieve in school learning and comprised a second instrument. The two instruments were associated with the attending, valuing and responding levels of the affective domain of the Bloom Taxonomy (Bloom, 1956; Krathwohl, Bloom and Masia, 1964). Students were asked to rate the 37 items on a three-point Likert scale of 'agree', 'disagree' or 'uncertain'. Responses yielding a highly positive attitude were assigned a numerical value of 3, while those responses yielding a highly negative attitude received a value of 1. The intermediate response of uncertain was assigned a value of 2. The school attitudes questionnaire was administered with the other questionnaires comprising the student survey on each of the three occasions in order to examine changes in students' attitudes towards school and academic motivation over the period of the study. Table 4.3 presents each item in the sub-scales and indicates the direction of scoring.

Table 4.3 Items comprising the school attitude questionnaire with sub-scale components of Like School (LS) and Academic Motivation (AM)

A1. We have interesting lessons at school LS
A2. The most enjoyable part of my day is the time I spend at school LS
A3. I don't like school LS *
A4. I find school interesting and challenging LS
A5. I enjoy everything I do at school LS
A6. The things I look forward to in school are weekends and holidays LS *
A7. School is not very enjoyable LS *
A8. I like most of my school subjects LS
A9. I shall leave school as soon as possible LS *
A10. I am bored most of the time in school LS *
A11. I enjoy most of my school work LS
A12. I will be glad to leave this school LS *
A13. I want to stay at school as long as possible LS
A14. The sooner I can leave school the better LS *
A15. I don't like missing a day at school LS
A16. There is no point in me staying at school after I am fifteen LS *
A17. I agree with people who say "school days are the happiest days" LS
A18. I like being asked questions in class AM
A19. I tend to leave my homework to the last minute AM *
A20. I enjoy working out difficult problems AM
A21. I work hard all of the time in school AM
A22. I want as much education as I can get AM
A23. I find it hard to keep my mind on school work AM *
A24. I try my hardest to get high marks at school AM
A25. It is not worth spending a lot of time on a hard homework problem AM *
A26. In school we like to annoy the teacher by playing up AM *
A27. I don't always try my hardest at school AM *
A28. When I find the work at school difficult I do extra at home AM
A29. When the teacher is out of the room I tend to stop AM *
A30. I like to sit next to someone who is working hard all the time AM
A31. I don't always revise for tests AM *
A32. I always try to do my school work carefully and neatly AM
A33. I like to have homework every night because it helps me learn AM
A34. I like to complete all the work set AM
A35. Sometimes I forget to do all my homework AM *
A36. When I can't understand something I always ask a question AM
A37. Sometimes I pretend to be sick to avoid a test AM *

* reverse scoring; LS Like school; AM Academic motivation

Student self-esteem

The second attitude scale selected for this study was adapted from the Self-Esteem Inventory (SEI) designed by Coopersmith (1976, 1986). Self-esteem is defined by Coopersmith as follows:

> a set of attitudes and beliefs that a person brings with him or herself when facing the world. Self-esteem provides a mental set that prepares a person to respond. (Coopersmith, 1986, p.1)

Studies such as Peck (1989) report a positive relationship between self-esteem and school performance. Students who display feelings of confidence and self-respect generally perform well academically.

Although the Rosenberg Self-Esteem Scale (1965) is generally considered the standard against which other measures of self-esteem are compared (Blascovich and Tomaka, 1991), the assessment of self-attitudes in specific contexts offered by the Coopersmith scale make it a more useful and appropriate measure for this study.

The SEI scale was originally designed for measuring the self-esteem of children of age 10 to 15 years and was successfully used by students of age 16 years (Ross, 1974). For the purposes of this study, with the support of Blascovich and Tomaka (1991), the age range was extended to include Year 5 to Year 10 students, equivalent to a range in age of 9 to 16 years.

Items comprising the self-esteem scale were presented as statements to which students responded using a three-point Likert response scale labelled ‘agree’, ‘disagree’, or ‘uncertain’. This design deviated from the original two-point Likert response of ‘like me’ or ‘unlike me’, in order to provide some uniformity across scales and to give respondents the choice of uncertain. Some items were worded so that the response of ‘agree’ indicated a positive attitude while others indicated a negative attitude. Items marked as a favourable response were assigned a score of 3, while those indicating an unfavourable response were assigned a value of 1. Uncertain responses were scored 2.

Following the trialling of the survey at a South Australian metropolitan primary school, four items were removed from the original SEI scale on the basis that the majority of younger trial participants did not understand the items. The resulting self-esteem questionnaire thus consisted of 54 items, originally formulated within a framework of four self-evaluative attitudes: those of social, academic, family, and personal areas of experience. Of these 54 items, seven constituted a lie scale by providing a measure of defensiveness or test-wiseness. In such cases, a subject responded in accordance with their perception of the purpose of the test, thus biasing their answer and producing invalid data. Although Coopersmith (1967) did not specifically identify the items in the groups, Ross (1974) examined the content of each item and subsequently inferred the composition of the sub-scales. A similar examination by the researcher supports the arrangement. Accordingly, 25 items comprise the General-Self (G) component, eight items each comprise the Social Self-Peers (S) and Home-Parents (H) components, and six items comprise the School-Academic (A) component. The remaining seven items constitute the Lie Scale (L). Each item and its sub-scale representation are presented in Table 4.4.

Students’ ICT use and attitudes towards computers

The final instrument used in the student survey addressed certain practical issues and student attitudes towards computers. Because a student’s computer attitude is related to the type and degree of experience that he or she has had with computers, the measurement of practical aspects of computer experience was an important component of this study. Such information contributes towards the development of the context in which students’ attitudes are based and might assist school administrators in making appropriate school based decisions about the integration of technology into the learning environment.

In the first section of the computer attitude questionnaire, a number of questions were developed that identified practical aspects of students’ computer usage, access and general knowledge. In the second section, an adapted version of the Computer Attitude Scale by Jones and Clarke (1994) was used to measure students’ attitudes towards computers. A description of each section follows.

Table 4.4 Items comprising the self-esteem questionnaire with sub-scale components of School-Academic (A), Social Self-Peers (S), Home-Parents (H), General-Self (G), and Lie (L)

B1.	Things usually don't bother me G
B2.	I find it very hard to talk in front of the class A*
B3.	There are lots of things about myself I'd change if I could G*
B4.	I can make up my mind without too much trouble G
B5.	I'm a lot of fun to be with S
B6.	I get upset easily at home H*
B7.	It takes me a long time to get use to anything new G*
B8.	I'm popular with kids my own age S
B9.	My parents usually consider my feelings H
B10.	I give in very easily G*
B11.	My parents expect too much of me H*
B12.	It's pretty tough to be me G*
B13.	Things are all mixed up in my life G*
B14.	Kids usually follow my ideas S
B15.	I have a low opinion of myself G*
B16.	There are many times when I'd like to leave home H*
B17.	I often feel upset in school A*
B18.	I'm not as nice looking as most people G*
B19.	If I have something to say, I usually say it G
B20.	My parents understand me H
B21.	Most people are better liked than I am S*
B22.	I usually feel as if my parents are pushing me H*
B23.	I often wish I were someone else G*
B24.	I can't be depended on G*
B26.	I'm pretty sure of myself G
B27.	I'm easy to like S
B28.	My parents and I have a lot of fun together H
B29.	I spend a lot of time daydreaming G*
B30.	I wish I were younger G*
B31.	I always do the right thing L
B32.	I'm proud of my school work A
B33.	Someone always has to tell me what to do G*
B34.	I'm often sorry for the things I do G*
B35.	I'm never happy L*
B36.	I'm doing the best work that I can A
B37.	I can usually take care of myself G
B38.	I'm pretty happy G
B39.	I would rather play with children younger than I am S*
B41.	I understand myself G
B42.	No one pays much attention to me at home H*
B43.	I'm not doing as well in school as I'd like to A*
B44.	I can make up my mind and stick to it G
B45.	I really don't like being a boy/girl G*
B46.	I don't like to be with other people S*
B47.	I'm never shy L
B48.	I often feel ashamed of myself G*
B49.	Kids pick on me very often S*
B50.	I always tell the truth L
B51.	My teachers make me feel I'm not good enough A*
B52.	I don't care what happens to me G*
B53.	I'm a failure G*
B54.	I always know what to say to people L

* reverse scoring; A School-Academic items; S Social Self-Peers items; H Home-Parents items; G General-Self items; L Lie items

Practical aspects of ICT use and experience

Questions in the first part of the computer attitude questionnaire were designed to identify practical aspects of computer experience and provide a measure of the context in which the attitudes were based. Initial development of the items explored the main areas of ICT use outside of school, digital literacy and computer access. A variety of response formats was employed across the items, including simple yes/no answers, multiple selection of listed items, and Likert-type responses.

Students' use of ICT outside of school explored aspects of both hardware and software usage that would provide measures of additional exposure to ICT beyond the school that may influence student attitudes. The first question asked students what they used a computer for outside of school. Students responded to the three items listed below, on a three-point Likert scale of 'lots', 'sometimes', or 'not at all', with values of 2, 1 and 0, assigned respectively.

C1. Homework/projects/studying
C2. Playing computer games
C3. Using computer programs

Students were asked in the next question what else they used a computer for, and they were invited to select as many or as few as were applicable from a list of seven items, given below. If an item was selected, then it was given a score of one, while those that remained unselected were scored zero.

D1. Internet – Surfing
D2. Making web pages
D3 Word-Processing
D4. E-mail
D5. Chat Rooms
D6. Graphics/Animation
D7. Music

Since ICT are not just limited to computers, the internet and software, students were asked to indicate their usage of other forms of technology outside of school in the preceding week. Students were able to select as many or as few items from a list of eight, which included:

E1. Television
E2. Mobile phone
E3. Radio/CD/cassette player
E4. Digital camera
E5. Video player
E6. Video camera
E7. Scanner
E8. Fax machine

Students' general levels of computer access, knowledge and confidence were explored in an additional set of measures upon which student attitudes may be influenced. In order to gauge students' access to computers at home, students were asked if they had a computer at home (Item F1), to which a simple 'yes' (1) or 'no' (0) response was required. A follow-up question then asked what type of computer it was, allowing students to select one or more of three items:

F2. Windows PC
F3. Macintosh
F4. Gameboy, Nintendo or Playstation.

Three questions were next developed as a broad measure of students' confidence in using computers. Each question was answered on a three-point Likert scale worded specifically for each item. The values of 3, 2, and 1 respectively were assigned to the positive, middle and negative responses. The first question (Item F5) asked students how much they liked using a computer, and students could respond by selecting either, ‘I love it’, ‘I like it’, or ‘I don't like it’. The next question (Item F6) asked students how good they were at using a computer, and responses of ‘excellent’, ‘good’, or ‘not good’ could be chosen. The last question (Item F7) asked students how well they used the computer keyboard and required a response of ‘excellent’, ‘good’, or ‘not good at all’.

Further to examining practical aspects of ICT use, was students’ computer access in school. Since students did not generally have knowledge about the number of computers in their school, two questions were developed to provide an indication of student access to computers in school. The first question (Item F8) asked students how they were usually grouped when using computers in school. Students could select from ‘working individually’, ‘in pairs’, ‘in a small group’, ‘in a large group’, or ‘with the whole class’. Values 5 to 1 were assigned respectively. The second item (Item I1), posed as an attitudinal statement, asked students if they thought their school had enough computers for student use, and required them to respond to a five-point Likert scale ranging from strongly agree (5) to strongly disagree (1).

The last set of items examined students’ ICT use and knowledge acquisition, and these were presented as a series of activities. Students were asked if they could do an activity and, if so, whether they first learnt to do it at home, in school, or at another place. A response of ‘can’t do it yet’ received a score of 0, while ‘home’, ‘school’, and ‘other’ received nominal scores of 1, 2 and 3 respectively. The nine items include:

G1. Use the World Wide Web (WWW)
G2. Search the WWW using keywords
G3. Send an e-mail message
G4. Use spreadsheets or databases to store information
G5. Create stories, poems, and letters
G6. Draw pictures using the mouse
G7. Make your own website or home page
G8. Create your own multimedia presentation
G9. Create your own music or sound using a computer

Computer attitudes

In order to assess students’ general attitudes about computers, the attitude scale by Jones and Clarke (1994) was adopted for this study. The original scale consists of 40 items designed within a tripartite framework, which identifies affect (15 items), behaviour (10 items), and cognition (15 items) as the three major components of attitude. Each item is presented as a statement to which students respond using a five-point Likert scale consisting of ‘strongly agree’, ‘agree’, ‘uncertain’, ‘disagree’, and ‘strongly disagree’. Some of the items are worded so that the response of ‘strongly agree’ indicates a positive attitude, while other items are worded in such a way that a response of ‘strongly agree’ implies a negative attitude. Responses yielding a highly positive attitude are assigned a numerical value of 5, while responses yielding a highly negative attitude receive a value of 1. Intermediate responses are assigned the values of 4, 3 and 2 respectively. Table 4.5 presents each item and indicates the component representation by either A (affective), B (behavioural) or C (cognitive).

Summary

What makes this study stand out from previous research into the impact of ICT on students’ attitudes, reviewed in Chapter 2, results from a combination of the following features into a single comprehensive study.

1. The scale of the study, gained through multiple schools and multiple year-levels across the primary and secondary public school sector, provides access to thousands of student and their teachers, maximises the transferability of results, and allows for the use of complex multi-dimensional statistical techniques.
2. The instruments employed are designed to gauge attitudinal rather than achievement-based outcomes.
3. The procedures used for data collection use internet technology rather than paper-based surveys.
4. The use of common instruments across year-levels and settings allows for comparison between students, teachers, schools and settings.
5. Most importantly, the longitudinal nature of the study over a three-year period allows for comparison within students and an examination of how the increasing use of ICT in learning influences them.

Table 4.5 Items related to computer attitude with affective (A), behavioural (B), or cognitive (C) component representation

H1.	Computers intimidate and threaten me *A
H2.	All computer people talk in a strange and technical language *C
H3.	I learn new computer tasks by trial and error B
H4.	Working with a computer makes me feel tense and uncomfortable *A
H5.	Computers are difficult to understand *C
H6.	Other students look to me for help when using the computer B
H7.	I feel helpless when asked to perform a new task on a computer *A
H8.	Boys students like computers more than girls students do *+C
H9.	When I have a problem with the computer, I will usually solve it on my own B
H10.	I feel important when others ask me for information about computers A
H11.	Learning about computers is a waste of time *C
H12.	Using the computer has increased my interaction with other students B
H13.	Computers bore me *A
H14.	Anything that a computer can be used for, I can do just as well in another way *C
H15.	I develop short cuts, and more efficient ways to use computers B
H16.	Working with computers makes me feel isolated from other people *A
H17.	Working with computers will not be important to me in my career *C
H18.	I would like to spend more time using a computer B
H19.	I do not feel I have control over what I do when I use a computer *A
H20.	People who use computers are seen as being more important than those who don't C
H21.	If I can I will take subjects that will teach me to use computers B
H22.	Computers sometimes scare me *A
H23.	People who work with computers sit in front of a computer screen all day *C
H24.	I would like to learn more about computers B
H25.	I feel unhappy walking into a room filled with computers *A
H26.	Working with computers means working on your own, without contact with others *C
H27.	If I need computer skills for my career choice, I will develop them B
H28.	I'm no good with computers *A
H29.	To use computers you have to be highly qualified *C
H30.	If my school offered a computer camp I would like to attend it B
H31.	Working with a computer makes me feel very nervous *A
H32.	Using computers prevents me from being creative *C
H33.	I feel threatened when others talk about computers *A
H34.	Computers are confusing *C
H35.	Computers make me feel uncomfortable *A
H36.	You have to be a "brain" to work with computers *C
H37.	I get a sinking feeling when I think of trying to use a computer *A
H38.	Not many people can use computers *C
H39.	Computers frustrate me *A
H40.	People who work with computers make really good money C

* reverse scoring; + change scoring for boys; A affective; B behavioural; C cognitive items

5

Methodological Considerations when Analysing Data

The diverse range of research questions under investigation and the longitudinal and hierarchical design of this study, mean that it is unlikely that a single method of analysis is suitable for addressing and resolving all the issues raised. To do so, would undoubtedly lead to misleading findings, and overlook the complexity and detail captured within the data. Therefore, it is of primary importance to undertake an appraisal of the different data analysis methods and identify those procedures that are appropriate for testing and analysing the propositions forwarded in this study. The purpose of this chapter is to do just that.

The propositions of this study, advanced in Chapter 4, necessitate that several methods of analysis are required, and so, different statistical software packages need to be employed. When assessing the appropriateness of individual analytic methods and their application, some general methodological issues need to be considered. These considerations pertain to the treatment of missing values, the notion of causality, significance testing in social research, and analysis of multi-level data. This chapter addresses in detail these four aspects in the context of the data analytic techniques employed, namely, NORM, SPSS, WesVarPC, AMOS and HLM.

Dealing with Missing Values

In many areas of research and evaluation, the occurrence of missing data is commonplace (Kline, 1998; Raaijmakers, 1999). Unavoidable response losses can occur through technical failure, overlooked items, participant absenteeism, poor time management, or mid-study commencements or departures. The use of the internet in this study to administer and collect the data via online survey, runs the risk of data loss due to computer network conflicts, in which case any participant completing a survey may be unable to send their responses. Participants can inadvertently miss an item, or choose not to answer on ethical or personal grounds. Participants may also be absent during the collection period or submit an incomplete survey if they needed more than the allotted time. In longitudinal studies, such as this, transient participants may come into the project late or drop out early, resulting in missing occasions.

There are several concerns caused by incomplete data. Missing data may undermine the reliability of the statistics calculated because there is less information than originally intended. Another concern is that the assumptions behind many statistical procedures, like those employed in this study, are based on complete cases, and missing values can complicate the theory required. A complete data set overcomes these concerns and simplifies the analysis and interpretation process. However, there are additional considerations when obtaining a complete data set, as discussed below.

Listwise, pairwise, or multiple imputation

Three basic approaches to dealing with missing values include complete case analysis, which requires listwise deletion; available case methods, requiring pairwise deletion; and missing value replacement, which uses methods of imputation (Little and Rubin, 1987). Listwise deletion discards a whole case if missing values are present. If substantial amounts of data are missing from a case and the number of these cases are less than five per cent, then listwise deletion may be effective. However, in multivariate studies such as the current one, where there are large numbers of variables, the risk of a substantial reduction in sample size and considerable information loss, in addition to bias, makes the use of this approach inappropriate.

Pairwise deletion overcomes some of the failings of listwise deletion by using all cases for a particular variable when present. The disadvantage, however, is that the sample size changes from variable to variable depending on the pattern of missing data.

Replacement of missing values also has its problems. Substitution using means distorts covariance and reduces variance, while regression substitution tends to inflate variance away from zero (Schafer, 1997). With recent advancements in the development of software designed to impute missing data, however, many of these problems have been overcome. In particular, the use of multiple imputations overcomes the systematic underestimation of the variance estimates that occur with single imputation methods (Little and Rubin, 1987; Schafer and Olsen, 1998).

The use of multiple imputation with NORM

> Multiple imputation is a technique that replaces each missing or deficient value with two or more acceptable values representing a distribution of possibilities; this idea was originally proposed by Rubin (1977, 1978). (Rubin, 2004, p.2)

In Rubin’s method for multiple imputed inference, each of the simulated complete datasets is analysed by standard methods, and the resulting estimates and standard errors are combined to produce estimates and confidence intervals that incorporate missing data uncertainty (Rubin, 2004). One of the main reasons this effective technique has remained largely dormant since its proposal is because of the dearth of appropriate computational tools. However, recent developments in simulation methods, such as the Markov chain Monte Carlo (MCMC) procedure, have been implemented for the purpose of multiple imputations and have resulted in the development of software programs like NORM (Schafer, 1999). With such programs, more complicated models for missing data can be used, increasing the uncertainty built into the estimation (Schafer, 1997). The Rubin and Schafer approaches to multiple imputation have been discussed by many researchers (Rubin, 2004; Schafer, 1997, 1999; Twisk, 2003; Yang, 2000), and are not further detailed here.

Assumptions

As reflected in its name, NORM assumes that multivariate normality can be used, or in other words, each variable in the dataset is normally distributed (Schafer, 1999). In order to support the use of multiple imputation as an appropriate method in the replacement of missing data in this study, each variable is first tested for a normal distribution (see Chapter 7). The procedure by which NORM imputes missing data, as used in this study, is detailed next.

Preparing the data

NORM only accepts data in ASCII (tab-delimited text) format and expects the file to be named following the 8.3 convention. The 8.3 rule means that filenames should be no more than eight alphanumeric characters long, followed by a dot and three characters, in this case 'dat', which indicates the file type. The data should consist of rows of unique cases and columns of variables, where each score is separated by a space or tab. Missing values must be denoted, not by a blank space or period, but by a single numeric code, such as -99, that would not otherwise appear in the natural range of possible values for all the variables. Otherwise some non-missing values might accidentally be interpreted as missing. Additional considerations are that each case, or line of data, should be no more than 2000 characters in length, and non-numeric or text characters, like variable names, are not permitted and must be removed prior to using NORM.

One important limitation of the NORM procedure is that it does not preserve interactions among variables. Since this study does involve analysing interactions between, for example, participants in different schools, special measures are needed. In order to ensure that the interactions of interest are preserved during the imputations, the datasets need to be split by school. Imputing the resulting files separately, then, preserves all interactions involving school.

The multiple imputations procedure

Upon opening the NORM program and starting a new session, the missing value code can be entered and variables can be managed under the 'variables' tab. In this window, variable names are edited and variables are selected for the model and for writing to the imputed files, transformations can be applied, and rounding of the variable can be specified, along with examining the distribution. When NORM creates an imputed dataset (*.imp file), it is the combination of rounding variables to a specified decimal place (or integer) and the use of transformations, when data are not normally distributed, that generate imputed values resembling the observed data.

The next step in creating an imputed dataset involves the use of the expectation-maximisation (EM) algorithm, which is a general method for obtaining maximum-likelihood estimates of parameters from incomplete data. It can be found under the 'EM algorithm' tab. EM iterates between the E-step, which replaces missing statistics by their expected values given the observed data using estimated values for the parameters, and the M-step, which updates the parameters by their maximum-likelihood estimates, given the statistics obtained from the E-step (Schafer, 1997). In order to provide good starting values for the data augmentation (DA) used to create imputations, and to support in predicting the likely convergence behaviour of DA, it is common practice to run EM first.

The final step required to impute the missing data uses the DA algorithm, which simulates random values of parameters and missing data from their posterior distribution. This special form of the MCMC method is the procedure by which NORM creates proper multiple imputations for the missing data (Schafer, 1999). Under the 'Data augmentation' tab, the number of computed iterations, k, is set. By setting k large enough to ensure convergence, any number of proper multiple imputations can be produced. For example if k is set to 125 and an imputation is set for every 25th iteration, then five imputed versions of the dataset (*.imp) are created, along with an output file (*.out), reporting the results of DA, and a parameter file (*.prm), which stores the simulated values of the parameter. In most cases, the generation of five imputed files is sufficient to ensure good results.

Once the five imputed data files are obtained, they can be manipulated and analysed using any other statistics package. The usual practice is to combine the five imputed files back into a single set of results. Microsoft Excel is well suited for this purpose by importing each file into a separate worksheet. A sixth worksheet contains a simple formula that averages and rounds each cell of the five data arrays to produce a single set of data, ready for subsequent analysis.

Causal Inference between Factors

The foundations of this study are grounded on the notion of causal inference. Causality operates whenever the occurrence of one event, for example a changing school climate, infers the outcome of another event, such as change in students' attitudes towards school. A simple definition of cause and effect is given by Vogt (1993, p.31).

> To attribute cause, for X to cause Y, three conditions are necessary (but not sufficient): (1) X must precede Y; (2) X and Y must co vary; (3) no rival explanations account for the covariance between X and Y.

Clearly, the longitudinal nature of this study meets the first condition. As ICT are increasingly embedded into the learning environment (the cause), measurement on three separate occasions of the changing environment should show changes in the students within it (the effect). The second condition requires that there is a plausible relationship between the cause and effect. Since the students being tested attend the schools undergoing change, there is a direct and logical relationship between them. Whether or not change in the presumed cause (the schools) is associated with the change in the effect (the students), will be confirmed using statistical methods. In order to meet the third condition, the measurement of many possible interrelated factors, from school, teachers, students and the home environment, increases the likelihood of correctly attributing the cause to the effect, by testing all possibilities. This argument is supported by Tuijnman and Keeves (1994, pp.4340-4341):

> The function and purpose of the causal models, which are used in path analysis and structural equation modelling, are to specify as fully as possible the interrelations between variables so that appropriate statistical control might be employed.

However, with the measurement of as many interrelated factors as possible, comes the challenging task of data management and analysis. The software program, SPSS for Windows (Pallant, 2001; SPSS, 2001), provides a powerful statistical analysis and data management system in a graphical environment. The facility to conduct factor analysis and cluster analysis is of key importance in this study, and these are described next.

The use of SPSS for factor analysis

> Factor analysis allows you to condense a large set of variables or scale items down to a smaller, more manageable number of dimensions or factors. It does this by summarising the underlying patterns of correlations and looking for 'clumps' or groups of closely related items. This technique is often used when developing scales and measures, to identify the underlying structure. (Pallant, 2001, p.91)

With more than 150 items in the student survey and around 100 items in the teacher survey, the use of factor analysis in this study was essential, particularly since it also fulfilled the requirements of a suitable dataset, namely, sufficient sample size and strength of the relationship among items (Pallant, 2001). At least 300 cases is recommended by Tabachnick and Fidell (1996), but these authors concede that smaller sample sizes are adequate if correlations are strong and the factors are distinct. By targeting six schools in this study, it was anticipated that responses from about 300 teachers and approximately 3000 students would be received. The strength of intercorrelations among items is assessed in SPSS using Barlett's test of sphericity (Bartlett, 1954) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974).

Factor extraction involves determining the smallest number of factors that best represents the inter-relations among a set of items. Although there are a variety of approaches that can be used to identify the number of underlying dimensions, the most common technique, and the approach used in this study, is principal component analysis (Ferguson and Takane, 1989).

In determining the number of factors to retain, an exploratory approach is generally adopted, determined by Kaiser's criterion and the scree test (Tabachnick and Fidell, 1996). Kaiser's criterion, or the eigenvalue rule, calls for selections of only those factors with eigenvalues greater than one, and is a default setting in SPSS. The eigenvalue of a factor represents the amount of total variance explained by that factor (Pallant, 2001). Catell's scree test (Catell, 1966) plots each successive eigenvalue on a graph. The point at which the shape of the curve changes direction and approaches horizontal indicates the number of factors to retain, as they contribute most to the explanation of variance in the dataset.

The use of rotation, which applies a transformation to the initial factor matrix, differentiates factors from one another and makes them easier to interpret. The most commonly used of all the rotation methods, orthogonal and oblique, and the one adopted in this study, is Varimax rotation, which minimises the number of items with high loadings on each factor (Pallant, 2001).

The use of SPSS for cluster analysis

> Cluster analysis is a generic name for a variety of mathematical methods, numbering in the hundreds, that can be used to find out which objects in a set are similar. (Romesburg, 2004, p.2)

The hierarchical cluster analysis procedure attempts to identify relatively homogeneous groups of cases based on selected characteristics, using an algorithm that starts with each variable in a separate cluster and combines clusters until only one is left. During the process, matrices are compared by unstringing them into lists and then computing a pairwise measure of resemblance between them. The most commonly used measure is the Pearson product-moment correlation coefficient with between-group linkage. An inspection of the resulting dendrogram plot allows clusters to be identified. In this study, the main use of the hierarchical cluster analysis procedure is to identify clusters of latent variables to form manifest variables.

Testing for Significance

Measuring the effect of a cause in longitudinal educational studies, such as this, generally requires the testing of difference or change. Of concern to this study, for example, is to determine to what extent students' attitudes towards school have changed. But a more important question is whether the difference is real or could be reasonably attributed to chance? Comparison of within and between group differences raises such questions, which take into account the statistical significance of findings.

Design effects in complex samples

The most widely used method in social research for determining significance is the t-test (Hair et al., 1995). Much to the concern of Tuijnman and Keeves (1994), the widespread but inappropriate reliance of researchers on significance tests assumes a simple random sample when most studies do not follow such a design. The design of this study is one such example of a complex sample, where design effects take place due to the nested nature of students within schools. Brick et al. (1997) further argue that there is generally no easy way to approximate unbiased and design-consistent estimates of variance analytically when complex samples are involved. However, some techniques do attempt to overcome complex sample characteristics. The software program WesVarPC utilises a class of techniques called 'replication methods' for estimating variances for complex sample designs, and accordingly this program is the preliminary method employed in this study for testing the significance of differences.

The use of WestVarPC

In sample surveys with complex designs or estimation methods, standard statistical software cannot produce both unbiased point estimates and appropriate standard errors of the estimates. Special methods and software are needed to avoid the biases that arise when statistical software assumes that the data are independent and identically distributed. WesVarPC is a software package that computes estimates and replicates variance estimates from survey data collected using complex sampling and estimation procedures (Brick et al., 1997; Morganstein and Brick, 1996). Replication methods are well suited to handling complex designs and estimation procedures, and WesVarPC is the only program to date that uses the replication method for variance estimation (Brick et al., 2000).

Using WesVarPC, a dataset is first imported, usually from SPSS, by selecting the identifier (such as school ID), the variables to be compared, and the replicate method, which for this study uses the first Jackknife method. The Jackknife 1 (JK1) method is applied when the sample selected consists of clusters rather than individual units. Next, the 'tables' menu is used to specify statistics to be computed along with their sampling errors. Preferences allow one to customise features in the output file, in order to test for significance in the multilevel data using the t-test probability.

Analysis of Multi-Level Data

The nesting of students and teachers within schools and the longitudinal design of the study, results in the gathering of information from students on three separate occasions, from teachers on one occasion, and from schools informed by secondary data sources. Potentially, this procedure has the characteristics of information obtained at four different levels, that of the individual student level, the between-student level, the teacher level, and the school level. However, there are effectively only three levels in the design of this study. Although students are nested within classes and could be linked to teachers, the realities of doing so in a longitudinal and cross-setting study, such as this, make it difficult and unsound for two reasons. First, students in primary and secondary school are taught by different teachers from year to year. Second, while primary school students do generally have the same teacher for the entire year, secondary school students have many teachers, one for each subject, during a year. The underlying reasoning in linking students with teachers assumes that teachers may influence student outcomes, but this causal relationship can only be tested if a class of students is influenced by a single teacher. Clearly, the design of this study does not support the analysis of students linked to teachers: the result is a three-level study comprising the within-student level, the between-student and between-teacher level, and the school level.

In examining multi-level data, care must be taken to employ the correct analytical techniques, particularly if data from different levels are combined into one single-level model. Failing to do so may result in bias and incorrect estimates of error due to the aggregation of lower-level data or the disaggregation of higher-level data onto the same level (Snijders and Bosker, 1999). Although it would be possible to form a single-level model containing the student, teacher and school level data, the complexity of such a model, and the bias introduced by the manipulation of data to a single level, would appear to achieve little. Such an examination seems further counterproductive, when more appropriate statistical techniques are available for handling multi-level data. Two such techniques include structural equation modelling or path analysis and hierarchical linear modelling.

In order to avoid such bias and inaccuracies, the examination of the complete system in a single model, by including data obtained from the school, teacher and student levels, is done using the HLM program (Bryk and Raudenbush, 1992). But only to examine a complex system of interrelated factors as a whole, can result in the loss of important and interesting detail. Therefore the formation and examination of the student and teacher data as two single-level path models in isolation is carried out using the AMOS statistical program (Arbuckle and Wothke, 1999).

The use of AMOS for path analysis

Path analysis or structural equation modelling is a statistical methodology that takes a hypothesis-testing approach by examining a series of dependence relationships simultaneously. According to Byrne (2001, p.3):

> The term *structural equation modelling* conveys two important aspects of the procedure: (a) that the causal processes under study are presented by a series of structural (i.e. regression) equations, and (b) that these structural relations can be modelled pictorially to enable a clearer conceptualization of the theory under study.

When estimating structural equation models using maximum likelihood procedures, AMOS (Arbuckle and Wothke, 1999) depends on certain statistical distribution assumptions that are generally met by this study. First, observations must be independent, and second, the exogenous variables must meet certain distributional requirements, like having a multivariate normal distribution (Arbuckle and Wothke, 1999). Exogenous variables are synonymous with independent variables so that changes in their value are not explained by the model. Background variables, such as age, gender and teaching experience are examples of exogenous factors. Endogenous variables, on the other hand, are synonymous with dependent variables and are influenced by exogenous variables in the model, either directly or indirectly (Byrne, 2001). In a causal relationship, the dependent and independent variables are determined by theory, prior experience, or other guidelines that allow the researcher to distinguish which independent variables predict each dependent variable. In order to specify these relationships, AMOS provides two systems of approach, namely AMOS Basic and AMOS Graphics. The Basic version is macro driven and suitable for simplifying many specialised modelling tasks. The approach used in this study employs AMOS Graphics, which has a user-friendly graphical interface that literally allows the model to be built progressively.

Building the model

The ease with which path diagrams can be drawn using AMOS Graphics, belies the true complexity of the relationships being modelled. The graphical menu contains the necessary components and tools for specifying a model. Observed or manifest variables are represented by rectangles, and unobserved or latent variables are represented by ellipses. The error term, represented by a circle, indicates it is a latent error. Causal relationships between variables are represented by path lines with a single arrowhead. An exogenous variable, therefore, only has paths departing from it, whereas an endogenous variable has paths entering and leaving it.

In specifying the model and the datasets to be used, an additional feature in AMOS, employed in this study, allows sub-groups to be analysed simultaneously in the one model. The student dataset, for example, contains responses on three separate occasions. Within the same path model, groups can be created, one for each occasion, which include in the analysis only the data pertaining to the particular occasion. Further flexibility in the program, found under interface properties, provides control over whether or not different groups have different path diagrams.

Trimming the model

When the calculations are completed in AMOS, two forms of output are produced, namely text output and graphic output. The text output file, in XHTML format, provides interactive control over the appearance of tables, which can then be copied into other applications, such as Microsoft Excel or Word. The graphics output, presents standardised and unstandardised regression estimates for each path on the path diagram.

While inspection of the path diagram provides an intuitive and aesthetic understanding of the causal relationships, the text output provides the actual information on which judgments can be based. By inspecting critical ratios, levels of significance, and magnitudes, paths can be assessed for their significance and trimmed if they do not meet pre-determined criteria. In this study, the criteria for trimming paths are based on a significance level of 0.05 and a minimum cut-off magnitude of the standardised regression estimate of 0.1. Modification indices provide additional assistance in optimising a model by suggesting the reinstatement of paths likely to be significant, but this is only available if the dataset is complete. Caution, however, is required when assessing modifications indices so that only modifications that make theoretical and common sense are considered (Arbuckle and Wothke, 1995). The removal and replacement of paths should be a systematic and iterative process, requiring many runs and repeated inspections, in order to obtain an optimal model with an acceptable goodness of fit.

The use of HLM for hierarchical linear modelling

The Hierarchical Linear Modelling (HLM Version 5) software program (Bryk and Raudenbush, 1992) attempts to take into consideration the hierarchical nature of complex multilevel data, resulting from nested samples like the one used in this study. In HLM, each level in the nested structure is formally represented by its own sub-model. Raudenbush and Bryk (1994, p.7) explain that "these sub-models express relationships among variables within a given level, and specify how variables at one level influence relations occurring at another".

According to Raudenbush and Bryk (1994; 2002), the advantages that HLM has over single-level techniques, involve its ability to improve the estimation of individual effects, to formulate and test cross-level effects, and to partition variance and covariance components among levels of analysis. For these reasons, HLM was employed in this study.

Like the other analytic techniques discussed in this chapter, HLM also assumes an underlying model that is normal and linear. The model consists of a structural component, which is based on a standard linear function of the regression coefficients, and a random component, which assumes independent errors with equal variance (Bryk and Raudenbush, 1992). In this study, the structural component of the model requires the use of latent variables. However, the construction of latent variables, similar to those formed in the path analysis, is currently beyond the capabilities of HLM. In order to overcome this obstacle, the construction of latent variables outside HLM, using principal components analysis within SPSS, provides an effective solution.

Building a three-level model

When building a three-level model using the HLM program, three stages are typically involved (Raudenbush, Bryk and Congdon, 2000). The first stage requires the construction of the sufficient statistics matrix (SSM) file. This preparatory process involves assigning the appropriate raw data file to each level, linked by a common unit of identification. If, for example, Levels 1, 2 and 3 were assigned the data files containing occasion (within-student), student (between-student, within-school), and school (between-school), respectively, then the linking unit would be school ID. Once the SSM file is created, it provides the input for all subsequent analyses.

The second stage involves the execution of analyses based on the SSM file, or in other words, specifying the model. Using the Windows mode in HLM, model construction requires five steps, which include specifying:

1. the Level 1 model by selecting the outcome (alone provides the fully-unconditional model) and any predictors that then become the intercept and slope,
2. the Level 2 prediction model, where each Level 1 predictor becomes a Level 2 outcome variable that, in principle, describes the distribution of growth curves,
3. Level 1 coefficients as random or non-random across Level 2 units,
4. the Level 3 prediction model, where each Level 2 coefficient becomes an outcome and Level 3 variables are selected to predict between-school variation in the Level 2 coefficients, and
5. Level 2 coefficients as random or non-random across Level 3 units.

The last stage in building a three-level model evaluates the fitted models based on residual files. HLM produces two residual files, one at Level 2 and one at Level 3, both containing estimates of the respective outcome variables, along with empirical Bayes residuals, fitted values, and ordinary least square residuals.

Optimising the model

Inspection of the output text file at each stage of model development, provides estimates of the proportion of variance associated with each level, captioned by 'Final estimation of variance components'. Comparison between these values, at incremental stages of the model's development, with values from the fully-unconditional model can provide an indication of the amount of variance explained by the predictor variables at each level. The objective during this developmental process is to arrive at a final model that explains as much variance as possible.

Deviance also needs to be regularly examined, since it is used to compare the goodness-of-fit between models. As the number of estimated parameters rises, the deviance should be seen to reduce, providing the addition of each parameter is appropriate.

In deciding on parameters to retain, inspection of the table captioned 'Final estimation of fixed effects' after each addition, provides guidance. Examination of the t-ratio indicates the significance of the gamma coefficient, which in effect is the metric path coefficient. Those predictors with an absolute t-ratio below 2.00 and a p-value in excess of 0.1 are deemed non-significant and should not be retained in the model. Although a significance level of 5 per cent would be optimal, the 10 per cent level was chosen in order to support the development of more meaningful models.

Summary

Important methodological issues are addressed in this chapter that inform the way in which the data collected for this study is approached and analysed. These issues pertain to the treatment of missing values, the notion of causality, significance testing in social research, and analysis of multi-level data. In responding to these concerns, analytic methods sensitive to the issues are explored, accompanied by discussions about the associated statistical software programs.

The treatment of missing data is most effectively achieved using NORM and the method of multiple imputations. The discussion on causal inference, a cornerstone of this study, highlights the importance of measuring an interrelated system as a whole, resulting in large numbers of variables and the need for factor and cluster analysis using SPSS. The longitudinal and nested aspects of this study raise the issue of design effects in complex samples and the merits using WesVarPC for testing the significance of difference.

In the final section, issues concerning the analysis of multi-level data are addressed. In order to optimise the entire dataset, but not at the expense of detail, two methods of analysis are necessary. AMOS was selected for its ability to conduct single-level path analysis and show interaction effects between factors within levels, while HLM was chosen for its ability to conduct multi-level analysis and reveal the interaction effects between factors across levels.

In addressing these methodological issues, the subsequent analyses undertaken in the remaining chapters of this project, present a state-of-the-art approach to understanding the impact on students and teachers of embedding ICT into the learning environment.

6

Preparation of the Data

This chapter describes the numerous steps involved in preparing the raw data for subsequent analysis, from matching and coding responses to imputing missing data, testing validity and reliability, as well as the development of factors. More importantly, this chapter examines the factors that form the basis from which the student and teacher models described in Chapters 10 and 11 are constructed.

Data Preparation

With data collected involving teachers and students in six schools and spanning three years, the task of preparing the data for subsequent analysis was not unchallenging. The raw data sets involved the management of 96 separate files in total, sub-divided by school, teacher or student, occasion, and questionnaire section. Initial preparation of the raw files required conversion from tab-delimited text files generated in the online data collection process, into Microsoft Excel files. The resulting data sets consisted of rows and columns in the form of rectangular matrices. Each row of the data matrix corresponded to a case, which consisted of columns representing responses to the questionnaire items for each case. The raw data files were scrutinised and cleaned for spurious cases that might arise, most commonly, from administrative testing or, less frequently, from respondent error or misuse. The files were then reconstituted by manually matching cases within schools, across surveys and occasions, to form two raw data files that contained the entire responses from students and teachers taking part in the study over the three years. Schools and participants were coded and further cleaning of the data was undertaken, such as rescoring reversed items and recoding nominal data.

Prior to undertaking any analysis, it was necessary to evaluate the data’s completeness using screening procedures that involve an examination of descriptive statistics and frequency distributions (Kline, 1998), as explained in the following sections.

Response rates and types of missing data

Notwithstanding the careful selection of each school and the encouragement and support given during the administration of the surveys, in order to ensure that as complete as possible a sample of the relevant student population and the entire teaching population could be obtained, unavoidable response losses occurred, through technical failure, student and teacher absenteeism, mid-study commencements or departures, or poor time management on behalf of the respondents. In order to determine a response rate, the responses received were calculated against the official population numbers reported in School Context Statements, available for every South Australian school on the Department of Education web site. Table 6.6 details the student and teacher response rates in each school and contrasts the reported population against the responses received, being mindful that some students were present in all three years of the study, while others were present for two years, and others still for just one year, because they finished the respective levels of schooling.

Table 6.6 Response rates of students and teachers in each primary and secondary school across all three years

	Student (Years 5 to 10)			Teacher (All)		
SCHID	**Population**	**Responses**	**Rate**	**Population**	**Responses**	**Rate**
P1	157	156	100%	28	28	100%
P2	228	224	98%	39	26	67%
P3	408	391	96%	47	36	77%
P4	242	230	95%	34	20	59%
Primary	1034	1001	97%	148	110	76%
S1	718	695	97%	72	67	93%
S2	1206	931	77%	117	94	80%
Secondary	1924	1626	87%	189	161	87%
Total	2958	2627	94%	337	271	79%

Response rates from the student cohort across the primary sector and in the first of the secondary schools are all above 95 per cent. Secondary school S2 achieved a response rate of only 77 per cent; it was the largest of the schools and found it more challenging to ensure that all students had the opportunity to complete the surveys on the three occasions. Unfortunately the response rates were not as complete in the teacher cohort. The first primary school achieved a full return, whereas the fourth primary school, with a higher temporary teaching population, only managed a response rate of 59 per cent. Across the secondary schools, an overall response from teachers of 87 per cent is deemed acceptable.

The preliminary preparation of teacher data was reasonably straightforward, since teachers were only required to respond on one occasion, so matching them across occasions to establish missing cases was unnecessary. Nonetheless, a cursory comparison of teacher ID was undertaken, in case any teachers did respond on more than one occasion. The few occurrences of multiple responses by individuals that were found were averaged. With a tolerable response rate of 79 per cent, slightly lower than the widely used requirement of 85 per cent (Rosier and Ross, 1992), the resulting raw data set consisted of responses from 271 teachers.

However, the complexity of the student cohorts and their responses to the student questionnaire on the three occasions, was another matter. Moreover, this complexity was compounded by the problem that some students did not complete the survey on a particular occasion. So that although there was acceptable representation of students, based on 2627 cases (shown in bold in Figure 6.1) with a response rate of 94 per cent, within this sample, three per cent of cases had missing occasions and others had missing sections and items. For clarity, Figure 6.1 illustrates the diagonal configuration of the student groups as students track across year-levels and occasions.

For example, the same group of students in Year 5 on the first occasion were expected to complete surveys on the following two occasions in Year 6 and then Year 7. The total number of students in each group is also presented in Figure 6.1. With reference to the same example, 224 students were expected to complete the surveys on three occasions. However, not all students completed the expected number of surveys: Figure 6.1 shows that nine students did not complete the first occasion, six students missed the second occasion, and eight students failed to submit on the third occasion. The configuration of this missing data does not necessarily mean that they came from different students, but that some of those missing responses could have come from the same students. Consequently, some students responded on only one or two of the three occasions. Therefore, from 2627 students, 5011 responses were expected but only 4884 were received. In the cases where groups only had one opportunity to participate, there are effectively no missing data.

	STUDENT GROUPS			**MISSING OCCASIONS**			**FINAL GROUPS**		
	Occ1	**Occ2**	**Occ3**	**Occ1**	**Occ2**	**Occ3**	**Occ1**	**Occ2**	**Occ3**
Yr 5	**224**	**203**	**160**	9	3	0	216	196	160
Yr 6	**228**	224	203	4	6	7	222	216	196
Yr 7	**186**	228	224	0	9	8	184	222	216
Yr 8	**393**	**397**	**317**	14	6	0	378	388	312
Yr 9	**322**	393	397	10	19	4	309	378	388
Yr 10	**197**	322	393	0	11	17	195	309	378
N	5011 responses			127 missing			4863 resolved		

Figure 6.1 The student groups arranged by year-level and occasion, in together with the number of missing occasions

In addition to missing occasions, which occurred when a student was absent during the collection period, three other types of missing data were identified in both the student and teacher raw data sets. The first kind involved isolated omitted items, where respondents either inadvertently missed an item or chose not to respond for personal reasons. The second type was identified as being an incomplete section if less than 25 per cent was missing. Such cases usually arose when students or teachers ran out of time before completing the section and were instructed to submit an incomplete survey rather than not at all. The third kind of missing data occurred when more than 25 per cent of a section or the entire section was missing. This usually resulted from a respondent inadvertently missing a section, or far less frequently, from a server crashing during the transfer of data, so that only some or none of the survey was received.

Treatment of missing data

A multiple imputation procedure, rather than mean replacement, was used to estimate and replace missing data. Using multiple imputation maintains the variance without introducing bias, and while the mean does not introduce bias it does influence variance. The Windows based program, NORM (Darmawan, 2002; Schafer, 1999), employed in the analysis, and the imputation method, are described in Chapter 5.

In preparing the data for analysis, the aim was to retain as many complete cases as possible. Accordingly, the data sets containing 271 teacher and 4884 student responses were prepared for imputation by deconstructing the cases into survey sections and removing any cases that were identified as having more than 25 per cent missing. The proportion of missing values for each item was less than 16 per cent, which according to Kline (1998) is acceptable. The incomplete data sets were each imputed five times using the NORM program and then averaged to produce the final complete data sets. These were then reconstructed back into the teacher and student databases to form data sets that had no missing data of the first or second type, but did have some missing sections and occasions. Those cases that had missing sections or occasions, constituted only three per cent of students and seven per cent of teachers, and were removed. The resulting student database of 2560 participants with 4863 responses and no missing data was used in the subsequent analyses conducted in this study. The complete teacher database of 252 responses, however, required one last modification before it was ready for further testing and analysis.

A teacher subset

Since only the students in upper primary and lower secondary schools were surveyed, then only the teachers involved in teaching these students, during the three years, needed to be considered. In order to establish the subgroup of teachers, a question in the teacher survey asked teachers to indicate the year levels they were teaching. The choices ranged from Reception (R) through to Year 12, with teachers teaching more than one year-level in most cases. For example, a middle school teacher in a primary school might teach Years 5 and 6; clearly teaching those students involved in the target sample. However, some teachers might teach other year-level combinations, such as Years 3 and 5. Since one of their classes was involved the student sample, they were included in the teacher subgroup. In this way, some 33 junior primary and senior secondary teachers who did not teach middle school students were not considered in the present study. Accordingly, the complete teacher database consisting of 219 responses was used in the subsequent analysis.

Testing for Validity

The validity of a value is a descriptive term used to indicate how accurately the recorded values reflect the concept being measured. Burns (1998) describes five types of validity, which include predictive, concurrent, content, construct and face validity. From a research point of view, construct validity is generally considered most important, and is the type of validity employed in this study. Construct validity refers to the degree to which inferences can legitimately be made from the measures being studied to the theoretical constructs on which those measures are based (Trochim, 2000). Factor analytic techniques have been widely used, especially in the behavioural sciences, to assess the construct validity of a measure. The technique examines whether items considered to represent a particular construct have a stronger or preferred factor loadings on one construct compared to all others (Stevens, 1996).

In this study, all items representing one or more of the research constructs, for example, student self-esteem, were subjected to exploratory factor analysis (EFA) using principal component analysis with varimax rotation. Although a pre-existing measure like student self-esteem was originally designed with the constructs of general, social, academic, and parent self-esteem components, it was not presumed that these constructs were necessarily valid for the students in this study. Given the age of this and the other pre-existing scales, it was important that these measures were tested for validity using factor analysis to confirm that they were still relevant tools and measured what they purported to measure. It was equally important that the purpose-designed scales in this study were also tested. In identifying the factors, four commonly employed rules were followed: a) retain only factors whose eigenvalues were greater than 1.0; b) retain only items with a minimum factor loading of 0.30; c) remove items with loadings above 0.50 on two or more factors; and d) remove factors with only one item. For the purposes of validating the measures, the constructs derived from principal component factor analysis are presented in the following section. More importantly, though, the factors developed in this chapter form the basic units of measurement from which the student and teacher models are constructed in Chapters 10 and 11.

Factor Analysis

The instruments employed to collect the teacher and student attitudinal data comprised a combination of self-developed and pre-existing tools, assembled into a set of teacher and student questionnaires, detailed in Chapter 5. Based on this arrangement and the sub-structures within them, the items were tested using exploratory factor analysis. The method for doing so was an iterative process where whole sections of surveys were analysed and then reanalysed, gradually removing poorly fitting items until clear factors emerged. When the inclusion or exclusion of items was not clear, additional strategies were employed, chiefly that of hierarchical cluster analysis. The cluster analysis procedure identifies relatively homogeneous items using, in this case, between-group linkage and Pearson correlation, to produce dendrogram plots. The use of cluster analysis provided an additional way of viewing the arrangement of items and confirmed the results of the factors analysis. Both factor and cluster analyses were conducted using the SPSS program (Pallant, 2001).

In order to test for factorability, the Kaiser-Meyer-Olkin (KMO) index of sampling adequacy and Bartlett’s test of sphericity were used. Tabachnick and Fidell (1996) have recommended a correlation coefficient of 0.3, a KMO index above 0.6 and Bartlett’s p-value less than 0.5 as appropriate for factor analysis. This study employed both Kaiser’s criterion (eigenvalue above 1.0) and scree test for factor extraction or determining the smallest number of factors to best represent the inter-relations among the set of variables. The Kaiser criterion has been recommended in situations where the number of variables is less than 30 or when the number of respondents is greater than 250 (Stevens, 1996). All factorial scales had a KMO index greater than 0.6 and Bartlett’s p-value less than 0.5, indicating that factor analysis was appropriate. The resulting loading plots from the exploratory factor analysis are presented to guide and support the discussion of each factor formation.

Teachers’ intended use of computer applications in the classroom

In order to examine teachers’ intentional computer use and intended learning objectives, two scales were specifically developed for this study. Although in the development of these scales there was no intentional cross matching of ICT use with learning objectives, a factor analysis of both combined scales was conducted to examine the extent to which items interrelated in order to resolve the most appropriate factors. Given the nature and diversity of the items, it was not surprising to find little correlation between the two scales. However, one item from each scale, both pertaining to email communication, was found to have strong intercorrelation. The item, H4, from the second scale had stronger correlations with items from the first scale and was examined in that context. Accordingly, factor analysis of 10 items, including Item H4, resulted in a KMO index of 0.71 and a clear distinction between the types of application into three groups. Broadly, they are described as open learning (*appopn*), focused learning (*appfoc*), and communication environments (*appcom*). Figure 6.2 presents the component plot and Table 6.2 summarises the items and their factor loadings.

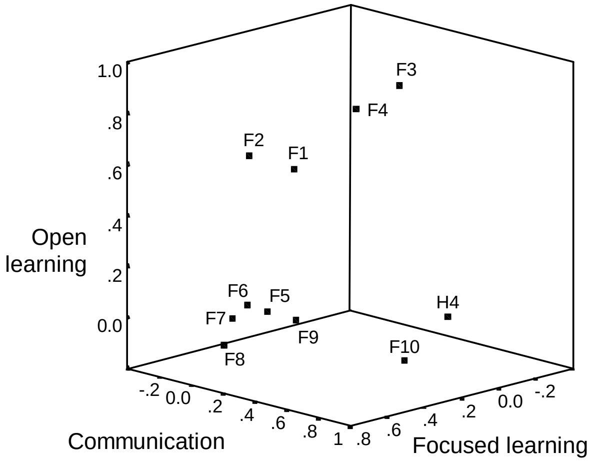


Figure 6.2 The component plot for teachers' intended use of computer applications in the classroom

The first four applications presented in the scale and summarised in Table 6.2 clustered together and broadly came under the umbrella of open learning environments (*appopn*). These items included skill development games, simulation environments, knowledge-based environments and word processing. Five applications, considered to be more explicit in their designed use, grouped together and were described under the banner of focused learning environments (*appfoc*). These applications included packages like Powerpoint, Photoshop, Excel, Hyperstudio, and Internet Explorer. The remaining two items defined the scale of communication environments (*appcom*). The distinction of these two items from the others suggests the importance teachers place on email as a learning outcome.

Table 6.2 Items and their factor loadings for open learning environments (*appopn*), focused learning environments (*appfoc*), and communication environments (*appcom*)

		appopn	***appfoc***	***appcom***
F1	games for practising skills	0.56		
F2	simulations for exploration environments	0.57		
F3	encyclopaedias and other reference materials on CD-ROM	0.79		
F4	word processing	0.73		
F5	software for making presentations		0.66	
F6	graphics oriented printing		0.65	
F7	spreadsheets or database programs		0.62	
F8	multimedia authoring environments		0.66	
F9	World wide web browser		0.58	(0.40)
H4	Communicating electronically with other people			0.81
F10	Electronic mail			0.80

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

Student learning objectives intended by the teacher

In order to gauge teachers' current learning objectives for their students when using computers, a list of 10 items was presented and teachers were invited to select as many or as few as were applicable. Prior to factor analysis, Item H4 was removed to form a separate scale with Item F10, measuring teachers intended teaching of electronic communication. The remaining nine learning objectives underwent factor analysis, which revealed two distinct components by separating the behavioural objectives and the cognitive objectives. The arrangement achieved a KMO index of 0.71. Figure 6.3 presents the components of cognitive and behavioural learning objectives and Table 6.3 details the items and their loadings.

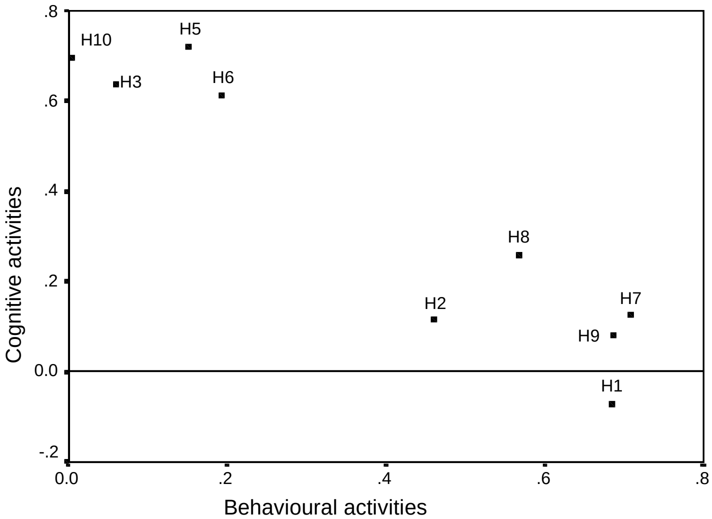


Figure 6.3 The component plot for student learning objectives intended by the teacher along cognitive and behavioural dimensions

Table 6.3 Items and their factor loadings for behavioural learning objectives (*objbeh*) and cognitive learning objectives (*objcog*)

		objbeh	*objcog*
H1	for mastery	0.68	
H2	for remediation	0.46	
H7	improving computer skills	0.71	
H8	learning to work collaboratively	0.57	
H9	learning to work independently	0.69	
H3	finding out about ideas and information		0.64
H5	analysing information		0.72
H6	synthesising and presenting information		0.61
H10	evaluating and selecting the most appropriate resource for the intended audience		0.70

Five of the nine learning objectives related to behavioural aspects of learning (*objbeh*) and included working independently or collaboratively, improving skills and mastery, or using the computer for remediation. Items comprising the scale are presented in Table 6.3. The remaining four items, related to cognitive aspects of learning (*objcog*) and reflect the higher cognitive levels in Blooms Taxonomy of analysing, synthesising and evaluating (Anderson, 1999; Bloom, 1956; Pohl, 2000).

Teachers' ICT use in performing administrative activities

Eight items were developed that asked teachers to identify how often they used the computer when preparing lessons or reporting on students' work. Factor analysis yielded a KMO index of 0.80 and identified two components from the items: those pertaining to regular or general administrative activities (*aagen*) and those considered to be advanced (*aaadv*). The component plot of teachers' ICT use in preparing and reporting is shown in Figure 6.4 and is followed by an explanation of the items that comprise them in Table 6.4.

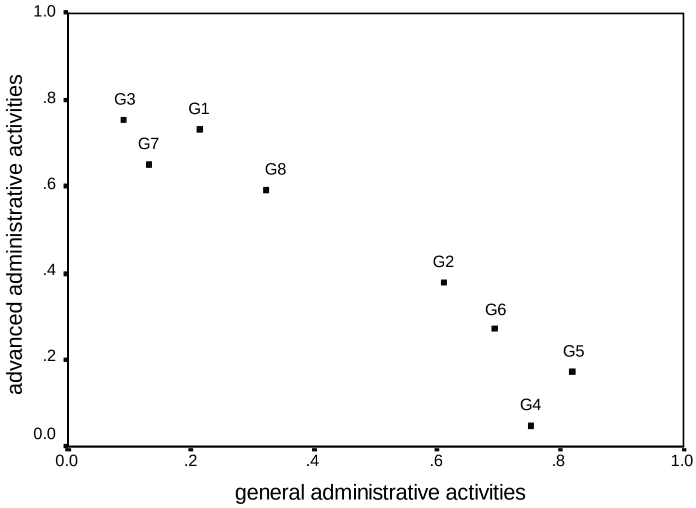


Figure 6.4 The component plot for teachers' ICT use in performing advanced and general administrative activities

Four items in the original scale combined to form an indication of teachers' advanced uses of ICT when it came to preparing lessons or reporting (*aaadv*), and broadly involved the use of the Internet and graphic-rich media. The three items in this scale are presented in Table 6.4. The remaining items were considered to be normal administrative duties (*aagen*) and included activities such as preparing lesson plans, recording students grades, making handouts and sharing ICT based materials.

Table 6.4 Items and their factor loadings for advanced administrative activities (*aaadv*) and general administrative activities (*aagen*)

		aaadv	***aagen***
How often when preparing teaching programs or for reporting purposes do you use computers to:			
G1	get information from the internet for use in lessons	0.73	
G3	use video cameras, digital cameras, scanners to prepare lessons	0.75	
G7	post student work, ideas, resources on the WWW	0.65	
G8	report on students use of learning technologies	0.59	
How often when preparing teaching programs or for reporting purposes do you use computers to:			
G2	write lesson plans or related notes		0.61
G4	record or calculate student grades		0.75
G5	make handouts for students		0.82
G6	exchange computer files with other teachers/students		0.69

The influence of ICT on teaching practice

Factor analysis of 15 items presented under two questions that focused on how teachers' were influenced by ICT, resulted in a KMO index of 0.87 and confirmed that the questions were distinct from each other and that the teaching practice items remained as a group, forming one component (*prac*). The 10 items comprising the second question formed two distinct components that were described as peripheral ICT (*perict*) and computer online access (*wwwpc*). The items comprising the factors are presented in Table 6.5 following their component plot representation shown in Figure 6.5.

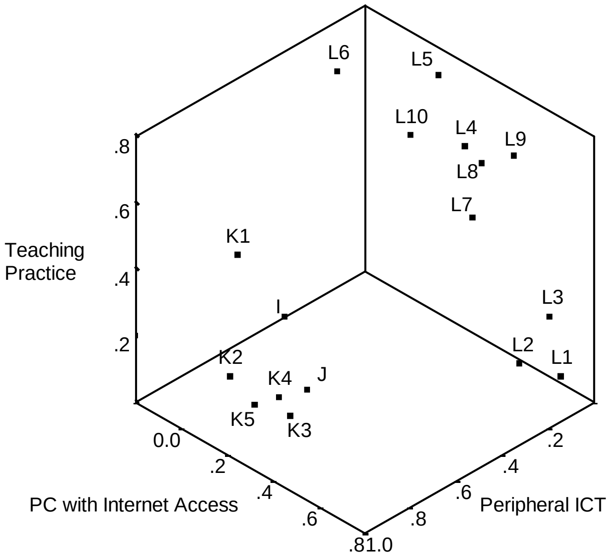


Figure 6.5 The component plot showing the influence of ICT on teaching practice, internet acess, and peripheral ICT

The first item in Table 6.5 designed for this study, examined teachers' encouragement of students' ICT use and was included in the items that explored influences on teaching practice. The next item asked teachers to what extent they incorporated students' use of ICTs in reporting. In addition, five items presented under the question of how learning technologies influence teaching practice, were developed to explore the impact of aspects of teaching practice (*prac*), such as classroom organisation and teaching methods, on students' attitudes. Interestingly, Figure 6.5 shows that the first item, focusing on classroom organisation, appears to relate strongly to teachers' beliefs about peripheral ICT while the remaining items inter-relate to the value teachers' place on computers with Internet access.

Of the ten items that examined the importance that teachers placed on various forms of ICT, three items remained distinct and pertained to student and teacher access to computers with internet capability (*wwwpc*). The three items are presented in Table 6.5 and suggest that teachers considered these to be highly important. The remaining seven items can be described as peripheral ICT (*perict*) and include equipment and software like, scanners and digital cameras, presentation system and software, multimedia authoring software and reference materials.

Teachers' beliefs about improved learning outcomes

Teachers' beliefs about factors influencing students' learning outcomes were another aspect of interest in this study. Eleven items were developed that asked teachers' beliefs about the importance of ICT in influencing issues of teaching practice and student behaviour. Factor analysis of the 11 items resulted in a KMO of 0.64 and the formation of two components, one pertaining to teacher's beliefs about aspects of teaching (*tissus*) and the other relating to teachers' beliefs about student behaviour (*stueff*). The items presented in Figure 6.6 are described in detail in Table 6.6.

Table 6.5 Items and their factor loadings for the influence of ICT on teaching practice (*prac*), online computer access (*wwwpc*), and peripheral ICT access (*perict*)

		prac	*wwwpc*	*perict*
I	Do you encourage your students to use learning technologies?	0.66		
J	To what extent do you incorporate students' use of ICTs in current reporting?	0.58		
How have learning technologies influenced the way you do, or think about the following?				
K1	the way you organise space in your classroom	0.67		
K2	the way you break your class period into activities	0.80		
K3	your beliefs about curriculum priorities	0.77		
K4	your teaching methods	0.80		
K5	your teaching goals	0.84		
In your planning for the use of learning technologies with your students rate the value of the following equipment and software:				
L1	teacher computer with internet connection		0.79	
L2	5+ computers in the vicinity		0.70	
L3	WWW access in the classroom		0.77	
In your planning for the use of learning technologies with your students rate the value of the following equipment and software:				
L4	scanner for photos and graphics		(0.41)	0.69
L5	video camera			0.76
L6	a telephone in you classroom			0.69
L7	a class presentation system (large TV, datashow)			0.50
L8	digital encyclopaedia's and reference works			0.56
L9	presentation software (Powerpoint)		(0.47)	0.62
L10	multimedia authoring software (Hyperstudio)			0.64

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

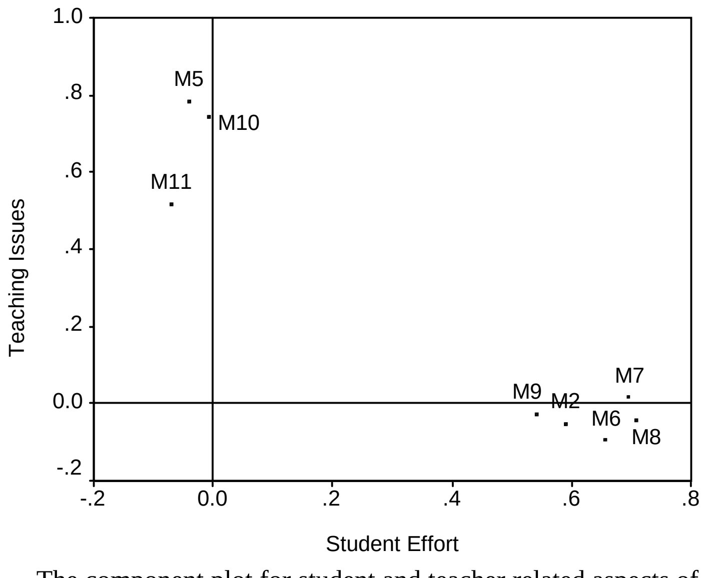


Figure 6.6 The component plot for student and teacher related aspects of improved learning outcomes

Table 6.6 Items and their factor loadings for teachers' beliefs about student effort (*stueff*) and teaching issues (*tissus*)

		stueff	*tissus*
Respond to the following statements in relation to the belief about your use of learning technologies and the influence on the improvement of student learning outcomes.			
M2	Average students are communicating and producing in ways only gifted ones did before	0.59	
M6	Students take more initiatives outside of the class time - doing extra research or polishing their work	0.66	
M7	Students writing quality is better when they use word processing	0.70	
M8	Students work harder at their assignments when they use computers	0.71	
M9	Students are more willing to do second drafts	0.54	
M5	A teacher has to give up too much instructional responsibility to the computer software; I feel I am not really teaching		0.78
M10	It is difficult to integrate computer activities into most of my regular lesson plans		0.74
M11	Too many students need my help at the same time		0.52

Three items, Item M1 (Students create better looking products than they could do with just writing and other traditional media), Item M3 (Computers provide a welcome break for students from more routine learning activities), and Item M4 (Students help one another more while doing computer work), were rejected on the basis of the analysis since they did not load significantly on either factor.

Teacher's confidence and support using ICT

A series of questions were developed that concerned teachers' confidence in using ICT in teaching practice and beliefs about the level of ICT support teachers were given within their school. Factor analysis divided the 15 items into two distinct components with a highly acceptable KMO index of 0.91. Described as teachers' confidence using ICT (*tconf*) and teacher support in using ICT (*tsupp*), the items comprising the two factors are plotted in Figure 6.7 and detailed in Table 6.7.

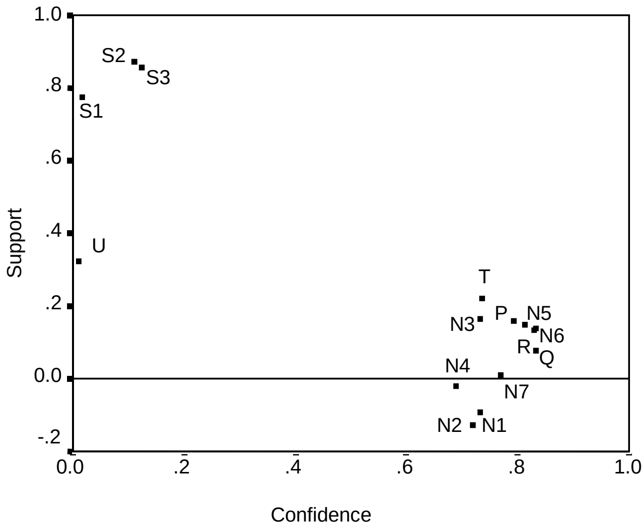


Figure 6.7 The component plot for teacher's confidence and support using ICT

Interestingly, Item T, which asked teachers how much they supported other teachers in using ICT, was strongly associated with confidence (*tconf*) but clearly showed a support component. Although Item U had a weak factor loading on teacher support (*tsupp*), it was clearly aligned with *tsupp*, and with further corroboration from cluster analysis, was retained.

Table 6.7 Items and their factor loadings for teachers' confidence using ICT (*tconf*) and teacher support in using ICT (*tsupp*)

		tconf	*tsupp*
Rate your level of confidence in doing the following tasks with your students:			
N1	manage files	0.73	
N2	create a new database	0.72	
N3	prepare a slide show	0.73	
N4	use a WWW search engine	0.69	
N5	develop a multimedia document	0.81	
N6	manipulate graphics	0.83	
N7	author web pages	0.77	
P	implementing learning technologies in the classroom	0.79	
Q	introducing an unfamiliar learning technology application to your students	0.83	
R	Rate your competence for applying learning technologies with your class	0.83	
T	To what extent do you actively support other teaching staff in the use of learning technologies, their needs and problems?	0.74	
Rate the level of support within your school in the following areas:			
S1	technical/hardware		0.77
S2	adoption of LT		0.87
S3	staff training and PD from other staff		0.86
U	How often do you seek advice from others in the use of learning technologies?		0.32

Teachers' home computer use and confidence in using different computer platforms

When confidence in using different operating platforms was examined against teachers' computer use at home, the arrangement of the six items produced a highly contentious component plot. Yet with a moderate KMO index of 0.73 and further confirmation from the examination of dendrogram plots, it was decided to retain all items comprising the two factors. Accordingly, Windows-based home computer use (*thuse*) was formed as a measure of home computer access and confidence in using other platforms (*oplats*) provided an additional measure of ICT confidence. The two components are presented in Figure 6.8 and the items comprising them are listed in Table 6.8.

The preferred alliance of the Microsoft Windows environments with home computer ownership suggests that the majority of teachers used a Windows-based computer at home.

Teachers' confidence using peripheral ICT

The final question in the teacher survey was specifically developed to measure teachers' use of peripheral ICT. With an acceptable KMO index of 0.79, the 15 items comprising the question split into two factors, differentiating between common technology (*comict*), like television, and specialised ICT (*specit*), like scanners and CD-burners. Figure 6.9 present the component plot and Table 6.9 details the items and their factor loadings.

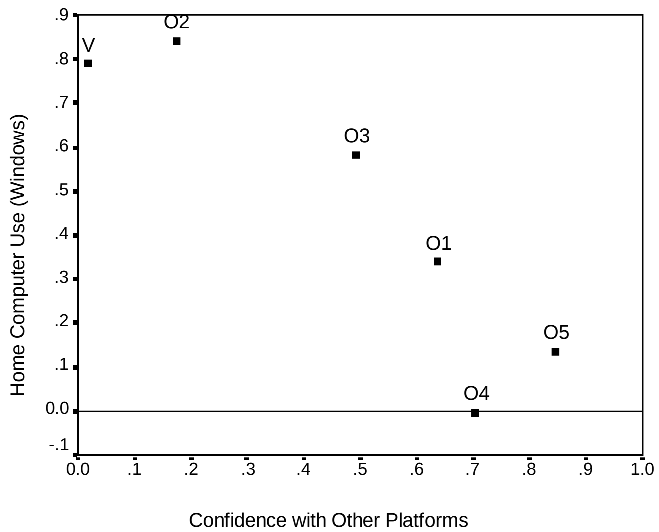


Figure 6.8 The component plot for teachers' home computer use and confidence in using other platforms

Table 6.8 Items and their factor loadings for Windows-based home computer use (*thuse*) and confidence in using other platforms (*oplats*)

		oplats	***thuse***
Rate your level of confidence in the following operating environments:			
O1	MS-DOS	0.64	
O4	Macintosh	0.70	
O5	Unix/Linux	0.85	
O2	Windows 3/95/98		0.84
O3	Windows NT	(0.49)	0.58
V	Do you use a computer at home?		0.79

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

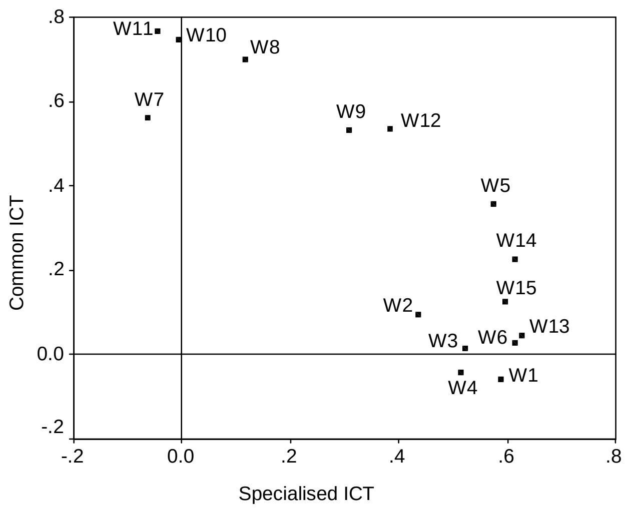


Figure 6.9 The component plot for teachers' confidence using peripheral ICT

Table 6.9 Items and their factor loadings for common ICT (*comict*) and specialised ICT (*specit*)

		specit	*comict*
List any peripheral technologies that you are confident in using within your teaching programs.			
W1	Hand helds/Palm tops	0.59	
W2	Digital whiteboard	0.44	
W3	Video conferencing	0.52	
W4	Digital video conferencing	0.52	
W5	Digital camera	0.57	
W6	data shows	0.61	
W13	CD-Burner	0.63	
W14	Modem	0.61	
W15	Scanner	0.59	
W7	Television		0.56
W8	Radio		0.70
W9	Fax Machine		0.53
W10	CD or cassette player		0.74
W11	Video player		0.77
W12	Video camera		0.54

Although many of the peripheral technologies showed clear alignment to a component, it was evident that some were less aligned, which suggested that digital cameras (Item W5) appeared to be a technology that was emerging from being considered specialised to being considered commonplace, whereas fax machines (Item W9) and video cameras (Item W12) had just made the transition.

A summary of the variables derived from the teacher questionnaire using exploratory factor analysis is presented at the end of this chapter in Table 6.18. The following sections continue the analysis of items from self-developed and pre-existing scales, in order to derive factors that pertain to questions from the student questionnaire.

Students usage of ICT outside of school

Questions in the first part of the student ICT survey were developed by the researcher to identify practical aspects of computer experience and provided a measure of the context in which the attitudes were based. Students' use of ICT outside of school explored aspects of both hardware and software usage that would provide measures of additional exposure to ICT beyond that of the school. Factor analysis of the 18 items resulted in a KMO index of 0.80 and the formation of five components. With the ability to plot only three dimensions, the alignment of five factors is not easily presented. However, Figure 6.10 attempts to do so, by plotting all items on three elected factors, that of entertainment (*ictent*), ICT-rich homework (*icthwk*), and internet (*ictweb*). These and the other two factors, general software use (*ictsof*), and ICT hardware use (*icthar*), are presented with their constituent items in Table 6.10.

Following factor analysis, the combination of the two items regarding homework (Item C1) and word-processing (Item D3), summarised above in Table 6.10, indicated a strong association between the use of word-processing software and schoolwork completed at home to form the factor ICT-rich homework (*icthwk*). Three items were grouped together to provide a measure of students' activities on the internet during out-of-school hours and were identified as internet use (*ictweb*). A measure of general software use (*ictsof*) by students outside of school included five items in the scale that combined together. Since ICT was not simply limited to computers, the internet and software, students were asked to indicate their usage of other forms of technology, such as television and mobile phones, outside of school during the last week. Students were able to select as many or as few from a list of eight items. Factor analysis of these items (indicated by the letter E, shown above in Figure 6.10), separated three items, generally described as entertainment use (*ictent*), from those described as general ICT hardware (*icthar*).

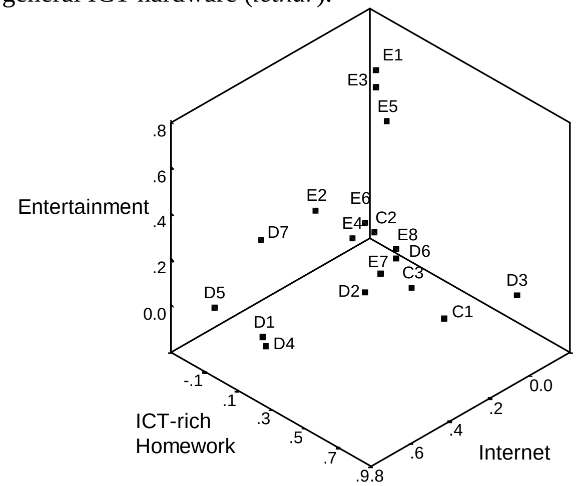


Figure 6.10 The component plot for students usage of ICT hardware and software outside of school

Table 6.10 Items and their factor loadings for ICT-rich homework (*icthwk*), internet (*ictweb*), general software use (*ictsof*), general ICT hardware use (*icthar*), and entertainment use (*ictent*)

		icthwk	***ictsof***	***icthar***	***ictweb***	***ictent***
Outside of school, do you use a computer for:						
C1	Homework/projects/studying	0.64				
D3	Word-Processing	0.80				
C2	Playing computer games		0.78			
C3	Using computer programs		0.69			
D2	Making web pages		0.36			
D6	Graphics/Animation		0.58			
D7	Music		0.43			
D1	Internet – Surfing				0.72	
D4	E-mail				0.77	
D5	Chat Rooms				0.74	
What other forms of technology have you used outside of school in the last week?						
E1	Television					0.76
E3	Radio/CD/cassette player					0.75
E5	Video player					0.57
E2	Mobile phone			0.40		
E4	Digital Camera			0.66		
E6	Video camera			0.74		
E7	Scanner			0.59		
E8	Fax machine			0.65		

Students' computer literacy and confidence using ICT

Students' general levels of computer knowledge and confidence were examined as an additional set of measures upon which student attitudes might be influenced. Twelve items underwent factor analysis and confirmed the arrangement of items into three scales, graphically presented in Figure 6.11. The items comprising student computer confidence (*sconf*), web-based knowledge (*litweb*), and general computer knowledge (*litgen*), are detailed in Table 6.11.

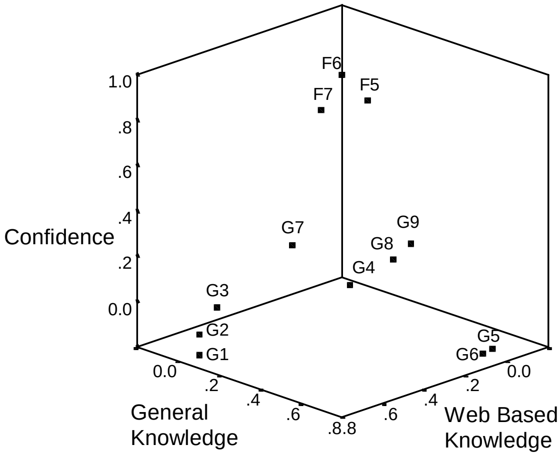


Figure 6.11 The component plot for students' computer confidence, web-based literacy, and general literacy using ICT

Table 6.11 Items and their factor loadings for student computer confidence (*sconf*), web-based knowledge (*litweb*), and general computer knowledge (*litgen*)

		sconf	*litweb*	*litgen*
F5	How much do you like using a computer?	0.69		
F6	How good are you at using a computer?	0.80		
F7	How well do you use the computer keyboard?	0.65		
Can you do the following:				
G1	Use the World Wide Web (WWW)		0.78	
G2	Search the WWW using keywords		0.77	
G3	Send an e-mail message		0.68	
G7	Make your own website/home page		0.42	
G4	Using spreadsheets or databases to store information			0.34
G5	Create stories, poems, letters etc			0.72
G6	Draw pictures using the mouse			0.70
G8	Create your own multimedia presentation			0.52
G9	Create your own music or sound using a computer			0.48

With a KMO Index of 0.69, Table 6.11 shows that three items combined together to gauge students' general confidence in using computers (*sconf*). The remaining nine items formed two scales: four items emphasised web-based knowledge (*litweb*), and five items focussed on general computer knowledge (*litgen*).

Students' computer access

The final area examining practical aspects of students' ICT use was that of computer access. The expectation was that changes in computer access would influence student attitude. Of the four items that were included in the scale, two were designed to measure levels of computer access at home (*acshom*) while the other two items were developed to gauge levels of computer access at school (*acssch*). Factor analysis of the items, shown in Figure 6.12, confirmed the two scales but only achieved a tolerable KMO index of 0.51. Cluster analysis was employed to examine further the items and supported the final analysis. Table 6.12 presents the items and their factor loadings.

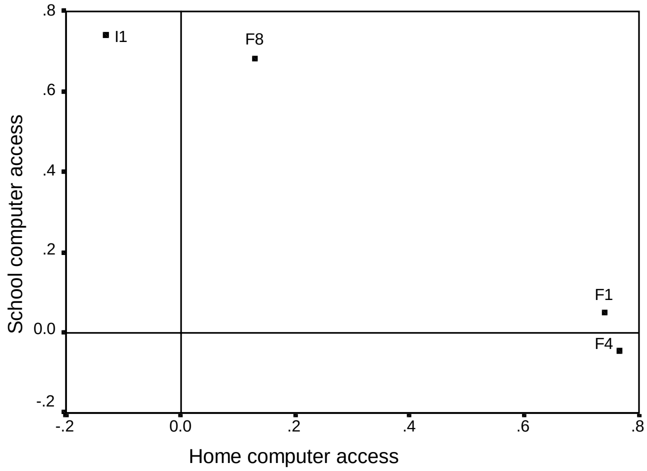


Figure 6.12 The component plot for students' computer access in school and at home

Students' home access (*acshom*), presented in Table 6.12, included Item F1 that asked students if they had a computer at home. In the questionnaire, students were also asked whether it was a Windows or Macintosh computer. In preparing Item F1 for analysis, both questions were combined, as some students did not indicate that they had a computer but did indicate what type of computer it was. Since students did not generally have knowledge about the number of computers in their school, two questions were developed to provide an indication of student access to computers in school (*acssch*). Additional preparation of Item F8 was required before factoring was achieved, by reversing the scoring of the responses to reflect the implication that if students regularly worked in larger groups on computers it was because there were not enough computers for students to work individually or in pairs.

Table 6.12 Items and their factor loadings for students' access to computers at home (*acshom*) and at school (*acssch*)

		aschom	***acssch***
F1	Do you have a computer at home?	0.74	
F4	Gameboy/Nintendo/Playstation	0.77	
F8	When I use a computer at school it is usually…		0.68
I1	I think my school has enough computers for students to use for their work		0.74

Student attitudes towards computers

In order to assess general attitudes about computers, the attitude scale by Jones and Clarke (1994) was adopted for this study. The original scale consisted of 40 items designed within a tripartite framework, which identified affect, behaviour and cognition as the three major components of attitude. Factor analysis was employed to confirm that the items were interpreted and assigned correctly to either an affective, behavioural or cognitive domain.

An initial analysis of all items showed inter-correlation between the affective and cognitive aspects and required an isolated inspection of the affective items to confirm that all but one item belonged to the affective domain. Once removed, the remaining

14 items all loaded onto one factor, supporting the original design. The behavioural and cognitive items, including the rejected affective item, were examined without the other affective items. Six items (Items 3, 8, 14, 20, 27, and 40) that showed poor correlation or strong negative loadings were removed. Factor analysis of the remaining 20 items confirmed their original interpretation with the rejected affective item more closely aligned to the behavioural component. Figure 6.13 presents the remaining 34 variables with their original assignment of A: affective, B: behavioural, or C: cognitive, followed by the item number. A detailed description of the affective (*comaff*), behavioural (*combeh*) and cognitive (*comcog*) aspects of computer attitude and the 34 items that comprise them are presented in Table 6.13. Although the item numbers are the same in the corresponding figures and tables, the letter of H in the table has been reassigned in Figure 6.13 to A, B, or C, in order to assist with interpretation.

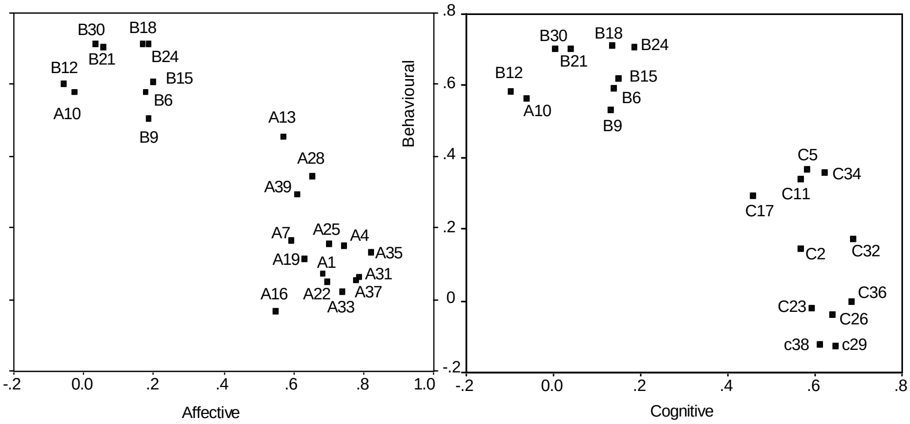


Figure 6.13 The component plots for affective, behavioural and cognitive components of students' computer attitude

Although presentation of the components in Figure 6.13 on a three-dimensional plot would have been ideal, the similar position of the affective and cognitive components, in comparison to the behavioural component, resulted in the apparent mixing of the affective and cognitive components. A better presentation showing clear distinction between the components resulted when they were plotted in two-dimensions independently of each other. The KMO coefficient of each analysis were both above 0.90 and highly acceptable.

Student attitudes towards school

The school attitudes questionnaire, adapted from Keeves (1974), comprised two tools, Like School and Academic Motivation, both of which were associated with the attending, valuing, and responding levels of the affective domain of the Bloom Taxonomy (Bloom, 1956; Krathwohl, Bloom and Masia, 1964). Items in these scales both had satisfactory levels of reliability (K-R20 = 0.84 and 0.82 respectively) and a significant inter-correlation of 0.65 (Keeves, 1974). However, with advancements in statistical techniques since the development of the original scales, confirmatory factor analysis using SPSS was conducted to re-examine the consistency and structure of these scales. The analysis provided greater resolution and revealed additional internal structure in both scales.

With a KMO of 0.91, factor analysis separated the affective and behavioural components of the Like School scale, resulting in two factors, described as school enjoyment (*likenj*) and staying at school (*liksta*) as shown in Figure 6.14. Twelve items from the original 17-item scale, ranging from a strong dislike for school to finding school interesting and challenging, aligned to the affective component of school attitude. This scale provided a measure into students' general enjoyment of school (*likenj*). The remaining five items were strongly behavioural in nature and related to a student's desire to stay at school (*liksta*). The items and their factor loadings are presented in Table 6.14.

Table 6.13 Items and their factor loadings for affective (*comaff*), behavioural (*combeh*), and cognitive (*comcog*) components of computer attitude

		aff	***beh***	***cog***
H1	Computers intimidate and threaten me	0.68		
H4	Working with a computer makes me feel tense and uncomfortable	0.75		
H7	I feel helpless when asked to perform a new task on a computer	0.60		
H13	Computers bore me	0.59	(0.42)	
H16	Working with computers makes me feel isolated from other people	0.55		
H19	I do not feel I have control over what I do when I use a computer	0.63		
H22	Computers sometimes scare me	0.70		
H25	I feel unhappy walking into a room filled with computers	0.70		
H28	I'm no good with computers	0.66		
H31	Working with a computer makes me feel very nervous	0.79		
H33	I feel threatened when others talk about computers	0.74		
H35	Computers make me feel uncomfortable	0.82		
H37	I get a sinking feeling when I think of trying to use a computer	0.78		
H39	Computers frustrate me	0.62		
H6	Other students look to me for help when using the computer		0.58	
H9	When I have a problem with the computer, I will usually solve it on my own		0.51	
H10	I feel important when others ask me for information about computers		0.57	
H12	Using the computer has increased my interaction with other students		0.59	
H15	I develop short cuts, and more efficient ways to use computers		0.61	
H18	I would like to spend more time using a computer		0.70	
H21	If I can I will take subjects that will teach me to use computers		0.70	
H24	I would like to learn more about computers		0.71	
H30	If my school offered a computer camp I would like to attend it		0.70	
H2	All computer people talk in a strange and technical language			0.57
H5	Computers are difficult to understand			0.58
H11	Learning about computers is a waste of time			0.57
H17	Working with computers will not be important to me in my career			0.46
H23	People who work with computers sit in front of a computer screen all day			0.59
H26	Working with computers means working on your own, without contact with others			0.64
H29	To use computers you have to be highly qualified			0.65
H32	Using computers prevents me from being creative			0.69
H34	Computers are confusing			0.62
H36	You have to be a "brain" to work with computers			0.68
H38	Not many people can use computers			0.61

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

Students' motivation to achieve in school learning was measured by 20 statements ranging from, lacking effort and involvement in school learning, to a desire to succeed in school learning and achieve academically. Factor analysis revealed three underlying aspects of academic motivation, focusing on learning (*motlrn*), achievement (*motach*), and effort (*moteff*). A KMO index of 0.92 was obtained and the configuration of items is shown in Figure 6.15. Students' motivation to learn (*motlrn*) was involved in six statements and five statements examined students' motivation to achieve academically (*motach*). The remaining nine items formed a factor that reflected aspects of the amount of effort students' employed in learning and doing their schoolwork (*moteff*). Table 6.15 presents the items comprising the three components of academic motivation and their factor loadings.

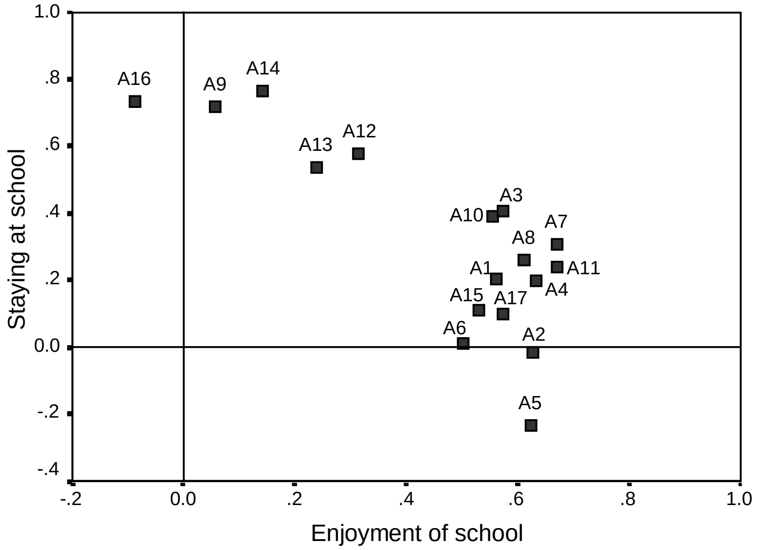


Figure 6.14 The component plot for the Like School scale showing two distinct factors relating to behavioural and affective aspects of attitude towards school

Table 6.14 Items and their factor loadings for school enjoyment (*likenj*) and staying at school (*liksta*)

		likenj	***liksta***
A1	We have interesting lessons at School	0.55	
A2	The most enjoyable part of my day is the time I spend at school	0.63	
A3	I don't like school	0.56	(0.42)
A4	I find school interesting and challenging	0.63	
A5	I enjoy everything I do at school	0.62	
A6	The things I look forward to in school are weekends and holidays	0.52	
A7	School is not very enjoyable	0.67	
A8	I like most of my school subjects	0.60	
A10	I am bored most of the time in school	0.54	
A11	I enjoy most of my school work	0.65	
A15	I don't like missing a day at school	0.53	
A17	I agree with people who say “school days are the happiest days”	0.57	
A9	I shall leave school as soon as possible		0.71
A12	I will be glad to leave this school		0.58
A13	I want to stay at school as long as possible		0.53
A14	The sooner I can leave school the better		0.76
A16	There is no point in me staying at school after I am Fifteen		0.73

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

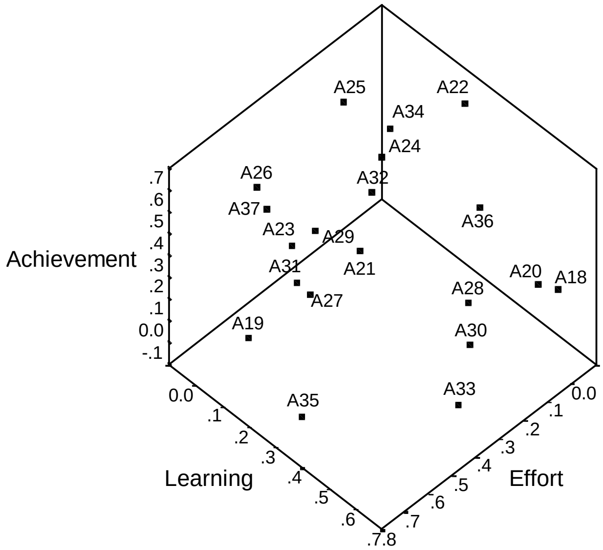


Figure 6.15 The component plot for the Academic Motivation scale showing three underlying factors of achievement, learning and effort

Table 6.15 Items and their factor loadings for motivation to learn (*motlrn*), to achieve (*motach*), and to use effort in learning (*moteff*)

		motlrn	*motach*	*moteff*
A18	I like being asked questions in class	0.63		
A20	I enjoy working out difficult problems	0.62		
A28	When I find the work at school difficult I do extra at home	0.51		
A30	I like to sit next to someone who is working hard all the time	0.54		
A33	I like to have homework every night because it helps me learn	0.58		(0.42)
A36	When I can't understand something I always ask a question	0.40		
A22	I want as much education as I can get		0.59	
A24	I try my hardest to get high marks at school		0.52	
A25	It is not worth spending a lot of time on a hard homework		0.57	
A32	I always try to do my school work carefully and neatly		0.47	
A34	I like to complete all the work set		0.65	
A19	I tend to leave my homework to the last minute			0.72
A21	I work hard all of the time in school			0.45
A23	I find it hard to keep my mind on school work			0.51
A26	In school we like to annoy the teacher by playing up		(0.45)	0.47
A27	I don't always try my hardest at school			0.59
A29	When the teacher is out of the room I tend to stop			0.45
A31	I don't always revise for tests			0.51
A35	Sometimes I forget to do all my homework			0.68
A37	Sometimes I pretend to be sick to avoid a test			0.45

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

Student self-esteem

In order to assess students' self-esteem, the Self-Esteem Inventory (SEI) designed by Coopersmith (1967; 1986) was employed. Following testing, the revised scale consisted of 54 items, originally formulated within a framework of four self-evaluative attitudes: social, academic, family and personal areas of experience, in addition to a so-called 'lie scale'. Although Coopersmith did not specifically identify the items in the groups, Ross (1974) examined the contents of each item and subsequently inferred the composition of the sub-scales, concurring with Coopersmith's original framework of general-self (G), social self-peers (S), school-academic (A) and home-parents (H), along with the lie scale (L). Indeed, upon examining each item, the prescribed framework appeared logical. However, factor analysis of the 54 items suggested that the composition of the four sub-scales might differ from that originally proposed by Coopersmith and endorsed by Ross.

An initial factor analysis of the 54 items, including those that constituted the lie scale, resulted in the formation of ten factors with a KMO index of 0.93. The ten factors were inspected for item continuity and each exhibited alignment with one of the four sub-scales. Not all items identified with their originally assigned sub-scale and found greater association within another sub-scale. Furthermore, the majority of the items in the lie scale showed no statistically different behaviour to the other items and were found to align with the academic, social and the general-self components of self-esteem. Rather than being treated as a separate lie scale or removal from the study altogether, the items were included under the academic, social and the general-self sub-scales. Two items in the lie scale, however, were removed from subsequent analysis (Item B25 and Item B40), because they displayed poor correlation between the other items and negatively loaded onto the factor involved.

Similar to Coopersmith's original design, three of the scales, that of social (*sesoc*), school (*sesch*) and home (*sehom*), each contained only a smaller number of items. Social self-peer attitudes (*sesoc*) were measured by eight statements. The items ranged widely from being popular with 'kids' to knowing what to say to people. School-academic attitudes (*sesch*) contained six statements resulting from the factor analysis. These statements varied between being proud of their school work, to not doing as well in school as they would like. Interestingly, the two lie items included in this scale, relating to doing the right thing and telling the truth, were not directly attributable to schooling, but were clearly associated in students' minds. Home-parents attitudes (*sehom*) was the most intact scale following factor analysis. All but one of the original items was included in this scale, resulting in seven items relating to a student's feelings about their parents and home. Figure 6.16 presents the component plot showing the three underlying factors of social, school and home self-esteem and also indicates the original assignment of each item, specified by a letter and the item number. The items comprising the three factors and their loadings are presented in Table 6.16.

The remaining 31 items from the self-esteem scale formed a scale that reflected aspects of the students' general attitudes about themselves. Presented in Figure 6.17, the items generally identified with a tripartite model of affective, behavioural and cognitive aspects of self-esteem. However, these components were assigned for presentation purposes only as the items were not sufficiently resolved during factor analysis, and resulted in a single scale to describe students' general-self attitude (*segen*). A KMO index of 0.92 was obtained. The 31 items presented in Table 6.17 are not accompanied by factor loadings since only one factor is identified.

The use of exploratory and confirmatory factor analysis in this study provides interesting and productive outcomes. The self-developed measures, used in the teacher and student questionnaires, certainly needed exhaustive exploratory analysis to form and validate factors that accurately reflect the concepts being measured. Of equal importance, though, was the use of confirmatory factor analysis to validate and re-assign items in the pre-existing scales selected for the student questionnaire. Clearly, the analytic technique is highly effective in resolving all manner of items into logical and describable factors ready for subsequent modelling.

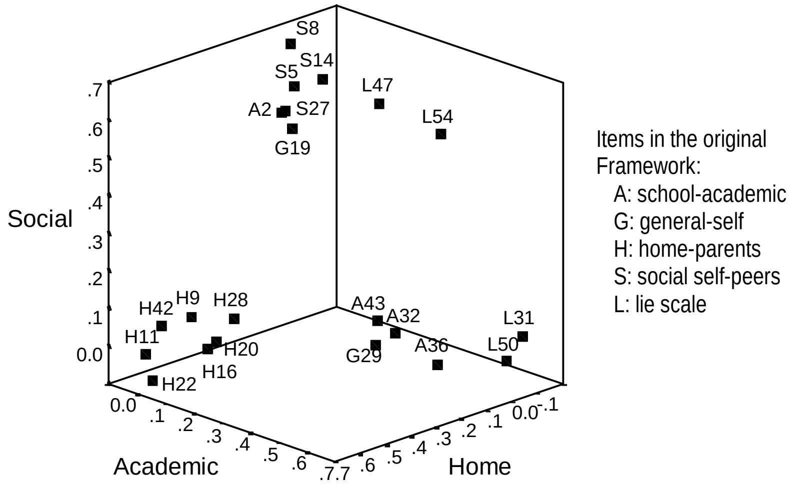


Figure 6.16 The component plot showing three underlying factors of social, school and home self-esteem

Table 6.16 Items and their factor loadings for social self-peer (*sesoc*), school-academic (*sesch*) and home-parents (*sehom*) aspects of student self-esteem

		sehom	***sesoc***	***sesch***
B9	My parents usually consider my feelings	0.60		
B11	My parents expect too much of me	0.66		
B16	There are many times when I'd like to leave home	0.59		
B20	My parents understand me	0.69		
B22	I usually feel as if my parents are pushing me	0.70		
B28	My parents and I have a lot of fun together	0.62		
B42	No one pays much attention to me at home	0.67		
B2	I find it very hard to talk in front of the class		0.48	
B5	I'm a lot of fun to be with		0.59	
B8	I'm popular with kids my own age		0.67	
B14	Kids usually follow my ideas		0.61	
B19	If I have something to say, I usually say it		0.47	
B27	I'm easy to like		0.58	
B47	I'm never shy		0.51	
B54	I always know what to say to people		0.48	0.33
B29	I spend a lot of time daydreaming			0.38
B31	I always do the right thing			0.67
B32	I'm proud of my school work	(0.32)		0.57
B36	I'm doing the best work that I can			0.59
B43	I'm not doing as well in school as I'd like to			0.41
B50	I always tell the truth			0.70

Note: values in brackets show moderate association (above the 0.3 cut-off) with another factor

However, preparation and preliminary analysis of the data is not complete without also testing for reliability and normal distribution, presented in the next section.

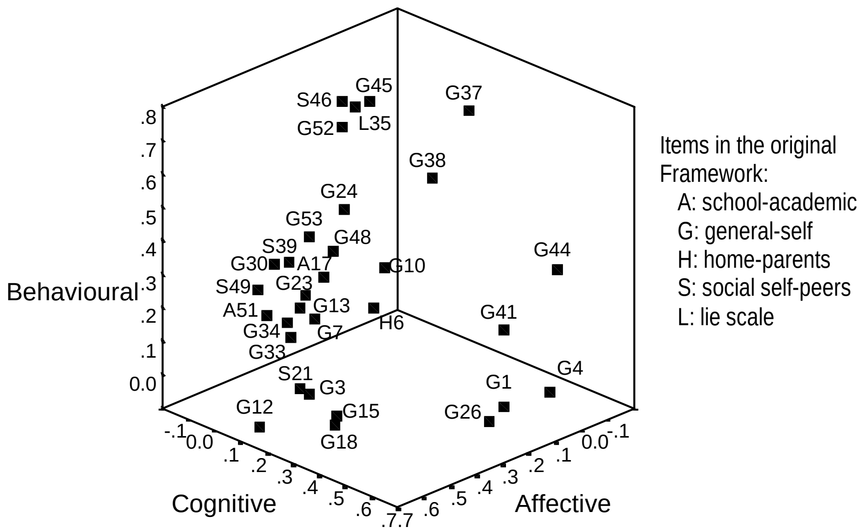


Figure 6.17 The component plot for the general-self sub-scale showing proximal alignment to a tripartite framework of self-esteem

Table 6.17 Items for the general-self (*segen*) component of self-esteem

B1	Things usually don't bother me
B3	There are lots of things about myself I'd change if I could
B4	I can make up my mind without too much trouble
B6	I get upset easily at home
B7	It takes me a long time to get use to anything new
B10	I give in very easily
B12	It's pretty tough to be me
B13	Things are all mixed up in my life
B15	I have a low opinion of myself
B17	I often feel upset in school
B18	I'm not as nice looking as most people
B21	Most people are better liked than I am
B23	I often wish I were someone else
B24	I can't be depended on
B26	I'm pretty sure of myself
B30	I wish I were younger
B33	Someone always has to tell me what to do
B34	I'm often sorry for the things I do
B35	I'm never happy
B37	I can usually take care of myself
B38	I'm pretty happy
B39	I would rather play with children younger than I am
B41	I understand myself
B44	I can make up my mind and stick to it
B45	I really don't like being a boy/girl
B46	I don't like to be with other people
B48	I often feel ashamed of myself
B49	Kids pick on me very often
B51	My teachers make me feel I'm not good enough
B52	I don't care what happens to me
B53	I'm a failure

Testing for Reliability and a Normal Distribution

While validity indicates how accurately and meaningfully a value reflects the concept being measured, reliability refers to how dependable the measure is. Both are important in establishing that an instrument truly measures what it purports to measure and that it does so consistently for every respondent. In addition, many statistical techniques assume a normal distribution, so testing for normality is also required.

Reliability

Reliability refers to the consistency, stability over time, and dependability of the values (Burns, 1998), or in other words, how free they are from random error. Although there are four commonly used methods for computing reliability estimates, which include test-retest, alternate forms, split-half, and internal-consistency, it is this last method that was employed in this study. The internal consistency of a scale indicates the reliability to which the constituent items all measure the same underlying attribute. In developing the internal-consistency method, Kuder and Richardson (1937) formulated measures of reliability that used item statistics as the basic unit of measurement. A frequently used statistic, and the one adopted in this study, is the Cronbach alpha coefficient. Cronbach's alpha takes a value of 1.0 when the total score variance is perfectly attributable to the common factor running through the test items. The factors extracted from the exploratory analysis were also subjected to reliability testing using the Cronbach alpha coefficient and are summarised in Table 6.18 with all the factors.

Normality

Since many of the statistical and modelling methods used in this study depend on normality assumptions, preliminary analysis requires testing the variables for normal distribution. Two commonly used characteristics that indicate whether data are normally or non-normally distributed are skewness, which tests for symmetry, and kurtosis, which tests for peakedness (Burns, 1998).

In a normally distributed sample, the values of skewness and kurtosis are close to zero. However, absolute values of three and eight, respectively, are still acceptable (Kline, 1998). Histogram plots were also used to examine the normality of the data distribution, by fitting a normal curve and observing the closeness of fit. Table 6.18 also presents the skewness and kurtosis of each factor. All factors apart from one had skewness values of less than three and kurtosis values of less than eight. Entertainment use (*ictent*) had an acceptable skewness of –2.69 but a slightly higher kurtosis of 9.71, which was unavoidable since nearly all students had used such basic forms of technology as television and radio.

Teacher and student background items

General background information was collected from all teachers and students participating in the study, using the respective Background sections of the teacher and student surveys. The teacher items requested information about gender (SEX), what type of teaching position they held (TYPE), the number of years teaching (TEXP), ICT subject areas specialisation (ICTT), and their teaching load (LOAD). The student items requested information about gender (SEX), date of birth (AGE), and language background (NESB). Since these items were antecedent in nature and independent of any other item, they formed factors in their own right. Furthermore, as each factor only contained one item, a test for reliability using the Cronbach alpha coefficient was inappropriate. However, each factor still required testing for normal distribution. The teacher and student background items were tested and found to be approximately normally distributed, as summarised in Table 6.18.

Table 6.18 Teacher and student factors with reliability and normality indicators

Factor	Description	Alpha	Skewness	Kurtosis
Teacher Factors (N=219)				
SEX	Gender of individual		-0.10	-2.01
TEXP	Years of teaching experience		-1.62	1.12
ICTT	ICT specialist teacher		0.52	-1.74
TYPE	Teacher type		2.86	6.22
LOAD	Teaching load		-1.53	1.17
appopen	Open learning environments	0.62	-0.06	-0.57
appfoc	Focused learning environments	0.70	0.46	-0.32
appcom	Communication environments	0.37	0.77	-0.73
objbeh	Behavioural learning objectives	0.56	-0.52	-0.39
objcog	Cognitive learning objectives	0.53	-0.99	0.10
aaadv	Advanced administrative activities	0.64	0.13	-0.19
aagen	General administrative activities	0.65	-0.36	-0.22
prac	Influence of ICT on teaching practice	0.87	-0.18	-0.49
wwwpc	Online computer access	0.79	-1.58	3.03
perict	Peripheral ICT access	0.82	-0.72	0.97
stueff	Student effort	0.63	-0.58	-0.11
tissus	Teacher related learning outcomes	0.34	0.31	-0.34
tconf	Teachers' confidence using ICT	0.93	-0.33	-0.49
tsupp	Teacher support in using ICT	0.71	-0.43	-0.29
thuse	Home computer use (Windows)	0.63	-0.95	1.00
oplats	Confidence in using other platforms	0.68	0.11	-0.42
comict	Common ICT	0.70	-1.80	3.05
specit	Specialised ICT	0.74	0.72	0.56
Student Factors (N=2560)				
AGE	Age of individual in years		-0.34	-1.08
SEX	Gender of individual		0.09	-1.99
NESB	What language is spoken at home		2.71	5.36
icthwk	Text-rich homework	0.44	-0.74	-0.01
ictweb	Internet	0.39	-0.52	0.32
ictsof	General software use	0.59	-0.02	0.48
icthar	General ICT hardware use	0.64	0.96	0.99
ictent	Entertainment use	0.43	-2.69	9.71
sconf	Student computer confidence	0.62	-0.10	0.83
litweb	Web-based knowledge	0.61	-1.90	4.69
litgen	General computer knowledge	0.42	-1.65	4.56
acshom	Computer access at home	0.25	-0.50	-0.04
acssch	Computer access at school	0.14	-0.52	0.77
comaff	Affective component of computer attitude	0.92	-0.86	1.88
combeh	Behavioural component of computer attitude	0.83	0.08	0.18
comcog	Cognitive component of computer attitude	0.84	-0.70	1.90
likenj	School enjoyment scale	0.85	-0.09	-0.42
liksta	Staying at School	0.74	-0.91	0.73
motlrn	Motivation to Learn	0.65	0.25	0.01
motach	Motivation to Achieve	0.65	-0.74	0.58
moteff	Motivation to use effort in learning	0.80	0.06	-0.42
sesoc	Social self-peer	0.67	-0.16	0.13
sesch	School-academic	0.62	0.14	-0.20
sehom	Home-parents	0.80	-0.74	0.15
segen	General-self	0.87	-0.44	0.12

Summary

This chapter details the evolution from raw data into 48 teacher and student factors that reasonably fulfil the requirements for validity, reliability and normality. Table 6.18 presents a summary of the teacher and student factors, the majority of which were developed through the use of exploratory and confirmatory factor analysis. The formation of these variables provides the basis on which the student and teacher models, examined in Chapters 10 and 11, are constructed and analysed. But first, a descriptive analysis of the variables is necessary in order to profile the schools, teachers and students participating in this study, and this is the subject of the next three chapters.

7

Schools: Teacher and Student Background Factors

One of the major aims of this study was to measure longitudinal change in school climate due to the increased use of ICT across the curriculum. In order to understand this climate of change, the contexts in which change occurred must first be detailed. This chapter, therefore, aims to provide general demographical information about the schools, complemented by the profiles of the teachers and students who belong to them and who participated in this study.

Setting the Scene

Information and communication technologies have become a major focus of state and national efforts to improve student educational outcomes. Around Australia, millions of dollars have been channelled towards the integration of technology into school curricula. South Australia is no exception, as a major departmental initiative affirms:

> The use of learning and information technologies has the potential to enhance learning for all students in our schools. In recognition of this, the South Australian Government established the $85.6 million DECS*tech* 2001 Project aimed at ensuring that by the year 2001 technology … is able to be an embedded, integrated part of learning activities, and technological applications will be, at all levels, curriculum driven. (DETE 1999, p.1)

The call for quality research into the effectiveness of learning technologies is a common feature in much of the related literature (Kilvert 1997, Cuttance 2001), and raises the broad question of how schools use technology to transform and improve the quality of student learning. The DECS*tech* 2001 Project held a similar concern, and as one of its main objectives, flagged the need for research into student learning outcomes and the changes "attributable to the use of learning technologies across the full spectrum of learning areas" (DETE 1999, p.22).

The major school based impetus for the DECS*tech* Project and the sample for this study, involved four primary and two secondary public schools in the metropolitan suburbs of Adelaide, South Australia (Filsell and Barnes, 2002). The Project spanned a three-year period, during which time the schools were intensively involved in a process of development and change. The first year was an establishment year where the schools identified their needs, planned and initiated strategies to build curricula more widely enriched by ICT. Over the following two years, students and teachers continued to experience changes in the learning environment as ICT were increasingly embedded throughout the different curricula, with the objective of improving student learning outcomes.

The Schools: An Overview

The six Adelaide metropolitan schools, originally chosen from among many entrants for the DECS*tech* Project, were selected on both the quality of their submission and because they represented a diverse spectrum of learning environments. They were not selected on the degree to which ICT was already embedded in their curriculum or the extent of their ICT resources.

The diversity of these environments and the aims of the study required the analysis to be sensitive at the student, classroom and school levels (Archer 1999; Rowe 1996) as discussed in Chapter 4 on the design of the study. At the classroom level, the teacher provides the greatest influence, and differences in the teacher's approach are evident. Students reflect these differences when they attribute their success or failure in a subject to a particular teacher. School level differences are evident when a visitor observes a distinct culture unique to a school. Usually the Principal and other senior teachers have the greatest influence in shaping the climate of the school since they are in a position of leadership and provide guidance to less experienced teachers. Also at the school level, other influences emerge, stemming from the different structuring of primary and secondary schools in South Australia.

A typical South Australian public primary school assigns a teacher to a classroom of about 25 students for the whole school year. The teacher teaches in all curriculum areas (English, mathematics, science, art, social studies, drama, technology, and health) and can set up, permanently or semi-permanently, a variety of learning materials such as books, models, technology and pictures to support his or her teaching. The curriculum content and assessment is outcomes-based and guided by a national standard (for example, the Australian Education Council and Curriculum Corporation 1990) that allows for flexibility in planning, implementation and assessment of work.

In contrast, a typical high school provides curriculum-specific teachers, in mathematics for example, who teach the subject to different groups of students from Year 8 to Year 12. Student learning is compartmentalised into specific curriculum areas and very little cross-curriculum learning is engaged in. Teachers do not have their own classroom where they can have easy and secure access to learning materials. Without this sense of ownership, classrooms are usually sparsely adorned. The specialisation of teachers means that they generally only associate with other teachers in their curriculum area. By Year 10, most schools stream their students into Advanced, Intermediate and Standard classes, which lead students into publicly assessed or school assessed topics. The pressure placed on teachers by the school and by parents to achieve good results in the final year examinations restricts flexibility of how and what can be taught.

Although there are general similarities across primary schools and across secondary schools, as described above, individual differences due to any number of demographic factors, such as structure, school size, or teaching profile, result in each school having a unique school context with unique characteristics. Demographic information about each school involved in the study, with a particular focus on ICT resources and its priority in the school, was collected in the first and second years of the study and is presented in the following section. Furthermore, School Context Statements, available for every South Australian school on the Department of Education web site, were consulted for additional information. For purposes of confidentiality, the names of the schools are not disclosed but are simply referred to as P1, P2, P3 and P4, to represent the four primary schools, and as S1 and S2, to indicate the two secondary schools.

All six schools, primary and secondary, were given support, through the appointment of Technology Project Managers to research, develop and model exemplary ways to embed learning technologies across the curriculum over the three-year life span of the project. In order to assist in this aim, additional support was provided in the form of cash grants to upgrade ICT facilities. As part of their commitment to the project, the schools were supported in disseminating their experiences through focus school programs and liaising with educational organisations to participate in research. This study is the result of one such research project.

The four primary schools

The first of the four primary schools (P1), and the smallest, consists of approximately 250 students from Reception to Year 7. This northern suburbs school is located in an established community involving families who have lived in the district since its establishment, with those who live in Housing Trust and other rental accommodation. The community is supportive of the school. The area is characterised by high unemployment and economic disadvantage. Significant numbers of students are on a government assistance scheme for underprivileged families, called 'School Card', and the school has a strong Aboriginal education program. High levels of transience occur with up to 150 students entering or leaving the school during a calendar year. Approximately 25 per cent of families own their own homes, while the remainder live in rented accommodation. The school was involved in the disadvantaged Schools Program and is a recipient of Commonwealth Literacy Funding. Special student programs are provided in Early Literacy, Cross Age Tutoring, Learning Assistance Program (LAP), Funtastics (Coordination), Peer Tutoring, and Single Sex Maths Groups. Special education is provided for 11 students through special non-graded curriculum plans (NCP). These NCP students did not participate in the study. The main priority of the school was to increase student directed curriculum through supporting the development and implementation of learning technologies.

Further south, the second primary school (P2) has approximately 370 students from reception to Year 7. Historically, most of the students come from families who are residents of the local area and many of these parents have had a long association with the school, in many cases, attending it themselves or knowing someone who did. These parents, in particular, are proud of the school's history, its good reputation in the local community and the traditions of the school. New families are now moving into the neighbourhood to take advantage of the affordable real estate offerings. There are also a significant number of low-income families living in Housing Trust and other rental accommodation in the local area, which influences the number of transient enrolments (approximately 13%) each year. Some of these families gain additional support for their children by accessing a range of community welfare services. These agencies work closely with the school. This school also provided special education for 13 students through special non-graded curriculum plans (NCP). Again, these NCP students did not participate in the study. Approximately half of the students qualify for the School Card Scheme. The school receives additional funding from the Commonwealth Literacy Disadvantaged Schools Program to support literacy and numeracy programs. Approximately 16 per cent of students have a non-English speaking background. The school's ESL General Support Program is based on ESL in the Mainstream practices. Although ICT was a priority in the school, full network and internet access was only made available during the second year of the study, as a result of the school's participation in the DECS*tech* project. Prior to this development, the school had a computing suite of 17 multi-media stand-alone IBM computers set up in a computing suite with a display device for instructional use, along with an IBM compatible computer in each classroom. A number of Apple laptop computers were available for staff and student use on a booking basis. Coaching support was available to class teachers and they were expected to keep their skills up-dated in the use of learning technologies across the curriculum.

The third primary school (P3) is located in the western suburbs in a diverse and supportive community. There are high levels of involvement in community sporting activities and high levels of interest in environmental, community and global issues. This large school of approximately 600 students, comprise separate junior primary (Reception-3) and primary (4-7) schools managed by two Heads and under one Principal. Nearly 30 per cent of students are supported by School Card and 14 per cent of students are from non-English speaking backgrounds. The school development priorities of ICT and Literacy supported its long-term objectives to develop cultures of effective communication, of local and global inquiry and of critical thinking and creativity. This school has been recognised in the educational community for its participation and success in educational reform with a strong tradition of using ICT, and was selected as an Apple Distinguished School and a Technology Focus School during 1995 to 1998.

The last of the primary schools (P4), located in the northern suburbs, caters for a diverse range of students from Reception to Year 7. The area is characterised by families where many people participate in part-time work. The school provides for approximately 350 students with a strong focus on developing an information literate community. Students come from a range of socio-economic backgrounds but mainly feature in the middle socio-economic range. Forty per cent are recipients of School Card. Approximately 10 per cent of children come from families where at least one of the parents speaks little English. The core business declared by the school is the provision of a success oriented Teaching and Learning Environment. The staff provide this through teaching and learning programs in the eight areas of study by utilising the SACSA framework, student interests and needs, and school policies as a basis for programming, assessment and reporting to parents and students. Through the extensive use of learning teams, constructivist approaches to learning and curriculum integration of ICT are encouraged and supported.

The two secondary schools

The first of the two secondary schools (S1) is located in the western suburbs, consisting of a broad and varied socio-economic base. The community has a strong local identity similar to that of a large country city and produces over 50 per cent of the state's manufactured goods. The school provides for a diverse range of approximately 670 students from Years 8 to 13, as well as Adult Re-entry. The school has a significant number of Aboriginal students and as a Focus school, has been recognised as a leader in catering for students with disabilities. Approximately 55 per cent of students are eligible for School Card. As a Learning Technology Discovery School, ICT is a priority as a learning tool and to this end extensive resources intend to be invested during the following years. The aim of a student to computer ratio of about 5:1, with computer pods around the school and an extensive Curriculum Network and library connection is undergoing implementation. Integrating Learning Technologies in all areas of study is a priority for this school and staff professional development is an integral part of this program. A strategic partnership with Microsoft allowed the school to deliver the Microsoft Certified Professional course and the 3COM Networking Certificate.

The second high school (S2) is much larger with approximately 1200 students from Year 8 to Year 13 and is located south of Adelaide in a medium to high socio-economic area. The school caters for a diverse student population and maintains a strong academic tradition. Approximately 20 per cent of students are from a non-English speaking background and bring a richly diverse cultural heritage to the school. At the same time, there are a number of students who come from disadvantaged socio-economic backgrounds. Approximately 23 per cent of students are School Card holders. With one of the highest student to computer ratios of approximately 3:1, the school is focused on embedding ICT throughout the curriculum in ways that enhanced students' learning and supported their development of lifelong learning skills. It is intended that the integration of ICT into the curriculum will evolve on the premise that students acquire skills and apply them through all curriculum areas. This ethos of 'technology across the curriculum' ensures that the curriculum is driven by a focus on the ways that IT can enhance teaching and learning rather than viewing skill acquisition as an end in itself. A staff-learning program supports teachers' skill development to explore different ways of structuring and delivering programs. In addition, a sophisticated fibre-optic network is available to operate both curriculum and administration servers for over 350 computers, in which all students have their own account for accessing the school's file server, operate their own e-mail account, access the internet through password control, and manage their own printing credits.

A comment about the presentation of data

In order to communicate best the profiles of each school and the relationships between the factors and the individual items from which they are derived, each characteristic is presented in graphic form. However, an item is usually characterised by an integer in the 100s based on the count, while the factor is generally characterised by a real number less than one based on an average ratio. The differences in scale between the items and their factor, requires that for both to be graphed on the same axes, a dual scale is needed. In this study, the convention follows that the right axis indicates the items, usually the number of teachers or students, plotted in bar graph format, while the left axis indicates the derived factor as a ratio or percentage, plotted in line graph format for easy distinction (see for example, Figure 7.3).

Background Factors

Six metropolitan Adelaide schools, four primary and two secondary schools, are involved in this study, and the teachers and students within them comprise the sample. Clearly, there are differences between the primary and secondary settings, as discussed above in this chapter. However, although the schools are located within similar environments and although they operate under the same Government education system, within both settings the schools differ markedly as each has its own unique characteristics.

Of particular relevance to this chapter, is the descriptive analysis of data collected through the teacher and student surveys, in order to give meaning to the characteristics and factors derived in the previous chapter. At a school level, for example, these factors may include the size of the school, the male to female teacher ratio, and the proportion of students from a non-English speaking background (Ehrenberg, Goldhaber and Brewer, 1995). While the value of each characteristic is different for each school, they are treated as constant or static over the period of the study. Although there is the possibility that teachers and students may leave or begin at the schools mid-way through the study period, potentially altering the male to female teacher ratio, the school size, or any other characteristic, it is found that these variations in enrolments and staffing changes are not significant, and thus, the data can be treated as constant over the period. The remainder of this chapter details the school, teacher and students characteristics derived from the responses to the teacher and student surveys detailed in Chapter 4.

School size (SIZER)

Mok and Flynn (1997, p.69) investigated the effect that school size had on students and found "no apparent relationship between school size and quality of school life". In order to provide an estimate of the size of each school, based on the number of students in this study, the relevant School Context Statements, available online, were consulted and the data pertaining to the number of students and teachers attending during the research period were extracted. An average student number for each school was calculated based on the enrolment figures for each of the three years. Table 7.1 summarises the student and teacher profiles of each school and presents the ratio of school size (SIZER), derived from the number of students attending a school, against the student population in all six schools. Since this study involves only students in Years 5 to 10, the percentage of upper primary (UP) and lower secondary (LS) students in each school along with the standard deviations (SD) for each cohort are presented in Table 7.1, and indicate that student intake from year to year is generally stable.

Table 7.1 The primary and secondary school profiles of students and their teachers, subdivided into lower and upper cohorts, along with the percentage of upper primary (UP) and lower secondary (LS) to yield the school size ratio (SIZER)

Primary	**Lower R-4 (SD)**	**Upper 5-7 (SD)**	**UP%**	**Teachers**	**Size**	**SIZER**
P1	153 (3.79)	84 (3.58)	38.6%	28	238	0.069
P2	227 (7.42)	132 (4.84)	36.8%	39	360	0.105
P3	358 (11.78)	248 (12.20)	40.9%	47	605	0.176
P4	220 (7.25)	137 (7.62)	38.4%	34	356	0.104
Secondary	**Lower 8-10 (SD)**	**Upper 11-13 (SD)**	**LS%**			
S1	433 (20.91)	232 (6.31)	65.1%	72	665	0.194
S2	730 (6.51)	475 (8.98)	60.6%	117	1206	0.352

Of the 219 middle-school teachers selected from the teaching population, most were focused on teaching Years 5 to 10 students. However, some also taught in the junior primary and senior secondary areas, as shown in Figure 7.1 and Figure 7.2. The numbers of teachers across all year-levels are depicted by the line graphs for each school and are interpreted using the axis on the right side. The numbers of students responding in upper primary and lower secondary year-levels are depicted by the bar graphs and are interpreted using the left side axis. These graphs also give a relative indication to the size of each school and the distribution of teachers across each year-level. Figure 7.2 most clearly illustrates the relationship between the number of Year

8 to Year 10 students and their teacher, and the relative student and teacher numbers from school to school. The relationships are not as clear in Figure 7.1 and reflect the poorer response rates of teachers in some primary schools.

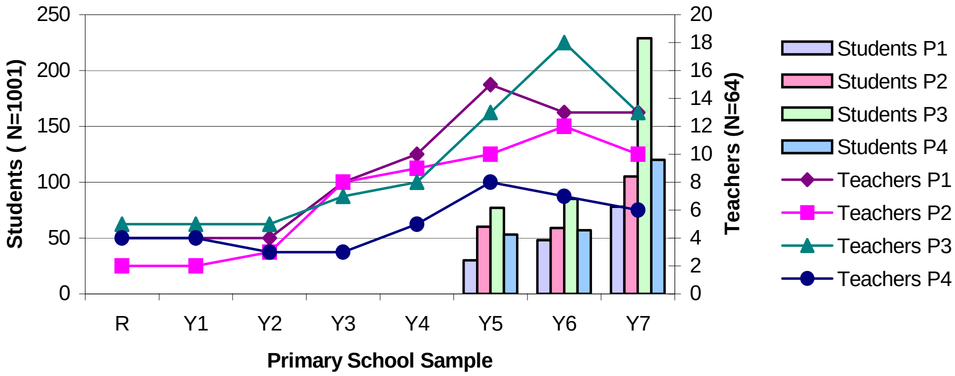


Figure 7.1 The number of students in upper primary and the distribution of teachers across all year levels (R-Y7) in the four primary schools (P1, P2, P3, P4)

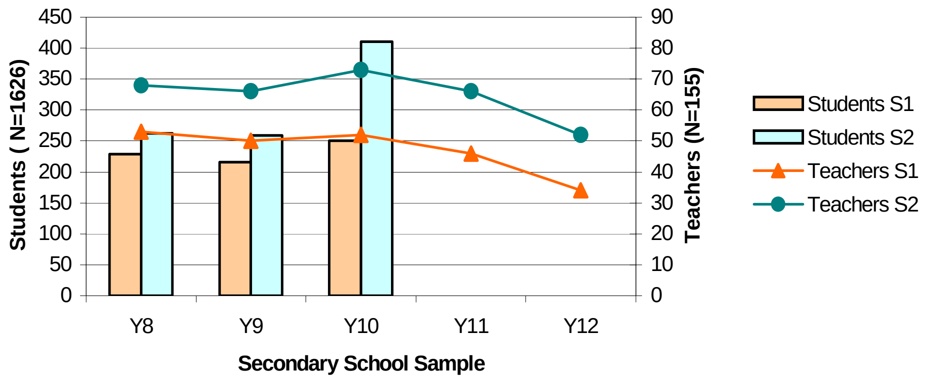


Figure 7.2 The number of students in lower secondary and the distribution of teachers across all year levels (Y8-Y12) in the two secondary schools (S1, S2)

Teacher gender balance (TMR)

Among the 219 teacher participants, 103 were male and 116 were female. Although the number of male and female teachers appears roughly even, an examination on a school level reveals a quite different gender balance. Figure 7.3 presents the gender balance of teachers in each school and the male teacher ratio (TMR), derived from the number of male teachers against the total number of male and female teachers (N) in each school.

What is evident in the gender distribution among teachers in the primary schools (P1, P2, P3, P4), where Figure 7.3 shows substantially more female than male teachers is, representative of most public primary schools in Australia. The TMR for these schools is well below an even balance, with values between five and 25 per cent. The first of the secondary schools (S1) presents a similarly representative sample with an even spread of male and female teachers, indicated by a TMR of around 0.5, which is not the case in the last school (S2), where male teachers out number female teachers 2:1.

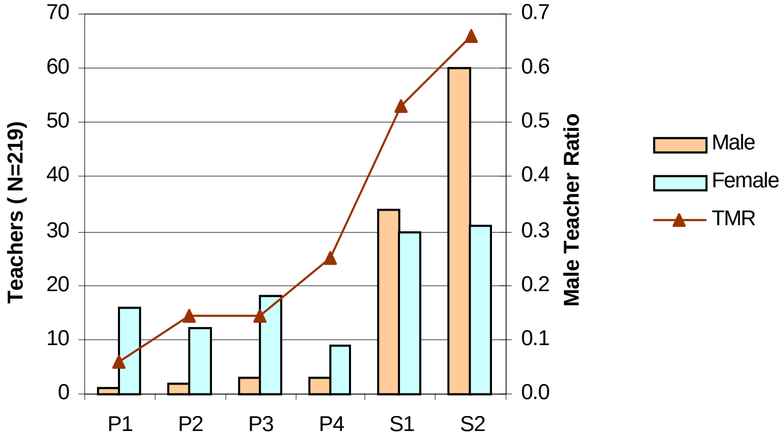


Figure 7.3 Gender balance of teachers in each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools, along with the male teacher ratio (TMR)

Teaching experience (TEXP)

Teachers were requested to indicate their number of years of full time equivalent teaching experience. They had the opportunity to select incrementally from under a year, to over 17 years of teaching experience. For easy comparison, Figure 7.4 shows the number of teachers with full time equivalent teaching experience presented in five-year blocks.

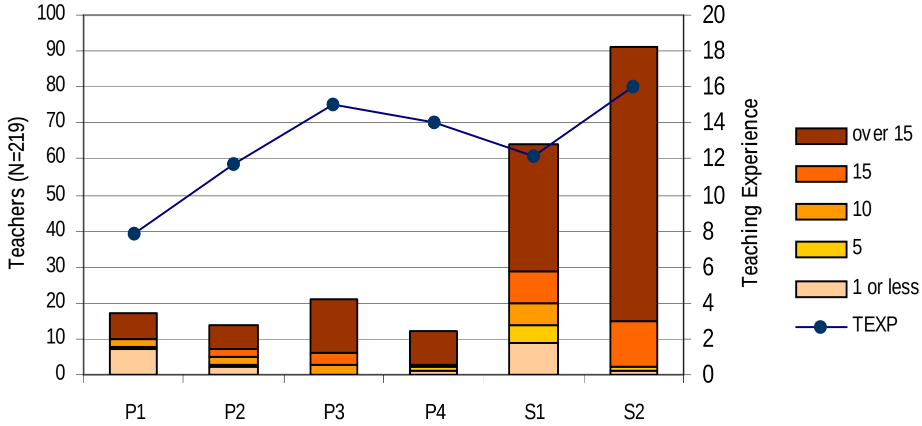


Figure 7.4 The number of teachers and their level of teaching experience teachers in each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools, in terms of the teaching experience factor (TEXP)

The demographics of the staff of these metropolitan schools are not unlike that of the educational sector broadly with a highly experienced and ageing teacher population. This is confirmed by the normalised full time teaching experience factor (TEXP), estimated for each school by Equation 7.1. The first primary school (P1), shows in Figure 7.4, a low TEXP and a large proportion of new teachers. The opposite is observed in the second secondary school (S2), where nearly the entire staff has over 15 years teaching experience and shows a high TEXP.

Equation 7.1

$$TEXP = \frac{\sum_{i=1}^{N} T_i .EXP_i}{N}$$

Computer teachers and ICT specialists (ICTT)

In order to gain information about the number of ICT teachers and specialists in each school, two questions were presented. The focus of the first question examined teachers' area of specialisation, allowing them to nominate more than one from a list of 15 possible items. The list included, pre-school, junior primary, primary school, middle school, senior secondary, gifted and talented, resource based learning, vocational education and training, information technology, teacher librarian, NESB students, work experience, Aboriginal and/or Anangu, augmentative communication, and counselling. The second question asked teachers to describe their current teaching in terms of curriculum area and allowed 12 possible choices that included Aboriginal education, mathematics, health and physical education, technology, the arts, SOSE, science, computing, special education, English, and LOTE. The structural nature of primary and secondary schools means that primary school teachers teach all curriculum areas to one class, while secondary school teachers teach one specialised topic to many classes. For simplicity Figure 7.5 summarises the teachers' areas of specialisation by condensing the 15 items into five broad areas, which include primary (containing pre-school, junior primary and primary school), middle school, senior secondary, support services (teacher librarian, NESB students, work experience, Aboriginal or Anangu, augmentative communication, and counselling), and specialist learning (gifted and talented, resource based learning, and vocational education and training). A sixth area, labelled IT and computing, brings together the information technology item in the first question with the computing item in the second question, to give some insight into the proportion of ICT specialists and computing teachers in each school. It is from this information that the teacher ICT ratio (ICTT) is derived against the total number of teachers in each school. Interestingly, Figure 7.5 suggests an inverse relationship between ICTT and school size, with the larger secondary schools showing fewer ICT teachers and specialists.

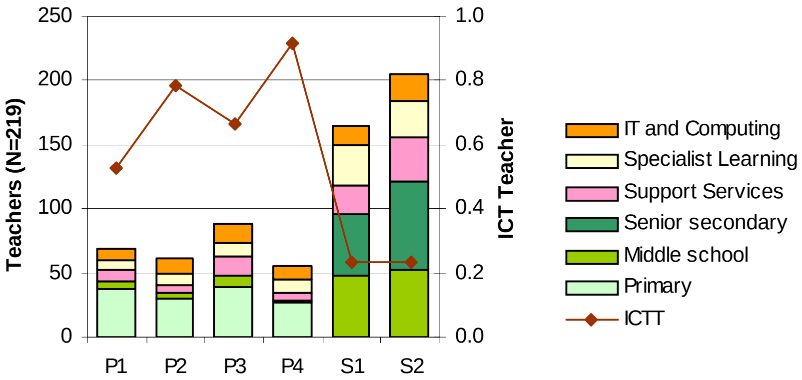


Figure 7.5 Teaching specialisations of teachers in each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools, along with the teacher ICT ratio (ICTT)

Teacher type (TYPE) and teaching load (LOAD)

Further to asking teachers to describe their areas of specialisation, other aspects of their positions, such as their appointment type and their teaching load, were investigated in order to provide additional characteristics about each school. Teachers were asked to describe their appointment type as a) Teacher, b) Permanent against Temporary (PAT)[1], c) School Service Officer (SSO), or d) Aboriginal Education Worker (AEW). The number of teachers selecting each type of position within each of the schools is summarised in Figure 7.6. In this group of schools there were no AEW teachers working at the schools or they did not participate in the study, so AEW is not present in Figure 7.6. The teacher type ratio (TYPE) is derived for each school by dividing those who selected the 'teacher' item by the entire number of staff. Given the small number of staff who did not select the 'teacher' item, the TYPE values are around 1.0 for most schools.

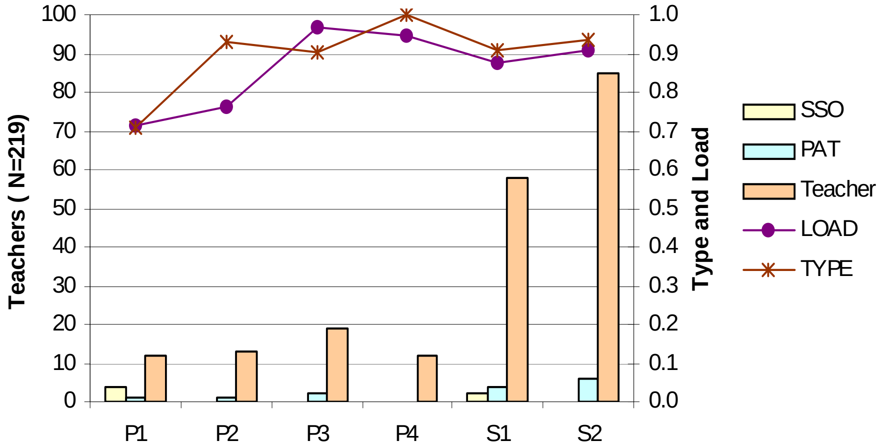


Figure 7.6 Type of teaching appointment (TYPE) and average teaching load (LOAD) of teachers in each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Teachers were also asked to describe their workload by selecting incrementally from a part-time position of 0.4 to a full-time position of 1.0. Figure 7.6 also presents the average teaching load (LOAD) in each school. The closer the LOAD value is to 1.0, the greater the proportion of full time teaching staff. Thus, schools like P1 and S1 have proportionally more temporary or part time teachers than their respective counterparts, which generally reflects the types of teacher appointments in each school.

Student gender balance

A total of 1001 students in upper primary, from Years 5 to 7, and 1626 students in lower secondary, from Years 8 to 10, returned at least one survey during the three-year study period. Of the 2627 students, 1381 were male and 1246 were female. A factor for gender ratio could be derived from the number of male students against the student population in each school, but given that these were public, co-education schools, it would be reasonable to expect that each school had a similar number of boys and girls (as shown in Figure 7.7), and therefore, the factor would have an insignificant effect because of the homogeneity across the population.

---

[1] Permanent against Temporary (PAT) is a South Australian based scheme that enables teachers to maintain permanency within the system while working in short-term or temporary teaching appointments.

A further breakdown of the data refines the student cohorts by showing, in Table7.2, the actual number of student responses on a gender basis. These numbers correspond to those original values presented in Figure 6.1, which gave the student groups and the number of missing occasions, arranged by year-level and occasion. The number of students and average age at the time of data collection by year-level and gender, demonstrates that the demographics of the student sample are representative of the broader Australian public education sector.

Table 7.2 The number, mean age, and standard deviation of male and female students participating in the study on the three occasions in each year level

		Occ 1		Occ 2		Occ 3	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**
Yr 5	N	84	131	112	88	86	74
	Mean Age	10.74	10.63	10.85	10.79	10.82	10.74
	SD	0.32	0.38	0.37	0.39	0.38	0.28
Yr 6	N	110	114	94	124	104	92
	Mean Age	11.73	11.81	11.91	11.81	11.68	11.68
	SD	0.45	0.41	0.32	0.34	0.40	0.35
Yr 7	N	91	95	111	108	84	132
	Mean Age	12.6	12.68	12.86	12.91	12.77	12.7
	SD	0.34	0.35	0.37	0.44	0.31	0.34
Yr 8	N	212	167	197	194	157	160
	Mean Age	13.82	13.75	13.91	13.82	13.81	13.76
	SD	0.40	0.37	0.44	0.35	0.38	0.36
Yr 9	N	170	142	215	159	200	193
	Mean Age	14.72	14.69	14.94	14.84	14.81	14.74
	SD	0.36	0.37	0.42	0.37	0.46	0.34
Yr 10	N	115	82	160	151	220	156
	Mean Age	15.8	15.71	15.8	15.82	15.82	15.77
	SD	0.42	0.31	0.38	0.41	0.43	0.36

Students of non-English speaking backgrounds (NESB)

What may vary from school to school, is the proportion of students from a non-English speaking background. While students could select the language spoken at home, for the purposes of deriving a school factor, languages other than English were assigned a value of 1 to yield a school language ratio (NESB). Figure 7.7 presents the proportion of students from non-English speaking background contrasted against the size of each school and the balance of male and female students.

Summary

The resulting set of factors derived from the teacher and student background data are presented in Table 7.3, and includes for each school the school setting (SET), the school size (SSIZE), the male teacher ratio (TMR), teaching experience (TEXP), the proportion of IT specialists and Computing teachers (ICTT), the average teaching load (LOAD), the type of teaching position (TYPE), and the proportion of students from non-English speaking background (NESB).

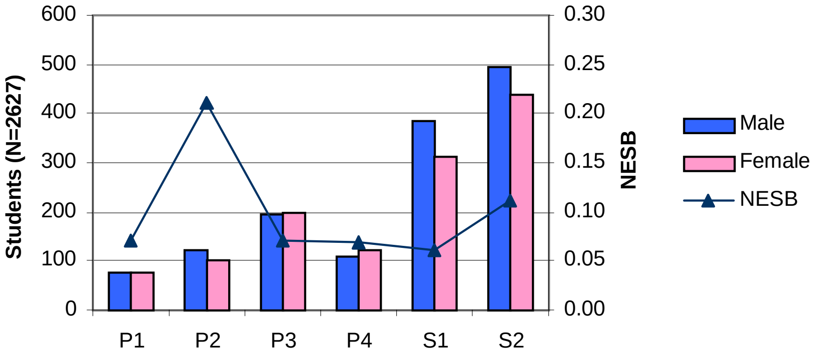


Figure 7.7 Proportion of students from non-English speaking background contrasted against the size of each primary (P1, P2, P3, P4) or secondary (S1, S2) school

Table 7.3 Background factors derived from the teacher and student data providing a profile of each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Variable	Description	Schools					
SCHID	School ID	P1	P2	P3	P4	S1	S2
SSET	School setting	1	1	1	1	2	2
SIZER	School size	0.07	0.11	0.18	0.10	0.19	0.35
TMR	Male teacher ratio	0.06	0.14	0.14	0.25	0.53	0.66
TEXP	Teaching experience	8.09	11.79	14.98	14.00	12.23	16.05
ICTT	ICT teacher specialisation	0.53	0.79	0.67	0.92	0.23	0.23
LOAD	Average teaching load	0.71	0.76	0.97	0.95	0.87	0.91
TYPE	Type of teaching position	0.71	0.93	0.91	1.00	0.91	0.93
NESB	Students language background	0.07	0.21	0.07	0.07	0.06	0.11

With a general demographic examination of the schools, teachers, and students complete, a detailed analysis of teachers' and students' attitudes and behaviours towards the use of ICT in teaching and learning, gained through the respective surveys, is undertaken in the following two chapters.

8

Teachers: Beliefs about Teaching with ICT

Continuing the descriptive analysis of the previous chapter, this chapter profiles the teacher factors, identified in Chapter 6, in order to give meaning to the underlying concepts. Before doing so, however, the use of hierarchical cluster analysis is used to assist in the formation of the latent variables required for path and HLM analyses in Chapters 10 and 11. The discussion of the 18 teacher factors, therefore, are arranged on the basis of the resulting cluster analysis, in order not only to give some understanding of the individual teacher variables and the items that comprise them, but also to give a broader sense of the underlying composition of the latent variables. The descriptive results in this chapter are generated using SPSS (2001) and Excel (Microsoft, 2000).

Content analysis of the factors, broadly describing teachers' current and planned use of ICT, in addition to beliefs about support and confidence in using ICT, are presented at the item level, again through the use of graphical methods. Meaningful interpretation of the graphs is assisted by reflecting the response scales, used in the original questions presented in Chapter 5, on the axes of the graphs. For example, if a series of questions required teachers to respond on a 5-point Likert scale of high confidence [5] to no confidence [1], then the teacher response axis shows a maximum value of 5 and each increment corresponds to the possible responses. The dual axes are another feature of the graphs, where the left axis presents the average teacher response and the right axis presents the school-level indices of the factor. In order to draw attention to the differences between schools, the scale of the right axis is presented in a magnified format. The resulting school-level indices and any major differences between the schools are discussed in the chapter summary. These results are an essential step in the preparation needed for the subsequent analyses.

Clustering Teacher Factors

The hierarchical cluster analysis procedure was used to identify relatively homogeneous factors using, in this case, between-group linkage and the Pearson correlation. The resulting dendrogram plot, presented in Figure 8.1, was employed in conjunction with content analysis of each variable to establish the latent variables needed in subsequent analyses. The aim was to group together similar factors to form meaningful latent variables but not at the expense of detail. For example, while variables relating to teachers' confidence and home computer use clustered together and could have formed a single latent variable, a rescaled distance of 6 was selected so that two clusters were retained. In all, nine latent variables were formed (CONFID, HOMUSE, TEACH, OUTCOM, SUPPORT, COMMON, EFFORT, OPENLN, and ISSUES), as shown in Figure 8.1, and provided the structure for the following discussion of the 18 teacher variables.

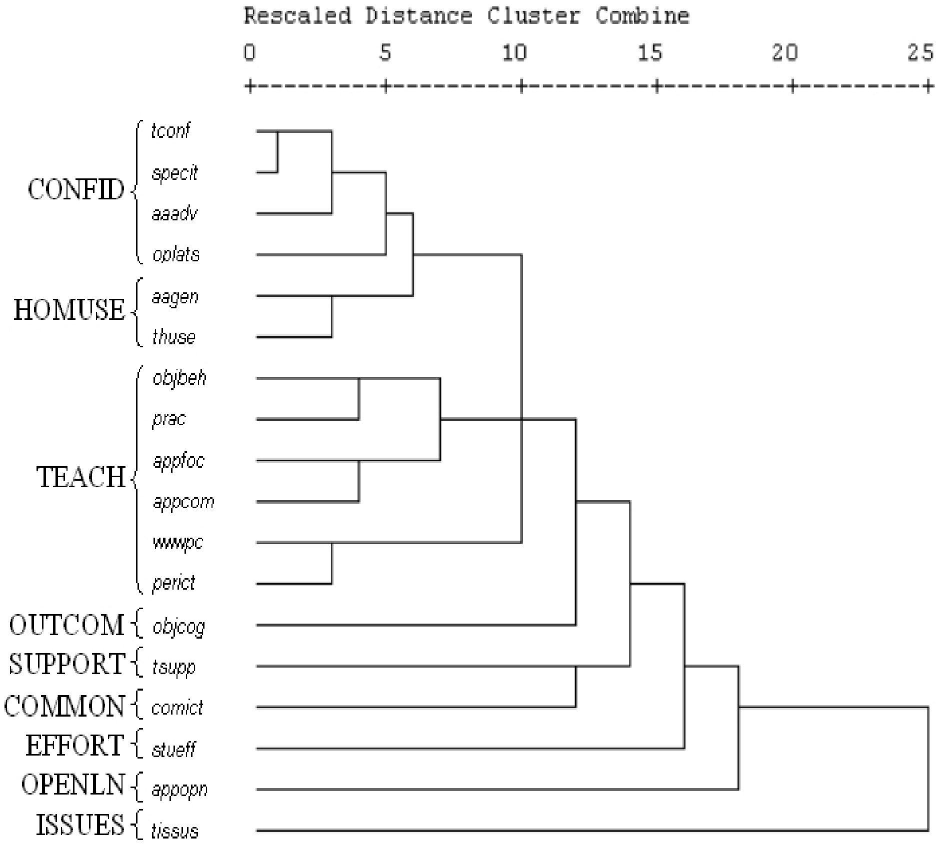


Figure 8.1 Dendrogram presenting the cluster analysis of 18 teacher factors forming nine latent variables

General Confidence Using ICT

Teachers' confidence in implementing ICT into their regular classroom practice was a major focus of this study. Accordingly, a series of questions were developed to measure these beliefs, and this section details the four resulting factors that cluster together and the items that comprise them.

Teachers' confidence using ICT (*tconf*)

A total of 11 items factored together to form a measure of teachers' confidence using ICT (*tconf*)[2], as shown in Figure 8.2. Most teachers felt some level of confidence or highly confident [corresponding to 4 and 5 on the response scale] in using search engines (81% of teachers) and managing files (78% of teachers) with their students. Teachers generally lacked confidence with their students in activities like authoring web pages and applying ICT in the classroom, where only an average of 27 per cent of teachers reported at least some level of competence. It is interesting, then, that most teachers (84%) felt confident in implementing ICT in the classroom, drawing a distinction between 'applying ICT' and 'implementing ICT' in the classroom. This distinction suggests that teachers' immediate use of ICT in their teaching was of more concern than the process of embedding ICT in the curriculum. Further supporting this interpretation, 59 per cent of teachers felt at least some confidence, if not highly confident, in introducing unfamiliar ICT applications to their students.

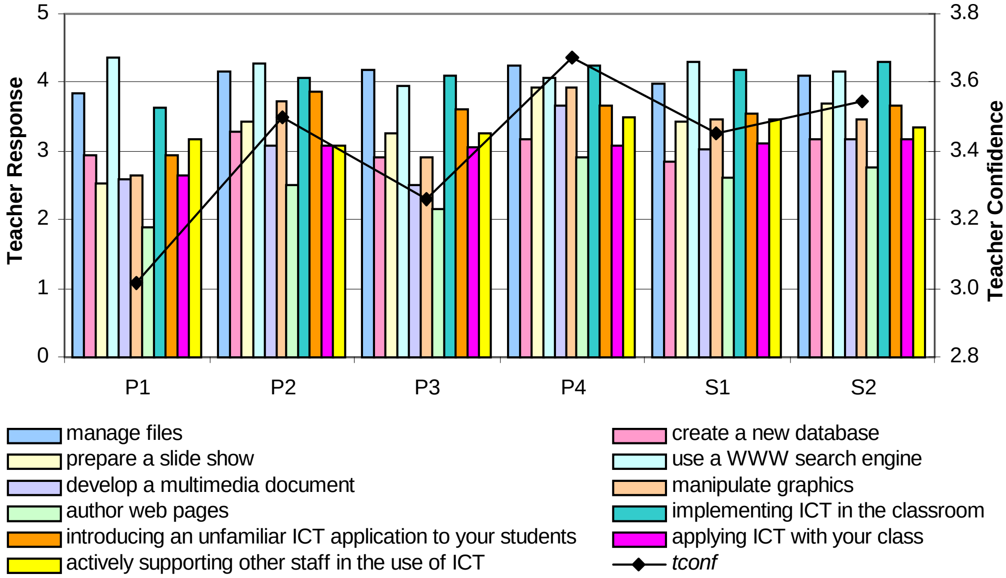


Figure 8.2 Teachers' confidence using ICT, contrasting average teacher response to each item against the Teacher Confidence index (*tconf*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Specialised ICT (*specit*)

Forms of ICT that are commonly associated with computers include CD-burners, digital cameras, modems and scanners. In this study, these and other technologies were factored together and described as specialised ICT (*specit*)[3], since only a minority of teachers felt confident in using them in their teaching practice. On average, only 29 per cent of teachers stated they were confident in using specialised ICT, compared to 87 per cent of teachers who were comfortable using common ICT, described previously. Figure 8.3 presents the nine items from which teachers were asked to select. Of these technologies, two-thirds of teachers felt competent in using

[2] Refer to Table 6.7, for the factor analysis of *tconf*.

[3] Refer to Table 6.9, for the factor analysis of *specit*.

digital cameras (65%), scanners (60%), and modems for internet connection (59%) with their students. The use of data shows was selected by only 28 per cent of teachers and just 19 per cent said they would use CD-burners with their students. Far fewer teachers (8%) were confident in conferencing, and using digital whiteboards and palm-tops in their teaching practice.

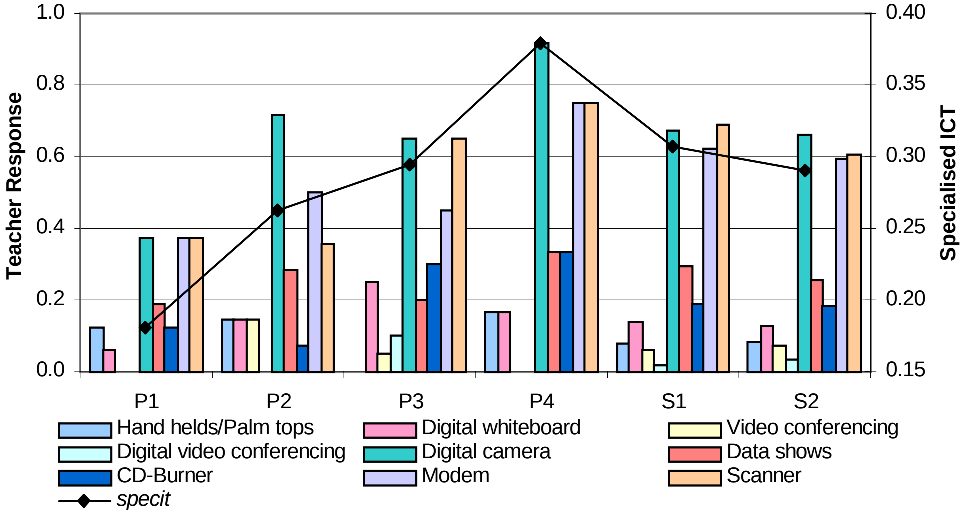


Figure 8.3 Specialised ICT, contrasting average teacher response to each item against the Specialised ICT index (*specit*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Advanced administrative activities (*aaadv*)

Three items grouped themselves to form a factor that was described as advanced administrative activities (*aaadv*)[4] as these were activities found to be commonplace in the cohort. Figure 8.4 presents the uniform profile of teachers' responses across all schools, and indicates that getting information from the internet for use in lessons was the most common activity. However, such use was only done on a frequent basis [equivalent to 4 on the scale] by 36 per cent of teachers, with the majority (41%) using the computer occasionally [3]. The use of digital cameras and scanners to prepare lessons was stated as being undertaken by only 16 per cent of teachers on a frequent basis and posting students' work on the web, by only three per cent of teachers.

Confidence in using other platforms (*oplats*)

As an additional indication of confidence, teachers were asked to rate their level of confidence in other operating environments (*oplats*)[5], with responses presented in Figure 8.5. The three platforms included Macintosh, MS-DOS and Unix/Linux. Almost half of the teachers (48%) said they were confident [4], if not highly confident [5] in using Macintosh computers. One third of teachers (36%) felt competent in using MS-DOS, and only six per cent were comfortable using the Unix/Linux operating platform.

---

[4] Refer to Table 6.4, for the factor analysis of *aaadv*.

[5] Refer to Table 6.8, for the factor analysis of *oplats*.

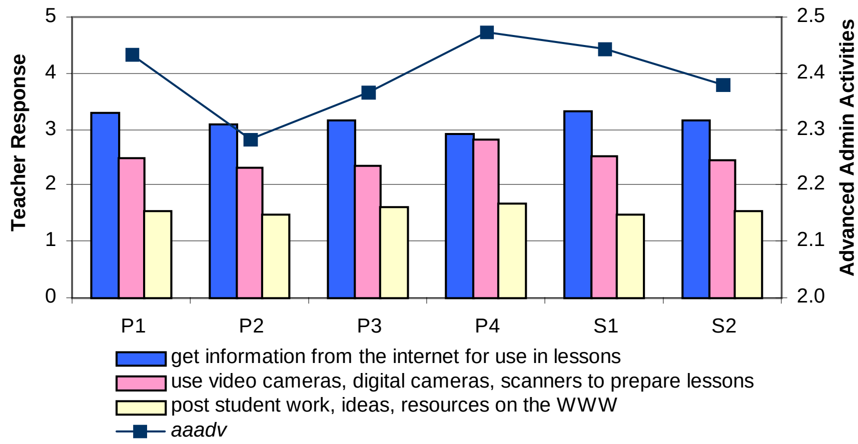


Figure 8.4 Advanced administrative activities, contrasting average teacher response to each item against the Advanced Administrative Activities index (*aaadv*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

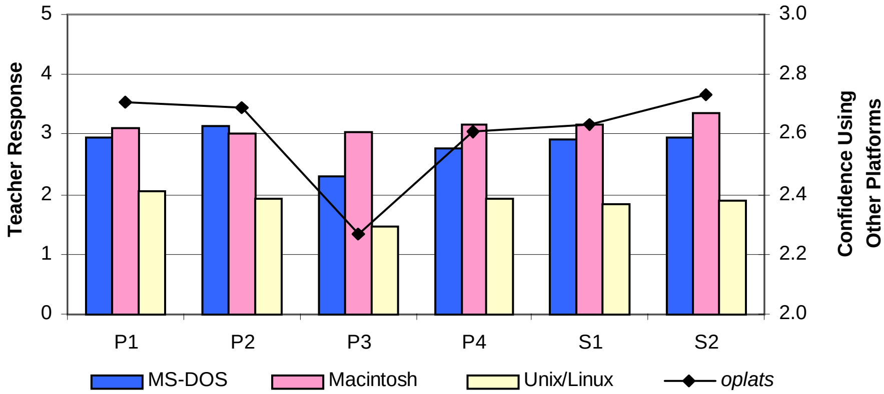


Figure 8.5 Teacher confidence in using other platforms, contrasting average teacher response to each item against the Confidence Using Other Platforms index (*oplats*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Home and General ICT Use

As a measure of teachers' home and general computer use, a number of questions were developed for this study that focused on teachers' use of computers at school and home for general use and administrative activities. This section details the two factors to emerge and the items that comprise them.

General administrative activities (*aagen*)

Teachers were asked how ICT influenced the way they did or thought about various administrative activities. Four tasks were considered to be general administrative activities (*aagen*)[6] and are presented in Figure 8.6 as the average teacher response for

[6] Refer to Table 6.4, for the factor analysis of *aagen*.

each school. The scale shows a maximum score of 5, which corresponds to 'always' using the computer to perform the task. On average, 75 per cent of teachers stated that they 'frequently' or 'always' used the computer to make handouts for students, whereas only 57 per cent tended to prepare lesson plans on the computer. Fewer still, used computers to grade students (38%) or manage files (20%).

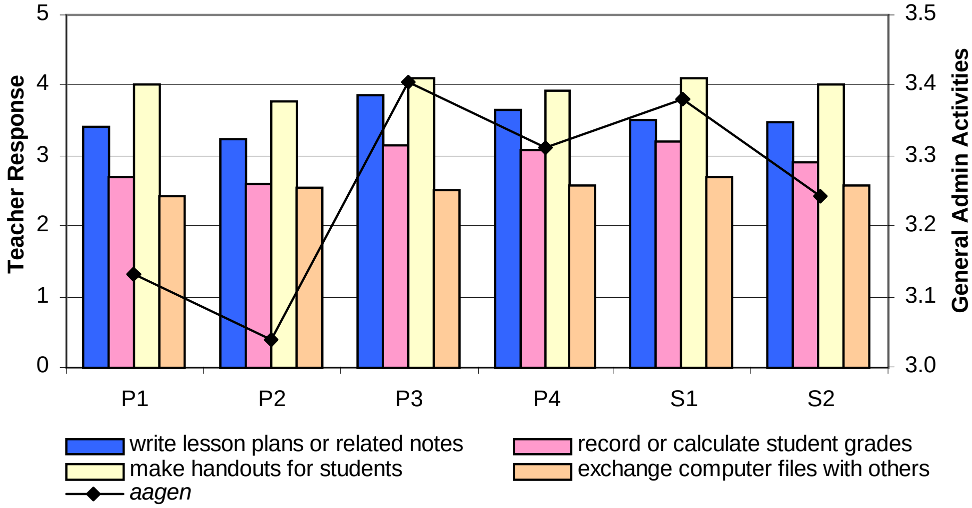


Figure 8.6 General administrative activities, contrasting average teacher response to each item against the General Administrative Activities index (*aagen*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Home computer use (*thuse*)

The composition of items that formed a measure of home computer use (*thuse*)[7] was unexpectedly achieved through a combination of teachers' level of computer use at home and their confidence in using Microsoft Windows operating environments. Figure 8.7 presents the measure of home computer use (*thuse*). That these items factored together, suggests that most teachers used Windows-based computers at home, though this question was not specifically asked. Only three per cent of teachers said they never used a computer home [corresponding to 1 on the response scale] and 71 per cent used it frequently [4] or always [5]. Most teachers (88%) felt confident [4 and 5] using Microsoft Windows home versions, with far fewer (46%) feeling competent in using the network version.

Teaching Practice Using ICT

In order to understand and measure teachers' use of ICT and how it influenced their teaching practice, a series of questions was developed that broadly covered aspects of software access and usage, student learning objectives, and teaching practice. This section details the six factors that reflect teachers' use of ICT in their teaching practice and the items that comprise them.

[7] Refer to Table 6.8, for the factor analysis of *thuse*.

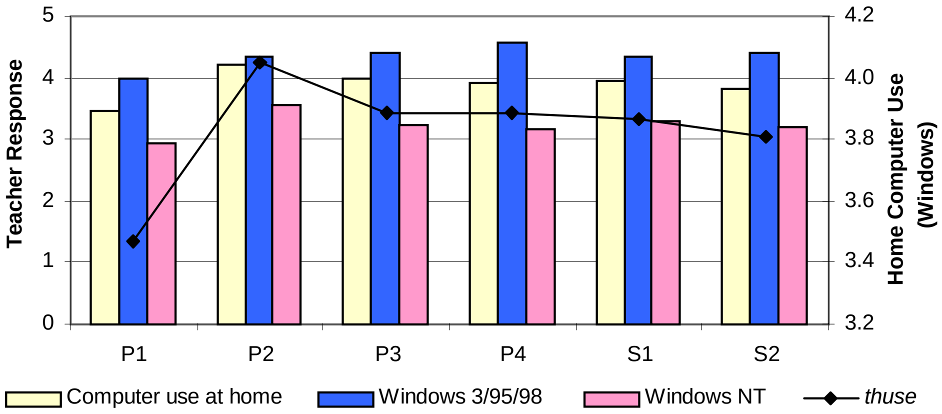


Figure 8.7 Home computer use, contrasting average teacher response to each item against the Home Computer Use index (*thuse*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Behavioural learning objectives (*objbeh*)

When teachers were asked about the learning objectives they had for students' computer use, 79 per cent considered that improving computer skills was important. Likewise, learning to work independently (82%) and collaboratively (72%), were also highly valued. Clearly, the least important learning objectives in this category were for Bloom's (1956) lower levels of learning, that of remediation (28%) and mastery (46%). Figure 8.8 presents the resulting factor, broadly described as behavioural learning objectives (*objbeh*)[8], derived by averaging the five items.

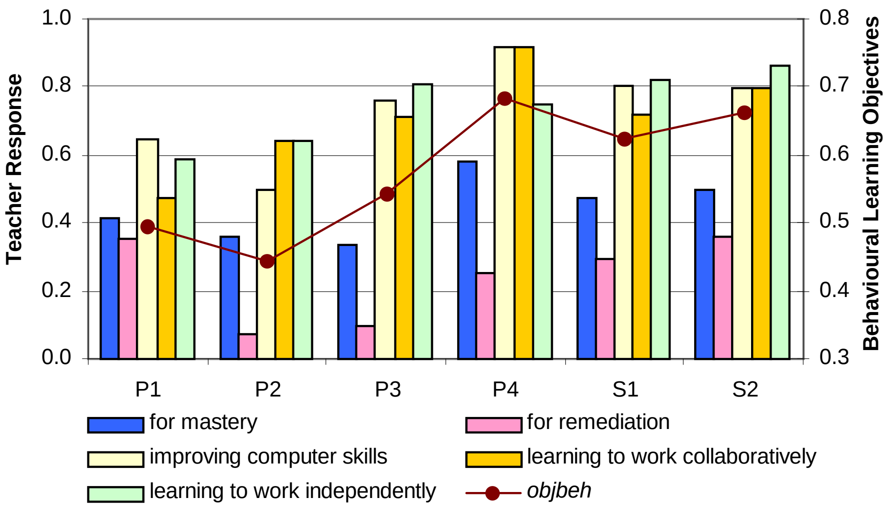


Figure 8.8 Behavioural learning objectives, contrasting average teacher response to each item against the Behavioural Learning Objectives index (*objbeh*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

[8] Refer to Table 6.3, for the factor analysis of *objbeh*.

Influence of ICT on teaching practice (*prac*)

Teachers were asked how ICT influenced the way they undertook or thought about aspects of their teaching practice (*prac*)[9]. Figure 8.9 presents the average teacher responses in each school for the seven items. With an average scale response of [3] across schools, 84 per cent of teachers said that they frequently encouraged students to use ICT as a reflection of their teaching practice. Teaching methods (29% of teachers) and goals (25%) were also strongly [4] influenced by teachers' use of ICT, though the majority of teachers (50%) found that they were only influenced to a medium extent. The lowest responses from the primary schools revealed that only 46 per cent of teachers reported students' ICT use on a frequent basis. In the secondary schools, 53 per cent of teachers considered that ICT had at least a medium influence [3] in the way they organised their classroom, which is not surprising since the nature of secondary schools, discussed in the previous chapter, means that teachers generally have less control over the organisation of the space in classrooms.

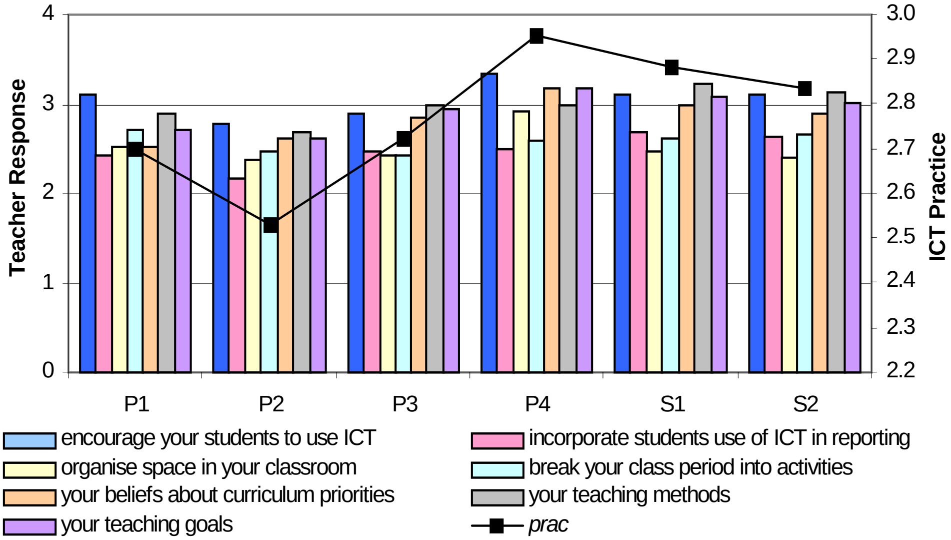


Figure 8.9 Teachers' responses to how they think ICT has influenced their teaching practices, contrasting average teacher response to each item against the ICT Practice index (*prac*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Focused learning environments (*appfoc*)

Open-ended learning applications, as described by Handal and Herrington (2003), are tools such as spreadsheets, graphics packages and presentation software. However, in the context of this study, a more specific descriptor was required, and accordingly they were summarised as focused learning environments (*appfoc*)[10], since each tool had a focused purpose. The index for each school was calculated by averaging the five items presented in Figure 8.10. Web browsers predominated, with an average of three lessons planned per term, by 49 per cent of teachers. Nearly 85 per cent of teachers indicated that they planned to use focused forms of learning applications

---

9 Refer to Table 6.5, for the factor analysis of *prac*.

10 Refer to Table 6.2, for the factor analysis of *appfoc*.

with their students. In most schools, web-browsers and presentation software were the most frequently used learning environments.

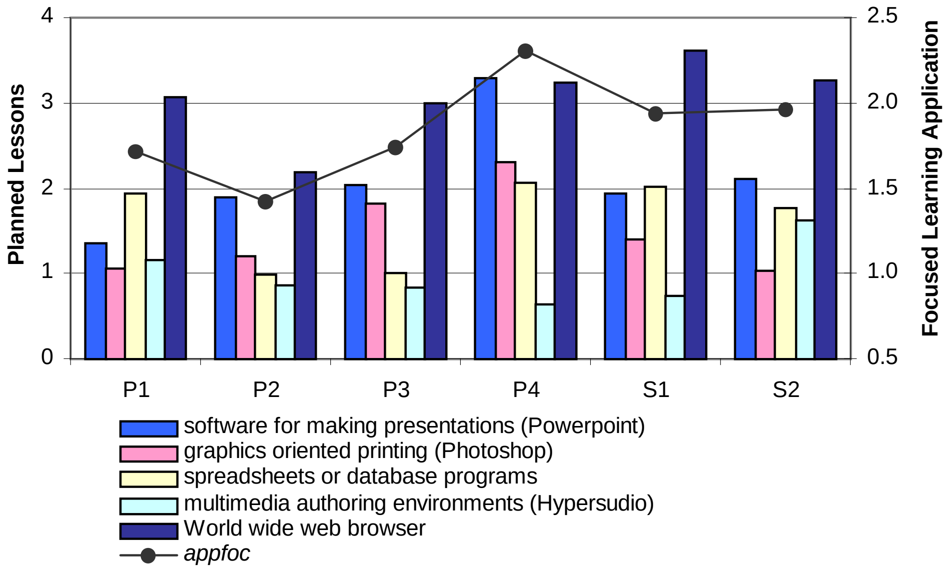


Figure 8.10 Focused learning applications that teachers planned to use in class, contrasting average teacher response to each item against the Focused Learning Application index (*appfoc*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Communication environments (*appcom*)

Meredyth et al. (1999) described the use of email discussion under the general term of communication uses. The present study defines the two items related to email discussion as communication environments (*appcom*)[11]. Since the items were measured by different scales, the simpler of the two, the dichotomous scale, was selected. Accordingly, planned use of electronic mail was reduced from a 4-point scale to a 2-point scale where the second, third and fourth options were recoded to a value of 1. Only 44 per cent of teachers planned for students to use email and 55 per cent had it among their objectives for students to communicate electronically with other people. An average of those teachers planning to use email with their students or listing it as an objective, produced the school indices presented in Figure 8.11.

Online computer access (*wwwpc*)

Teachers were asked when planning the use of ICT with their students, what level of importance they placed on a variety of equipment and software. In order to embed ICT successfully into the curriculum, 83 per cent of teachers said that they considered internet access for themselves and in the classroom to be of value, if not essential. Figure 8.12 presents the items and the corresponding reponse values of 4 and 5 on the scale.

More important, though, was access to at least five computers in or near their classrooms, with 90 per cent of teachers considering it to be valuable [4] or essential

[11] Refer to Table 6.2, for the factor analysis of *appcom*.

[5] in planning for their use of ICT with their students. The commonality between the three items of computer access with internet faclility resulted in a measure of teachers online computer access needs (*wwwpc*)[12], presented in Figure 8.12.

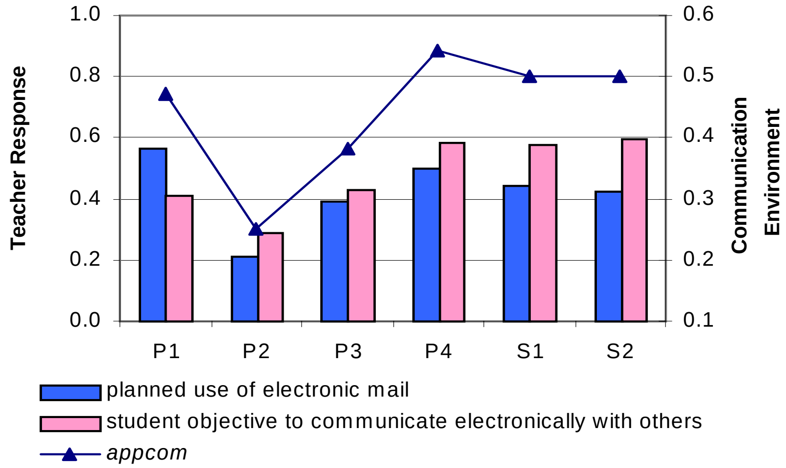


Figure 8.11 Communication environments that were planned and set as a student learning objective, contrasting average teacher response to each item against the Communication Environment index (*appcom*) for each school

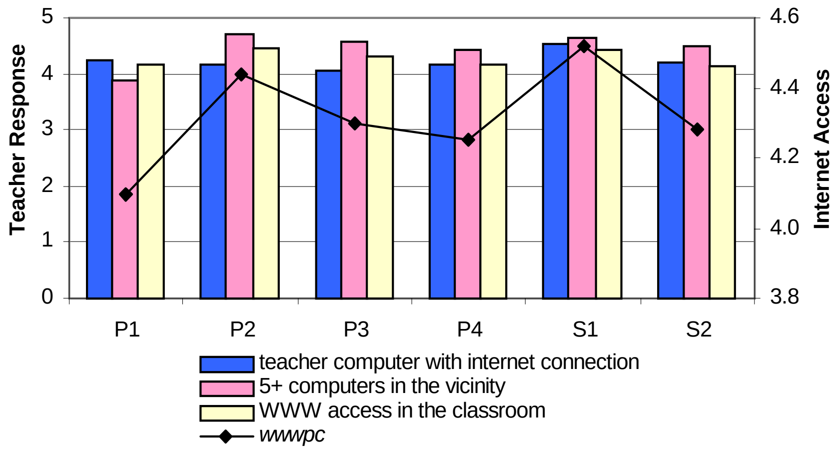


Figure 8.12 The importance to teachers of a computer with internet access, contrasting average teacher response to each item against the Internet Access index (*wwwpc*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Access to peripheral ICT (*perict*)

The access needs of teachers to a variety of hardware and software, described as peripheral ICT (*perict*)[12], was also measured for this study. Figure 8.13 presents the seven items comprising the factor. Again, those schools with the lowest use of ICT by teachers, reported the greatest need for these facilities. The profiles of peripheral ICT

---

[12] Refer to Table 6.5, for the factor analysis of *wwwpc* and *perict*.

needs were similar across the schools. The most valuable [4] or essential [5] facility needed, as indicated by 74 per cent of teachers, was access to a classroom data show. This was closely followed by the need for presentation software and digital reference material, where 65 per cent of teachers rated them as valuable or essential in planning for the use of ICT with their students.

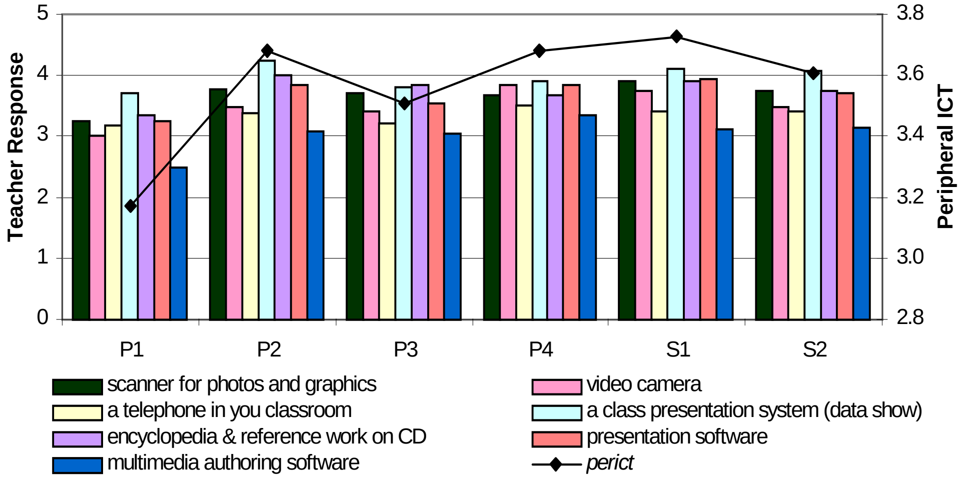


Figure 8.13 The importance to teachers of peripheral ICT, contrasting average teacher response to each item against the Peripheral ICT index (*perict*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Beliefs about Learning Outcomes, Support, Student Effort, ICT Use, and Issues

The six remaining teacher factors were sufficiently different that they did not cluster with any other factor and, as such, remained as single variables. The factors address various aspects of teachers' beliefs about ICT use and adoption, levels of school support, influence of ICT on student effort, and issues arising from embedding ICT into the curriculum. This section details the six resulting factors and the items that comprise them.

Cognitive learning objectives (*objcog*)

In this study, those objectives that were broadly described as cognitive learning objectives (*objcog*)[13], belonged to Bloom's (1956) higher levels of learning. Teachers' views about setting cognitively related learning objectives for their students were quite similar in profile across the schools, presented in Figure 8.14. Finding out about ideas and information was most valued by teachers, with some 88 per cent setting it as an objective. However, 80 per cent also said that synthesising and presenting information were important. The resulting index, broadly described as cognitive learning objectives (*objcog*), was calculated by averaging teacher responses to the four cognitive items.

[13] Refer to Table 6.3, for the factor analysis of *objcog*.

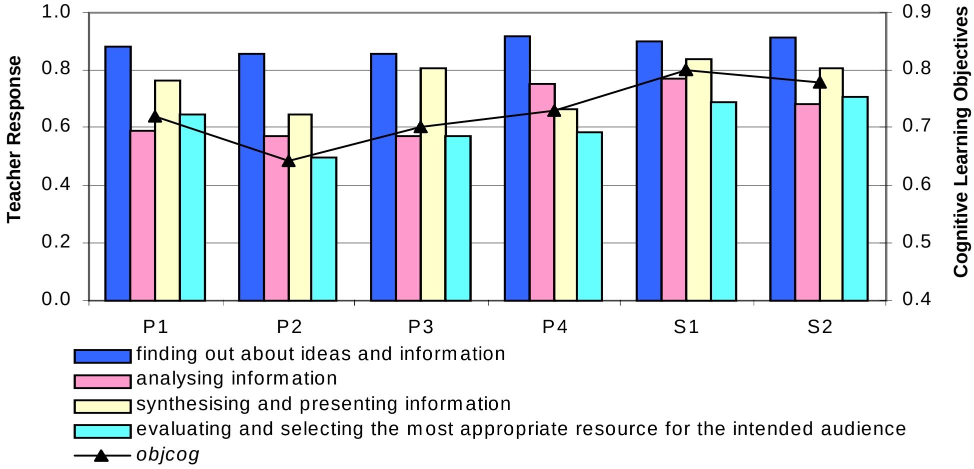


Figure 8.14 Cognitive learning objectives, contrasting average teacher response to each item against the Cognitive Learning Objectives index (*objcog*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Teacher support in using ICT (*tsupp*)

In order to gauge teachers' beliefs about the level of support (*tsupp*)[14] they considered their school provided in embedding ICT into the curriculum, four questions were asked and these responses are presented in Figure 8.15. Over 90 per cent of teachers rated their school as good [3 on the response scale], if not excellent [4], in providing technical support, professional development, and supporting them in the adoption of ICT in their teaching practice. This positive response is reflected in the last item, which asked teachers how often they sought support from others in the use of ICT. Only four per cent of the cohort said that they always [4] went to others for ICT advice and support, suggesting that the majority of teachers (96%) were reasonably independent and had an adequate level of professional development and school support.

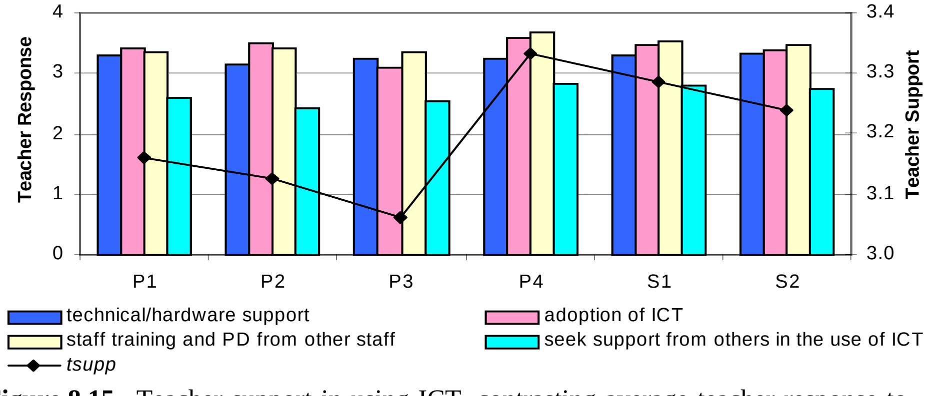


Figure 8.15 Teacher support in using ICT, contrasting average teacher response to each item against the Teacher Support index (*tsupp*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

[14] Refer to Table 6.7, for the factor analysis of *tsupp*.

Common ICT (*comict*)

The diverse range of technologies that are described under the umbrella term of ICT, can include commonplace and mass-penetration devices around the home, like television, music players, and video players and cameras, and office devices like fax machines. All of these technologies were described in this study as common ICT (*comict*)[15]. The average responses given by teachers when asked to indicate any peripheral technologies they were confident using in their teaching program, is presented in Figure 8.16. Over 90 per cent of teachers said that they were confident in using television (95%), CD or cassette players (94%) and video players (93%) with their students. Only 73 per cent of teachers felt confident using video cameras in their teaching practice.

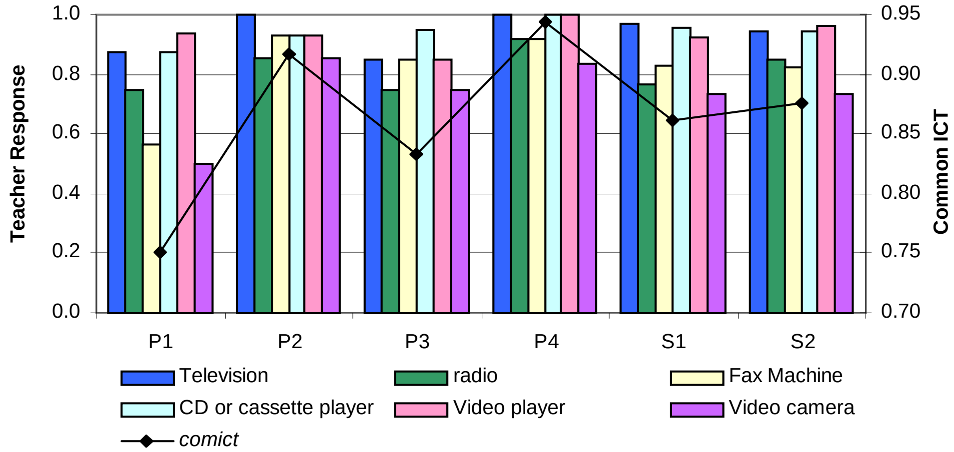


Figure 8.16 Common ICT, contrasting average teacher response to each item against the Common ICT index (*comict*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Student effort (*stueff*)

An important aspect of this study was to measure teachers' beliefs about ICT, teaching and learning. A number of questions were posed that related to teachers' beliefs about the impact that ICT had on students' academic effort and resulting work. Figure 8.17 presents the five items comprising the factor summarised as student effort (*stueff*) [16]. One of the strongest beliefs, with only 13 per cent of teachers disagreeing (corresponding to a value of 1 on the response scale), was that students were more willing to do a second draft when using a computer. Most teachers (62%) believed [3] that students took more initiative outside of class to improve their work when ICT was used, while some teachers (26%) had no opinion [2]. The least believed statement, that average students produced work at a gifted standard when using computers, was considered false [1] by only 24 per cent of teachers.

[15] Refer to Table 6.9, for the factor analysis of *comict*.

[16] Refer to Table 6.6, for the factor analysis of *stueff*.

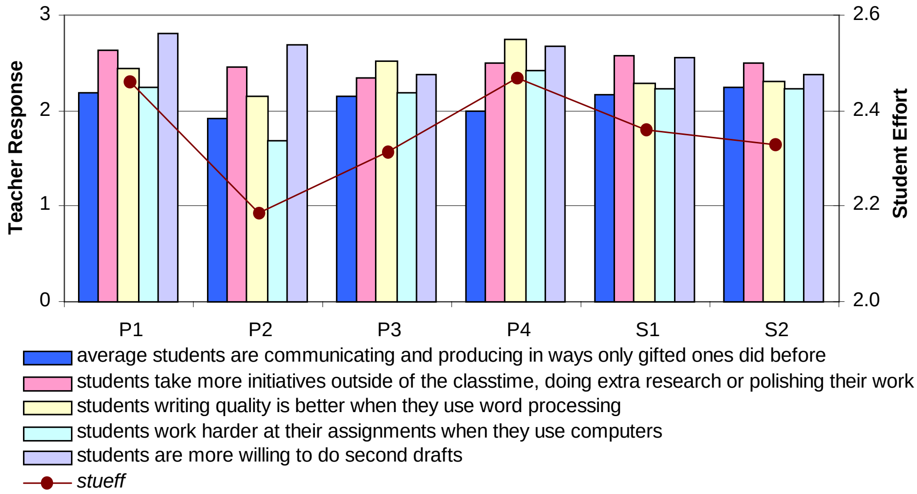


Figure 8.17 Teachers' beliefs about the impact that ICT has on students' academic effort and resulting work, contrasting average teacher response to each item against the Student Effort index (*stueff*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Open learning environments (*appopn*)

In planning for their teaching and students' learning, teachers were asked to indicate how many lessons they currently planned for their students to use a variety of software applications in the classroom during that term. In this study, learning environments pertain to specific educational software (Koper, 2000). Open-ended learning environments, like word-processors, are regarded as flexible tools that are curriculum non-specific and allow students to demonstrate their learning, according to their level of development and preferred learning style. Figure 8.18 presents the four applications, broadly described as open learning environments (*appopn*)[17], by graphing the average number of planned lessons per term against each school.

Of the 219 teachers who participated in the study, 41 per cent said that they did not plan for the use of these forms of learning technologies in their teaching, and only 10 per cent planned for at least 10 lessons in the term (see Figure 8.18). Across all schools, word-processing was most commonly planned for use in lessons (79% of teachers) with an average of four lessons planned per term across schools. This was closely followed by the use of electronic reference materials (67% of teachers) at an average of three lessons per term.

Teaching issues (*tissus*)

Three items, presented in Figure 8.19, were developed that related to teachers' beliefs about issues arising from embedding ICT into their teaching practice (*tissus*)[18]. The low teacher response rates across the schools suggest that these beliefs were not strongly held. The most widely believed statement, that too many students needed the teacher's help at the same time, only had the agreement [3] of one third of the teachers, with the other two-thirds equally divided between no opinion [2] and

[17] Refer to Table 6.2, for the factor analysis of *appopn*.

[18] Refer to Table 6.6, for the factor analysis of *tissus*.

disagreement [1]. It was reassuring to see that these largely negative items were not widely supported. However, 27 per cent of teachers still believed [3] it was difficult to integrate ICT into their lessons and five per cent agreed [3] that they did not feel like they were really teaching when using computers.

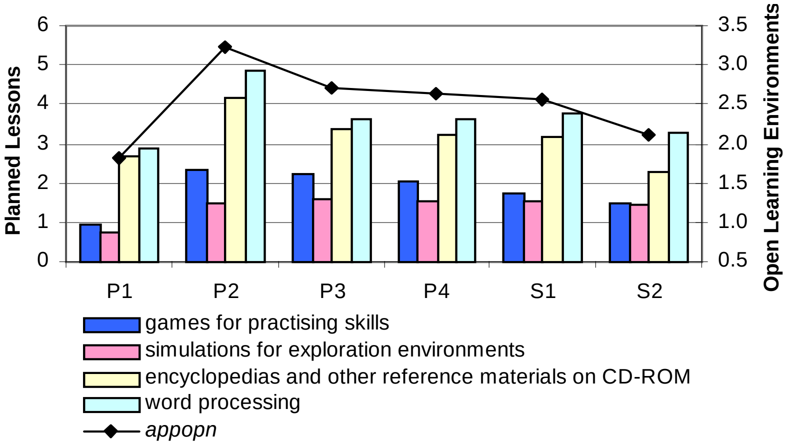


Figure 8.18 Open learning environments that teachers planned to use in class, contrasting average teacher response to each item against the Open Learning Environments index (*appopn*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

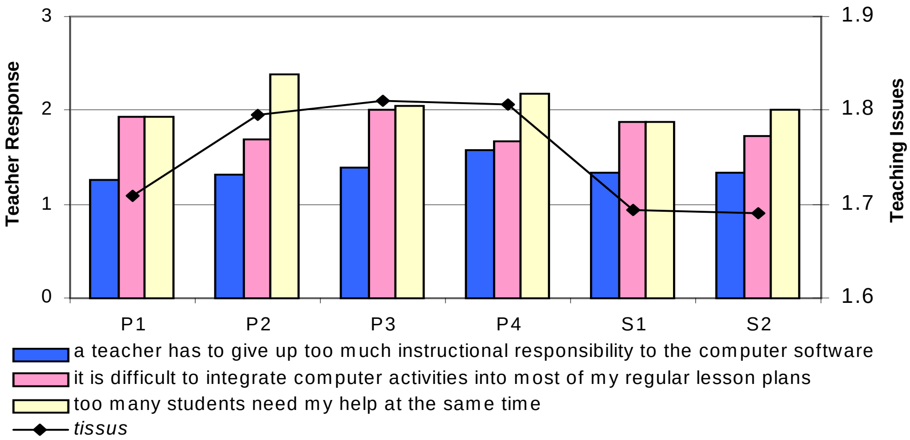
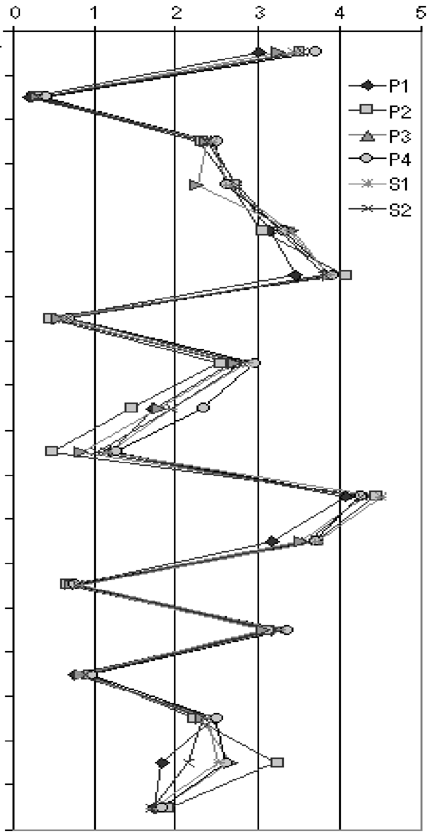


Figure 8.19 Teachers' beliefs about issues arising from embedding ICT into their teaching practice, contrasting average teacher response to each item against the Teaching Issues index (*tissus*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Summary

This chapter presents a profile of each of the teacher factors, identified in Chapter 6, with an in-depth examination of the items that comprise them. While it was essential to understand the underlying concepts being measured by each variable at a teacher-level, of equal importance was determining the school-level indices that would also contribute to the major analyses conducted in Chapters 10 and 11. Differences in the teaching cohorts and the prevailing climates of the six schools, resulted in a set of unique indices that described each school. Figure 8.20 summarises the teacher factors that contribute to the school-level indices by averaging each schools' responses from their teachers. In each case, the school with the highest mean response is presented in bold.

Teacher Responses



Clusters	Factors	P1	P2	P3	P4	S1	S2
		School Indices					
CONFID	*tconf*	3.02	3.50	3.26	**3.67**	3.45	3.55
	specit	0.18	0.26	0.30	**0.38**	0.31	0.29
	aaadv	2.43	2.27	2.37	**2.47**	2.44	2.38
	oplats	2.71	2.69	2.27	2.61	2.64	**2.73**
HOMUSE	*aagen*	3.13	3.03	**3.40**	3.31	3.38	3.24
	thuse	3.47	**4.05**	3.88	3.89	3.86	3.81
TEACH	*objbeh*	0.49	0.44	0.54	**0.68**	0.62	0.66
	prac	2.70	2.53	2.72	**2.95**	2.88	2.83
	appfoc	1.73	1.42	1.76	**2.31**	1.94	1.95
	appcom	1.19	0.47	0.83	**1.24**	1.14	1.02
	wwwpc	4.10	4.43	4.31	4.25	**4.52**	4.28
	perict	3.17	3.71	3.51	3.68	**3.73**	3.61
OUTCOM	*objcog*	0.72	0.64	0.70	0.73	**0.80**	0.78
SUPPORT	*tsupp*	3.16	3.13	3.06	**3.33**	3.29	3.24
COMMON	*comict*	0.75	0.92	0.83	**0.94**	0.86	0.88
EFFORT	*stueff*	2.46	2.20	2.31	**2.47**	2.36	2.33
OPENLN	*appopn*	1.84	**3.22**	2.66	2.62	2.53	2.14
ISSUES	*tissus*	1.71	**1.88**	1.81	1.81	1.69	1.69

Note: *tconf* = Teacher confidence; *specit* = Specialised ICT; *aaadv* = Advanced administrative activities; *oplats* = Confidence in using other platforms; *aagen* = General administrative activities; *thuse* = Home computer use (Windows); *objbeh* = Behavioural learning objectives; *prac* = Influence of ICT on teaching practice; *appfoc* = Focused learning applications; *appcom* = Communication environments; *wwwpc* = Importance of internet access; *perict* = Importance of peripheral ICT; *objcog* = Cognitive learning objectives; *tsupp* = Teacher support; *comict* = Common ICT; *stueff* = Student effort; *appopn* = Open learning applications; *tissus* = Teaching issues.
In each case, the school with the highest mean response is presented in bold.

Figure 8.20 Summary of the school-level indices derived by aggregating the teacher factors for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

For easy comparison between schools, Figure 8.20 also presents a profile of each school by graphing the factors on a common scale, keeping in mind that different scales are used. Where teachers are similar in each school, the indices are close together, and where there are differences, a spread across each factor is evident. The factor showing the largest spread (with a standard deviation of 0.5) is that of open learning environments (*appopn*). Clearly there were differences between the first and second primary schools. In primary school P1, 42 per cent of teachers said that they had no intention of using open learning applications, like word-processors or CD-

ROM reference materials, in their lessons. At the other end of the spectrum, only 27 per cent of teachers in primary school P2 comprised an equivalent cohort. Although the second primary school gave a high rating in open learning applications (*appopn*), the teachers gained the lowest rating in their use of focused (*appfoc*) and communication (*appcom*) learning environments, particularly in comparison to primary school P4. Whether these differences were sufficient enough to have had an impact on student attitudes, are examined in Chapters 10 and 11.

9

Students: Change Across Grades and Over Time

This chapter presents the final set of indices, describing the student population from a statistical basis, in addition to presenting the longitudinal data as students track across grades and occasions.

A total of 2560 students participated in this study on one, two or three occasions. Although the availability of longitudinal data has provided the opportunity to examine student change over time, for the purposes of presenting the student factors, aggregated responses are used in the relationships presented in this chapter. Content analysis of the factors, broadly describing students' access, use, literacy and confidence in using ICT, in addition to attitudes about computers, school and self, are presented at the item level. Like the method used in the previous chapter, the use of a graphical format is again adopted, with axis increments corresponding to the possible responses and dual axes showing average student response (for example, an axis from zero to one, represents a no/yes response scale) and the school-level index. The resulting average student and school-level indices, as well as highlights of the main differences between the schools, are discussed in the chapter summary. These results are an essential step in the preparation needed for the subsequent analyses.

Following on from the descriptive analysis of the teachers' characteristics presented in the previous chapter, this chapter reports a similar investigation by profiling the student factors that are identified in Chapter 6. Once again, the use of hierarchical cluster analysis assists in the formation of the latent variables required for the path and HLM analyses in the chapters that follow. Arrangement of the discussion is on the basis of the configuration of the resulting clusters, but, first, practical aspects of student ICT use and then the attitudinal scales are addressed. The discussion provides insight into the 22 individual student variables and the items that comprise them, while also giving a broader sense of the underlying composition of the latent variables.

Clustering Student Factors

Hierarchical cluster analysis identified relatively homogeneous factors using between-group linkage and Pearson's correlation coefficient. The resulting dendrogram plot, presented in Figure 9.1, was employed after consideration of the content of each variable to form the latent variables necessary for subsequent analyses. The aim was to group together similar factors to form meaningful latent variables, but not at the expense of detail and meaning. Figure 9.1 shows the 'distances' between variables in terms of the patterns of item response (Wu, 2003). For example, the affective and cognitive components of computer attitude are closest or most similar in terms of the way in which students responded to the items. Figure 9.1 also presents the nine latent variables that are formed (COMATT, ICTUSE, HOMWK, HOMACC, ENTRMT, SCHATT, SELFATT, ICTLIT, and SCHACC). Although it provides the structure for the following discussion of the 22 student variables, continuity dictates that the attitudinal factors, those of computer (COMATT), school (SCHATT) and self (SELFATT) attitude, are considered last. Accordingly, the purpose of this chapter is to examine and discuss the student data in its entirety; that is, in its longitudinal form as students change over time.

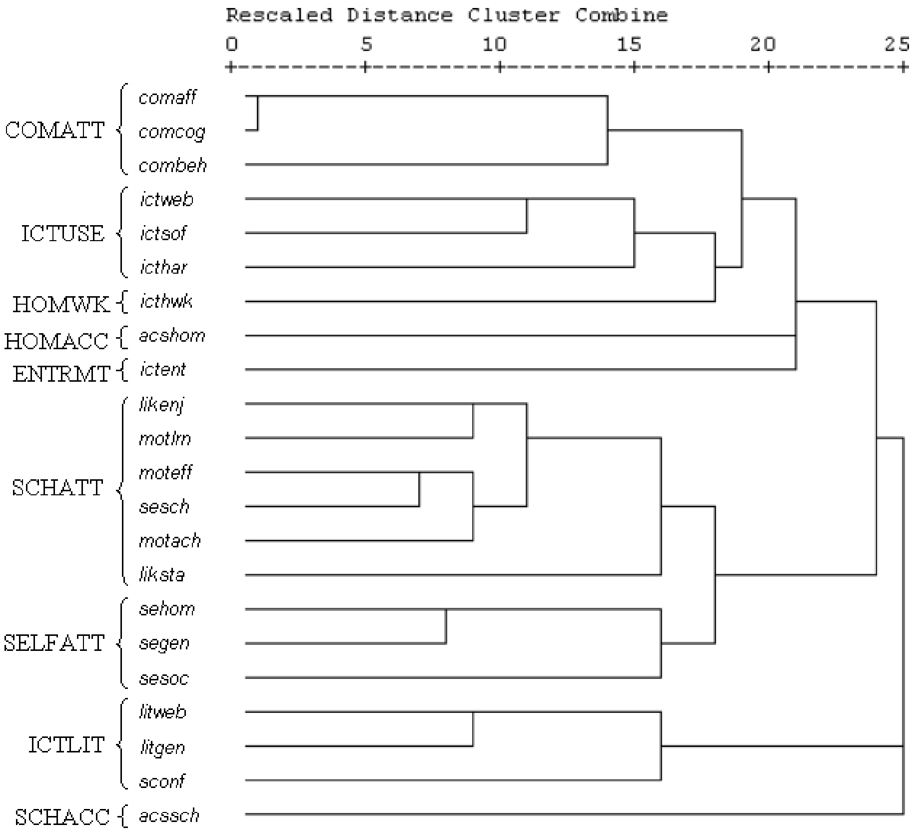


Figure 9.1 Dendrogram presenting the cluster analysis of 22 student factors forming nine latent variables

Change Within Students Over Time

Given the longitudinal nature of the study, information was collected from primary and secondary students on three separate occasions and across six year-levels. Such data provided the opportunity to measure change in students as their schools undertook the process of embedding ICT into the curriculum. The student database of 2560 participants with 4863 responses and no missing data was used in the comparative analysis of each factor. Presented with the content analysis of each factor, the comparative analysis examines the same groups of students in the primary and secondary settings as they change across year-levels and over time.

Students were, in effect, tracked from one year-level to the next as they moved from one occasion to the next. For example, those students who were in Year 5 when the study began, participated on all three occasions. Because these students were tracked to Year 6 on the second occasion, through to Year 7 on the final occasion of the study, they provided one of several groups of students for whom within-student changes can be measured. Similarly, there was a group of Year 8 students on the first occasion who could be tracked across time, in addition to four other groups of students, who had the opportunity to respond on two occasions. A clearer understanding of these groups is obtained by reference to Figure 6.1 in Chapter 6, which illustrates the diagonal configuration as students move across year-levels and occasions.

Change between students over time

However, change in the same student over the three-year period, to some extent, was expected. As they got older, their computer knowledge increased, even under normal educational environments. However, if the adoption of ICT through the curriculum had been effective, then a change should be observed in students of the same grade from one occasion to the next. In other words, in a normal educational environment, it would be expected that, for example, the Year 5 students were similar to Year 5 students of the previous year and those of the subsequent year. However, due to the changing educational environment in which these students were immersed, it would be reasonable to expect that over the duration of the study, their attitudes and computer skills might change from one year-level cohort to the next. Interestingly, the between-student analysis using WesVarPC (discussed next) yielded similar significance outcomes as the within-student analysis, consequently only the within-student analyses are discussed in this chapter.

Significance testing using WesVarPC

Since students were clustered within schools, allowances had to be made for these circumstances when testing for significance between occasions in this study. In order to test for significant change between groups in an appropriate way, the computer program WesVarPC (Brick et al., 1997) was used. By doing so, problems of significance due to group effects in multilevel data were taken into consideration. In this analysis, the difference between estimates was regarded as being significant (at the 0.05 level) if the probability was smaller than five per cent for a difference with allowances made for the clustering of students within schools. In other words, the 0.05 level of significance was chosen for the rejection of the null hypothesis of no difference between students who were sampled within school groups. Significance testing was performed between occasions 1 and 2, occasions 2 and 3, and occasions 1 and 3, for each student factor.

Presenting change

The main format in which changes in the student factors are presented uses bar graphs and represents the mean response of the students clustered by occasion. Any changes in mean attitude over the period can thus be viewed easily. If the changes are sufficiently different, greater than approximately twice the standard errors associated with a cluster sample design (set at the probability of 0.05), these changes are considered to be statistically significant and potentially attributable to any major influence in the environment. In order to assist in easy interpretation, the graphs are enhanced by the addition of convex curves, used to indicate where a significant difference between occasions is recorded. Graphs were generated using Microsoft Excel and enhanced in Microsoft Word's graphics editor.

ICT-rich Entertainment and Homework

A composite of instruments was designed for this study in order to gauge practical aspects of students' ICT experience inside and outside of school. Among them were measures of students' use of entertainment technology and computers for studying and doing homework. This section examines the two resulting factors that clustered together, the items that comprise them, and any changes that occurred over the three occasions.

Entertainment use (*ictent*)

Three items were factored together to form a measure that is described as entertainment use (*ictent*)[19], as is shown in Figure 9.2. These mass-penetration technologies include such devices as television, video players, radios and CD or tape cassette players, and it is not surprising to see that most students were very familiar with these. Over 95 per cent of students reported that they had used television, radio and music players outside of school that week and the use of video was commonplace to 82 per cent of the student cohort. The difference between primary and secondary school groups suggests that secondary school students used these forms of technology more often or were more likely to have had access to them than were the primary school students.

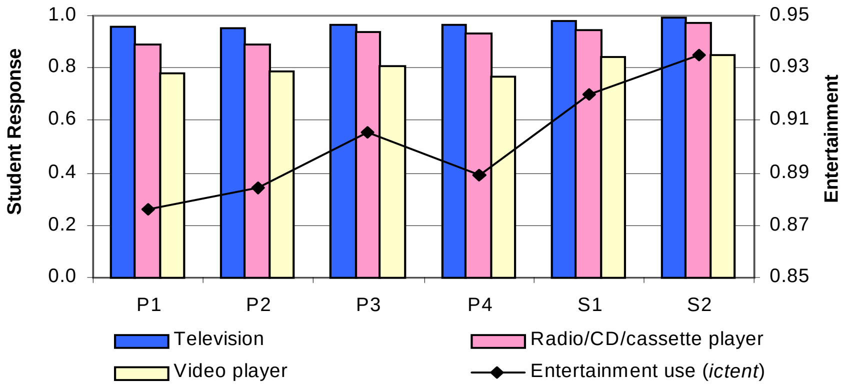


Figure 9.2 Students use of forms of entertainment technology outside of school, contrasting average student response to each item against the Entertainment index (*ictent*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

[19] Refer to Table 6.10, for the factor analysis of *ictent*.

ICT-rich homework (*icthwk*)

The composition of items that formed a measure of ICT-rich homework (*icthwk*)[20] was achieved through the combination of the types of tasks students used computers for and the kinds of applications they used at home. Students' responses to both items are presented in Figure 9.3. That homework factored with word-processing suggests that the major form of homework that students were using the computer for was text-based. There was surprisingly little difference between primary and secondary students' use of the computer for homework, projects and studying. Approximately 77 per cent of primary school students, compared to 88 per cent of secondary school students, used the computer for this purpose. With an average of 65 per cent of students, even less difference existed between the cohorts in their use of word-processing.

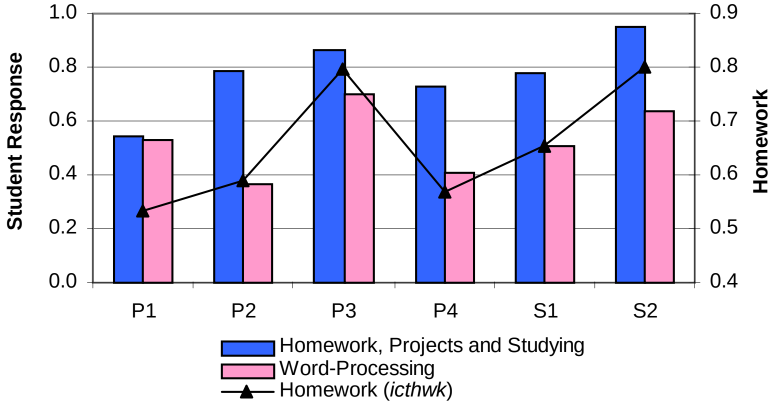


Figure 9.3 Students use of the computer outside of school for homework, contrasting average student response to each item against the Homework index (*icthwk*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Change in ICT-rich entertainment and homework

The extent of students' use of technology outside of the classroom and beyond that of the computer is clearly quite high and results extensively from the use of television. But how students' use of these and other technologies in the home varied over the three years of the study, was of importance. Change in students' use of entertainment technologies and computers for doing homework is presented in Figure 9.4, grouped by occasion and by setting.

Interestingly, Figure 9.4 suggests that in an environment increasingly influenced by the use of ICT, students' use of entertainment technologies like television and radio, declined, and significantly so, over the duration of the study. A possible interpretation of this result is that students were spending more time using computers and less time watching television or listening to music. However, this is not reflected in their increased use of computers for homework and study. For this factor, no significant changes are apparent over the life-span of the study.

---

[20] Refer to Table 6.10, for the factor analysis of *icthwk*.

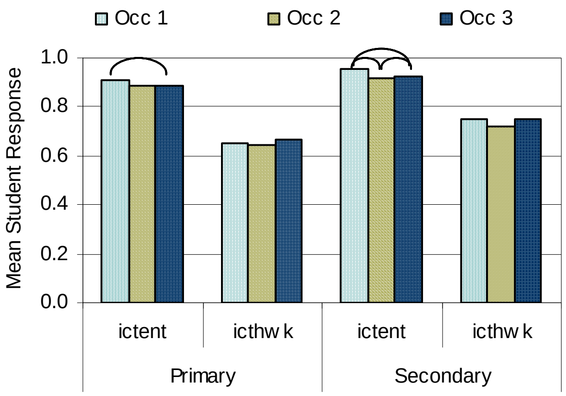


Figure 9.4 Change in students' use of technology for entertainment (*ictent*) and homework (*icthwk*), where the convex curves represent a significant change in attitude between occasions at the 0.05 level

Access to Computers

An important measure necessary in providing an accurate account of the context in which student attitudes may change, is the level of access to computers, both at home and at school. Of the four items developed for this study, two were designed to measure levels of computer access at home, while the other two items were developed to gauge levels of computer access at school. This section presents those items and the aggregated responses by students in each school, along with the disaggregated data through which change is examined.

Computer access at home (*acshom*)

With 95 per cent of students having access to a computer at home (*acshom*)[21], digital technologies outside of school were clearly commonplace. Figure 9.5 presents the high levels of computer ownership in all but those students in the first primary school. Meredyth et al. (1999, p.125) contended that "there is an apparent relationship between income and use of computers outside of school". That the primary school P1 is located in a low to middle-income area, may explain the comparatively lower number of students (76%) with home computer access, though the affordability of game stations, is evidently not an issue. Students were also asked whether it was a Windows or Macintosh computer. Not surprisingly, the Microsoft Windows platform dominated the market with a Windows to Macintosh ratio of 7 to 1. Gaming systems, like Playstation, were also a popular activity with approximately half of the student population owning a system.

Computer access at school (*acssch*)

Of equal interest was the measure of students' computer access at school (*acssch*)[22]. Since students did not generally know what their school's student to computer ratio was, two questions were developed to provide an indication of school computer access. Figure 9.6 presents these items. Students were asked how they usually used a computer at school, distinguishing between 'individual' (corresponding to [1] on the response scale), 'pairs' [2], 'small group' [3], 'large group' [4], or 'whole class' [5]

[21] Refer to Table 6.12, for the factor analysis of *acshom*.

[22] Refer to Table 6.12, for the factor analysis of *acssch*.

work. Most commonly, students reported that they used computers on their own (48%) or in pairs (29%), and together these accounted for 77 per cent of responses. This result concurs with the findings of Meredyth et al. (1999). The underlying interpretation of this item suggests that, if students regularly work individually or in pairs on a computer, it is because there are sufficient computers in the school for students to use. Supporting this interpretation, were the responses given to a belief-based item where students were asked if they thought their school had enough computers for students to use for their work. Only 23 per cent of students 'disagreed' [2] or 'strongly disagreed' [1] to the statement.

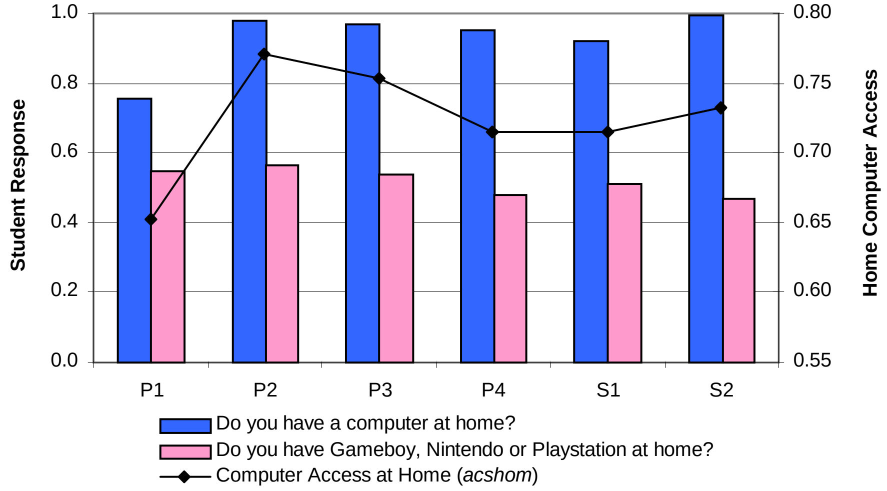


Figure 9.5 Home computer access, contrasting average student response to each item against the Home Computer Access index (*acshom*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

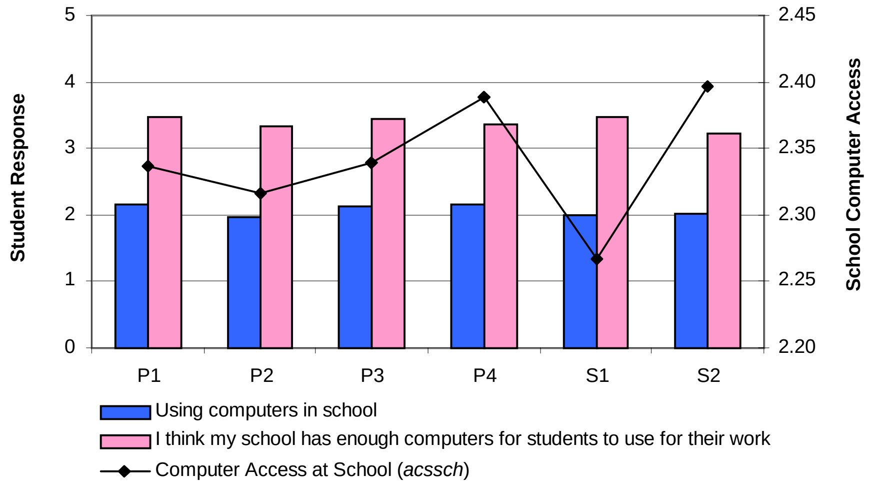


Figure 9.6 School computer access, contrasting average student response to each item against the School Computer Access index (*acssch*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

In order to calculate the school computer access index, responses to the first item required reverse scoring, so that a response of 'working individually' received a score of [5], equivalent to a response of 'strongly agree' in second item. For this reason, the index line, shown in Figure 9.6, does not directly reflect an average of the two items. The resulting school-level index suggests that students in secondary school S1 had the most difficulty or the greatest demand for accessing computers in their school.

Change in access to computers

Changes in the responses given by students over the three-year period due to the adoption of ICT in schools could not be clearly understood without assessing the context by which these changes might have been influenced. The changing levels of computer access, both at school and in the home as presented in Figure 9.7, are two such measures of context.

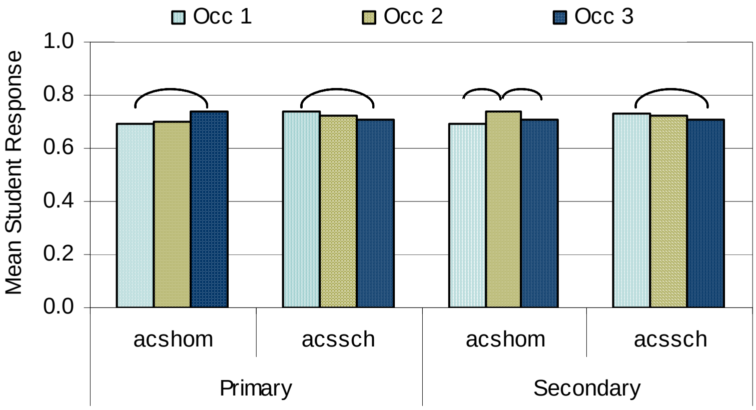


Figure 9.7 Change in students' access to computers at home (*acshom*) and school (*acssch*), where the convex curves represent a significant change in attitude between occasions at the 0.05 level

In examining change between occasions for primary and secondary school students, Figure 9.7 shows a significant increase in students' potential access to a computer in the homes of primary school students. Change in levels of access are less clear for secondary school students. With a significant increase in the first half of the study followed by a significant but smaller decline in the second half, an overall outcome of no change in home computer access resulted.

Although students' potential levels of computer access had generally improved outside of school, it might not necessarily follow that students had gained greater access within school, even though many schools chose to allocate their resources to address this need. Judging by students' responses to the crude measures of school computer access over the three years, it is apparent in Figure 9.7 that students increasingly believed that their schools did not have sufficient computers for them to access for their work. Over the first to last occasions of the study, the apparent decline in computer access in the primary and secondary schools were large enough to be significant. This drop might have been a result, not of a decline in the actual numbers of computers in the schools, but in response to the increased demand on a limited resource. Indeed, one of the secondary schools involved in the project, claimed the highest student to computer ratio in the public school sector and averaged one computer to three students. Therefore it might have been the case that it was more important how they were used, rather than how many were available.

ICT Use Outside of School

In anticipation of the likely importance of the home environment to students' development and use of ICT skills, a number of questions were developed for this study that asked students about their use of computers and peripheral technologies outside of school. Broadly falling into the categories of internet, software, and hardware use, the three resulting factors and their items are presented in this section, in addition to the examination of their change over time.

Internet use (*ictweb*)

A measure of students' internet use (*ictweb*)[23] was formed by three items, presented in Figure 9.8. So called 'surfing the internet' was the most common web-related activity with 68 per cent of primary students and 84 per cent of secondary students using the computer for this purpose. Using email and visiting chat-rooms were also more common among secondary school students, with 64 per cent communicating online compared to 46 per cent of primary school students.

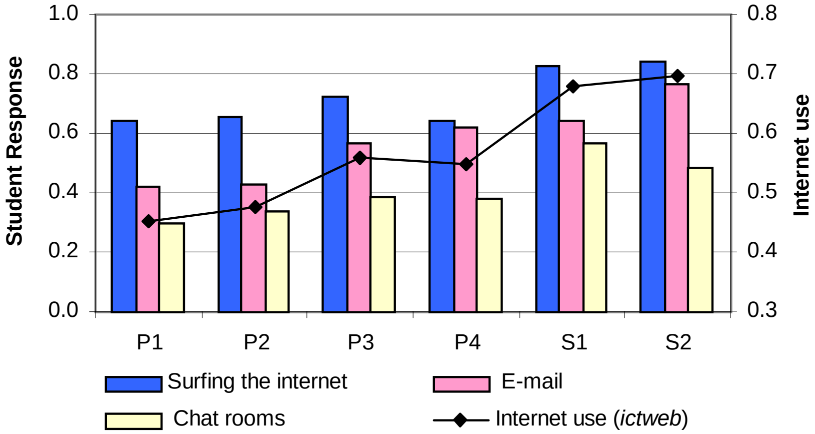


Figure 9.8 Students use of the internet outside of school, contrasting average student response to each item against the Internet Use index (*ictweb*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

General software use (*ictsof*)

A total of five items factored together to form a measure of students' use of general software applications outside of school (*ictsof*)[23]. As shown in Figure 9.9, the non-specific items, playing computer games and using computer programs, received the highest number of responses from, on average, 83 per cent of students. Students' use of music software was more predominant in the secondary settings: 66 per cent of secondary students compared to 58 per cent of primary students selected the item. Graphics and animation software were more frequently used by students in the primary school (40%) and less frequently by students in the secondary school (35%).

[23] Refer to Table 6.10, for the factor analysis of *ictweb* and *ictsof*.

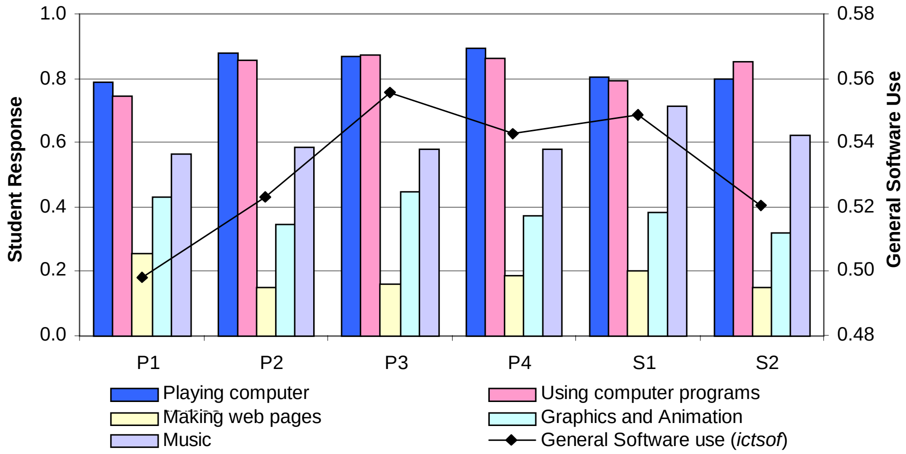


Figure 9.9 Students use of general software applications outside of school, contrasting average student response to each item against the General Software Use index (*ictsof*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

General hardware use (*icthar*)

In comparison to students' use of software, their use of peripheral hardware (*icthar*)[24], comprising five items, was far less. At the top of the frequency scale, presented in Figure 9.10, were mobile phones. Fifty-three per cent of primary students and 65 per cent of secondary students reported that they had used a mobile phone that week. The use of video cameras (24%) and scanners (29%) received similar levels of reported use by students in the primary and secondary settings. With an average response of 14 per cent of students, the least frequently used hardware were digital cameras and fax machines.

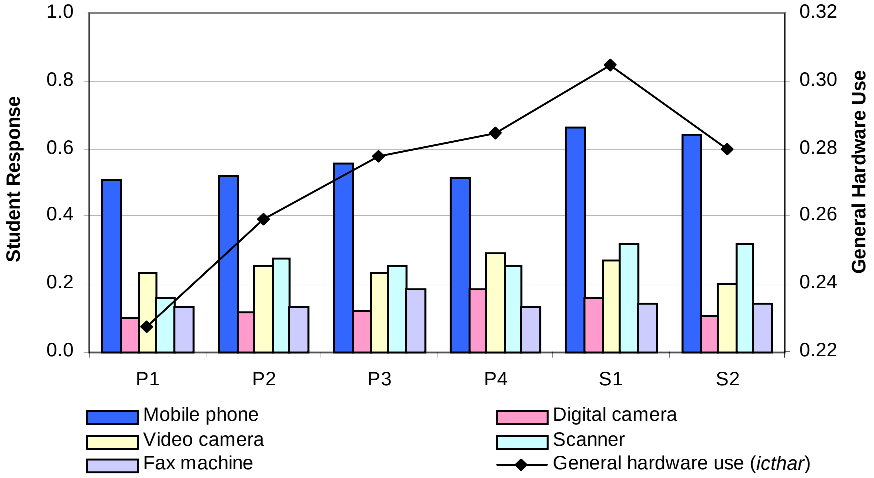


Figure 9.10 Students use of general forms of hardware outside of school, contrasting average student response to each item against the General Hardware Use index (*icthar*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

[24] Refer to Table 6.10, for the factor analysis of *icthar*.

Change in ICT use outside of school

With an increase in the amount and diversity of ICT within school, it was of interest to gauge to what extent, if any, students' usage of ICT outside of school varied over the three-year period. Figure 9.11 presents change in students' use of the internet (*ictweb*), software (*ictsof*), and hardware (*icthar*) outside of school.

Across all factors, increases in usage outside of school were evident over the three years (see Figure 9.11). Web-based communications, the internet, e-mail, and chat-rooms, showed significant increases in usage outside of school, particularly in the primary cohort, where increases were significant on every test. Secondary students also improved in their web-based computer usage but only from the first to last occasion. Primary students also showed significant increase in their use of software outside of school during the study, but this change was not as apparent in the secondary group. Most consistent in growth for the primary and secondary school students, was the use of peripheral ICT hardware outside of school, largely due to the increasing popularity of mobile phones. Between each occasion significant increases occurred in all but the second to third occasion for the primary school students. Arguably, these changes outside of school could be attributed to the influence of the schools embedding ICT into the curriculum.

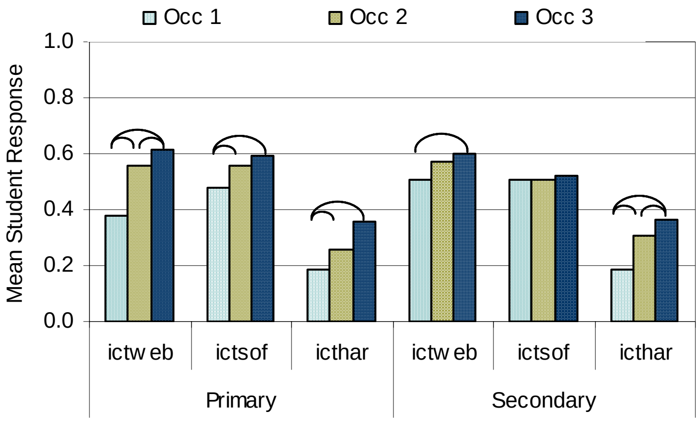


Figure 9.11 Change in students' use of the internet (*ictweb*), software (*ictsof*), and hardware (*icthar*) outside of school, where the convex curves represent a significant change in attitude between occasions at the 0.05 level

ICT Literacy and Confidence

Students' levels of ICT literacy and confidence using ICT in their learning were of key concern to this study. Accordingly, a list of nine proficiencies identified as common in the use of computers was developed. Students were asked to indicate which of these skills they had and where they first acquired them: at home, at school, or so-called 'other'. The reported responses, which reveal a high level of skill possession, are summarised in Figure 9.12. The average number of proficiencies possessed by students was eight and 55 per cent of students surveyed reported that they had all the skills listed. Average skill acquisition across all proficiencies was very similar between home (41%) and school (42%), and only four per cent of students gained the skills in other locations. Proficiencies that tended to be learnt outside of school, in the home or another place, included using the internet (80%), making websites (54%), and using spreadsheets (58%). The remaining skills were, on average, first acquired at school by 52 per cent of the students.

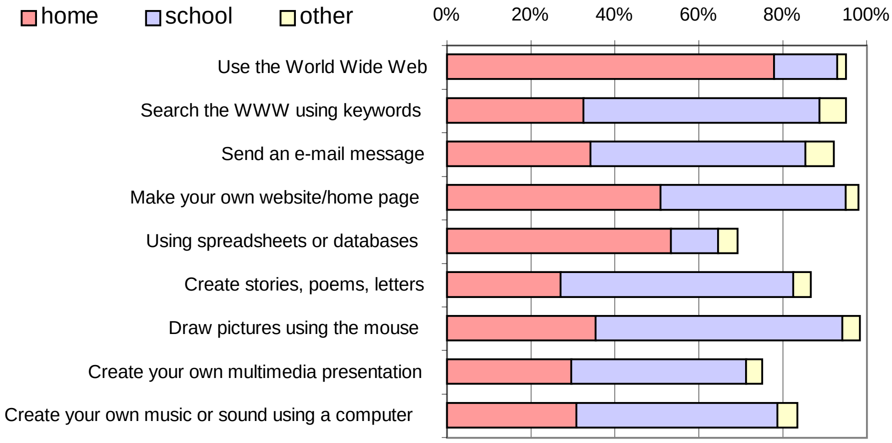


Figure 9.12 Students' computer literacy and where they acquired the skills, at home, school, or elsewhere

However, as compelling as the presentation in Figure 9.12 of students' acquisition of computer skills is, it does not give a breakdown at the school level of the two factors that resulted from the factor analysis. Therefore, the remainder of this section presents the two resulting ICT literacy factors and their change over time, in addition to another factor, measuring students' ICT confidence, which also comprises the latent variable described as ICT literacy and confidence.

Web-based knowledge (*litweb*)

Four items from the nine listed, factored together under the concept of web-based knowledge (*litweb*)[25]. Figure 9.13 clearly shows that students were highly proficient in these skills. Approximately 93 per cent of primary students and 96 per cent of secondary students indicated that they could use and search the internet, send email and make a homepage.

General computer knowledge (*litgen*)

Five remaining literacies, described as general computer knowledge (*litgen*)[25], are presented in Figure 9.14 on a school-by-school basis. The least well-known skills, and yet still claimed by the majority of students, were using spreadsheets (68%) and creating multimedia presentations (73%). A high proportion (85%) of students indicated that they could create stories and sounds on the computer and nearly all students (98%) claimed they could draw pictures using the computer mouse. Only a four per cent difference, in favour of the older students (84% in secondary school), existed between the average number of general skills acquired.

[25] Refer to Table 6.11, for the factor analysis of *litweb* and *litgen*.

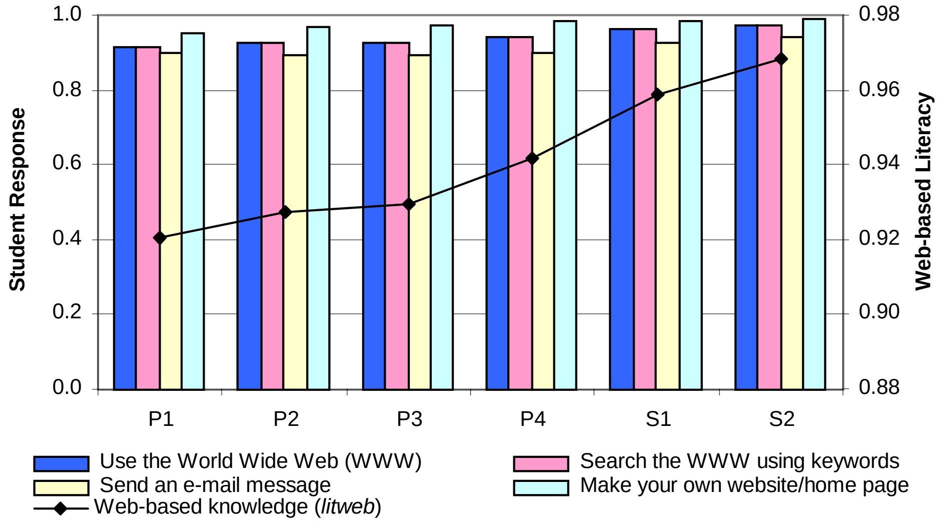


Figure 9.13 Web-based literacy, contrasting average student response to each item against the Web-based Literacy index (*litweb*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

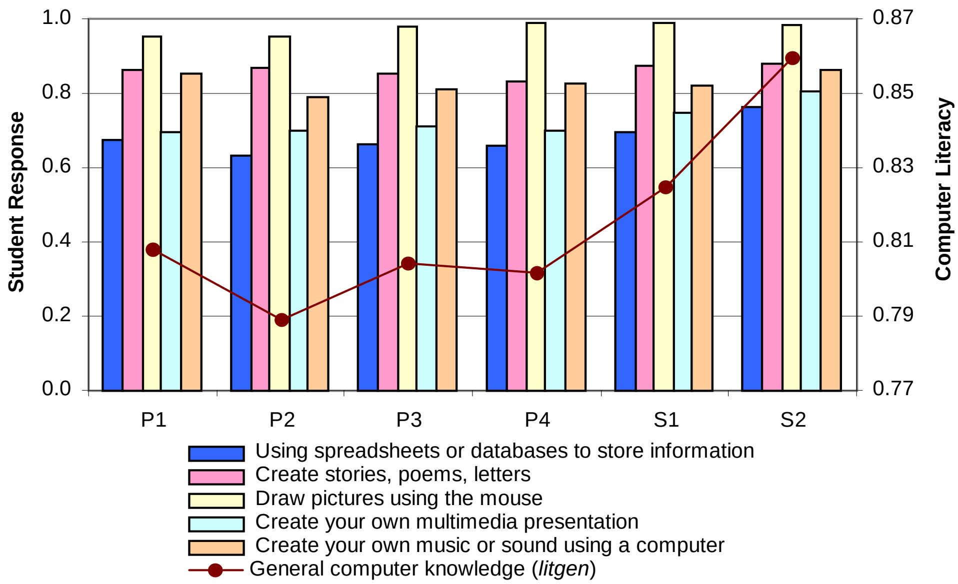


Figure 9.14 General computer literacy, contrasting average student response to each item against the Computer Literacy index (*litgen*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Student computer confidence (*sconf*)

Three belief-style questions developed for this study asked students how much they liked and were good at using the computer and keyboard. The common concept underpinning these three items, presented in Figure 9.15, is loosely described as computer confidence (*sconf*)[26]. When students were asked how much they liked using a computer, 63 per cent stated they liked it (corresponding to a value of [2] on the response scale) and 29 per cent claimed they loved it [3]. Beliefs about how good students were at using a computer were a little more modest with the majority (72%) rating their skill level as good [2] and far fewer (18%) claiming to be excellent [3]. Keyboard competence was the final indicator of confidence to be measured. Only 21 per cent of students considered they were not at all good [1] at using the keyboard, while 79 per cent believed they had good [2] or excellent [3] keyboard skills. Only two per cent of students did not like and believed they were not good at using computers, reflecting very low confidence. At the opposite end of the scale, nine per cent of students gave the highest rating to each question, reflecting a high level of computer confidence.

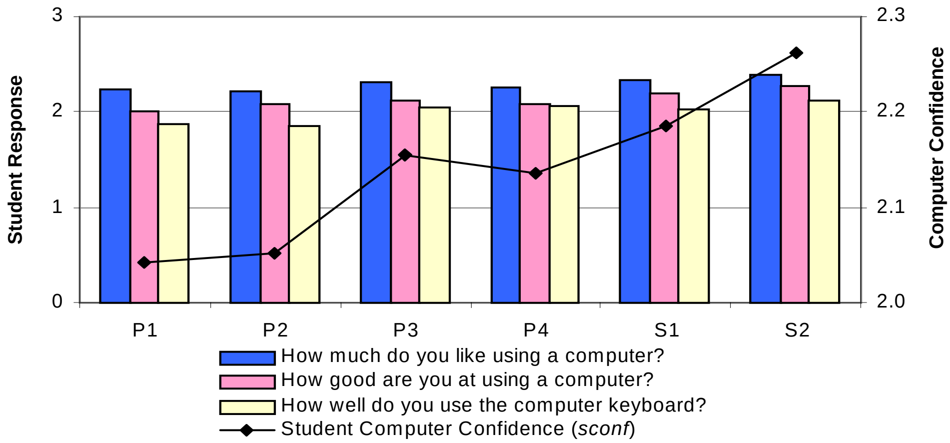


Figure 9.15 Students computer confidence, contrasting average student response to each item against the Computer Confidence index (*sconf*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Change in ICT literacy and confidence

Inquiry into students' acquisition of computer knowledge and skills provides insight into the extent of that knowledge. Of greater concern, is how that knowledge and the confidence that generally accompanies it, changes over time. Figure 9.16 presents the three measures of students' web (*litweb*) and general (*litgen*) ICT literacy and computer confidence (*sconf*), keeping in mind that they are measured on different scales. Students' ICT literacy and confidence were consistently the most responsive measures to the changing primary and secondary school environments, with significant changes across each occasion in all but one instance. Moreover, the changes in all cases were positive. Accordingly, it could be argued that, due to the increased use of technologies in school, students in both primary and secondary school, were supported in their acquisition of ICT knowledge and skills and had improved confidence in using computers for learning.

The next three sections in this chapter discuss the main instruments that were administered to students participating in the study. The instruments were formed from

[26] Refer to Table 6.11, for the factor analysis of *sconf*.

a series of pre-existing attitudinal questionnaires that examined students' attitude towards computers, school and school learning, and self-esteem.

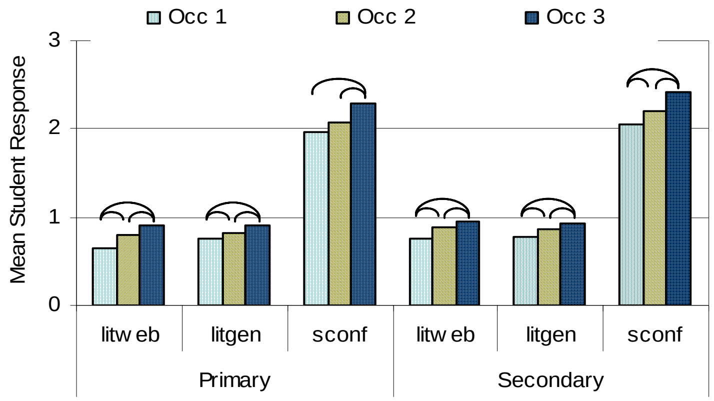


Figure 9.16 Change in students' web (*litweb*) and general ICT literacy (*litgen*) and computer confidence (*sconf*), where the convex curves represent a significant change in attitude between occasions at the 0.05 level

Computer Attitudes

Students' attitudes towards computers were examined by 34 items that factored together and identified with either the affective, behavioural or cognitive aspects of attitude. Because of the large number of items involved in each component, individual presentation using bar graphs is not feasible and so, only the average school-level indices are shown. However, the items comprising each factor are presented in Chapter 6[27]. Accordingly, Figure 9.17 presents the affective (*comaff*), behavioural (*combeh*) or cognitive (*comcog*) aspects of students' attitudes towards computers for each school. In responding to these items, students could select from a 5-point Likert scale of 'strongly disagree' to 'strongly agree' and this is recorded on the vertical graph axis. A discussion of each component follows, along with an analysis of change.

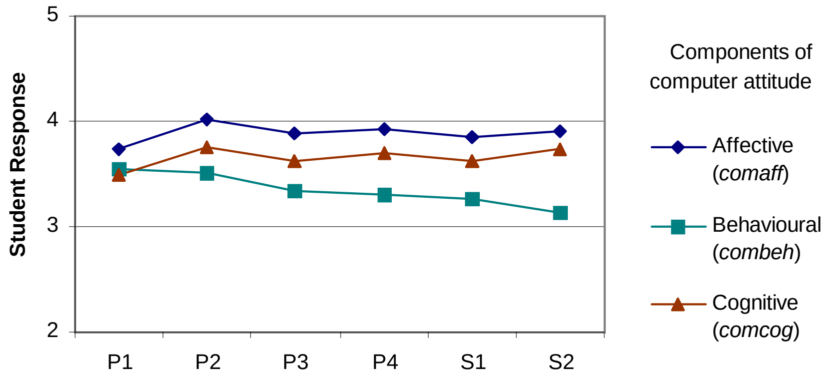


Figure 9.17 Average student response to the affective (comaff), behavioural (combeh), and cognitive (comcog) components of students' attitudes towards computers for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

[27] Refer to Table 6.13, for the factor analysis of *comaff*, *combeh* and *comcog*.

Affective attitudes towards computers (*comaff*)

The 14 items that comprised the affective component of computer attitude (*comaff*) contained the encoding of feelings associated with an attitudinal object (Jones and Clarke, 1994). The items required students to respond to a selection of negatively worded items that ranged from being highly intimidated and threatened by computers and feeling helpless when asked to perform new tasks on a computer, to being bored and frustrated with computers. Of the three attitudinal components, the affective component most positively reflected students' attitudes towards computers, as shown in Figure 9.17. In responding to these negatively worded items, 54 per cent of students disagreed [4] and 22 per cent strongly disagreed [5], and as a consequence 76 per cent of students had positive feelings towards computers. In fact, with 20 per cent of students undecided [3], only four per cent of all students actually had negative affective attitudes.

Behavioural attitudes towards computers (*combeh*)

The behavioural component of computer attitude (*combeh*) included nine items that reflected behavioural intentions, verbal statements regarding behaviour and overt behaviours in response to a specific object (Jones and Clarke, 1994). Students responded to positively worded items that ranged from wanting to learn more about computers and using computers more often, to finding ways to use computers more efficiently and wanting to learn new tasks independently by trial and error. In all but the first primary school, the behavioural aspect was the least positive reflector of computer attitude. The same applied particularly so for students in the two secondary schools. On average, 51 per cent of students were undecided [3] in their behavioural attitudes towards computers, and only 36 per cent agreed [4] or strongly agreed [5].

Cognitive attitudes towards computers (*comcog*)

Eleven items comprised the cognitive component (*comcog*) and referred to beliefs, knowledge structures and thoughts held, regarding the attitudinal object (Jones and Clarke, 1994). Students responded to statements that ranged from being creatively inhibited when using computers and believing computers to be a waste of time, to finding computers difficult to understand and isolating. Whereas a high proportion of students (30%) neither agreed nor disagreed [3], the majority of students (56%) disagreed [4] to these negatively worded items and an additional nine per cent strongly disagreed [5].

Particularly for both the affective and cognitive components of computer attitude, the relatively flat profiles shown in Figure 9.17 indicate that students in primary and secondary school appeared to hold similar attitudes towards computers.

Change in computer attitudes

In order to examine the change potentially brought about by the increased use of ICT in learning, on the students' affective, behavioural and cognitive attitudes towards computers, the items were administered each year on three occasions. Figure 9.18 presents the change in each attitudinal component for the primary and secondary students and indicates those changes that are significant at the 0.05 level between occasions by way of a convex curve.

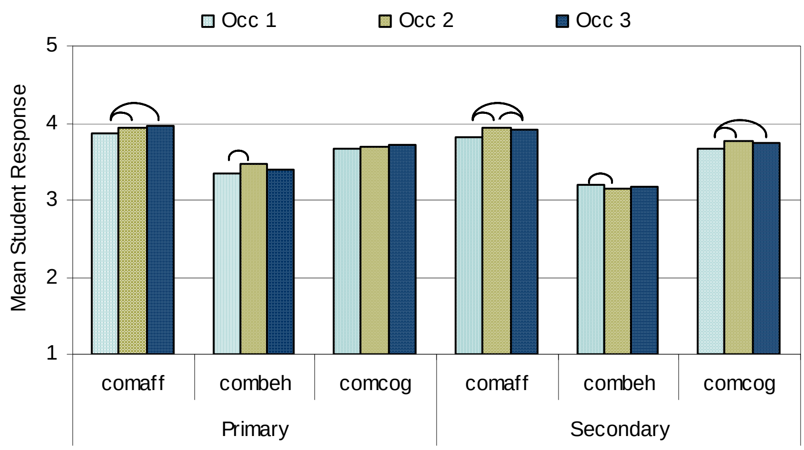


Figure 9.18 Change in students' affective (*comaff*), behavioural (*combeh*) and cognitive (*comcog*) attitudes toward computers in learning, where the convex curves represent a significant change in attitude between occasions at the 0.05 level

In an environment where students were increasingly confronted about their feelings towards computers, the positive shift, overall, in affective attitudes (*comaff*) is encouraging (see Figure 9.18). Primary students showed increases in their affective computer attitudes on all three occasions, significantly so between the first and second, and the first and last occasions. Secondary students showed a significant increase and then a decline, but overall, they showed significant growth over the period and generally held positive feelings towards technology. These changes in affective attitudes could, arguably, be attributed to the increased use of ICT and appears to be equally supportive in both the primary and secondary school environments.

Students appear to find the increased use of ICT behaviourally (*combeh*) more confronting, particularly among the older cohort, as shown in Figure 9.18. The only significant change in the primary sector occurred between the first and second year of the study, resulting in an improvement in behavioural computer attitudes. The influence of technology on behavioural attitudes in the secondary school environment was less favourable and shows a significant decline in attitudes between the first and second occasion. The final testing occasion appears to be more encouraging with sufficient improvement that resulted in an overall drop in behavioural attitude that is not significant. Across the secondary cohort, a decline in behavioural computer attitudes is observed and may indicate an increased pressure on access to computers.

The cognitive component of computer attitude, shown in Figure 9.18, reveals no significant change in the primary students' attitudes, though the trend is positive. More encouragingly, the older students show positive shifts in cognitive attitude towards computers over the time period. Between the first and second occasions, and the first and third occasions, the shifts are significant and are a probable result of secondary school students' increased exposure to ICT.

School Attitudes

Following cluster analysis, six factors, comprising 43 items, combined to form a comprehensive measure of students' attitudes towards school. Five factors, originating from an adaptation of Keeves' (1974) questionnaires, were school enjoyment (*likenj*)[28], staying at school (*liksta*)[28], motivation to learn (*motlrn*)[29], motivation to achieve (*motach*)[29], and motivation to use effort in work (*moteff*)[29]. The 37 items comprising these tools were associated with the attending, valuing and responding levels of the affective domain of the Bloom Taxonomy (Krathwohl, Bloom and Masia, 1964). The last factor originated from the Coopersmith Self-Esteem Inventory (1967; 1986) and consisted of six self-evaluative items that focused on the school-academic (*sesch*)[30] areas of experience. Figure 9.19 presents the six measures of students' attitudes toward school. The axis reflects the possible responses of 'agree', 'undecided', or 'disagree', and can be interpreted that above the value of 2 (undecided) reflects positive attitudes, and below 2 reflects negative attitudes towards school. This section considers each factor and the students' responses to them, in addition to the comparison between occasions.

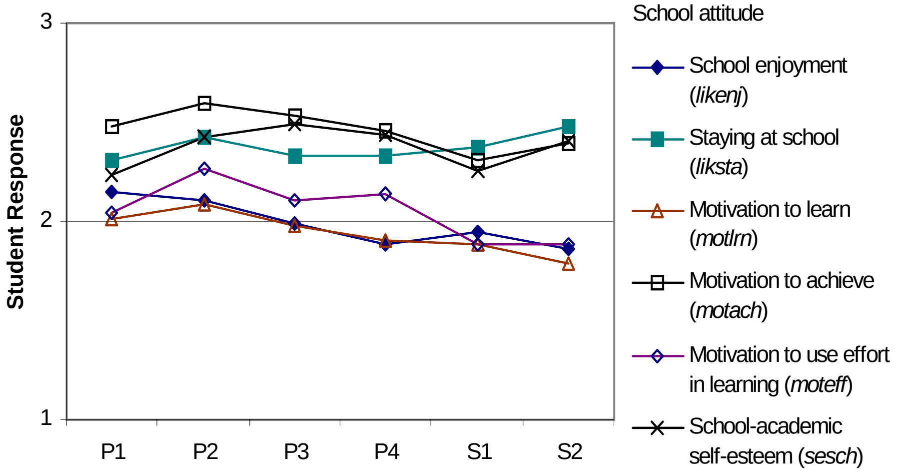


Figure 9.19 Average student response to school enjoyment (*likenj*), staying at school (*liksta*), motivation to learn (*motlrn*), motivation to achieve (*motach*), motivation to use effort in work (*moteff*), and school-academic self-esteem (*sesch*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

School enjoyment (*likenj*)

As a measure of school enjoyment (*likenj*), students responded to 12 items that ranged from disliking school and finding school boring to enjoying everything done at school and liking most of the subjects. Where items were worded negatively, the scoring was reversed. Figure 9.19 shows that 62 per cent of primary students and 70 per cent of secondary students were undecided [2] as to whether they enjoyed school. Not surprisingly, enjoyment [3] for school was more evident in younger students, those in primary school (22%), than in older students where only 11 per cent of secondary students responded positively.

---

[28] Refer to Table 6.14, for the factor analysis of *likenj* and *liksta*.

[29] Refer to Table 6.15, for the factor analysis of *motlrn*, *motach* and *moteff*.

[30] Refer to Table 6.16, for the factor analysis of *sesch*.

Staying at school (*liksta*)

The remaining five items of the original Like School scale (Keeves, 1974) assessed behavioural aspects of school attitude reflected in statements such as a desire to stay at school as long as possible, being glad to leave school, and seeing no point in staying at school. In comparison to the previous factor (school enjoyment), Figure 9.19 shows that students responded more positively towards staying at school (*liksta*). In fact, 53 per cent of students agreed [3] that they would prefer to stay at school and only seven per cent did not want to stay at school [1]. These attitudes were consistently held across the primary and secondary settings.

Motivation to learn (*motlrn*)

Six of the original 20 items comprising Keeves' (1974) Academic Motivation scale, factored together and formed a measure described as students' motivation to learn (*motlrn*). The statements involved a combination of behaviour and affective aspects of motivation to learn and the positively worded items ranged from an enjoyment of working out difficult problems, to preferring to sit next to someone who worked hard all the time. Across all schools, this factor rated the lowest, as Figure 9.19 shows. While the majority of students (70%) were undecided [2], a further 13 per cent in the primary cohort and 21 per cent in the secondary cohort disagreed [1] with the statements, resulting overall, in a low motivation to learn.

Motivation to achieve (*motach*)

Students' motivation to achieve (*motach*) was measured by five items, all but one being positively worded. Items included statements about trying to get high marks at school, doing schoolwork carefully and neatly, and wanting to get as much education as possible, in addition to not wanting to spend time on hard homework problems. Figure 9.19 shows that, certainly in the primary setting, students responded most positively to the statements. Approximately 63 per cent of primary students, compared to 46 per cent of secondary students, reflected a positive [3] attitude to achieve academically.

Motivation to use effort in work (*moteff*)

The remaining nine motivational items reflected students' motivation to use effort in work (*moteff*). The behavioural focus of these mainly negatively worded items ranged from working hard in school, to forgetting to do homework, pretending to be sick to avoid tests, and playing up to annoy the teacher. Showing the greatest difference between the primary and secondary settings (see Figure 9.19), 29 per cent of primary students, compared to only 11 per cent of secondary students, responded positively [3] to the statements. The majority (59% of primary students and 65% of secondary students), however, were undecided [2] in their academic motivations.

School-Academic self-esteem (*sesch*)

In order to gauge students' school and academic self-attitude (*sesch*), six statements were posed, some positively and some negatively worded. The items ranged from being proud of schoolwork, and always doing the right thing, to spending a lot of time daydreaming, and not doing well in school. Among the most positive of school attitude measures, 55 per cent of primary students and 46 per cent of secondary students reported positive [3] academic self-attitudes. Only eight per cent of students felt negatively [1] towards their academic self.

Change in school attitudes

The six attitudinal factors of school enjoyment (*likenj*), staying at school (*liksta*), motivation to learn (*motlrn*), motivation to achieve (*motach*), motivation to use effort in work (*moteff*), and school-academic self-attitude (*sesch*) that form a measure of students' self-esteem, are presented in Figure 9.20 as they change over each occasion.

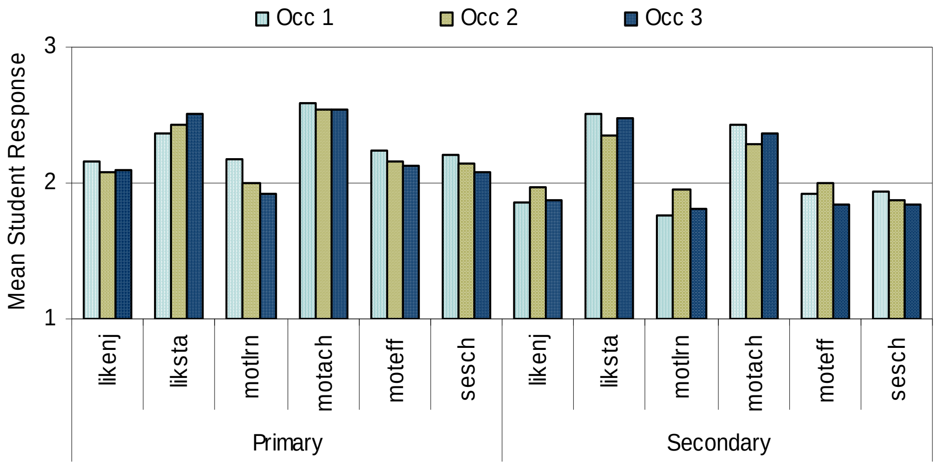


Figure 9.20 Change in students' attitudes towards school enjoyment (*likenj*), staying at school (*liksta*), motivation to learn (*motlrn*), motivation to achieve (*motach*), motivation to use effort in work (*moteff*), and school-academic self-attitude (*sesch*), with no significant change in attitudes between occasions at the 0.05 level

Across the primary and secondary cohorts, changes in all six measures of school attitude can be seen (see Figure 9.20). In many cases, the differences are close to but do not quite reach the set significance level of 0.05. The only increase in primary students' attitudes, though not significant, was their desire to stay at school, while all other factors showed non-significant declines during the three-year period. Students in secondary school, on the other hand, reveal small improvements, overall, in their enjoyment of school, and their motivation to learn. Although both primary and secondary school students maintained strong motivation towards school learning, it clearly declined over the period of the study, perhaps as a reflection of age. The influence of learning technologies on students' attitudes towards school is unclear, since no significant changes are observed in the evidence presented in this chapter.

Self-Esteem

The main focus of this study was students' self-esteem. The Coopersmith Self-Esteem Inventory (1967; 1986) was evaluated and selected as the most appropriate tool for the task. In this inventory, self-esteem is viewed as a many-faceted personality characteristic that might vary according to differences in age, gender, life experiences and aptitude and could be described as, "a personal judgement of worthiness that is expressed in the attitudes the individual holds towards him or her self" (Coopersmith 1967, p.5). Four areas of self-attitude were examined in the original scale and included general interests, peer, parents and school. However, cluster analysis of all student factors saw the school-academic component of self-esteem more closely align with other measures of school attitude, and consequently was relocated and is detailed in the previous section. The remaining three components of general-self (*segen*)[31], social self-peer (*sesoc*)[32], and home-parents (*sehom*)[32] combined 46 items to form an overall measure of self-esteem and provided important information on the influences on students of embedding ICT into the curriculum. Figure 9.21 presents information on the three measures of students' self-attitudes that are formed from the averaged student responses to the statements of either agree, undecided, or disagree, reflected by the axis. Accordingly, values above 2 (undecided) on the scale can be interpreted as positive self-esteem, while those falling below 2 reflect negative self-esteem. This section presents each factor and the students' responses to them, along with an examination of how they changed over time.

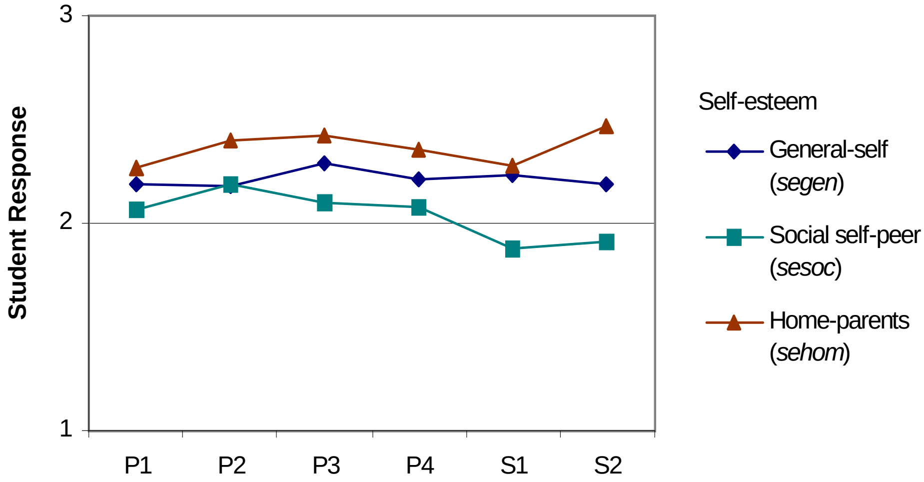


Figure 9.21 Average student response to the three components of self-esteem, which include general-self (*segen*), social self-peer (*sesoc*), and home-parents (*sehom*) for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

Social self-peer (*sesoc*)

Eight items that were mainly positively worded went into forming the social self-peer (*sesoc*) component of students' self-esteem. Students responded to a selection of socially oriented statements that ranged from being popular with kids their own age, and not being shy, to finding it hard to talk in front of the class. The average responses for each school are presented in Figure 9.21 and clearly show a difference between students in the primary and secondary settings. Twice as many secondary students (18%) compared to primary students (9%) indicated a low [1] social-peer attitude. Conversely, twice as many primary students (26%) as secondary students (13%) reported positive [3] social self-esteem. The combined result suggest that primary students had a more positive self-esteem in the social-peer situation than their secondary counterparts.

[31] Refer to Table 6.17, for the items of *segen*.

[32] Refer to Table 6.16, for the factor analysis of *sesoc* and *sehom*.

Home-Parents (*sehom*)

Students' self-attitude towards parents and in the home environment (*sehom*) was characterised by a mix of seven positively or negatively worded items ranging from being considered and understood by their parents to, wanting to leave home and being pushed too hard. Across all schools, as is shown in Figure 9.21, the home-parent self-esteem component gained the most positive responses from students. In fact, only one per cent of primary and secondary students responded negatively [1] to the statements. Though the majority (58%) of students were indifferent or undecided [2] in their self-attitudes towards parents and home, 41 per cent responded in a positive [3] manner, and this indicates that students participating in this study maintained a positive self-attitude in their family environment.

General-self (*segen*)

Having the most number of items of the three scales, general-self (*segen*) contained a selection of 31 positively or negatively worded items. Students responded to a variety of statements ranging from not being easily bothered and having a high opinion of themselves to often wishing they were someone else and taking a long time to get used to anything new. The resulting profile of general-self attitudes for each school is shown in Figure 9.21. Little difference in general-self attitudes between any of the schools suggests a robust and reliable measure of self-attitude. The majority of students (67%) were undecided [2] or felt indifferent to many of the statements, but another 30 per cent of students did indicate a positive self-attitude. Only four per cent of students, both primary and secondary, reported having low self-esteem.

Change in self-esteem

The three areas that formed an overall measure of students' self-esteem, that of social self-peer (*sesoc*), home-parents (*sehom*), and general-self (*segen*), were tested on three occasions and provided important information into the influences on students of embedding ICTs into the curriculum. Figure 9.22 presents the three self-evaluative factors on each occasion for the primary and secondary students. The influence of ICT on peer and social relationships is an interesting but little studied area in relation to computer adoption research. In both the primary and secondary settings, students showed an improvement in social self-esteem, significantly so in the primary students, and this might reflect the effectiveness of the communication aspects of learning technologies.

With the acquisition of ICT being equally shared between school and home, as is shown in Figure 9.12, the influence on students' beliefs about parents and home is an important and relevant aspect of self-esteem to examine. Compared to the other measures of self-esteem, Figure 9.22 shows that the use of ICT appears to have relatively little influence on students' attitudes towards parents and the home environment. Over the three-year period, however, an increase in students' attitudes towards their parents is experienced across the cohort, but no differences are significant.

In terms of general aspects of students' self-esteem, the use of ICT in learning appears to be beneficial across all age groups. Figure 9.22 shows that in both the primary and secondary schools, students' views of themselves improved with each year and significantly so from the first to last years of the study.

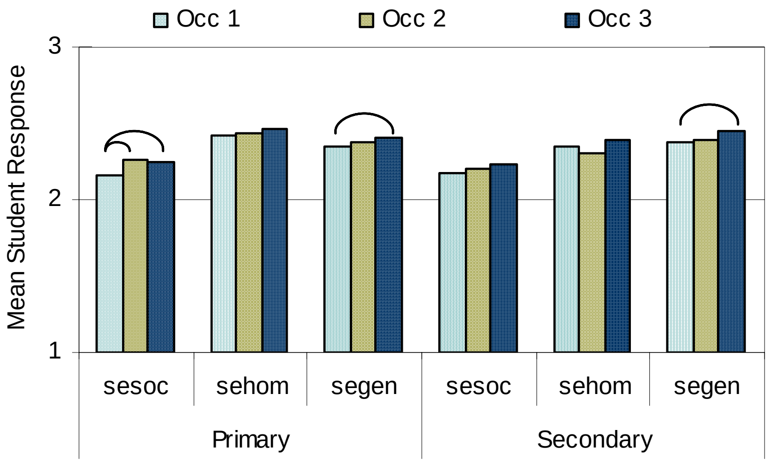
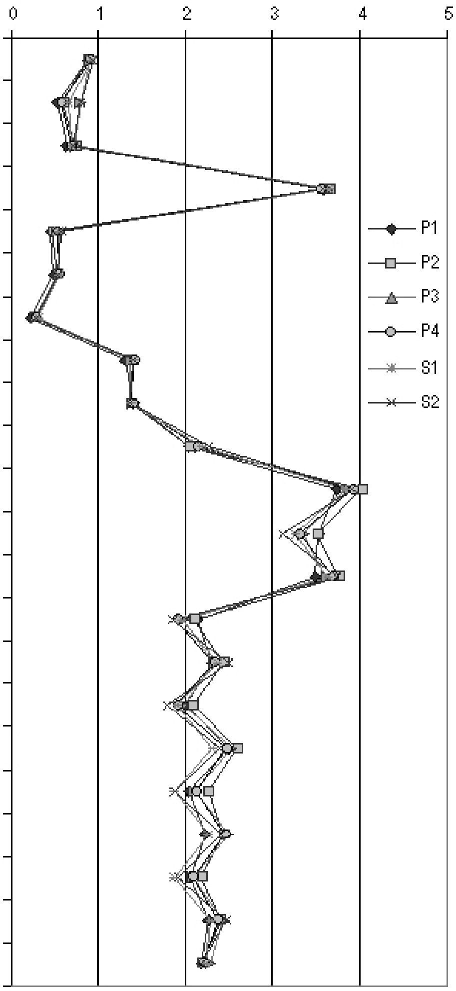


Figure 9.22 Change in students' social self-peer (*sesoc*), home-parents (*sehom*), and general-self (*segen*) aspects of self-esteem, where the convex curves represent a significant change in attitude between occasions at the 0.05 level

Summary

This chapter presents a school-by-school profile of each student factor and the items that comprise them, in addition to examining how these factors change over time. By doing so, understanding is gained of the underlying concepts being measured by each variable at a student level. Of equal importance, however, the school-level indices that also contribute to the major analyses conducted in subsequent chapters are calculated and discussed. Differences in the student cohorts and the prevailing climates of the six schools, result in a set of unique indices that describe each school. Figure 9.23 summarises the student factors that contribute to the school-level indices by averaging each school's responses from its students. In each case, the school with the highest mean response is presented in bold.

The additional benefit of presenting the profiles of the six schools on the same axes allows for easy comparison between schools (see Figure 9.23). Where students are similar in each school, the indices are close together, and where there are differences, a spread across each factor is evident. Clearly, for the majority of factors, students' responses were very similar in each school. As a general measure of spread, the standard deviation at maximum, was found to be only 0.16, for the behavioural component of computer attitude (*combeh*). Whether this and other differences are sufficient enough to have an impact on student self-esteem, are examined in Chapters 10 and 11.



Clusters	Factors	P1	P2	P3	P4	S1	S2
		School Indices (mean)					
ENTRMT	*ictent*	0.88	0.88	0.91	0.89	0.92	**0.94**
HOMWK	*icthwk*	0.53	0.59	**0.80**	0.57	0.66	**0.80**
HOMACC	*acshom*	0.64	**0.74**	0.73	0.69	0.70	0.72
SCHACC	*acssch*	3.60	**3.66**	3.63	3.55	3.65	3.57
ICTUSE	*ictweb*	0.46	0.47	0.54	0.53	0.56	**0.58**
	ictsof	0.50	0.52	**0.56**	0.54	0.55	0.52
	icthar	0.23	0.26	0.28	0.29	**0.31**	0.28
ICTLIT	*litweb*	1.30	1.37	1.36	**1.42**	**1.42**	1.41
	litgen	**1.42**	1.37	1.38	1.40	1.37	1.38
	sconf	2.04	2.05	2.17	2.14	2.19	**2.27**
COMATT	*comaff*	3.74	**4.02**	3.88	3.92	3.84	3.91
	combeh	**3.54**	3.51	3.34	3.30	3.27	3.12
	comcog	3.48	**3.76**	3.61	3.70	3.63	3.74
SCHATT	*likenj*	**2.15**	2.11	1.98	1.89	1.95	1.86
	liksta	2.31	2.43	2.33	2.33	2.37	**2.48**
	motlrn	2.01	**2.09**	1.98	1.90	1.89	1.79
	motach	2.48	**2.60**	2.53	2.46	2.31	2.39
	moteff	2.05	**2.26**	2.11	2.13	1.88	1.88
	sesch	2.23	2.43	**2.49**	2.44	2.26	2.40
SELFATT	*sesoc*	2.06	**2.19**	2.09	2.08	1.87	1.91
	sehom	2.26	2.40	2.42	2.36	2.28	**2.47**
	segen	2.19	2.18	**2.28**	2.21	2.23	2.19

Note: *ictent* = Entertainment use; *icthwk* = Text-rich homework; *acshom* = Computer access at home; *acssch* = Computer access at school; *ictweb* = Internet; *ictsof* = General software use; *icthar* = General hardware use; *litweb* = Web-based knowledge; *litgen* = General computer knowledge; *sconf* = Student computer confidence; *comaff* = Affective component; *combeh* = Behavioural component; *comcog* = Cognitive component; *likenj* = School enjoyment; *liksta* = Staying at school; *motlrn* = Motivation to learn; *motach* = Motivation to achieve; *moteff* = Motivation to use effort in work; *sesch* = School-Academic; *sesoc* = Social Self-Peer; *sehom* = Home-Parents; *segen* = General-Self.
In each case, the school(s) with the highest mean response is presented in bold.

Figure 9.23 Summary of school-level indices derived by aggregating the student factors for each of the four primary (P1, P2, P3, P4) and two secondary (S1, S2) schools

10

Factors of Influence

This chapter closely examines the teacher and student level factors by hypothesising and testing two models using path analysis, also referred to as structural equation modelling. The chapter begins with a preliminary discussion about path analysis, model development and significance testing, and then presents the main sections that detail the results and analyses of the teacher and student models.

Levels of Analysis

Models of the adoption of ICT in schools have been advanced from theory and previous research that incorporate not only information obtained about students, but also data concerning the students' teachers and their school. In an attempt to look at a system of interrelated variables as a whole, the advancement and testing of models that incorporate student, teacher and school level information is important. However, problems arise from the inclusion of data obtained from different levels into one model or single level analysis. When data are combined from two or more levels into a single-level analysis, data can either be aggregated from a lower level (for example, student data) to a higher level (such as school) or disaggregated from a higher level to the lower level (for example, assigning school-level data to each student). Both techniques, however, introduce bias in regression models, resulting in the magnitude of the effects associated with the aggregated or disaggregated variables being over- or under-estimated, in addition to error estimations being incorrectly calculated when data are disaggregated.

Simplifying complexity

Since information was collected from teachers and students in four primary and two secondary schools and on three separate occasions from the students but not the teachers, the preliminary formation of two single-level models is appropriate. These data are presented conceptually in Figure 10.1 and show the two-dimensional aspect of the teacher data, with teachers from two settings on a single occasion, and the three-dimensional aspect of the student data, with students from two settings on three occasions. For the purposes of presentation, the models in Figure 10.1 are arranged to form two layers. However, in the analysis conducted in this chapter, they are treated as two single-level models independent from one another.

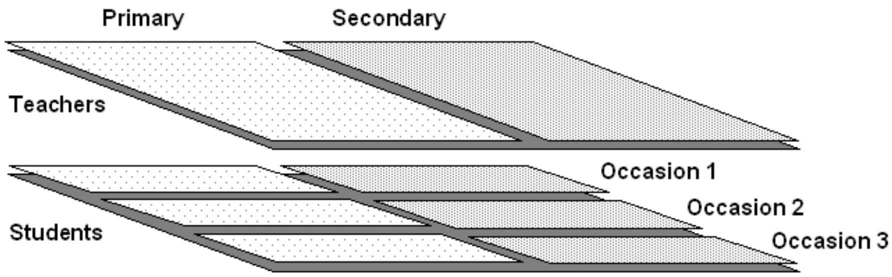


Figure 10.1 Conceptual presentation of the two single-level models showing the primary and secondary settings with teachers on one occasion and students on three occasions

The first model (upper layer) in Figure 10.1 utilises the teacher data to investigate between-teacher factors that influence teacher adoption of ICT in the primary and secondary settings. The second single-level model (lower layer) makes use of the student data, but initially combines the complete data set to a single occasion, enabling the exploration of between-student factors that influence student self-esteem in the primary and secondary settings. If the student data, which contains responses for each student on at least one occasion was used intact, the assessment would assume that every case came from a unique student, distorting the model and the apparent influences of the variables. The issue of bias is also avoided since all variables in the student single-level model have had the same treatment, so that there is not a mix of aggregated with disaggregated data. However, the existence of student data collected on three occasions adds further complexity to a systematic analysis of the data by allowing for additional exploration of within-student factors as they change over time.

All of these different dimensions to the teacher and student data require individual analysis, resulting in as many as ten separate models. Two models are required for teachers to reflect the primary and secondary school settings. Similarly, two models for the primary and secondary students are needed, in addition to three models for each of the three occasions. To present and analyse all these models separately would reduce the complexity of the discussion but would result in excessive repetition. Since the primary and secondary student models, established using the aggregated student data, are used as the bases for re-analyses at the occasion level, separate discussions are unnecessary. Therefore, in order to streamline the discussion and focus on the factors of influence, only four models are presented in diagrammatic form: the primary and secondary teacher models, and the primary and secondary student models. The unavoidable complexity of the 10 models, however, is still presented in the related tables and it is from these tables that the results are advanced. In order to present such an array of information in one table, only the essential details are included. The complete statistical outputs for the inner and outer student path models in the primary and secondary settings, and over the three occasions, are detailed in Dix (2007). Accordingly, the structure of this chapter is framed around an examination of the factors of influence in the teacher and student single-level models.

In order to investigate the factors that influence teacher adoption of ICT and those that influence change in student self-esteem, the method undertaken in this study employed path analysis or structural equation modelling. The single-level path analyses were carried out using the procedure of grand mean comparison, conducted with the AMOS statistical program (Arbuckle and Wothke, 1999), as discussed in Chapter 5, to test the path models conceptualised in Chapter 3, refined in Chapter 6, and hypothesised here.

Single-level path models

Path models provide an efficient way of describing the latent structure underlying a set of observed variables, by explaining how the observed and latent variables are related to one another (Keeves, 1988a; Lietz, Miller and Kotte, 2002). A path model is defined by two sets of linear equations: that is, an inner or structural model and an outer or measurement model. The inner model is defined as the hypothesised relationship among latent variables, and depending on the path direction, are called either criterion or predictor variables. The outer model is defined as the relationships between the latent variables and manifest variables in the model. It should be noted that all latent variables in the model are estimated using the outward or unity mode, and as such, only factor loadings between manifest variables and latent variables that are not unity, are presented.

In all models, both the metric or unstandardised and the standardised regression coefficients of each direct path are presented. An indication of the relative importance of a path within a model is indicated by the relative magnitude of the associated standardised coefficient. Therefore, in order to compare the relative strengths of paths to one another within a model, the scale-free standardised coefficient is used (Pedhazur, 1997). However, the standardised coefficient is not suitable for the comparison of paths between models. According to Pedhazur (1997), the standardised path loading reflects not only the presumed effect of the associated variable but also the variance and the covariance of variables included in the model, in addition to the variance of the excluded variables subsumed under the error term. Because these variables are sample-specific and may vary from one population to another, the standardised coefficient is not generalisable across settings or populations. Therefore, use of the unstandardised path coefficient for between-model comparison is appropriate, but several issues need to be considered when making such comparisons (Pedhazur, 1997). First, being unstandardised, the magnitude of the coefficient depends on the unit used in the measurement of the variable, so the magnitude of a coefficient belies its significance. Secondly, many measures used in social research do not employ an interval scale, which limits such variables to a dichotomous scale (for example, male = 0, female = 1). Lastly, when the reliability of the measure of an independent variable differs across groups, comparison of the coefficients may lead to an erroneous interpretation. Accordingly, when comparing the effects of different variables within a single-level model, the standardised path coefficients were used, and for the comparison of the same variables between models, the unstandardised path coefficients were used in this study, and hence there is the need for reporting both standardised and unstandardised regression coefficients.

The tables presented in this chapter detail the unstandardised (URW) and standardised regression weights (SRW) associated with each direct (D) path shown in the related path model. The standard errors (SE) and critical ratios (CR) of the regression weights are also given, along with the level of significance (p) for the regression weights. The inner model tables also include an additional set of values for each factor, where appropriate, showing the standardised total path effects (T), estimated by calculating the effect of both the direct and indirect paths. Path coefficients were retained using a significance level of 0.05 and a minimum cut-off magnitude of the standardised regression weights of 0.1, while paths not meeting these strict criteria were removed. The variable names for manifest variables are given in lowercase italics, while variable names for latent variables are given in uppercase.

Testing significance between two paths

When comparing two path models it has been the general practice to observe differences in the unstandardised regression coefficients and draw inferences. However, without the use of significance testing, it would not be known whether the differences are within the normal variations of error and noise or are in fact significant. The standard method used for testing difference between two regression coefficients is by way of a t-test, although its application in path analysis has not been widely used.

When comparing between inner models, the t-test is straightforward and makes use of the unstandardised regression coefficient and standard error. However, if the same procedure were used to compare between the outer models, the results would not be meaningful. As stated above, the outer model relates the manifest variables to the latent variables. When a latent variable is only reflected by one manifest variable, the path has a loading of 1.00 and there is no standard error or standardised regression coefficient. Comparison of outer model paths of unity mode latent variables is unnecessary as they are always equal to 1.00. However, when more than one manifest variable contributes to a latent variable, unstandardised regression coefficients are generated for all but one of the path loadings, which by default is set to unity. Thus testing between models is possible using the unstandardised regression coefficient and standard error but one manifest variable always remains untestable. In order to overcome this problem, the standardised regression coefficient is used to test between models, despite the issues of bias described above. Since a standardised regression coefficient is, in effect, a correlation, then t-testing is possible, by first converting the standardised regression coefficient using the Fisher transformation (Thorndike, 1978). This transformation, presented in Equation 10.1, produces a function that is not truncated, and attempts to overcome the effects of truncation involved in the correlation coefficients. Accordingly, the t-test for significant difference between two correlation coefficients (Thorndike, 1978), employed in the outer model comparison, is presented in Equation 10.2, while the t-test between two regression coefficients, employed in the inner model comparison, is presented in Equation 10.3.

Equation 10.1 Fisher transformation

$$z = \frac{1}{2}\ln\left(\frac{1+y}{1-y}\right)$$

Equation 10.2 t-test for the outer model

$$t = \frac{z_s - z_p}{\sqrt{(n_p - 3)^{-1} + (n_s - 3)^{-1}}}$$

Equation 10.3 t-test for the inner model

$$t = \frac{x_s - x_p}{\sqrt{\frac{n_p \varepsilon_p^2 + n_s \varepsilon_s^2}{n_p + n_s}}}$$

Where: y is the standardised regression (correlation) coefficient
x_p, x_s are the regression coefficients
ε_p, ε_s are the standard errors of the regression coefficients
n_p, n_s are the number of cases

The critical values of t = |1.96| and |2.58| are required for significance testing at 0.05 and 0.01 levels respectively. For the purposes of this study, an acceptable level of significance was set at p = 0.05 or t = |1.96| and is indicated in the tables of comparison by an asterisk. The one per cent level of significance is indicated by a double asterisk. A positive t-value indicates a rise in coefficient between the first and second regression coefficients being tested. By comparing two path models, the similarities and differences between the factors of influence within each model can be ascertained.

Factors Influencing Teachers

In this section, the analysis of factors influencing teachers' adoption of ICT in teaching practice in the primary and secondary settings is reported. This analysis of factors influencing teaching practice considers all 219 teachers participating in this study and examines the behaviour of the between-teacher factors. The variables included in the path models are obtained from the teacher questionnaire following factor and cluster analyses, as discussed in Chapters 6, 7 and 8.

The hypothesised path model of factors influencing teaching practice, advanced in Chapter 3, is presented in Figure 10.2, and indicates that 13 variables are hypothesised to influence teaching practice (PRAC). These variables include teachers' gender (SEX), type of teaching position (TYPE), teaching load (LOAD), ICT teacher specialisation (ICTT), teaching experience (TEXP), general ICT confidence (CONFID), beliefs about student work (EFFORT), implementation issues (ISSUES), home and general ICT use (HOMUSE), common hardware used (COMMON), planned learning outcomes (OUTCOM), planned use of ICT (OPENLN), and beliefs about school support (SUPPORT). However, five of these variables, namely SEX, TYPE, LOAD, ICTT and TEXP, included in the structural model are considered to be exogenous latent variables because they are independent of any other manifest or latent variable. The other nine endogenous variables, including PRAC, are formed as latent variables measured by one or more manifest variables in an outward mode.

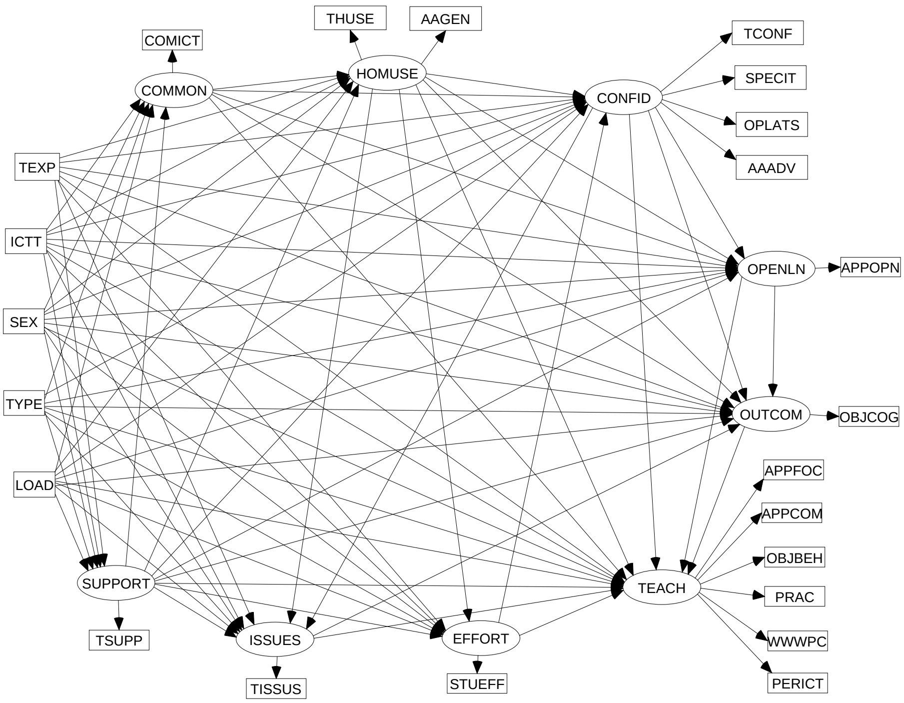


Figure 10.2 Hypothesised path model of teacher-level factors influencing teaching practices using ICT

In all, the path model of factors influencing teaching practice includes 14 latent and 23 manifest variables, which are presented with descriptions in Table 10.1.

Table 10.1 Variables in the teachers' hypothesised single-level path model

Latent Variables and Descriptions		**Manifest Variables and Descriptions**	
SEX	Teacher gender	*sex*	Male=0, Female=1
TYPE	Type of teaching position	*type*	Teacher=0, PAT/SSO=1
LOAD	Teaching load	*load*	Full-time=1.0, 0.4≤Part-time<1.0
ICTT	ICT teacher	*ictt*	ICT experience=1, non-specialist=0
TEXP	Teaching experience	*texp*	Full-time equivalent in years
CONFID	General ICT confidence	*tconf*	Teacher confidence
		specit	Specialised ICT
		oplats	Confidence in using other platforms
		aaadv	Advanced administrative activities
EFFORT	Beliefs about student work	*stueff*	Student effort
TEACH	Teaching practice and ICT	*appfoc*	Focused learning applications
		appcom	Communication environments
		objbeh	Behavioural learning objectives
		prac	Influence of ICT on teaching practice
		wwwpc	Importance of internet access
		perict	Importance of peripheral ICT
ISSUES	Implementation issues	*tissus*	Teaching issues
HOMUSE	Home and general use	*aagen*	General administrative activities
		thuse	Home computer use (Windows)
COMMON	Common hardware used	*comict*	Common ICT
OUTCOM	Planned learning outcomes	*objcog*	Cognitive learning objectives
OPENLN	Planned use of ICT	*appopn*	Open learning applications
SUPPORT	Beliefs about school support	*tsupp*	Teacher support

This section presents and analyses the two resulting teacher path models for the primary and secondary settings. Discussion of each significant latent variable includes a within-model examination using the standardised regression coefficients of the primary and secondary school models, followed by a discussion of the between-model differences by statistically comparing the unstandardised regression coefficient. When discussed in the text, variables are presented in brackets and are followed by either the standardised or unstandardised coefficients for the primary and then the secondary teacher models. Common sense dictates that the first step in analysis involves the examination of the path loadings for the outer model, followed by an examination of the paths of influence for the inner model. But first, a brief discussion about the development of each model is presented.

Primary and secondary school teacher path models

Of the 219 teachers who participated in the study, 64 are from primary schools and 155 are from secondary schools, and their responses provide the data upon which the primary and secondary school teacher path models, presented in Figure 10.3 and Figure 10.4 respectively, were developed. The models are constructed independently of each other since they involve completely different groups of teachers in quite different settings. The path loadings depicted in each model present the standardised regression coefficient first, followed by the unstandardised regression loadings in brackets. In the case where both models contain the same inner-model path between two latent variables, the path line is thicker in order to highlight the commonalities between the two models.

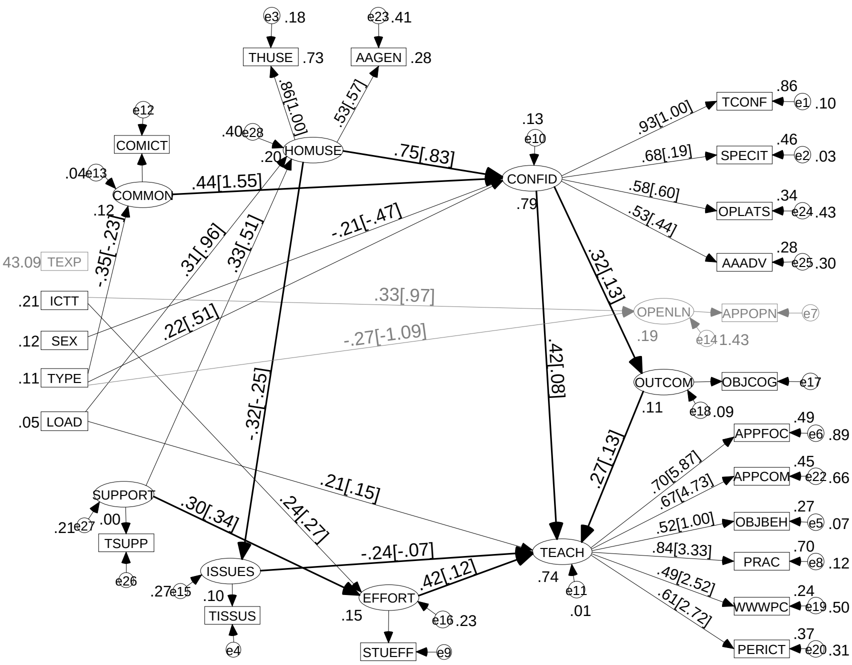


Figure 10.3 Teacher path model in the primary school setting showing standardised and [unstandardised] loadings, where the thicker lines indicate commonality between the primary and secondary school models

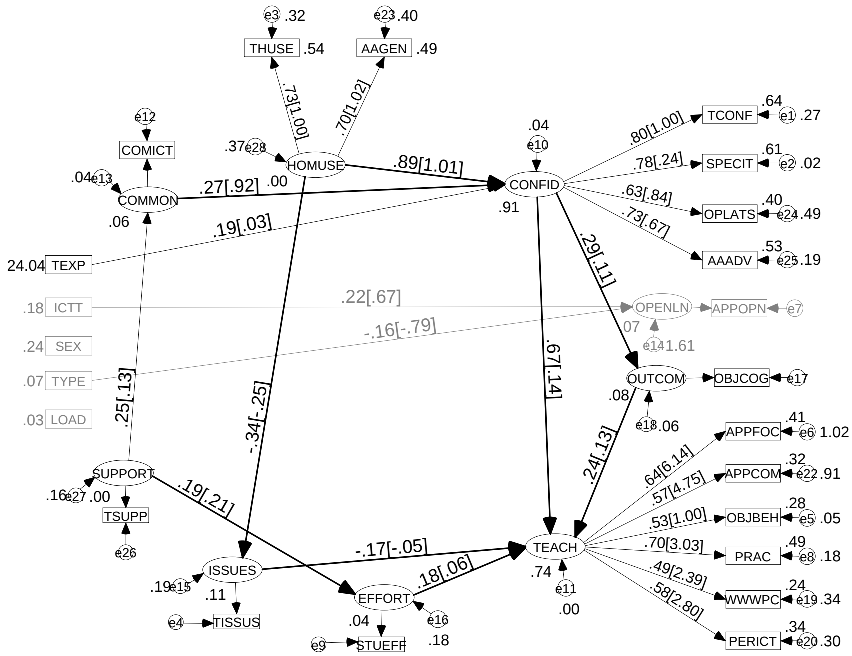


Figure 10.4 Teacher path model in the secondary school setting showing standardised and [unstandardised] regression weights, where the thicker lines indicate commonality between the primary and secondary school models

The trimming of non-significant paths in a search for simplicity and parsimony from the hypothesised teacher model in Figure 10.2 above, results in the removal of a number of variables in each model. In the primary teacher model (see Figure 10.3), two variables, namely, teaching experience (TEXP) and teachers' planned use of ICT (OPENLN) with its associated manifest variable, open learning applications (*appopn*), have no significant influence on any other variable. In the secondary teacher model (see Figure 10.4), five factors, namely, ICT teacher specialisation (ICTT), teacher gender (SEX), teacher type (TYPE), teaching load (LOAD) and, as for the primary teacher model, teachers planned use of ICT (OPENLN), have no significant effects. Accordingly, these factors are not considered in the following discussions of the outer and inner models.

In testing the goodness of fit of the teacher model, that is, how well the data fits the model, two widely used measures are adopted. The goodness of fit index (GFI) was devised by Jöreskog and Sörbom (1984) for maximum likelihood and unweighted least squares estimation, and generalised to other estimation criteria by Tanaka and Huba (1985). GFI is less than or equal to 1, where a value of 1 indicates a perfect fit. GFI values above 0.8 indicate a well-fitting model. The GFI of the teacher model was 0.805. The second measure of fit uses the root mean square error of approximation, called RMS by Steiger and Lind (1980) and RMSEA by Browne and Cudeck (1993). A RMSEA of 0.05 or less would indicate a close fit of the model in relation to the degrees of freedom. The RMSEA of the teacher model was 0.044. Both the GFI and RMSEA measures indicate a well fitting model.

Outer model analysis

The outer model results are summarised in Table 10.2 for each of the eight latent variables and their associated manifest variables in the primary and secondary teacher models. In both the primary and secondary teacher models, the results of the outer model show that all 18 manifest variables contribute significantly to reflect their respective latent variable. Given the construction of these latent variables using cluster analysis, as detailed in Chapter 8, this finding is not surprising.

Table 10.2 Outer model results for the primary and secondary teachers

Variables		Primary Teachers (N=64)				Secondary Teachers (N=155)				
Latent	**Manifest**	**URW**	**S.E.**	**SRW**	**z**	**URW**	**S.E.**	**SRW**	**z**	**t**
COMMON	*comict*	1		1		1		1		
SUPPORT	*tsupp*	1		1		1		1		
ISSUES	*tissus*	1		1		1		1		
EFFORT	*stueff*	1		1		1		1		
HOMUSE	*thuse*	1		0.86	1.27	1		0.73	0.93	-2.25*
	aagen	0.57***	0.14	0.53	0.59	1.02***	0.13	0.70	0.87	1.83
CONFID	*tconf*	1		0.93	1.63	1		0.80	1.09	-3.54**
	specit	0.20***	0.03	0.68	0.83	0.24***	0.02	0.78	1.05	1.47
	oplats	0.60***	0.12	0.58	0.67	0.84***	0.11	0.63	0.75	0.54
	aaadv	0.44***	0.10	0.53	0.60	0.67***	0.07	0.73	0.92	2.14*
OUTCOM	*objcog*	1		1		1		1		
TEACH	*prac*	3.33***	0.79	0.84	1.21	3.03***	0.51	0.70	0.87	-2.23*
	objbeh	1		0.52	0.58	1		0.53	0.60	0.12
	appcom	4.73***	1.25	0.67	0.82	4.75***	0.91	0.57	0.65	-1.14
	perict	2.72***	0.77	0.61	0.70	2.80***	0.53	0.58	0.66	-0.27
	wwwpc	2.52**	0.82	0.49	0.53	2.39***	0.50	0.49	0.54	0.04
	appfoc	5.87***	1.53	0.70	0.86	6.14***	1.09	0.64	0.76	-0.66

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$ level of significance

However, examination of the loadings of the manifest variables does provide an indication of which manifest variable best reflects the latent variable and whether these differ between the teacher cohorts. Where differences between the primary and secondary regression weights do occur, significance testing in the form of a *t*-test (see Equation 10.2) is conducted and is shown in the last column of Table 10.2. If the difference is significant at the five per cent level, then *t* is larger than the absolute value of 1.96, and if highly significant at the one per cent level, then *t* is larger than 2.58 in absolute value. In the following discussion, the acronym, followed by the regression coefficients for the primary setting and then the secondary setting, along with the *t* value, are presented in brackets where appropriate.

Unity variables

Common hardware used (COMMON) by teachers during teaching is reflected by only one manifest variable, namely common ICT (*comict*). Since *comict* is the only manifest variable indicating the latent construct of COMMON, the unity mode is employed in the analysis with an unstandardised and standardised regression loading value of 1.00. Since the path loadings of the primary and secondary models are the same, t-testing is unnecessary.

Similarly, the following four latent variables, namely beliefs about school support (SUPPORT), reflected by the manifest variable teacher support (*tsupp*), implementation issues (ISSUES), reflected by the manifest variable of teaching issues (*tissues*), beliefs about student work (EFFORT), reflected by the manifest variable of student effort (*stueff*), and planned learning outcomes (OUTCOM), reflected by the manifest variable of cognitive learning objectives (*objcog*), all involve use of the unity mode.

Home and general ICT use (HOMUSE)

Teachers' home and general ICT use (HOMUSE) is reflected by two manifest variables, namely general administrative activities (*aagen*, 0.53, 0.70, NS)[33] and home Windows-based computer use (*thuse*, 0.86, 0.73, -2.25), constructed in the outward mode. In both teacher models, home computer use is the dominant manifest variable. However, comparison between settings using the z-scores shows that home computer use is a significantly stronger reflector in the primary teacher model at the 0.05 level of significance.

General ICT confidence (CONFID)

Teachers' general ICT confidence (CONFID) is an outward mode latent variable reflected by four manifest variables, which included teacher confidence (*tconf*, 0.93, 0.80, -3.54), specialised ICT (*specit*, 0.68, 0.78, NS), confidence in using other platforms (*oplats*, 0.58, 0.63, NS), and advanced administrative activities (*aaadv*, 0.53, 0.73, 2.14). In both the primary and secondary settings, the strongest reflector of this construct is teacher confidence and it is significantly stronger in the primary teacher model. The order of the other manifest variables, however, differs in each model. The results suggest that primary teachers' confidence is better reflected by their ability to perform regular ICT tasks like managing files and searching the internet, rather than advanced tasks such as using digital cameras to prepare lessons and posting resources on the internet. In the secondary setting, results suggest that

[33] The three values indicate the estimates obtained for the primary and secondary teacher models, and the t-statistic for the significance of the difference in those cases where a significance occurs, otherwise NS is recorded.

while teachers' ICT confidence is also reflected by their ability to perform regular ICT tasks, of similar importance is the need for additional ICT training and the ability to do advanced administrative tasks. This finding nicely reflects the differing needs of the primary and secondary teachers.

ICT-rich teaching practice (TEACH)

Teaching practice using ICT (TEACH) is reflected by six manifest variables, namely the influence of ICT on teaching practice (*prac*, 0.84, 0.70, -2.23), focused learning applications (*appfoc*, 0.70, 0.64, NS), communication environments (*appcom*, 0.67, 0.57, NS), behavioural learning objectives (*objbeh*, 0.52, 0.53, NS), the importance of internet access (*wwwpc*, 0.49, 0.49, NS), and the importance of peripheral ICT (*perict*, 0.61, 0.58, NS). With similar profiles for the primary and secondary teachers, teaching practice is the strongest reflector in both settings, but is significantly stronger in the primary teacher model. This result suggests that primary school teachers place greater emphasis on encouraging their students to use ICT and their teaching goals, and methods have been more strongly influenced by the adoption of ICT. The weakest reflectors of this construct are the importance placed on internet access and behavioural learning objectives. There is no difference between the models, suggesting that internet access for use in general teaching practice and the planning of behavioural learning objectives, like improving computer skills, is of low importance.

With only several minor differences between the ways in which the latent variables are represented by their respective manifest variables in primary and secondary teacher models, it can be surmised that the latent variables represent the same qualities for both teacher cohorts, which allows for a direct comparison of the inner models.

Inner model analysis

The teacher path models in the primary and secondary school setting, presented in Figure 10.3 and Figure 10.4 respectively, best illustrate the inner-path causal relationships between the criterion and predictor variables. Table 10.3, tabulates those coefficients and presents the inner model results for the analysis of the teacher-level factors that influence teaching practice using ICT. Path coefficients were selected using a significance level of $p \le 0.05$ and a minimum cut-off magnitude of the standardised regression weight of SRW≥0.1. Non-significant paths were removed and paths are compared within models using the standardised regression coefficient (SRW) and between models using the unstandardised regression weight (URW).

Of the 13 latent variables hypothesised to influence ICT use in teaching practice, there is only one latent variable that does not contribute in either of the primary or secondary teacher models. The latent variable, teachers' planned use of ICT (OPENLN), reflected by its associated manifest variable, open learning applications (*appopn*), does not contribute to teaching practice at a significant level. Although the exogenous latent variables, type of teacher (TYPE) and ICT teaching specialisation (ICTT), do significantly influence teachers' planned use of ICT (OPENLN), it, in turn, does not influence, directly or indirectly, teaching practice (TEACH), and accordingly is removed from the final models. However, this finding in itself is compelling and suggests that teachers' planned use of ICT in their teaching does not result in them actually using it in their lessons. In other words, a teacher's intention to use ICT is not a reliable predictor that their teaching practice will be ICT rich.

The remaining latent variables do influence teaching practice in the primary and secondary teacher models but in different ways. In order to understand the similarities and differences, within and between the models the unstandardised and standardised loadings are presented in Table 10.3, along with the direct (D) and total (T) effects where applicable. The main focus of the discussion draws on comparisons between the primary and secondary teacher models, particularly when the differences are significant. These differences are due, in most cases, to the existence of paths in one model but not in the other.

Table 10.3 Inner model results for the primary and secondary teachers

Criterion	Predictors		Primary Teachers (N=64)			Secondary Teachers (N=155)			
			URW	S.E.	SRW	URW	S.E.	SRW	t
COMMON	TYPE	D	-0.234*	0.08	-0.35				5.48**
	SUPPORT	D				0.13***	0.04	0.26	3.84**
HOMUSE	SUPPORT	D	0.51**	0.20	0.33				-4.69**
	LOAD	D	0.96*	0.40	0.31				-4.46**
ISSUES	HOMUSE	D	-0.25*	0.11	-0.32	-0.25***	0.07	-0.34	-0.04
	SUPPORT	T	-0.13	0.09	-0.11				2.73**
	LOAD	T	-0.24	0.13	-0.10				3.38**
EFFORT	SUPPORT	D	0.34**	0.13	0.30	0.21*	0.09	0.19	-1.32
	ICTT	D	0.27*	0.13	0.24				-3.81**
CONFID	HOMUSE	D	0.83***	0.16	0.75	1.01***	0.14	0.89	1.26
	COMMON	D	1.55***	0.32	0.44	0.92***	0.20	0.27	-2.62**
	TYPE	D	0.51*	0.22	0.22				-4.37**
		T	0.15	0.20	0.06				-1.34
	SUPPORT	T	0.42	0.20	0.25	0.12	0.05	0.07	-2.68**
	LOAD	T	0.80	0.41	0.23				-3.58**
	SEX	D	-0.47**	0.19	-0.21				4.55**
	TEXP	D				0.03***	0.01	0.19	4.01**
OUTCOM	CONFID	D	0.13**	0.05	0.33	0.11***	0.03	0.29	-0.70
	COMMON	T	0.21	0.13	0.14	0.10	0.04	0.08	-1.44
	HOMUSE	T	0.11	0.09	0.24	0.11	0.04	0.26	-0.05
TEACH	CONFID	D	0.08**	0.03	0.42	0.14***	0.03	0.67	2.07*
		T	0.10	0.06	0.50	0.15	0.03	0.74	1.30
	EFFORT	D	0.13***	0.04	0.42	0.06**	0.02	0.18	-2.59**
	OUTCOM	D	0.13**	0.05	0.27	0.13***	0.04	0.24	0.02
	ISSUES	D	-0.07*	0.03	-0.24	-0.05*	0.02	-0.17	0.68
	LOAD	D	0.15*	0.07	0.21				-4.03**
		T	0.24	0.09	0.35				-4.80**
	COMMON	T	0.16	0.10	0.22	0.14	0.05	0.20	-0.30
	HOMUSE	T	0.10	0.05	0.45	0.16	0.04	0.72	1.39
	SEX	T	-0.05	0.03	-0.11				2.63**
	SUPPORT	T	0.09	0.04	0.27	0.03	0.01	0.09	-2.82**
	TEXP	T				0.00	0.00	0.14	4.75**

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$ level of significance. D=Direct effect; T=Total effect.

One of the most interesting differences between the primary and secondary teacher models is that of the exogenous latent variables. While the primary teacher model reveals significant influences from teacher gender (SEX), teacher type (TYPE), teaching load (LOAD) and ICT teaching specialisation (ICTT), but not teaching experience (TEXP), the secondary teacher model shows that only teaching experience is a significant influence.

Use of common hardware (COMMON)

In comparison with their PAT and SSO colleagues (TYPE, -0.35, NS, 5.48), primary school teachers are more confident in the use of common hardware (COMMON) like television and video players within their teaching programs. Teachers in secondary school, on the other hand, are more confident in their use of common hardware within their teaching programs, if they feel the school is supportive (SUPPORT, NS, 0.26, 3.84). These factors of influence on teachers' use of common hardware are significantly different in each setting and suggest that teacher permanency is important in primary school, whereas levels of ICT support are important in the secondary school.

Home and general ICT use (HOMUSE)

Primary teachers' home and general ICT use (HOMUSE) is positively affected by teachers' beliefs about school support (SUPPORT, 0.33, NS, -4.69), and teaching load (LOAD, 0.31, NS, -4.46). Accordingly, full-time teachers and those who feel more supported in school, are more likely to own and use a computer. These paths of influence are not significant in the secondary setting, resulting in a significant difference between the primary and secondary teachers in their home and general ICT usage.

ICT adoption issues (ISSUES)

Adoption issues (ISSUES) relating to teachers' concerns about computer use in teaching practice are similarly affected, in both settings, by their home and general ICT use (HOMUSE, -0.32, -0.34, NS). Accordingly, the issues arising from ICT adoption in the classroom are less important to those teachers who own and use their own computers.

Primary school teachers' concerns about ICT are also affected, indirectly and to a much lesser extent, by teaching load (LOAD, -0.10, NS, 3.38) and beliefs about school support (SUPPORT, -0.11, NS, 2.73), suggesting that the more supported full-time primary teachers feel by their school, the fewer concerns they have about teaching with ICT. These additional influences are significantly different from the secondary school teachers.

Beliefs about student work (EFFORT)

Primary and secondary school teachers' beliefs about student work (EFFORT) are similarly affected by beliefs about school support (SUPPORT, 0.30, 0.19, NS). Those teachers who feel well supported by their school believe that students are able to put greater effort in their work when using computers, suggesting that a supportive school climate is supportive to students as well as teachers. An additional positive influence on teachers' beliefs about student effort, but only in the primary setting, is that of ICT teaching specialisation (ICTT, 0.24, NS, NS). In many schools, and particularly so for the primary schools involved in this study, it is the specialist ICT teachers who provide the support to other, less skilled teachers and students.

General ICT confidence (CONFID)

Of the seven factors found to influence teachers' general ICT confidence (CONFID), home computer use (HOMUSE, 0.75, 0.89, NS) has the greatest influence on primary and secondary school teachers, and to an equal extent. It follows then that teachers who own and use a computer at home are more confident in using ICT generally.

Teachers in both settings are also directly influenced by the use of common hardware (COMMON, 0.44, 0.27, -2.62) in their teaching, like television and video. Accordingly, teachers who regularly use electronic technologies in their teaching are more confident about using computers and other forms of ICT, although the effect is significantly stronger in the primary setting.

Although the direct effect of teacher type (TYPE, 0.22, NS, NS) in the primary setting suggests that contracted PAT and SSO teachers are more confident in using ICT than permanent teachers, the indirect effects are seen to counteract the influence so that the resulting total effect (TYPE, 0.06, NS, NS) is not significant.

The additional influences of teachers' beliefs about school support (SUPPORT, 0.25, NS, -2.68), teaching load (LOAD, 0.23, NS, -3.58), and teacher gender (SEX, -0.21, NS, 4.55) are only significant among the primary school teachers. They indicate that in primary schools, teachers are likely to be more confident in using ICT, if they are male, have full-time teaching loads and feel supported by their school.

The only additional influence evident in the secondary school teachers is that of teaching experience (TEXP, NS, 0.19, 4.01), suggesting that teachers with more years of teaching experience feel more confident in using ICT.

Planned learning outcomes (OUTCOM)

Both primary and secondary school teachers' planned learning outcomes (OUTCOM) were equally influenced by the direct effect of teachers' general confidence in using ICT (CONFID, 0.33, 0.29, NS). Accordingly, the more confident teachers are in using ICT, the more likely they are to set higher order learning objectives for their students, such as synthesising and presenting information.

The indirect effects of common hardware use (COMMON, 0.14, 0.08, NS) and home computer use (HOMUSE, 0.24, 0.26, NS) are not significantly different between the primary and secondary teachers, and this suggests that teachers who own a computer and are confident in using electronic media to support their teaching, are more likely to extend their students by planning challenging objectives.

ICT-rich teaching practice (TEACH)

Of the 13 latent variables that are hypothesised to influence directly ICT-rich teaching practice (TEACH), five constructs do so directly, while another five do so indirectly. Teachers in both primary and secondary schools are significantly influenced in their ICT-rich teaching practice by teachers' ICT confidence (CONFID, 0.42, 0.67, 2.07), beliefs about student work (EFFORT, 0.42, 0.18, -2.59), planned learning outcomes (OUTCOM, 0.27, 0.24, NS), ICT adoption issues (ISSUES, -0.24, -0.17, NS), common hardware use (COMMON, 0.22, 0.20, NS), and home computer use (HOMUSE, 0.45, 0.72, NS). The most influential of these factors is teachers' ICT confidence, which, in its total capacity, is similar in both settings. Thus, it can be surmised that teachers who own a computer, are confident ICT users and believe ICT supports students' learning, more readily use ICT in their teaching practice. Only one of these factors, namely teachers' beliefs about student effort, is significantly stronger in the primary school setting.

Other significant differences between the teachers in the primary and secondary settings also exist. Primary school teachers are also significantly influenced by teaching load (LOAD, 0.35, NS, -4.80), teacher gender (SEX, -0.11, NS, 2.63), and beliefs about school support (SUPPORT, 0.27, 0.09, -2.82). Similarly, secondary school teachers are uniquely influenced by teaching experience (TEXP, NS, 0.14, 4.75). These results suggest that, in addition to the other factors of influence common to teachers in both settings, primary school teachers who are male and working full-time in a supportive school environment, and experienced secondary school teachers, are more likely to adopt ICT-rich teaching practices.

Discussion of teacher models

In this section, it is hypothesised that 18 manifest variables and 13 latent variables significantly influence the use of ICT in teaching practice, shown above in Figure 10.2. The resulting analyses present quite a different outcome, with many of the inner model paths being non-significant and only nine paths shared. The results of the teacher path analyses conducted for the primary and secondary settings make it possible to conclude that for the teachers participating in this study, there are six factors that influence teaching practice significantly in both settings, either directly and indirectly, or both directly and indirectly. These six factors include:

a) teacher ICT confidence (CONFID, directly and indirectly);

b) beliefs about student work using ICT (EFFORT, directly);

c) planned learning outcomes (OUTCOM, directly);

d) teaching issues using ICT (ISSUES, directly);

e) common hardware use (COMMON, indirectly); and

f) computer ownership and use (HOMUSE, indirectly).

No antecedent factors are significant influences on teaching practice to teachers in both settings. However, five factors have significant influence for teachers in the primary schools:

a) teacher gender (SEX, indirectly);

b) teacher type (TYPE, indirectly);

c) teaching load (LOAD, directly and indirectly);

d) ICT teaching specialisation (ICTT, indirectly); and

e) beliefs about school support (SUPPORT, indirectly).

Similarly, there is one antecedent factor that significantly influences teaching practice in the secondary schools, namely, teaching experience (TEXP, indirectly). This is an interesting outcome given the lower variance of TEXP among secondary school teachers than among primary school teachers.

The next section conducts a similar analysis but considers the second of the two models, namely the student path model, and focuses on change over the three occasions of students in the primary and secondary school setting and the influence on self-esteem.

Factors Influencing Students

In this section, the analysis of factors influencing student self-esteem in the primary and secondary settings is conducted and reported. This analysis considers all 2560 participating students and examines the behaviour of the between-student factors as they change over time. The variables included in the path models are obtained from the student questionnaire following cluster analyses, as discussed in Chapter 9.

The hypothesised path model of factors influencing student self-esteem, advanced in Chapter 3, is presented in Figure 10.5 and indicates that 11 variables are hypothesised to influence student self-esteem (SELFATT). These variables include students' age

(AGE), gender (SEX), and non-English speaking background (NESB), access to ICT at school (SCHACC) and home (HOMACC), entertainment (ENTRMT), ICT-based homework (HOMWK), general ICT use (ICTUSE), level of ICT literacy and confidence (ICTLIT), attitude towards computers (COMATT), and attitude towards school (SCHATT). Three of these variables, namely SEX, AGE, and NESB, are exogenous latent variables because they are independent of any other manifest or latent variable. The other eight endogenous variables, including student self-esteem (SELFATT), are formed as latent variables measured by one or more manifest variables in an outward mode.

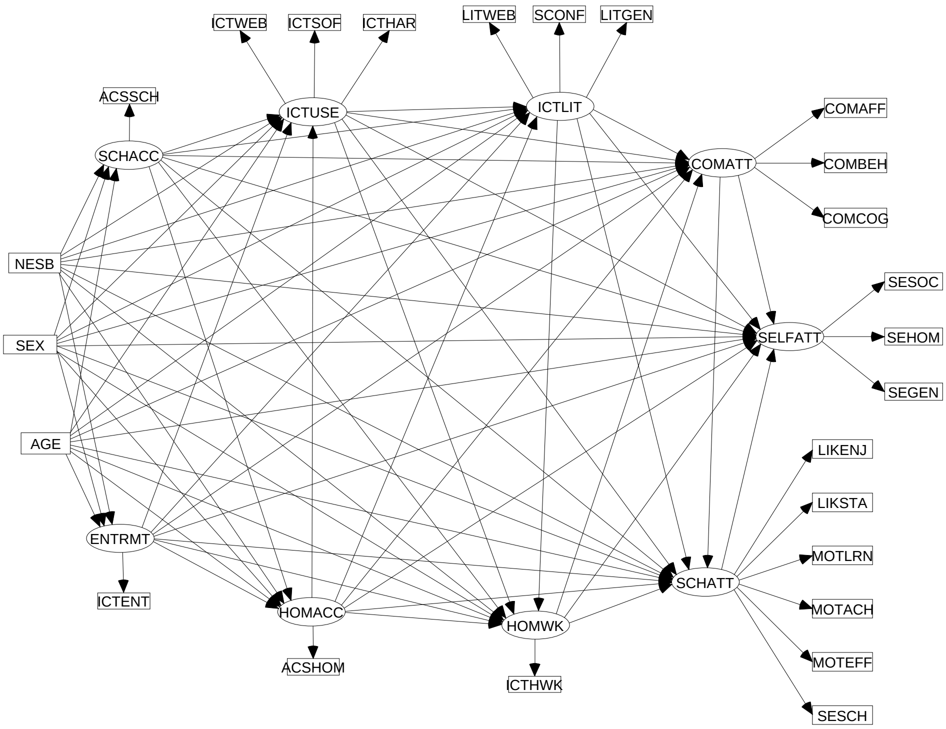


Figure 10.5 Hypothesised model of factors influencing student self-esteem

In all, the path model of factors influencing students' self-esteem includes 12 latent variables and 25 manifest variables, which are described in Table 10.4. In the previous section, the teacher model was considered under the condition of setting, that resulted in the primary and secondary teacher models. This section presents and analyses the two resulting student path models for the primary and secondary settings. However, with the existence of student data taken on three occasions, the primary and secondary student models are further examined as they change over time. Not only is there interest in the extent of change over time but there is also interest in the operation of change within the primary and secondary school settings. In order to do so, the development of six individual path models was necessary, broken down by setting and occasion.

A discussion about the development of the primary and secondary student path models is first presented, followed by analysis involving the examination over the three occasions of the path loadings for the outer and inner models.

Table 10.4 Variable in the single-level student model

Latent Variables and Descriptions		**Manifest Variables and Descriptions**	
SEX*	Student gender	*sex*	Male=0, Female=1
NESB*	Non-English speaking background	*nesb*	English=0, Other language=1
AGE	Age of student	*age*	Age in years
SCHACC	School access	*acssch*	Computer access at school
ENTRMT	Entertainment	*ictent*	Entertainment use
HOMACC	Home access	*acshom*	Computer access at home
HOMWK	ICT-based homework	*icthwk*	Text-rich homework
ICTUSE	ICT use	*ictweb*	Internet
		ictsof	General software use
		icthar	General hardware use
ICTLIT	ICT literacy and confidence	*sconf*	Student computer confidence
		litweb	Web-based knowledge
		litgen	General computer knowledge
COMATT	Computer attitude	*comaff*	Affective component
		combeh	Behavioural component
		comcog	Cognitive component
SCHATT	School attitude	*likenj*	School enjoyment
		liksta	Staying at school
		motlrn	Motivation to learn
		motach	Motivation to achieve
		moteff	Motivation to use effort in work
		sesch	School-Academic
SELFATT	Self-esteem	*segen*	General-Self
		sesoc	Social Self-Peer
		sehom	Home-Parents

* These variables do not change between occasions

Primary and secondary school student path models

A total of 978 primary students and 1582 secondary students participated on at least one of the three occasions. Some students participated on two occasions, and others participated on all three occasions. As discussed at the beginning of this chapter, the student data were initially aggregated to a single occasion, enabling the exploration of between-student factors that influenced student self-esteem in the primary and secondary settings. Using these aggregated responses of the primary and secondary students, the respective path models presented in Figure 10.6 and Figure 10.7, were developed. The models were constructed independently of each other since they involved completely different groups of students in very different settings. The path loadings depicted in each model present the standardised regression coefficient first, followed by the unstandardised regression weights in brackets. In the case where both models contain the same inner-model path between two latent variables, the path line is thicker in order to highlight the commonalities between the primary and secondary settings.

The trimming of non-significant paths from the hypothesised student model in Figure 10.5, results in the removal of two factors of influence from both primary and secondary student models. Accordingly, ICT literacy and confidence (ICTLIT) and its associated manifest variables, student computer confidence (*sconf*), web-based knowledge (*litweb*), and general computer knowledge (*litgen*), and school access (SCHACC) reflected by computer access at school (*acssch*) are not present in any of the following discussions of the outer and inner models. The removal of seemingly important variables is reassuring and suggests that the number of computers a school may or may not have for their students does not impact on their self-esteem.

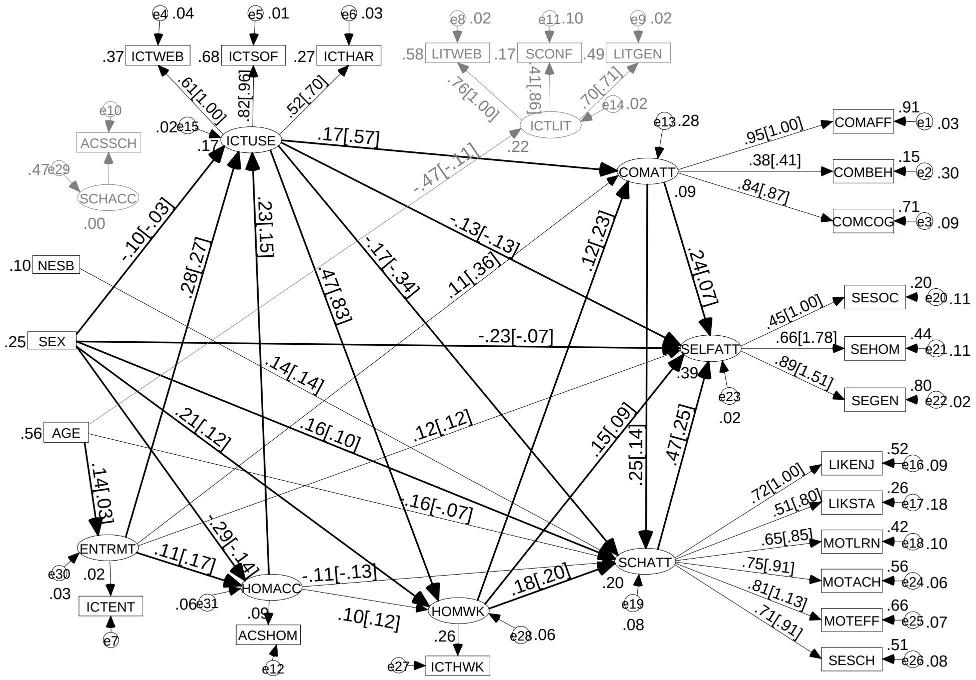


Figure 10.6 Primary student path model showing standardised and [unstandardised] weights, where the thicker lines indicate commonality between the primary and secondary school models

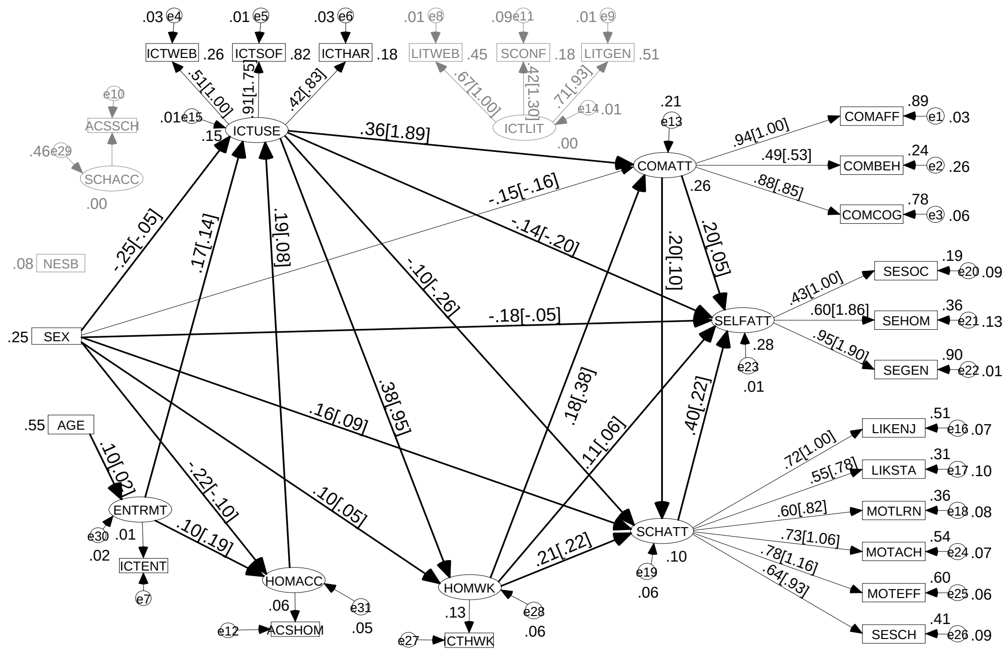


Figure 10.7 Secondary student path model showing standardised and [unstandardised] weights, where the thicker lines indicate commonality between the primary and secondary school models

Similarly, students' self-esteem also appears to be resilient to their level of computer knowledge or confidence in using ICT. The additional removal of students' non-English speaking background (NESB) from the secondary student model (see Figure 10.7) was also undertaken since it contributed nothing to that discussion.

As before, two widely adopted measures were used in testing the goodness of fit of the student model. The goodness of fit index (GFI) of the aggregated student model was 0.89 and the root mean square error of approximation (RMSEA) was 0.051, indicating an acceptable model.

Change over time

However, the existence of student data collected on three occasions allows for the additional exploration of within-student factors as they change over time and is the main focus of this section. Some 1828 responses were received by the 978 primary school students who participated over the three-year period. On the first occasion 622 surveys were completed, on the second occasion, 634, and on the third occasion, 572. Similarly, 3035 surveys were completed by the 1582 secondary students participating on the three occasions, with 882 on the first, 1075 on the second, and 1078 on the third occasion.

Using the primary and secondary student models (see Figure 10.6 and Figure 10.7), formed from the aggregated student data, a further three models for each setting were generated using the un-aggregated data. However, the development of the six models differs from the previous constructions. In each setting, the three occasions are fixed to the same model, rather than being constructed independently, since the data used consists of a similar cohort of students in the same setting. Furthermore, by comparing the same model over each occasion, a more accurate understanding of change is obtained. Results of the primary and secondary student models on the three occasions are presented in tabular form but not in graphical form, since the configuration of paths is no different to those shown in Figure 10.6 and Figure 10.7, although the path loadings do differ.

The goodness of fit index (GFI) for the primary and secondary student occasion models of 0.88, and the root mean square error of approximation (RMSEA) of 0.040 for the primary and 0.043 for the secondary, all indicate a good fit of the models.

In accordance with the previous section, a discussion of the outer models is followed by a discussion of the inner models. However, in order to avoid repetition, results of both the between-student across settings and within-student across occasions are presented and discussed under the heading of each latent variable.

Outer model analysis

Outer model results of the primary and secondary student models (see Figure 10.6 and Figure 10.7) are summarised in Table 10.5 and show the between-student differences in each setting. Further analysis of each outer model to examine within-student differences over the three occasions is presented in Table 10.6. Discussion of each of the seven latent variables and their associated manifest variables draws from both sets of outer model results. In both the primary and secondary student models, the results of the outer model show that all 22 manifest variables contribute significantly to reflect their respective latent variable. Once again, given the construction of these latent variables using cluster analysis, as detailed in Chapter 9, this finding is not surprising. Examination of the loadings of the manifest variables does provide information into which manifest variable best reflects the latent variable and whether these differ between the student cohorts and change over time. Where differences between the regression weights do occur, significance testing in the form of a t-test is conducted and is shown in the last columns of Table 10.5 and Table 10.6. If the difference is significant at the five per cent level, then *t* is larger than the absolute value of 1.96, and if highly significant at the one per cent level, then *t* is larger than 2.58 in absolute value. Note, however, that although a consistent treatment across all tables of significance indication using an asterisk system is preferred, as it is more meaningful, space restrictions require that within-student comparisons (see Table 10.6) are indicated in bold. Furthermore, in most cases, within-student discussions are limited to comparison between the first and third occasion t_{13}, thus focusing on overall change across the three-year study.

Table 10.5 Between-student outer model results for the primary and secondary models

		Primary Students (N=978)				Secondary Students (N=1582)				
		URW	**S.E.**	**SRW**	**z**	**URW**	**S.E.**	**SRW**	**z**	t_{ps}
ENTRMT	*ictent*	1		1		1		1		
HOMACC	*acshom*	1		1		1		1		
HOMWK	*icthwk*	1		1		1		1		
ICTUSE	*ictweb*	1		0.61	0.71	1		0.51	0.56	-3.77**
	ictsof	0.96***	0.06	0.82	1.17	1.75***	0.11	0.91	1.51	8.45**
	icthar	0.70***	0.06	0.52	0.57	0.84***	0.06	0.42	0.45	-2.93**
COMATT	*comaff*	1		0.95	1.85	1		0.95	1.78	-1.72
	combeh	0.41***	0.04	0.38	0.40	0.53***	0.03	0.49	0.53	3.12**
	comcog	0.87***	0.04	0.84	1.23	0.85***	0.02	0.88	1.38	3.85**
SCHATT	*likenj*	1		0.72	0.90	1		0.72	0.90	-0.10
	liksta	0.80***	0.05	0.51	0.56	0.78***	0.04	0.56	0.63	1.51
	motlrn	0.86***	0.05	0.65	0.77	0.82***	0.04	0.60	0.69	-1.89
	motach	0.91***	0.04	0.75	0.97	1.06***	0.04	0.73	0.94	-0.87
	moteff	1.13***	0.05	0.81	1.13	1.16***	0.04	0.78	1.04	-2.19*
	sesch	0.92***	0.04	0.71	0.89	0.93***	0.04	0.64	0.75	-3.39**
SELFATT	*sesoc*	1		0.45	0.48	1		0.43	0.46	-0.55
	sehom	1.78***	0.14	0.66	0.80	1.86***	0.12	0.60	0.70	-2.42*
	segen	1.51***	0.12	0.89	1.44	1.90***	0.13	0.95	1.80	8.85**

* $p \le 0.05$; ** $p \le 0.01$; *** $p \le 0.001$ level of significance

Unity variables

Entertainment use (ENTRMT) by students is reflected by one manifest variable, namely entertainment technology use (*ictent*). Since *ictent* is the only manifest variable indicating the latent construct of ENTRMT, the unity mode is employed in the analysis with an unstandardised and standardised regression loading value of 1.00. Two other latent variables are also reflected by only one manifest variable and accordingly are defined by the unity mode. These latent variables include, access to computers at home (HOMACC), reflected by computer access at home (*acshom*), and ICT-based homework (HOMWK), reflected by the manifest variable, text-rich homework (*icthwk*). Since the path loadings of the primary and secondary student models are the same, t-testing is unnecessary.

Table 10.6 Within-student outer model results for the primary and secondary models of the three occasions

Latent	Manifest	URW	SRW	z	URW	SRW	z	URW	SRW	z	t_{12}	t_{23}	t_{13}
Primary Student		**Occ1 (N=622)**			**Occ2 (N=634)**			**Occ3 (N=572)**					
ENTRMT	*ictent*	1	1		1	1		1	1				
HOMACC	*acshom*	1	1		1	1		1	1				
HOMWK	*icthwk*	1	1		1	1		1	1				
ICTUSE	*icthar*	**0.39**	0.34	0.36	**0.80**	0.56	0.63	**0.79**	0.51	0.57	**4.76**	-1.02	**3.63**
	ictsof	**0.98**	0.86	1.27	**0.95**	0.80	1.09	**1.01**	0.82	1.17	**-3.35**	1.46	-1.81
	ictweb	1	0.60	0.70	1	0.63	0.74	1	0.61	0.71	0.80	-0.62	0.16
COMATT	*comaff*	1	0.89	1.40	1	0.99	2.60	1	0.99	2.48	**21.22**	**-2.10**	**18.58**
	combeh	**0.55**	0.48	0.53	**0.25**	0.25	0.25	**0.30**	0.29	0.29	**-4.87**	0.74	**-4.01**
	comcog	**0.96**	0.89	1.41	**0.83**	0.84	1.21	**0.80**	0.80	1.11	**-3.53**	-1.69	**-5.13**
SCHATT	*likenj*	1	0.75	0.98	1	0.68	0.83	1	0.74	0.95	**-2.62**	**2.09**	-0.46
	liksta	**0.82**	0.56	0.63	**0.98**	0.57	0.65	**0.74**	0.49	0.53	0.39	**-2.08**	-1.69
	motach	**0.84**	0.74	0.94	**0.98**	0.75	0.97	**0.92**	0.75	0.97	0.51	0.04	0.54
	moteff	**0.95**	0.75	0.97	**1.13**	0.80	1.10	**1.13**	0.81	1.14	**2.39**	0.65	**2.97**
	motlrn	**0.90**	0.69	0.84	**0.92**	0.64	0.75	**0.87**	0.66	0.80	-1.51	0.81	-0.66
	sesch	**0.77**	0.63	0.75	**0.93**	0.68	0.83	**0.92**	0.73	0.93	1.43	1.83	**3.21**
SELFATT	*sesoc*	1	0.50	0.55	1	0.42	0.44	1	0.45	0.48	-1.91	0.68	-1.18
	sehom	**1.54**	0.64	0.76	**1.81**	0.60	0.69	**1.74**	0.67	0.82	-1.26	**2.29**	1.06
	segen	**1.17**	0.83	1.18	**1.82**	0.94	1.76	**1.57**	0.90	1.46	**10.25**	**-5.08**	**4.93**
Secondary Student		**Occ1 (N=882)**			**Occ2 (N=1075)**			**Occ3 (N=1078)**					
ENTRMT	*ictent*	1	1		1	1		1	1				
HOMACC	*acshom*	1	1		1	1		1	1				
HOMWK	*icthwk*	1	1		1	1		1	1				
ICTUSE	*ictweb*	1	0.60	0.69	1	0.49	0.54	1	0.47	0.51	**-3.39**	-0.75	**-4.10**
	ictsof	**1.20**	0.84	1.22	**1.75**	0.83	1.20	**2.03**	0.91	1.53	-0.44	**7.70**	**6.87**
	icthar	**0.40**	0.32	0.33	**0.92**	0.42	0.44	**1.05**	0.44	0.47	**2.59**	0.57	**3.13**
COMATT	*comaff*	1	0.92	1.58	1	0.95	1.80	1	0.97	2.11	**4.96**	**7.13**	**11.73**
	combeh	**0.54**	0.49	0.54	**0.45**	0.41	0.43	**0.45**	0.42	0.45	**-2.23**	0.36	-1.89
	comcog	**0.92**	0.92	1.58	**0.85**	0.89	1.40	**0.81**	0.85	1.27	**-3.91**	**-2.96**	**-6.72**
SCHATT	*liksta*	**0.72**	0.54	0.60	**0.55**	0.40	0.42	**0.78**	0.51	0.56	**-3.90**	**3.18**	-0.88
	motlrn	**0.78**	0.64	0.76	**0.93**	0.69	0.84	**0.97**	0.61	0.71	1.76	**-2.96**	-1.05
	motach	**1.04**	0.76	1.00	**0.70**	0.54	0.61	**1.22**	0.73	0.93	**-8.49**	**7.49**	-1.39
	moteff	**1.15**	0.81	1.14	**1.08**	0.83	1.19	**1.22**	0.72	0.90	1.08	**-6.59**	**-5.17**
	likenj	1	0.75	0.96	1	0.78	1.04	1	0.67	0.81	1.57	**-5.28**	**-3.45**
	sesch	**0.91**	0.68	0.83	**0.61**	0.51	0.56	**0.81**	0.49	0.54	**-5.90**	-0.43	**-6.32**
SELFATT	*sesoc*	1	0.38	0.40	1	0.40	0.42	1	0.44	0.48	0.54	1.24	1.72
	sehom	**2.00**	0.56	0.64	**2.71**	0.81	1.12	**1.57**	0.55	0.62	**10.54**	**-11.58**	-0.44
	segen	**2.10**	0.97	2.04	**1.98**	0.77	1.03	**1.70**	0.95	1.80	**-22.39**	**17.99**	**-5.32**

Values with a level of significance $p \leq 0.05$ are presented in bold.

General ICT use (ICTUSE)

Students' general ICT use (ICTUSE) is reflected by three manifest variables (see Table 10.5), namely internet use (*ictweb*, 0.61, 0.51, -3.77), general hardware use (*icthar*, 0.52, 0.42, -2.93) and general software use (*ictsof*, 0.82, 0.91, 8.45), constructed in the outward mode. The standardised regression loadings given after each manifest variable name, indicate that in both the primary and secondary student models general ICT use is most strongly aligned with general software use.

Between-student comparison reveals that there are significant differences in all three manifest variables in the way in which they load on general ICT use. These findings suggest that primary students view a larger component of general ICT use as using the internet, while secondary school students view it more so as using general software like playing games and using computer programs.

Within-student comparison over the three occasions presents yet another picture as primary and secondary students change over time (see Table 10.6). Over the three occasions of the study, the only significant change in primary students' general ICT use (ICTUSE) was shown in general hardware use (*icthar*, t_{13}=3.63). This finding suggests that during the course of the study primary students place greater importance on access to general hardware like, scanners, digital cameras and mobile phones as a reflection of their general ICT use. In the secondary setting, there are significant changes in all three manifest variables, with increases in general hardware use (*icthar*, t_{13}=3.13) and software use (*ictsof*, t_{13}=6.87) but a decline in web use (*ictweb*, t_{13}=-4.10). Accordingly, secondary school students made greater use of computer programs and hardware, like mobile phones and scanners, and less use of the internet, as a reflection of their general ICT use outside of school.

Attitude towards computers (COMATT)

Students' attitude towards computers (COMATT) is an outward mode latent variable reflected by tripartite components of attitude underpinning the manifest variables (see Table 10.5), which include the affective component (*comaff*, 0.95, 0.95, NS), behavioural component (*combeh*, 0.38, 0.49, 3.12) and cognitive component of attitude (*comcog*, 0.84, 0.88, 3.85). This construct appears to be closer to a bimodal rather than a trimodal structure based on the standardised regression coefficients, with the behavioural component being the weakest of the reflectors in both the primary and secondary settings.

Computer attitude is the only latent variable in which its manifest variables are reflected in the same way by the primary and secondary school students. The affective component of attitude is the strongest influence in both cases and there is little difference between primary and secondary students (*comaff*, t_{ps}=-1.72). Significant differences are evident in the attitudinal components of behaviour (*combeh*, t_{ps}=3.12) and cognition (*comcog*, t_{ps}=3.85). Relative to primary students, secondary students show higher behavioural and cognitive attitudes towards computers, but overall their computer attitudes are both aligned with their feelings about computers.

Moreover, Table 10.6 shows that there are significant positive increases in students' feelings about computers in the primary (*comaff*, t_{13}=18.58) and secondary (*comaff*, t_{13}=11.73) settings over the three years of the study. However, significant declines in cognitive attitudes towards computers are apparent in primary (*comcog*, t_{13}=-5.13) and secondary (*comcog*, t_{13}=-6.72) students, along with a significant decline in behavioural attitude but only in primary students (*combeh*, t_{13}=-4.01).

Attitude towards school (SCHATT)

Students' attitude towards school (SCHATT) is reflected by six manifest variables in the outward mode (see Table 10.5). These include, school enjoyment (*likenj*, 0.72, 0.72, NS), staying at school (*liksta*, 0.51, 0.56, NS), motivation to learn (*motlrn*, 0.65, 0.60, NS), motivation to achieve (*motach*, 0.75, 0.73, NS), motivation to use effort in work (*moteff*, 0.81, 0.78, -2.19), and academic self-esteem (*sesch*, 0.71, 0.64, -3.39). The strongest reflector of this construct in both the primary and secondary students is the motivation to put effort into work.

The only significant differences between the primary and secondary students, in the way in which the manifest variables loaded on students' attitude towards school, is in their motivation to use effort in work (*moteff*, t_{ps}=-2.19) and their academic self-esteem (*sesch*, t_{ps}=-3.39). Results suggest that, as a reflection of school attitude, secondary students are less motivated to put effort into their work and have lower academic self-esteem than their primary student peers.

Over the three occasions, distinct differences within the primary and secondary students are evident (see Table 10.6). In the primary setting, students' motivation to use effort in work (*moteff*, t_{13}=2.97) and academic self-esteem (*sesch* t_{13}=3.21) loads significantly stronger, in contrast to secondary students, where a significant decline in loading strength is apparent (*moteff*, t_{13}=-5.17; *sesch*, t_{13}=-6.32). Secondary students also experienced a decline in their enjoyment of school (*likenj*, t_{13}=-3.45). Results suggest that over the three years of the study, primary students' attitudes towards school are increasingly reflected by their motivation to learn and academic self-esteem, while these influences decline in secondary students' school attitudes.

Self-esteem (SELFATT)

Students' self-esteem (SELFATT) comprises three aspects of self-attitude (see Table 10.5) and includes general self-esteem (*segen*, 0.89, 0.95, 8.85), home self-esteem (*sehom*, 0.66, 0.60, -2.42), and social self-esteem (*sesoc*, 0.45, 0.43, NS). The standardised regression loadings indicate that in both primary and secondary settings, student's self-attitude is best reflected by their general self-esteem.

Between-student comparison shows significant differences between the primary and secondary students, which given the age difference between the cohorts, is not unexpected. Secondary students' self-esteem is reflected significantly stronger by their general self-esteem (*segen*, t_{ps}=8.85) but weaker by their home-parent self-esteem (*sehom*, t_{ps}=-2.42) in comparison to the primary students.

Within-student comparisons (see Table 10.6), as students change over time, reveal significant differences in the primary and secondary students, but only in their general self-esteem. Accordingly, as primary students' general self-esteem increasingly reflects their self-attitude (*segen*, t_{13}=4.93), the loading of secondary students' general self-esteem (*segen*, t_{13}=-5.32) declines.

This discussion confirms that there are differences between the outer models of the primary and secondary students, and suggests that while the latent variables represent similar things in both student models, the underlying compositions of influence differ in most cases. Differences brought about by age and school setting may explain these variations, reflected in the way the manifest variables load onto the respective latent variables. Therefore, during the discussion of the inner models, it should be kept in mind that there are these differences. Accordingly, the next section presents a discussion of results for the inner model of factors influencing students' self-esteem in the primary and secondary school settings, and over the three occasions.

Inner model analysis

Nine latent variables influence student self-esteem in the primary student model, whereas eight latent variables are influential in the secondary model. The path models, presented in Figure 10.6 and Figure 10.7 respectively, best illustrate the inner-path causal relationships between the criterion and predictor variables. Table 10.7 tabulates those coefficients and presents the inner model results of the between-student factors that influence student self-esteem. Within-student differences over the three occasions for the primary and secondary models are presented in Table 10.8. Discussion of each of the seven criterion variables that are influenced by the predictor variables draws from both sets of inner model results. Path coefficients were selected using a significance level of $p \leq 0.05$ and a minimum cut-off magnitude of the standardised regression weight of SRW≥0.1. Non-significant paths were removed and paths are now compared within models using the standardised regression coefficient (SRW) and between models using the unstandardised regression weight (URW). The direct (D) and total (T) effects, where applicable, are also presented.

Entertainment (ENTRMT)

Students' use of technology for entertainment (ENTRMT) is directly affected by student age (AGE, 0.15, 0.10, -2.99), indicating that the older the student, the more likely they are to use television, video and listen to music (see Table 10.7). However, the significant decline between the cohorts (AGE, t_{ps}=-2.99) indicates that this is of less importance to secondary students.

Within-student examination (see Table 10.8) shows that although there is an overall increase in the influence of age on entertainment use, it only becomes significant in each setting in the third year of the study (AGE_3, 0.12, 0.10). Although the change during the three-year period is not significant in the primary model (AGE, t_{13}=1.06), it is significant in the secondary model (AGE, t_{13}=3.93). This result indicates that unlike the primary students', secondary students are influenced by the increased use of learning technologies, with older students being more likely to use technology, such as television, video, and music players, for entertainment purposes as the study progressed.

Access to a computer at home (HOMACC)

Access to a computer at home (HOMACC) is directly influenced by two latent variables (see Table 10.7), that of student entertainment use (ENTRMT, 0.11, 0.10), but more strongly by that of student gender (SEX, -0.29, -0.22). Accordingly, male students in both primary and secondary schools, who have access to other forms of technology like television, videos and music players, are more likely to have a computer in the home. Furthermore, the apparent influence of gender on home computer access is significantly different between student cohorts (SEX, t_{ps}=3.55), with male secondary students more likely to own a computer than male primary students.

The way in which these influences changed over the duration of the study are shown in Table 10.8. In both the primary and secondary settings, student gender, with preference indicated by male students, is significant on all three occasions, but there is no significant change over the period. Students' entertainment appears to be an increasingly important influence in the primary setting, particularly on the second and third occasions of the study, although the growth is not large enough to be significantly different. These findings indicate that, independent of the increased use of ICT in school, male students are more likely to have access to a home computer than their female peers.

Table 10.7 Between-student inner model results for the primary and secondary models

Criterion	Predictors		Primary Students (N=978)			Secondary Students (N=1582)			
			URW	S.E.	SRW	URW	S.E.	SRW	t_{ps}
ENTRMT	AGE	D	0.03***	0.0`	0.15	0.02***	0.004	0.10	-2.99**
HOMACC	SEX	D	-0.14***	0.01	-0.29	-0.10***	0.01	-0.22	3.55**
	ENTRMT	D	0.17***	0.05	0.11	0.19***	0.05	0.10	0.39
ICTUSE	HOMACC	D	0.15***	0.02	0.23	0.08***	0.01	0.19	-3.55**
	ENTRMT	D	0.27***	0.04	0.28	0.14***	0.02	0.17	-4.72**
		T	0.30	0.04	0.30	0.16	0.03	0.19	-4.36**
	SEX	D	-0.03**	0.01	-0.10	-0.05***	0.01	-0.25	-1.93
		T	-0.06	0.01	-0.17	-0.06	0.01	-0.29	-0.38
HOMWK	ICTUSE	D	0.83***	0.07	0.47	0.95***	0.08	0.38	1.55
	HOMACC	D	0.12***	0.04	0.10				-5.17**
		T	0.24	0.04	0.21	0.08	0.02	0.07	-6.01**
	SEX	D	0.12***	0.02	0.21	0.05***	0.01	0.10	-4.71**
		T	0.06	0.02	0.10	-0.01	0.01	-0.01	-4.32**
COMATT	SEX	D				-0.16***	0.03	-0.15	-7.44**
		T	-0.02	0.02	-0.02	-0.27	0.03	-0.25	-10.76**
	ENTRMT	D	0.36**	0.12	0.11	0.38***	0.05	0.18	0.16
		T	0.59	0.13	0.18	0.35	0.06	0.08	-2.62**
	ICTUSE	D	0.57***	0.16	0.17				-5.85**
		T	0.76	0.18	0.22	2.25	0.20	0.43	7.82**
	HOMWK	D	0.23**	0.07	0.12	1.89***	0.18	0.36	11.36**
SCHATT	SEX	D	0.10***	0.02	0.17	0.09***	0.02	0.16	-0.94
		T	0.15	0.02	0.24	0.07	0.02	0.14	-4.26**
	AGE	D	-0.07***	0.01	-0.17				8.59**
	NESB	D	0.14***	0.03	0.14				-6.93**
	ICTUSE	D	-0.34***	0.09	-0.17	-0.26**	0.10	-0.10	0.84
		T	-0.07	0.09	-0.04	0.18	0.09	0.07	2.78**
	HOMACC	D	-0.13**	0.04	-0.11				5.04**
		T	-0.12	0.05	-0.10	0.01	0.01	0.01	4.53**
	HOMWK	D	0.20***	0.04	0.18	0.22***	0.03	0.21	0.53
		T	0.23	0.05	0.21	0.26	0.03	0.24	0.68
	COMATT	D	0.14***	0.02	0.25	0.10***	0.02	0.20	-2.04*
SELFATT	SEX	D	-0.08***	0.01	-0.23	-0.05***	0.01	-0.18	2.37*
		T	-0.03	0.01	-0.08	-0.04	0.01	-0.14	-1.34
	ICTUSE	D	-0.13**	0.05	-0.13	-0.20***	0.05	-0.14	-1.44
		T	-0.02	0.05	-0.02	0.02	0.05	0.01	0.81
	ENTRMT	D	0.12***	0.03	0.12				-5.88**
		T	0.15	0.04	0.15	0.003	0.01	0.002	-6.41**
	HOMWK	D	0.09***	0.02	0.15	0.06***	0.02	0.11	-1.57
		T	0.16	0.03	0.28	0.14	0.02	0.24	-1.11
	COMATT	D	0.07***	0.01	0.24	0.05***	0.01	0.20	-1.66
		T	0.11	0.02	0.35	0.08	0.01	0.28	-2.19*
	SCHATT	D	0.25***	0.03	0.47	0.22***	0.02	0.40	-1.28

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$ level of significance.

Table 10.8 Within-student inner model results for the primary and secondary models of the three occasions

Criterion	Predictors		URW	SRW	URW	SRW	URW	SRW	t_{12}	t_{23}	t_{13}
Primary Student			**Occ1 (N=622)**		**Occ2 (N=634)**		**Occ3 (N=572)**				
ENTRMT	AGE	D	0.02	0.10	0.017	0.08	**0.03**	**0.12**	-0.25	1.30	1.06
HOMACC	SEX	D	**-0.15**	**-0.25**	**-0.126**	**-0.22**	**-0.13**	**-0.24**	0.64	-0.35	0.27
	ENTRMT	D	0.17	0.10	**0.221**	**0.15**	**0.24**	**0.17**	0.67	0.28	0.93
ICTUSE	HOMACC	D	**0.15**	**0.24**	**0.099**	**0.16**	**0.16**	**0.24**	-1.60	1.60	0.09
	ENTRMT	D	**0.15**	**0.14**	**0.293**	**0.33**	**0.26**	**0.29**	**3.10**	-0.83	**2.27**
		T	**0.18**	**0.17**	**0.315**	**0.36**	**0.30**	**0.33**	**2.58**	-0.47	**2.09**
	SEX	D	-0.01	-0.03	**-0.062**	**-0.17**	-0.02	-0.04	**-3.19**	**2.94**	-0.25
		T	-0.03	-0.09	**-0.074**	**-0.21**	**-0.04**	**-0.10**	**-2.48**	**2.31**	-0.18
HOMWK	ICTUSE	D	**0.94**	**0.52**	**0.906**	**0.48**	**0.83**	**0.47**	-0.33	-0.86	-1.16
	HOMACC	D	0.11	0.09	0.017	0.02	0.03	0.03	**-2.02**	0.37	-1.56
		T	**0.25**	**0.22**	0.106	0.09	**0.16**	**0.14**	**-2.83**	1.05	-1.74
	SEX	D	**0.15**	**0.23**	**0.115**	**0.17**	0.06	0.10	-1.34	**-2.19**	**-3.71**
		T	**0.10**	**0.16**	0.046	0.07	0.03	0.04	**-2.23**	-0.85	**-3.24**
COMATT	ICTUSE	D	**0.31**	**0.11**	**0.756**	**0.20**	**0.75**	**0.21**	**2.34**	-0.02	**2.28**
		T	**0.56**	**0.19**	**0.982**	**0.26**	**0.88**	**0.24**	**2.09**	-0.42	1.43
	ENTRMT	D	**0.41**	**0.13**	0.307	0.09	0.14	0.04	-0.76	-1.16	-1.92
		T	**0.51**	**0.16**	**0.617**	**0.19**	**0.41**	**0.12**	0.67	-1.24	-0.62
	HOMWK	D	**0.27**	**0.17**	**0.249**	**0.12**	0.16	0.08	-0.16	-0.80	-1.00
SCHATT	SEX	D	**0.11**	**0.15**	**0.098**	**0.15**	**0.11**	**0.15**	-0.27	0.33	0.06
		T	**0.15**	**0.20**	**0.131**	**0.20**	**0.15**	**0.20**	-0.44	0.43	-0.00
	AGE	D	**-0.07**	**-0.16**	**-0.058**	**-0.16**	-0.04	-0.10	0.47	1.18	1.47
	NESB	D	**0.11**	**0.10**	**0.141**	**0.14**	**0.19**	**0.17**	0.68	1.13	1.72
	HOMACC	D	**-0.16**	**-0.13**	-0.072	-0.06	-0.13	-0.10	1.65	-1.05	0.52
		T	**-0.14**	**-0.11**	-0.070	-0.06	-0.13	-0.10	1.16	-1.08	0.19
	ICTUSE	D	-0.16	-0.08	**-0.245**	**-0.13**	**-0.41**	**-0.20**	-0.78	-1.39	**-2.12**
		T	0.03	0.02	-0.013	-0.01	-0.07	-0.03	-0.39	-0.43	-0.84
	HOMWK	D	0.08	0.08	**0.187**	**0.19**	**0.30**	**0.27**	**1.98**	**2.19**	**3.88**
		T	**0.13**	**0.12**	**0.203**	**0.20**	**0.32**	**0.28**	1.16	**2.03**	**3.20**
	COMATT	D	**0.20**	**0.29**	**0.064**	**0.13**	**0.11**	**0.20**	**-4.31**	1.54	**-2.56**
SELFATT	SEX	D	**-0.12**	**-0.29**	**-0.061**	**-0.19**	**-0.05**	**-0.14**	**3.19**	0.83	**3.77**
		T	**-0.06**	**-0.16**	**-0.032**	**-0.10**	-0.01	-0.03	1.86	1.47	**2.97**
	ICTUSE	D	**-0.16**	**-0.14**	-0.040	-0.05	0.00	0.00	1.93	0.73	**2.44**
		T	-0.002	-0.002	0.003	0.004	**0.13**	**0.12**	0.08	**1.98**	1.80
	ENTRMT	D	**0.20**	**0.16**	0.007	0.01	0.03	0.04	**-4.37**	0.74	**-3.58**
		T	**0.24**	**0.20**	0.032	0.04	0.08	0.08	**-4.68**	1.11	**-3.18**
	HOMWK	D	**0.12**	**0.19**	-0.028	-0.06	**0.11**	**0.19**	**-5.17**	**5.57**	-0.28
		T	**0.17**	**0.27**	0.037	0.08	**0.20**	**0.35**	**-3.61**	**4.83**	0.78
	COMATT	D	**0.06**	**0.16**	**0.074**	**0.31**	**0.06**	**0.20**	0.82	-1.36	-0.24
		T	**0.11**	**0.28**	**0.088**	**0.37**	**0.09**	**0.30**	-0.97	-0.18	-0.99
	SCHATT	D	**0.23**	**0.40**	**0.231**	**0.48**	**0.25**	**0.50**	0.00	0.57	0.51

Values with a level of significance $p \le 0.05$ are presented in bold. D=Direct effect; T=Total effect.

Continued…

Table 10.8 Continued

Secondary Student			**Occ1 (N=882)**		**Occ2 (N=1075)**		**Occ3 (N=1078)**				
ENTRMT	AGE	D	-0.001	-0.01	0.002	0.01	**0.02**	**0.10**	0.66	**3.00**	**3.93**
HOMACC	SEX	D	**-0.11**	**-0.20**	**-0.09**	**-0.19**	**-0.11**	**-0.22**	1.09	-1.17	0.06
	ENTRMT	D	0.21	0.09	0.15	0.09	0.15	0.09	-1.03	0.14	-0.90
ICTUSE	HOMACC	D	**0.10**	**0.18**	**0.08**	**0.19**	**0.07**	**0.19**	-0.92	-0.50	-1.36
	SEX	D	**-0.06**	**-0.19**	**-0.05**	**-0.26**	**-0.05**	**-0.26**	0.60	0.27	0.84
		T	**-0.07**	**-0.22**	**-0.06**	**-0.30**	**-0.06**	**-0.31**	0.80	0.27	1.04
	ENTRMT	D	**0.17**	**0.13**	**0.13**	**0.19**	**0.08**	**0.13**	-1.12	**-2.08**	**-2.45**
		T	**0.19**	**0.15**	**0.14**	**0.20**	**0.09**	**0.14**	-0.99	-1.52	-1.89
HOMWK	ICTUSE	D	**0.78**	**0.41**	**1.06**	**0.39**	**1.05**	**0.37**	**2.71**	-0.12	**2.60**
	SEX	D	0.02	0.03	0.03	0.05	**0.06**	**0.12**	0.42	**2.17**	**2.50**
		T	-0.04	-0.06	-0.04	-0.07	0.003	0.01	-0.05	**2.41**	**1.96**
COMATT	ICTUSE	D	**1.25**	**0.33**	**2.02**	**0.36**	**2.25**	**0.36**	**3.50**	0.89	**4.40**
		T	**1.48**	**0.39**	**2.28**	**0.41**	**2.55**	**0.41**	**3.02**	0.89	**3.91**
	SEX	D	**-0.22**	**-0.18**	**-0.17**	**-0.15**	**-0.12**	**-0.10**	1.32	1.22	**2.44**
		T	**-0.31**	**-0.26**	**-0.30**	**-0.26**	**-0.25**	**-0.21**	0.38	1.22	1.49
	HOMWK	D	**0.29**	**0.15**	**0.24**	**0.12**	**0.29**	**0.13**	-0.66	0.63	-0.04
SCHATT	SEX	D	0.09	0.13	0.03	0.04	**0.10**	**0.18**	**-2.46**	**3.10**	0.37
		T	0.05	0.08	0.01	0.01	**0.09**	**0.17**	-1.93	**4.00**	1.66
	ICTUSE	D	**-0.37**	**-0.17**	-0.23	-0.07	-0.17	-0.06	1.04	0.42	1.77
		T	0.12	0.05	0.18	0.05	0.16	0.06	0.46	-0.17	0.35
	HOMWK	D	**0.33**	**0.29**	**0.17**	**0.14**	**0.16**	**0.17**	**-3.66**	-0.15	**-4.25**
		T	**0.37**	**0.33**	**0.19**	**0.16**	**0.18**	**0.19**	**-3.55**	-0.30	**-4.67**
	COMATT	D	**0.16**	**0.27**	**0.10**	**0.17**	**0.06**	**0.14**	**-2.29**	-1.92	**-4.65**
SELFATT	SEX	D	**-0.06**	**-0.20**	-0.03	-0.10	-0.03	-0.08	**3.25**	-0.30	**2.70**
	ICTUSE	D	-0.09	-0.10	**-0.32**	**-0.25**	**-0.25**	**-0.14**	**-3.87**	1.02	**-2.49**
		T	-0.01	-0.02	-0.05	-0.04	0.04	0.03	-0.67	1.36	0.94
	HOMWK	D	-0.02	-0.03	**0.12**	**0.24**	0.06	0.09	**6.85**	**-2.83**	**3.70**
		T	**0.06**	**0.13**	**0.15**	**0.31**	**0.11**	**0.18**	**3.71**	-1.46	**2.01**
	COMATT	D	**0.05**	**0.19**	**0.06**	**0.24**	**0.08**	**0.28**	0.82	**2.08**	**2.85**
		T	**0.07**	**0.30**	**0.07**	**0.29**	**0.09**	**0.32**	-0.54	1.78	1.25
	SCHATT	D	**0.17**	**0.40**	**0.11**	**0.27**	**0.18**	**0.27**	**-3.10**	**3.14**	0.16

Values with a level of significance $p \leq 0.05$ are presented in bold. D=Direct effect; T=Total effect.

General ICT use (ICTUSE)

Students' general ICT use (ICTUSE) is affected by three latent variables (see Table 10.7), namely home computer access (HOMACC, 0.23, 0.19), entertainment (ENTRMT, 0.30, 0.19) and student gender (SEX, -0.17, -0.29). The results suggest that male students with greater access to a computer and other forms of technology at home are also likely to use the internet, computer programs, and work a scanner or digital camera. Differences amongst primary and secondary school students are significant for two latent variables that influence students' general ICT use. Entertainment (ENTRMT, t_{ps}=-4.36) loads more strongly in the primary model, as does home computer access (HOMACC, t_{ps}=-3.55), and indicates that these factors play a less important role in secondary school students' use of computers.

Although students' general ICT use is significantly influenced by home computer access (see Table 10.8), the nature of this influence remains constant over the three years for both primary (HOMACC, t_{13}=0.09) and secondary (HOMACC, t_{13}=-1.36) students. As such, students with access to a computer at home are more likely to have better general ICT use, but this occurs independently of their increased exposure to ICT in school. Students' use of technology for entertainment is another factor influencing their general ICT use, and does so significantly on the three occasions. For primary students, though, the total effect of entertainment (ENTRMT, t_{13}=2.09) is found to increase significantly over the period, suggesting that perhaps an effect of the changing school environment is in play. Accordingly, primary students with access to television and other forms of entertainment have a greater likelihood of using the internet, computer programs, or working a scanner or digital camera, and this might be influenced by the increased use of learning technologies in schools. Students' gender also impacts on their general ICT use, and the non-significant change over the period indicates that boys' preference for using ICT is a reasonably stable quality, independent of the increased use of ICT in schools.

ICT-rich homework (HOMWK)

ICT-rich homework (HOMWK), such as word-processing, is influenced by three latent variables (see Table 10.7). Students' general ICT use (ICTUSE, 0.47, 0.38) is significant in both settings and maintains a similar level of importance for primary and secondary students. Therefore students who are competent in using ICT, also use the computer to do their homework, projects, or study. The other two factors, namely home computer access (HOMACC, 0.21, 0.07) and student gender (SEX, 0.10, -0.01), are only significant for students in the primary setting, which is significantly different from the secondary students. These results imply that, in order for students to do ICT-rich homework, it is important for female primary students that they have access to a computer at home.

Although both primary and secondary students' ICT-rich homework is significantly influenced by general ICT use across all three occasions (see Table 10.8), it only varies significantly for the secondary students over the period (ICTUSE, t_{13}=2.60). This finding indicates that the changing school environment where ICT was increasingly used, has little influence in the primary setting but has a positive impact on secondary students' general ICT use, which in turn increases their likelihood of using computers to do their homework, study, or prepare projects. Computer access at home is a marginally significant influence on primary students' ICT-based homework over the three occasions. The declining trend in importance of this factor and the non-significant change over the three years, indicates that while home computer access is important for primary students to do their ICT-rich homework, the increased use of ICT in schools does not impact upon it. The influence of student gender, however, is quite different. In the primary setting, the significant change in the influence that gender (SEX, t_{13}=-3.24) has on ICT-rich homework, implies that over the three years of the study, the gender imbalance in preference to female primary students, is becoming less important as ICT are increasingly used in the schools. Although student gender also has a direct and significant influence on homework in the secondary setting, but only on the third occasion, the total effect resulting from the indirect effects, is not significant.

Attitude towards computers (COMATT)

By examining students' attitude towards computers (COMATT) in terms of student gender (SEX, -0.02, -0.25), entertainment (ENTRMT, 0.18, 0.08), general ICT use (ICTUSE, 0.22, 0.43), and ICT-rich homework (HOMWK, 0.12, 0.36), reveals that while none of the direct effects are very strong, and indeed some are not even significant in their total effect, the influence of students' general ICT use dominates (see Table 10.7). Interpretation indicates that the increased use of ICT, for general use and doing homework, promotes positive attitudes towards computers. Furthermore, male secondary students' computer attitudes are more positive than their female counterparts and primary students who use entertainment technology are more likely to have a positive computer attitude. These influences are significantly different and show clear differences between primary and secondary students. General ICT use (ICTUSE, t_{ps}=7.82), is highly influential in secondary students' attitudes towards computers, whereas access to entertainment contributes strongly in the primary setting (ENTRMT, t_{ps}=-2.62). Although gender has no effect on primary students' computer attitude, this is significantly different in the secondary setting, where male students maintain a more positive attitude towards computers (SEX, t_{ps}=-10.76). There is also a significant difference in the effect that ICT-rich homework (HOMWK, t_{ps}=11.36) has on computer attitude between primary and secondary students with a stronger effect dominating in the secondary setting.

As seen in Table 10.8, on all three occasions students' general ICT use maintains a significant influence on students' computer attitude, indicating that the more students use ICT the more positive is their attitude towards computers. Whether this is influenced by the increased use of ICT in school can possibly be claimed in the secondary schools, where there is a significant positive change in the total effect (ICTUSE, t_{13}=3.91). Primary students' entertainment use appears to be less influential with each passing year, but any change in its influence on computer attitude is not significant (ENTRMT, t_{13}=-0.62). Nevertheless, it could be said that the use of entertainment technologies like television and music players, has a positive influence on computer attitude. Similarly, ICT-rich homework also presents a non-significant trend of diminishing influence on students' attitudes towards computers, suggesting that students' attitudes towards computers improves if they are given computer based project and homework activities. In terms of gender, secondary male students' attitudes towards computers are more positive than those of their female counterparts, and appear to form independently of the increased use of ICT in school. However, the direct effect indicates that boys' computer attitudes are affected by the changing environment, implied by a significant change (SEX, t_{13}=2.44) over the three years, but in a diminishing capacity. It appears that the increased use of ICT in schools is reducing the differences in male and female students' attitudes towards computers, although these differences are not large enough to be considered significant at the 0.05 level.

Attitude towards school (SCHATT)

Students' attitude towards school (SCHATT) is significantly affected by three exogenous latent variable and two endogenous latent variables (see Table 10.7). Although there is a significant direct effect from two other endogenous variables, the total effect, taking into consideration the indirect paths, results in general ICT use (ICTUSE, -0.04, 0.07) and home computer access (HOMACC, -0.10, 0.01) being non-significant influences. In the primary setting, student age (AGE, -0.17, NS) and a student's language background (NESB, 0.14, NS) suggest that a positive school attitude is more likely in younger students and in those who come from a non-English speaking background. Secondary students' attitudes are not influenced by these factors, yielding a significant difference between the cohorts (AGE, t_{ps}=8.59; NESB, t_{ps}=-6.93). Both primary and secondary students' school attitudes, however, are significantly affected by the third exogenous variable, student gender (SEX, 0.24, 0.14), indicating that female students have a more positive attitude towards school than their male peers. Though not significantly different in the direct effect, the primary and secondary settings differ in the total effects (SEX, t_{ps}=-4.26), indicating that gender is a significantly stronger influence on the formation of school attitude in primary school. The two endogenous factors, namely ICT-rich homework (HOMWK, 0.21, 0.24) and computer attitude (COMATT, 0.25, 0.20), are also influential in the primary and secondary settings. The results indicate that a positive school attitude is promoted by study and homework that involves using computers, in addition to having a positive attitude towards computers. Only computer attitude varies significantly between the settings and, again, is stronger in the primary setting (COMATT, t_{ps}=-2.04).

Supported by previous research findings, it is no surprise to see that students' attitudes towards school are more positively held by female students. Furthermore, the apparent stability of student gender (see Table 10.8) is evidenced by no significant change over the three years of the study in the primary (SEX, t_{13}=-0.00) or secondary (SEX, t_{13}=1.66) settings. This result suggests that independent of the level of ICT adoption in school, girls probably maintain a consistently more positive view of school than boys. Another finding supported by previous research is the influence of students' age on school attitude, whereby older students hold poorer attitudes towards school. Apparent only in the primary students, the drop-off of significance in the third year of the study suggests that students' age might be less influential in forming school attitude as ICT is increasingly adopted in schools, though the difference is not large enough to be significant (AGE, t_{13}=1.47). That age is not a significant factor at all in the secondary students, suggests that as students get older the influence of age might also diminish. It is apparent that for primary students who come from non-English speaking backgrounds, they maintain a more positive attitude towards school than their peers who speak English as their first language. Once again, the stability of this factor of influence results in an increase over the three years that is not significant (NESB, t_{13}=1.72). Primary students' access to a computer at home only reached significance on the first occasion of the study, but its negative influence suggests that having a computer at home lowers students' attitudes towards school. Perhaps students view computers as a benefit of going to school, unless they already have one at home, a view that does not change over the period of the study (HOMACC, t_{13}=0.19). Although there are some significant direct effects from general ICT use, the total effects in the primary (ICTUSE, t_{13}=-0.84) and secondary (ICTUSE, t_{13}=0.35) settings yield a non-significant influence over the period. This finding suggests that students' use of computers in an increasingly ICT-rich learning environment does not greatly influence their attitude towards school. Of more interest, are the influences of ICT-rich homework and students' attitudes towards computers. Both provide a significant influence on students' attitudes towards school, on all three occasions, but do so in different ways. In the primary setting, ICT-rich homework presents a trend of increasing influence on school attitude (HOMWK, t_{13}=3.20). However, a reverse trend is apparent in the secondary students (HOMWK, t_{13}=-4.67). Arguably then, this outcome suggests that ICT-rich homework is increasingly important for primary students but of declining importance for secondary students in forming positive attitudes towards school, and that this is attributable to the increased use of ICT in school.

The last factor to be considered in this discussion about school attitude is the influence of students' attitudes towards computers. The significant influence of computer attitude on school attitude is apparent across all three occasions and implies that students who have a positive attitude toward computers are more likely to share a positive view of school. It is interesting in both the primary (COMATT, t_{13}=-2.56) and secondary (COMATT, t_{13}=-4.65) settings, then, that in an increasingly ICT-rich learning environment, significant change in the influence of computer attitude over the period is one of decline. Interpretation suggests that as ICT is adopted into mainstream practice, it is of less importance to students in defining their attitude towards school. In other words, computers just become the norm rather than a perceived highlight in daily school life.

Self-esteem (SELFATT)

Of the 11 factors hypothesised to influence directly students' self-esteem (SELFATT), analysis of the student path models result in only six latent variables doing so (see Table 10.7). Even though the factors affect self-esteem both directly and indirectly, only the standardised total path effects are discussed when present. Student gender (SEX, -0.08, -0.14) is the only antecedent variable to influence self-esteem and indicates that male students hold a higher self-esteem than female students. Although it is not significant in the primary setting but is significant in the secondary setting, the difference between the cohorts is not significant (SEX, t_{ps}=-1.34). Similarly, the endogenous latent variable, general ICT use (ICTUSE, -0.02, 0.01), is rendered non-significant in its total effect and there is little difference between the settings (ICTUSE, t_{ps}=0.81). Students' use of technology like television and music players is only significant in the primary setting (ENTRMT, t_{ps}=-6.41) and is a positive influence on self-esteem (ENTRMT, 0.15, 0.002). This result suggests that access to entertainment technologies play a bigger role in the positive development of primary students' self-esteem than it does in secondary students. The other three latent variables that are significant in both primary and secondary students include ICT-rich homework (HOMWK, 0.28, 0.24), computer attitude (COMATT, 0.35, 0.28) and school attitude (SCHATT, 0.47, 0.40). Of these, only computer attitude is a significantly stronger influence in the primary setting (COMATT, t_{ps}=-2.19). These results suggest that a positive self-esteem is strongly influenced by a positive school attitude, and is further promoted by having a positive attitude towards computers and by doing homework that involves using computers.

Within-student comparisons over the three occasions of the factors that influence students' self-esteem are found in Table 10.8. Student gender presents a significant but diminishing influence on students' self-esteem. In concurrence with previous studies, female students have a poorer self-attitude than their male peers. More interestingly, the importance of gender on self-esteem appears to decline over time in the primary (SEX, t_{13}=2.97) and secondary (SEX, t_{13}=2.70) settings, suggesting that the increased use of ICT in school promotes improved self-esteem in female students. General ICT use is interesting in its influence on self-esteem. Its transition from a negative influence to a positive one over the three occasions, though not significantly so in the primary (ICTUSE, t_{13}=1.80) or secondary (ICTUSE, t_{13}=0.94) settings, suggests that the increased use of learning technologies in schools has a supportive effect on the relationship between students' views about their use of ICT and self-esteem. Put simply, in the first year of the study, students' use of the internet and other ICT affected negative views of self-esteem, but adoption of ICT into mainstream practice during the following years, reversed this effect.

Another factor of influence that is seen to diminish in importance during the course of the study is primary students' use of entertainment technologies. The significant positive influence on self-esteem experienced in the first year, was rendered not significant in later years (ENTRMT, t_{13}=-3.18). It can be said, then, that while primary students' access to television, music, and other forms of entertainment was important to their self-esteem in the first year of the study, the apparent increase in access to other forms of technology in school reduced its importance.

The final three variables found to influence self-esteem significantly and positively in primary and secondary students are ICT-rich homework (HOMWK, t_{13}=0.78, 2.01), attitudes towards computers (COMATT, t_{13}=-0.99, 1.25), and attitudes towards school (SCHATT, t_{13}=0.51, 0.16). Over the three occasions of the study, trends in these factors are generally seen to strengthen, but only significantly so in one factor, that of ICT-rich homework, and only in the secondary setting. A trend emerges from the direct influence that ICT-rich homework has on self-esteem over the three occasions, by changing from being a negative to a positive influence on self-esteem. Although these changes are significant, their influence on self-esteem is not. By observing the total effect, however, a different picture emerges in which the influence of secondary students' use of computers to do their homework is significant and positive. Furthermore, a trend over the three years of the increasing importance on self-esteem of using computers for doing homework is also significant and arguably attributable to the increased use of learning technologies in schools (HOMWK, t_{13}=2.01). That is to say, in an increasingly ICT-rich school environment, using a computer to study and do homework is more likely to promote positive self-esteem. The apparent stability of students' attitudes towards school and computers over the duration of the study suggests that the increased use of ICT in school does not affect the way in which these factors influence self-esteem. Accordingly, those students with positive attitudes towards school and computers are more likely to maintain a positive self-esteem, independent of the increased adoption of technologies in the learning environment.

Discussion of student models

The main focus of this study, to understand the impact that ICT has on students, in particular their self-esteem, is a complex undertaking. A path model of factors influencing students' self-esteem is hypothesised that includes12 latent variables and 25 manifest variables, shown above in Figure 10.5. The resulting analyses found that many of the inner model paths are non-significant with 19 paths shared. The results of the student-level path analyses conducted for the primary and secondary settings make it possible to conclude that for students at the primary and secondary schools in this study, there are four endogenous factors that influence student self-esteem significantly in both settings, either directly and indirectly, or both directly and indirectly. These four factors include:

a) ICT-based homework (HOMWK, directly and indirectly),

b) general ICT use (ICTUSE, directly and indirectly),

c) attitude towards computers (COMATT, directly and indirectly), and

d) attitude towards school (SCHATT, directly).

Only one antecedent factor is found that significantly influences students' self-esteem in both settings, namely, student gender (SEX, indirectly).

Summary

This chapter examines the within-level factors by hypothesising and testing the teacher and student models using path analysis. The main sections presented in the chapter detail the results and analyses of the teacher and student models, and show some differences but many similarities between the primary and secondary settings. The results of the teacher-level path analyses identify six factors that significantly influence teaching practice in both settings: these include teacher ICT confidence, beliefs about student work using ICT, planned learning outcomes, teaching issues using ICT, common hardware use, and computer ownership and use. The results of the student-level path analyses provide five factors that significantly influence student self-esteem in both settings, namely student gender, ICT-based homework, general ICT use, attitude towards computers, and attitude towards school.

The next chapter examines the across-level factors influencing student self-esteem by using three-level hierarchical linear modelling (HLM) procedures.

11

Modelling Change

In Chapter 10, models of factors influencing student self-esteem and teacher adoption of ICT are constructed and analysed using the AMOS statistical program (Arbuckle and Wothke, 1999). This analysis focused on the use of single-level path modelling, and although it reveals many rich findings, it was unable to take into account the hierarchical nature of the data, that occasions are nested in students, which are nested in schools. Put simply, the single-level path analysis was able to show mediating effects between factors within levels, but was unable to show the interaction effects between factors across levels. Thus, the purpose in this chapter is to examine the across-level factors influencing student self-esteem using three-level hierarchical linear modelling (HLM) procedures.

The use of HLM makes it possible to analyse simultaneously up to three different levels of factors in order to determine which factors affect the dependent outcome variable (Bryk and Raudenbush, 1992). By using HLM, better estimates of school effects and variance are expected in addition to more appropriate error terms. Furthermore, not only does this approach estimate the direct effects at various levels, it also estimates the indirect or interaction effects between factors from different levels. What it cannot do is only to estimate the direct effects of factors on the criterion variable at the same level; thus the need for the path analysis undertaken in the previous chapter.

A further limitation of the HLM approach allows only one dependent or outcome variable to be analysed in a model at any one time. Since the main focus of this study is to examine the factors that influence change in student self-esteem, then the variable self-esteem (SELFATT) is the logical choice in selecting the dependent variable.

However, as seen in the previous chapter, student self-esteem (SELFATT) is a latent variable measured by three manifest variables, namely, general self-esteem (*segen*), home self-esteem (*sehom*), and social self-esteem (*sesoc*). A problem arises since HLM does not allow the formation of latent variables. Hence, in preparing the data, SPSS was used to calculate principal component scores for each latent construct that was not of unity mode so that the latent variable used in the path analysis (see Chapter 10) could be used in the HLM analysis. Those variables that were of unity mode include student gender (SEX; male = 0, female = 1), age (AGE; in years), language background (NESB; English = 0, NESB = 1), occasion (OCC; Occ1 = 0, Occ2 = 1, Occ3 = 2), and school setting (SET; primary = 0, secondary = 1).

The nature of the data collected in this study included students, measured on three occasions, their teachers, measured once over the three years, and demographic information from the six participating schools. The major impetus undertaken in these schools over the three-year period was increasingly to embed learning technologies into the curriculum. The broad aim of this study, therefore, was to investigate the impact that the changing school environment had on its students, and in particular, their self-esteem. Given the nature of the data and the focus of this study, the development and testing of two HLM models was necessary. Both proposed models place student self-esteem as the dependent variable, but each model differs in its approach by examining:

a) change in students over time, and

b) change in schools over time.

This chapter details the development and analysis of these two models by using three-level hierarchical linear modelling. Although the variables comprising each model are the same, the levels to which they are assigned differ, and so to avoid confusion, each model is examined and presented separately.

Change in Students Over Time

Measuring students' attitudes over a three-year period in schools that were in a process of change, afforded a unique opportunity to examine the impact of that change. For the purposes of this study, the focus of that change was directed towards the outcome variable of student self-esteem. With data collected on three occasions, change within students could be examined. With data collected from many students and their teachers across several schools, change between students and between schools could also be considered. The nested nature of such data, reflected by the three-level structure of HLM, is presented conceptually in Figure 11.1. The occasion level (Level 1 or micro-level) contains within-student variables that change over the three occasions. The student level (Level 2 or meso-level) contains static between-student variables, which include among others, the within-student variables aggregated to the student level. The school level (Level 3 or macro-level) contains school variables, which include among others, between-student variables and between-teacher variables aggregated to the school level. Prior to HLM analysis, each data file had to be sorted appropriately, so that the Level 1 data was sorted by school, student, and then occasion; Level 2 was sorted by school, and then student; and Level 3 was sorted by school.

The conceptual three-level HLM student model, presented in Figure 11.1, illustrates that factors from any level can directly influence the outcome variable, student self-esteem. However, it also suggests that higher-level factors can indirectly influence self-esteem by interacting with lower-level factors. The variables comprising and arranged according to the three levels of occasion, students and schools, are described in Table 11.1. References made to variables used in the HLM analyses reported in this chapter, are given in uppercase.

Variables measured at Level 1 are assigned a subscript of 1. Variables aggregated to the student level are assigned a subscript of 2, and those aggregated to the school level are assigned a subscript of 3. However for consistency, whether aggregated or directly measured, all variables are assigned the subscript of their level. When aggregated, most factors represent an averaged response of many cases and, at the school level, can be interpreted as representing a general school climate that might affect student self-esteem. However, one variable, that of school setting (SET), remains unchanged after aggregation.

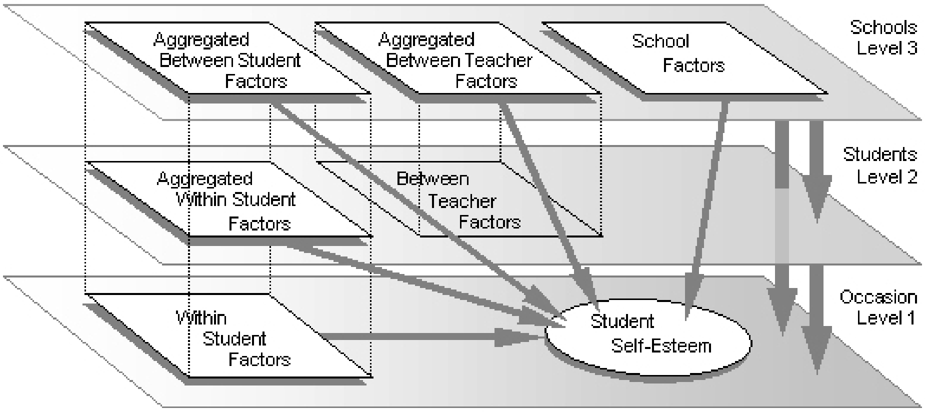


Figure 11.1 Conceptual three-level HLM student model

Table 11.1 List of variables used in the three-level student HLM model

Occasion	Student	School	Description
		$SIZE_3$	School size ratio
		TMR3	Male teacher ratio
		$TEXP_3$	Teaching experience
		$ICTT_3$	Ratio of computer teachers
		$TYPE_3$	Teacher type ratio
		$LOAD_3$	Teaching load
		$OPENLN_3$	Planned use of ICT
		$OUTCOM_3$	Planned learning outcomes
		$ISSUES_3$	Teacher Implementation issues
		$EFFORT_3$	Teacher Beliefs about student work
		$SUPPORT_3$	Teacher Beliefs on schools support
		$COMMON_3$	Common hardware used by teachers
		$HOMUSE_3$	Home and general ICT use by teachers
		$CONFID_3$	General ICT teacher confidence
		$TEACH_3$	Teaching Practice using ICT
	SET_2	SET_3	Primary (0) or secondary (1) setting
	$NESB_2$	$NESB_3$	NESB students (English=0; NESB=1)
$HOMWK_1$	$HOMWK_2$	$HOMWK_3$	Student ICT-based homework
$ENTRMT_1$	$ENTRMT_2$	$ENTRMT_3$	Student entertainment use
$HOMACC_1$	$HOMACC_2$	$HOMACC_3$	Student access to ICT at home
$SCHACC_1$	$SCHACC_2$	$SCHACC_3$	Student access to ICT at school
$ICTUSE_1$	$ICTUSE_2$	$ICTUSE_3$	Student general ICT use
$ICTLIT_1$	$ICTLIT_2$	$ICTLIT_3$	Student ICT literacy
$COMATT_1$	$COMATT_2$	$COMATT_3$	Student computer attitude
$SCHATT_1$	$SCHATT_2$	$SCHATT_3$	Student school attitude
	SEX_2		Student gender (Male=0; Female=1)
AGE_1			Student age
OCC_1			Occasion (Occ1=0; Occ2=1; Occ3=2)
$SELFATT_1$			Student self-esteem

$_1$ = Level 1; $_2$ = Level 2; $_3$ = Level 3

The fully unconditional student model

Preliminary analysis of the three-level HLM model involves processing the fully unconditional model in order to obtain the amount of variance available at each level (Raudenbush, Bryk and Congdon, 2000). The requirement of an unconditional model specifies the outcome variable with no predictor variables at any level. Accordingly, the model contained the outcome variable of student self-esteem with no other occasion level, student level or school level variables entered into the model. By doing so, the model represented how much variation in student self-esteem was allocated across the three levels, and allowed for the partitioning of variance in student self-esteem at the three levels (Raudenbush, Bryk and Congdon, 2000). The fully unconditional three-level student model is specified by three equations presented in Equation 11.1, Equation 11.2 and Equation 11.3.

At **Level 1** (see Equation 11.1), comprising 4863 cases, the self-esteem of each student on one or more occasions is modelled as a function of mean student self-esteem plus a random error.

Equation 11.1 $Y = \pi_0 + e$ Level 1

where:
- Y is the self-esteem on any occasion of a student in one of the six schools, specified as the outcome variable (n=4863);
- π_0 is the mean self-esteem over the three occasions of that student in their school, specified as the intercept; and
- e is a random within-student effect estimated by the deviation of that student's self-esteem score from their mean score over the three occasions.

According to Equation 11.1, a student's self-esteem on a particular occasion is considered to be equivalent to the average of that student's self-esteem over all three occasions. Therefore, the fully unconditional model at Level 1 assumes that there is no change in students' self-esteem over the period of the study, and that the associated error, e, for each student in each school is normally distributed with a zero mean and constant Level 1 variance, σ^2 (Bryk and Raudenbush, 1992).

The **Level 2** model, comprising 2560 cases and presented in Equation 11.2, places each student mean, π_0, as an outcome varying randomly around the school mean of self-esteem.

Equation 11.2 $\pi_0 = \beta_{00} + r_0$ Level 2

where:
- π_0 is the mean self-esteem over the three occasions of a student in a school (n=2560);
- β_{00} is the mean student self-esteem in the school; and
- r_0 is a random between-student effect estimated by the deviation of that student's mean self-esteem score over the three occasions from the school mean.

In the Level 2 equation of the unconditional model, no predictors are specified that contribute to explaining any differences between students, with the interpretation that the average self-esteem of a student is considered to be equivalent to the school mean in addition to a random error. It is assumed that r_0, the random effect associated with a student, is normally distributed with a mean of zero and variance τ_π, and that within each school, the variability between students is the same.

The **Level 3** model, comprising only six cases, represents the variability between schools, where the school mean of self-esteem, β_{00}, varies randomly around the grand mean measured across all schools, as presented in Equation 11.3. By estimating the fully unconditional model, a point estimate and confidence interval for the grand mean γ_{000} is produced. The random effect, u_{00}, associated with the school, is assumed to be normally distributed around a mean of zero and variance τ_β.

Equation 11.3 $\beta_{00} = \gamma_{000} + u_{00}$ Level 3

where: β_{00} is the mean student self-esteem in the school (n=6);
γ_{000} is the grand mean self-esteem across all schools; and
u_{00} is a random school effect estimated by the deviation of the average self-esteem in the school from the grand mean across all schools.

The results of the fully unconditional three-level HLM student model are presented in Table 11.2. In addition to producing the final estimates for the fixed and random effects, the hierarchical analysis also estimates the least squares reliability between students at Level 2 and between schools at Level 3. These reliabilities, also presented in Table 11.2, may be viewed as a summary measure of the reliability of the respective student and school means, and are used to assess whether the fixed or random treatment of an effect is employed in the analysis. A reliability value below 0.05 is assumed to have no random effects for that particular coefficient. As a consequence, the fixed effect is estimated, which implies that the size of the effect is the same across all cases involved.

Table 11.2 Null model estimations for the three-level HLM student model

Final estimation of fixed effects						
Fixed Effect	Coefficient	Std Error		t-ratio	Approx df	p-value
For INT_1, π_0						
For INT_2, β_{00}						
INT_3, γ_{000}	-0.01	0.07		-0.16	5	0.882
Final estimation of Level 1, Level 2 and Level 3 variance components						
Random Effect	Reliability	Std Dev	Variance	Chi-square	df	p-value
Level 1, e		0.79	0.62 (σ^2)			
INT1, r_0	0.50	0.60	0.36 (τ_π)	5135.52	2554	0.000
INT_1/INT_2, u_{00}	0.93	0.18	0.03 (τ_β)	124.22	5	0.000
Statistics for current covariance components model					Deviance	13318.35
					Number of estimated parameters	4

INT is the intercept.

It is from the three-level unconditional or null model that the proportion of variance available to be explained at each level in the hierarchical analysis may be estimated, by providing information about the variability of the outcomes at each level. The variance within students in Level 1 is represented by σ^2, the variance between students in Level 2 is given by τ_π, and the variance across schools in Level 3 is defined by τ_β. The ratios of variance at each level over the total variance from all levels, provides an estimation of the proportions of variance that are between occasions within students, between students within schools, and between schools, as summarised in Equation 11.4. The partition of total variance into its three components for the null model is shown further below in Table 11.3.

Equation 11.4 Proportions of variance

$\sigma^2/(\sigma^2+\tau_\pi+\tau_\beta)$ Level 1 proportion of variance within students
$\tau_\pi/(\sigma^2+\tau_\pi+\tau_\beta)$ Level 2 proportion of variance between students
$\tau_\beta/(\sigma^2+\tau_\pi+\tau_\beta)$ Level 3 proportion of variance between schools

The final student model

If the unconditional model provides an estimate of the variance available at each level, then it is the conditional model that attempts to explain or account for the available variance at each level. Student characteristics, like attitude towards computers or gender, and school characteristics, like size or general teacher confidence using ICT, may provide useful predictors of student self-esteem.

Accordingly, the development of the three-level HLM model investigating student self-esteem, was guided by the results of the path analysis conducted in the previous chapter using the AMOS software program. As a single-level technique, there were limitations brought about by concerns over the introduction of bias, had the between-student and school level factors been disaggregated to the within-student or occasion level. Although the path models could provide some guidance, the nature of the relationships between variables at the student and school levels might cause random variation among these units, so that the influence of one might have a bearing on the significance of another. Therefore, the development of the final three-level model through the gradual refinement of consecutive conditional models was undertaken. By comparing subsequent models with the null model and preceding models, it was possible to identify which model provided an improvement of fit, in that all variables included in the model were significant, the largest portion of available variance was explained, and the deviance was reduced. The proportion of variance explained by subsequent models was tested by using the general formula presented in Equation 11.5, and computations at each developmental stage of the model are given further below in Table 11.3.

Equation 11.5

$$\frac{Variance_{null} - Variance_{final}}{Variance_{null}}$$

Specification of the Level 1 model involved variables that were found to influence directly change in students' self-esteem over the three occasions of the study. Given that the focus of the study was to examine change over time, the variable of occasion (OCC) was first entered into the Level 1 equation and found to be significant. No other predictor variables were included in the final Level 1 model as there were insufficient degrees of freedom to estimate the variance within students, σ^2.

Another feature of the HLM program allows an exploratory analysis to be performed that tests for possible Level 2 predictor variables and guides their inclusion into the Level 2 model. This next step was conducted by entering between-student level variables into the equation one by one according to the t-value of each variable presented in the exploratory analysis output. A general guide used when selecting possible variables, in conjunction with the path models, was to choose variables with the largest t-value first, and then examine their significance in the model, along with looking for a reduction in the deviance and an increase in the variance explained. If the variable was significant at the 0.1 level and the deviance of the subsequent model decreased, then it indicated an improvement of fit and the variable was retained. With each addition of a variable into the model, the t-value output of the exploratory analysis was reanalysed and adjusted, altering the potential selection of variables. Generally, variables with a t-value less than |1.96| were not significant. Each inclusion into the Level 2 model also influenced the significance of other previously selected variables. In some cases, a seemingly significant variable, having t-values above |2.0|, was not significant when combined with other significant variables. These steps were repeated until a final Level 2 model with only significant effects at both levels and a reduction in the deviance was achieved.

The last step involved developing the third level of the model by examining the exploratory analysis output of the school level variables. As for the second level, the procedure employed the selection of likely variables one by one and checking for an improvement of fit. The school level variables were tested until a final Level 3 model with only significant effects at all three levels was obtained. The results of a step-by-step addition of significant variables leading to the development of the final model is presented in Table 11.3. As noted above, Table 11.3 also includes the partition of total variance into its three components for the null model (see Equation 11.4) and the computation of the proportion of variance explained at each developmental stage of the model (see Equation 11.5).

Table 11.3 Development of the three-level HLM student model

	Variance			**Deviance**	**NEP**	**$L1_{4863}$**	**$L2_{2560}$**	**$L3_{6}$**		**Predictors**
	σ^2	τ_π	τ_β			Variance available (%)				
Null	0.618	0.357	0.031	13318	4	61.4	35.5	3.1		Unconditional
						Variance explained (%)			Total (%)	
Level 1	0.604	0.355	0.016	13276	9	2.2	0.6	48.9	3.0	OCC_1
Level 2	0.602	0.256	0.022	12632	13	2.6	28.3	27.3	12.5	$SCHATT_2$
	0.599	0.241	0.023	12572	18	3.0	32.6	25.4	14.2	$COMATT_2$
	0.597	0.250	0.023	12558	24	3.4	29.9	24.6	13.5	$NESB_2$
	0.597	0.242	0.022	12546	31	3.4	32.3	28.7	14.4	$ENTRMT_2$
	0.596	0.257	0.024	12502	39	3.5	28.2	22.2	12.8	SEX_2
Level 3	0.597	0.254	0.024	12501	40	3.4	28.8	20.9	13.0	$ICTUSE_3$
	0.597	0.251	0.003	12491	41	3.4	29.7	90.7	15.4	$HOMWK_3$
	0.596	0.248	0.005	12483	42	3.6	30.5	83.3	15.6	$TYPE_3$
	0.597	0.243	0.003	12479	43	3.3	31.9	90.0	16.1	$SCHATT_3$
Final	0.597	0.247	0.003	12479	36	3.4	30.8	89.9	15.8	a
Proportion of total variance explained						2.1%	10.9%	2.8%		
Total variance explained by final model									15.8%	
Change in statistics				839	32					

NEP = Number of estimated parameters; a = Fixed coefficients with low reliability

The first set of calculations given in Table 11.3 shows that almost two thirds of the available variance (61%) is at Level 1, within students. Approximately one third (36%) of the variance is at Level 2, between students, and only a small amount of variance (3%) is at Level 3, between schools. The sequential addition of predictors at each level reduces the corresponding estimates of variance components, and generally increases the partitioned and total variance explained.

It should be noted that for certain key variables which are of theoretical interest the estimated reliabilities were low as a consequence of the limited number of schools involved in the study. Even though the analysis proceeded without difficulty and the effects recorded were meaningful, it was decided in the final step to fix the coefficients at the higher level. As a result, the estimates of effect are only changed slightly and some variance is shifted to a lower level.

The final student model resulted in only three per cent of the available within-student variance being explained, equivalent to only two per cent of the total variance. Given that only one factor, that of occasion (OCC), was included in Level 1, this outcome is understandable. At the between-student level, the greatest total variance was explained with 31 per cent of the available Level 2 variance accounted for, equivalent to 11 per cent of the total variance. Although only the smallest amount of variance between schools was available, the largest amount, some 90 per cent, was explained by Level 3, though this only resulted in three per cent of the total variance. Accordingly, the total amount of variance explained by the final student model was

16 per cent with a reduction in deviance of 839 and an additional 32 degrees of freedom. Although 16 per cent of variance explained does not seem adequate, if viewed as a multiple correlation by taking the square root, 0.4 is more acceptable. Furthermore, the Cohen (1992) formula rates this outcome as a moderate sized effect.

The equations comprising the final three-level HLM student model are presented in Equation 11.6, Equation 11.7, and Equation 11.8. Variables that are centred around their grand mean are presented in italics, while those that are uncentred are not italicised.

Equation 11.6 Level 1 Model

$$\mathrm{SELFATT}_1 = \pi_0 + \pi_1 \mathrm{OCC}_1 + e$$

Equation 11.7 Level 2 Model

$$\pi_0 = \beta_{00} + \beta_{01}\mathrm{NESB}_2 + \beta_{02}\mathit{ENTRMT}_2 + \beta_{03}\mathit{COMATT}_2 + \beta_{04}\mathit{SCHATT}_2 + r_0$$

$$\pi_1 = \beta_{10} + \beta_{11}\mathrm{SEX}_2 + r_1$$

Equation 11.8 Level 3 Model

$$\beta_{00} = \gamma_{000} + \gamma_{001}\mathit{HOMWK}_3 + u_{00}$$

$$\beta_{01} = \gamma_{010} + u_{01}$$

$$\beta_{02} = \gamma_{020} + u_{02}$$

$$^{a}\beta_{03} = \gamma_{030} + \gamma_{031}\mathit{ICTUSE}_3$$

$$\beta_{04} = \gamma_{040} + u_{04}$$

$$\beta_{10} = \gamma_{100} + \gamma_{101}\mathit{TYPE}_3 + u_{10}$$

$$\beta_{11} = \gamma_{110} + \gamma_{111}\mathit{SCHATT}_3 + u_{11}$$

The results of the final three-level HLM model for students' self-esteem are presented in Table 11.4. However, for a clearer understanding of the three-layered model Figure 11.2 presents a graphical interpretation of the equations comprising the three levels and includes the estimated regression coefficient and its standard error associated with each effect.

Clearly the biggest challenge associated with building a model that places schools at the uppermost level, is the impact that the number of schools involved has on the degrees of freedom. With only six schools involved, the degrees of freedom available is limited and there is little variance between schools. With one direct effect and three interaction effects, along with four Level 2 variables, 90 per cent of the Level 3 variance is explained, leaving only a small amount of variance to explain the effect of the teachers, which is mainly accounted for by ICT-rich homework (HOMWK).

By substituting Level 3 (Equation 11.8) into Level 2 (Equation 11.7), and then substituting these combined formula into Level 1 (Equation 11.6), the final model in expanded form is represented in Equation 11.9.

Equation 11.9 Final three-level student model

$$\begin{aligned}\mathrm{SELFATT}_1 = \; & \gamma_{000} + \gamma_{100}\mathrm{OCC}_1 + \gamma_{010}\mathrm{NESB}_2 + \gamma_{020}\mathit{ENTRMT}_2 + \gamma_{030}\mathit{COMATT}_2 \\ & + \gamma_{040}\mathit{SCHATT}_2 + \gamma_{001}\mathit{HOMWK}_3 + \gamma_{031}\mathit{COMATT}_2\mathit{ICTUSE}_3 \\ & + \gamma_{101}\mathrm{OCC}_1\mathit{TYPE}_3 + \gamma_{110}\mathrm{OCC}_1\mathrm{SEX}_2 + \gamma_{111}\mathrm{OCC}_1\mathrm{SEX}_2\mathit{SCHATT}_3 \\ & + u_{00} + u_{01}\mathrm{NESB}_2 + u_{02}\mathit{ENTRMT}_2 + u_{04}\mathit{SCHATT}_2 + u_{10}\mathrm{OCC}_1 \\ & + u_{11}\mathrm{OCC}_1\mathrm{SEX}_2 + r_0 + r_1\mathrm{OCC}_1 + e\end{aligned}$$

[a] Fixed coefficients with low reliability.

Table 11.4 Final estimations of the three-level HLM student model

Final estimation of fixed effects					
Fixed Effect	Coefficient	Std Error	t-ratio	Approx df	p-value
For INT_1, π_0					
For INT_2, β_{00}					
INT_3, γ_{000}	-0.176	0.04	-4.11	4	0.023
$HOMWK_3$, γ_{001}	1.150	0.25	4.67	4	0.009
For $NESB_2$, β_{01}					
INT_3, γ_{010}	-0.169	0.05	-3.17	5	0.029
For $ENTRMT_2$, β_{02}					
INT_3, γ_{020}	0.349	0.16	2.14	5	0.083
For $COMATT_2$, β_{03}					
INT_3, γ_{030}	0.128	0.02	6.19	2555	0.000
$ICTUSE_3$, γ_{031}	-0.305	0.15	-2.09	2555	0.038
For $SCHATT_2$, β_{04}					
INT_3, γ_{040}	0.472	0.03	18.14	5	0.000
For OCC_1 slope, π_1					
For INT2, β_{10}					
INT_3, γ_{100}	0.206	0.03	6.09	4	0.000
$TYPE_3$, γ_{101}	0.489	0.15	3.29	4	0.040
For SEX_2, β_{11}					
INT_3, γ_{110}	-0.099	0.02	-5.86	4	0.000
$SCHATT_3$, γ_{111}	-0.065	0.03	-2.58	4	0.059

Final estimation of Level 1, Level 2 and Level 3 variance components						
Random Effect	Reliability	Std Dev	Variance	Chi-square	df	P-value
Level 1, e		0.77	0.597 (σ^2)			
INT_1, r_0	0.09	0.50	0.247 (τ_π)	1832.54	1684	0.006
OCC_1 slope, r_1	0.05	0.19	0.034	1774.57	1697	0.093
INT_1/INT_2, u_{00}	0.28	0.06	0.003 (τ_β)	7.11	4	0.129
$INT_1/NESB_2$, u_{01}	0.20	0.06	0.004	4.28	5	>.500
$INT_1/ENTRMT_2$, u_{02}	0.52	0.29	0.083	11.03	5	0.050
$INT_1/SCHATT_2$, u_{04}	0.48	0.05	0.002	9.29	5	0.097
OCC/INT_2, u_{10}	0.39	0.05	0.003	10.52	4	0.032
OCC/SEX_2, u_{11}	0.30	0.02	0.001	6.97	4	0.136
Statistics for current covariance components model					Deviance	12479.31
					Number of estimated parameters	36

Note: INT = intercept. The chi-square statistics are based on only 1709 of 2560 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

Equation 11.9 reveals that student self-esteem may be viewed as a function of the intercept γ_{000}, six main fixed effects, four cross-level interaction effects, and a random error (u_{00} + $u_{01}NESB_2$ + $u_{02}ENTRMT_2$ + $u_{04}SCHATT_2$ + $u_{10}OCC_1$ + $u_{11}OCC_1SEX_2$ + r_0 + r_1OCC_1+ e). The first of the main fixed effects is a direct function of the occasion (OCC_1) on which self-esteem was taken. At the between-student level, four main effects are the direct effects from students' language background ($NESB_2$), students' entertainment use ($ENTRMT_2$), students' attitudes towards computers ($COMATT_2$), and students' attitudes towards school ($SCHATT_2$). The sixth direct effect involves school-wide ICT-rich homework ($HOMWK_3$). The four cross-level interaction effects involve the interaction of students' computer attitude with ICT use ($COMATT_2ICTUSE_3$), occasion with both teacher type (OCC_1TYPE_3) and student gender (OCC_1SEX_2), and a three-level interaction between occasion, student gender and school attitude ($OCC_1SEX_2SCHATT_3$).

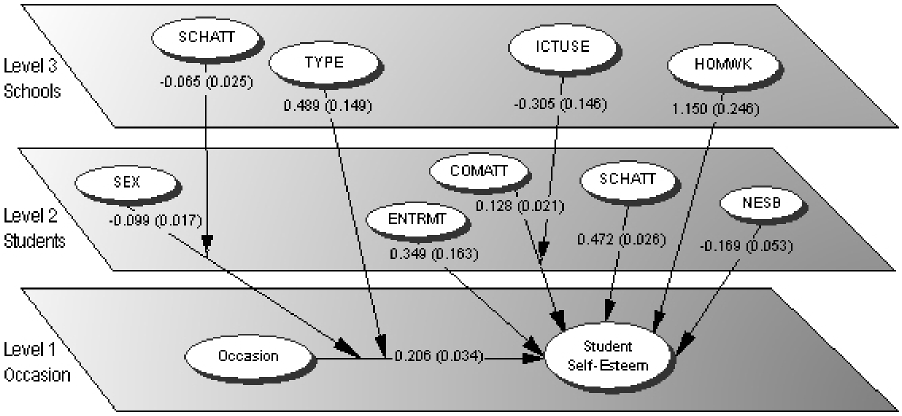


Figure 11.2 Diagramatic representation of the final three-level HLM student model showing the estimated regression coefficient and standard error associated with each effect

Direct effects in the student model

The direct effects on student self-esteem, presented in Equation 11.9, includes one factor at Level 1 (OCC), four factors at Level 2 (NESB, ENTRMT, COMATT, SCHATT), and one factor at Level 3 (HOMWK).

Occasion

One of the main endeavours of this study is to determine if a changing school environment impacts on students, and in particular, their self-esteem. The resulting significance of occasion (OCC, 0.21) at the within-student level, suggests that it does. Accordingly, the student model indicates that student self-esteem has increased over time, and arguably, this improvement is attributable to the school-wide adoption of ICT.

NESB

At the between-students level, the influence of students' language background (NESB, -0.17) is significant, suggesting that a student's language background is an important factor in their self-esteem. The negative influence indicates that students from a non-English speaking background are more likely to report a lower self-esteem than their peers.

Entertainment use

Also at the between-student level, students' entertainment use (ENTRMT, 0.35) is significant. Accordingly, the student model reveals that entertainment technology used by students like television and music players has a positive effect on their self-esteem.

Computer and school attitudes

The other Level 2 factors found to have direct and significant influences on student self-esteem are students' attitudes towards computers (COMATT, 0.13) and students' attitudes towards school (SCHATT, 0.47). Once again, the positive effects of both suggest that those students who have positive attitudes towards computers and school are more likely to have higher self-esteem than their peers.

ICT-rich homework

At Level 3, the prevailing school climate of ICT-rich homework (HOMWK, 1.15) is significant at the 0.05 level. The equation indicates that there are significant differences between schools in relation to the amount of ICT-rich homework being done by students, which may reflect the differences between primary and secondary school but this is not shown to be significant. The positive result suggests that students in those schools that promote ICT-rich homework are more likely to have positive self-esteem.

Interaction effects in the student model

Four cross-level interaction effects are present in the final student model. Generally, a cross-level interaction effect relates three variables to one another. Three of the interactions are of this kind and involve the outcome variable, a predictor, and a higher-level variable that influences the effect of the predictor on the outcome variable. The fourth cross-level interaction, however, involves not three, but four variables interrelated to one another. In this case, the outcome variable is directly influenced by a Level 1 predictor that is influenced by a Level 2 variable, which is also influenced by a Level 3 variable.

Isolating the variables involved in these four cross-level interactions, by setting the inconsequential variables to zero, results in a simplification of the final model (Equation 11.9) into three separate expressions presented as Equation 11.10, Equation 11.11 and Equation 11.12. Only three equations result, as two of the interactions involve the same variables, that of OCC and SEX, and combine to form one inseparable equation. However, to assist interpretation, each of these expressions requires a similar set of calculations to be performed that are detailed here to avoid repetition, the results of which are presented along side each expression in Table 11.5.

Table 11.5 Self-esteem interaction calculations for the student model

	High (1)	**Average** (0)	**Low** (-1)
Equation 11. 10 $SELFATT_1$	$= \gamma_{000} + \gamma_{030}COMATT_2 + \gamma_{031}COMATT_2ICTUSE_3 + e$		
	$= -0.176 + 0.128COMATT_2 - 0.305COMATT_2ICTUSE_3$		
Computer attitude COMATT	**School general ICT use by students** ICTUSE		
low (-1)	0.001	-0.304	-0.609
high (1)	-0.353	-0.048	0.257
Equation 11. 11 $SELFATT_1$	$= \gamma_{000} + \gamma_{100}OCC_1 + \gamma_{101}OCC_1TYPE_3 + e$		
	$= -0.176 + 0.206OCC_1 + 0.489OCC_1TYPE_3$		
Occasion OCC	**Proportion of teacher type** TYPE		
Occ1 (0)	-0.176	-0.176	-0.176
Occ2 (1)	0.519	0.030	-0.459
Occ3 (2)	1.214	0.236	-0.742
Equation 11. 12 $SELFATT_1$	$= \gamma_{000} + \gamma_{100}OCC_1 + \gamma_{110}OCC_1SEX_2 + \gamma_{111}OCC_1SEX_2SCHATT_3 + e$		
	$= -0.176 + 0.206OCC_1 - 0.099OCC_1SEX_2 - 0.065OCC_1SEX_2SCHATT_3$		
Occasion OCC	**Climate of school attitude** SCHATT		
		Male (SEX = 0)	
Occ1 (0)		-0.176	
Occ2 (1)		0.030	
Occ3 (2)		0.236	
		Female (SEX = 1)	
Occ1 (0)	-0.176	-0.176	-0.176
Occ2 (1)	-0.134	-0.069	-0.004
Occ3 (2)	-0.092	0.038	0.168

The first step in providing a graphical representation of each expression requires the substitution of the relevant gamma coefficients with values given in Table 11.4. The next step involves calculating coordinates, by comparing the extremes of one standard deviation above (1) and below (-1) the mean, and at the mean (0), for each variable. The substitution of values in each expression by either 1, -1 or 0, shows the behaviour of the interaction under the prescribed condition. For example, the condition of schools having a high proportion of permanent teachers, is achieved by substituting $TYPE_3$ with one standard deviation above the mean (1), whereas a low proportion requires a value one standard deviation below the mean (-1). Accordingly, the specified values in each expression are appropriately substituted to examine the various conditions and show the effects on students' self-esteem. Along with each expression (see Equation 11.10, Equation 11.11 and Equation 11.12), Table 11.5 indicates the values (given in brackets) that are used in the substitution process and presents the resulting measures of self-esteem.

The final step in the analysis involves plotting the self-esteem coordinates against the three conditions to produce the graphical representations of the three expressions, presented in Figure 11.3, Figure 11.4, and Figure 11.5 respectively. Interpretation of each interaction plot completes the discussion. Accordingly, the interpretation and analysis of the direct and interaction effects and their effects on student self-esteem, originally presented in Equation 11.9, now follow.

Student computer attitudes and school-wide student ICT use

The first interaction (see Equation 11.10) involves the school climate of student ICT use (ICTUSE, -0.31) at Level 3, interacting with students' attitude towards computers (COMATT, 0.13) at Level 2. Figure 11.3 shows the impact on students' self-esteem of the interaction effect of schools' general student ICT use with students' attitude towards computers. The figure shows that those students in schools that have a high level of student ICT usage and who have a positive computer attitude, have lower self-esteem than those students who have a poor attitude towards computers. Likewise, students with a positive computer attitude in schools that have an average or low level of student ICT usage, have higher self-esteem than those students who have a low computer attitude. As expected, there is a significant and positive relationship between students' computer attitudes and their self-esteem.

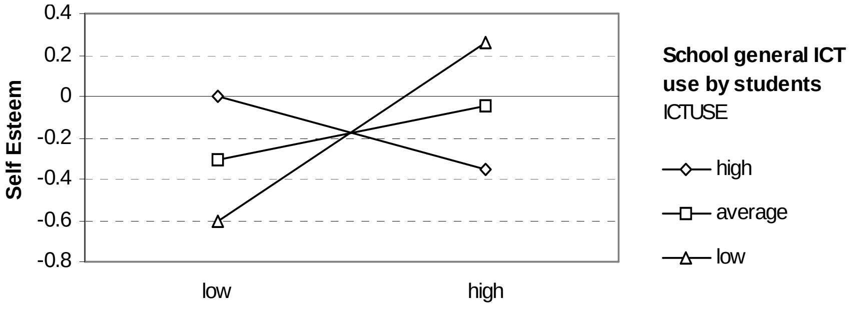


Figure 11.3 Impact on students' self-esteem of the interaction effect of schools' general student ICT use with students' attitude towards computers

Teacher-type and change over time

The second interaction is described by the expression in Equation 11.11 and shown in Figure 11.4. It examines the effect of how changes (OCC, 0.21) in the teaching profile of the school (TYPE, 0.49), in terms of the proportion of permanent, PAT and SSO teachers, impacts on student self-esteem. The figure shows that those students in schools that have an average to high proportion of permanent teachers, show an increase in self-esteem over the three occasions, while those students in schools with a high proportion of temporary teaching staff (PAT and SSO), show a decline in self-esteem over the three occasions.

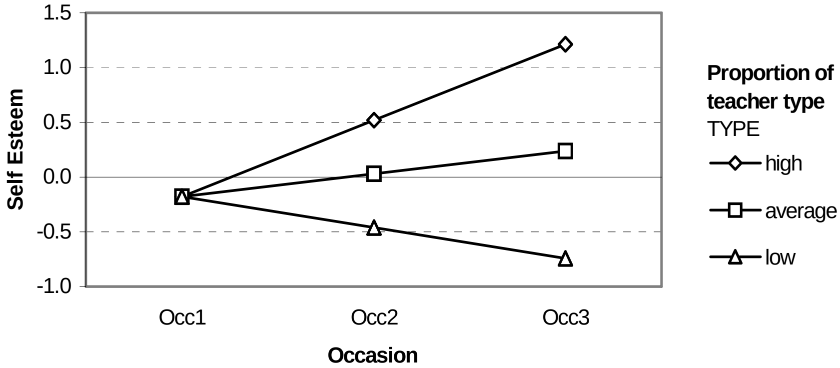


Figure 11.4 Interaction effect of the proportion of permanent teachers on students' self-esteem over the three occasions

Student school attitudes, gender, and time

The final interaction, shown in Figure 11.5 and expressed in Equation 11.12, presents a three-way influence on students' self-esteem of school-wide student school attitude (SCHATT, -0.07) and student gender (SEX, -0.10) over the three occasions (OCC, 0.21). Interestingly, male and female students show an opposite trend that is reflected by the significant but negative effect of the prevailing school attitude. However, for the purposes of graphically representing the interaction as shown in Figure 11.5, the setting of male = 0 and female = 1 means that the male trend is not observable, but instead, provides a baseline or average, by which the female trend is observed. First and foremost, the figure shows that male students maintain a higher self-esteem than female students over the three occasions in an average climate of school attitude. Independent of student gender or the prevailing school attitude, students' self-esteem improves over the three occasions. Relative to male students, however, female students appear to improve as the climate of school attitude declines. One possible explanation is that female students feel more inadequate in an environment where the general school atmosphere is positive.

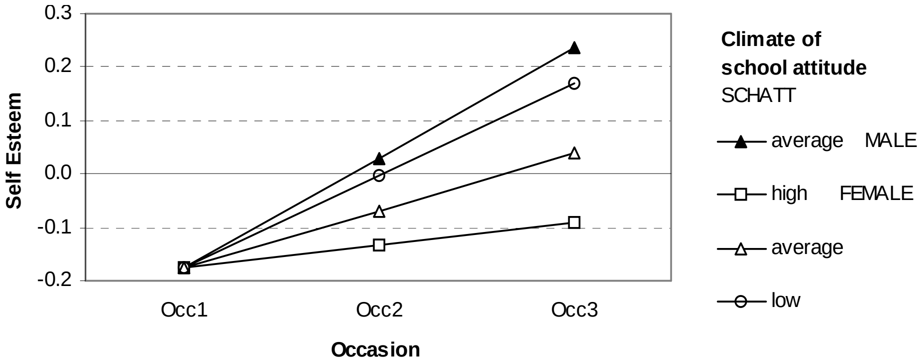


Figure 11.5 Three-way interaction effect on students' self-esteem of school-wide attitudes towards school and a students' gender over the three occasions

The same procedures used in estimating and analysing the three-level HLM student model, are used in the discussion of the school model, presented in the following section.

Change in Schools Over Time

As discussed at the beginning of this chapter, both proposed models place student self-esteem as the dependent variable but each model differs in its approach. The first model examines change in students over time by nesting occasions within students within schools. The second model, discussed in this section, examines change in schools over time by nesting students within occasions within schools. The conceptual three-level school model is presented in Figure 11.6.

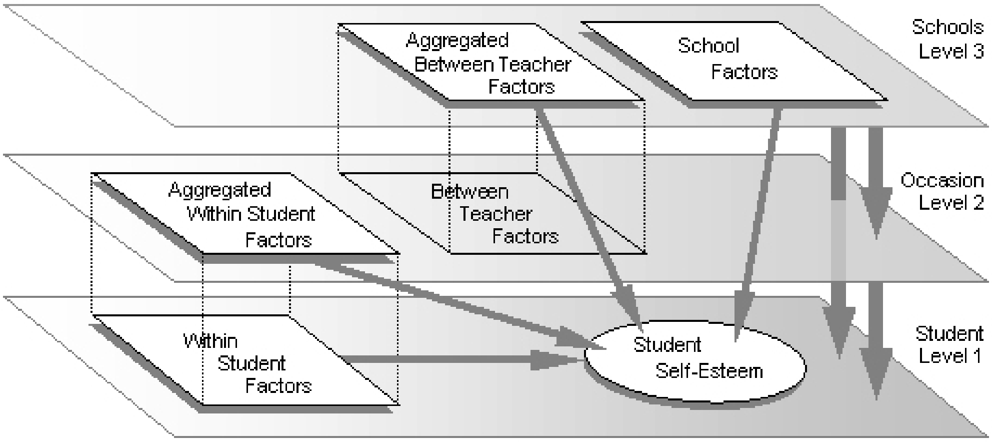


Figure 11.6 Conceptual three-level HLM school model

The student level (Level 1 or micro-level) contains within-student variables that change over the three occasions. However, in this model, Level 1 is sorted by school, occasion and then student, so that the student is nested within occasion. In fact, the only difference between both Level 1 data files is the way in which they are sorted. As such, it contains the same number of 4863 cases. The occasion level (Level 2 or meso-level) also changes over time and contains the within-student variables aggregated to the occasion. Effectively, this gives a measure of the school as it changes over time and contains 18 cases of six schools on three occasions, sorted by school and then occasion. The school level (Level 3 or macro-level) contains the static school variables, which include among others, between-teacher variables aggregated to the school level, giving six cases, which are sorted by school. Table 11.6 presents the variables comprising the three levels.

The fully unconditional school model

In order to obtain the amount of variance available at each level, the same procedures used for the student model are employed for the school model. The fully unconditional three-level school model is specified by three equations presented in Equation 11.13, Equation 11.14 and Equation 11.15.

As for the previous model, at **Level 1** in the null model, the self-esteem of each student is modelled as a function of mean student self-esteem plus a random error.

Table 11.6 List of variables used in the three-level HLM school model

Student	Occasion	Schools	Description
		$SIZE_3$	School size ratio
		TMR_3	Male teacher ratio
		$TEXP_3$	Teaching experience in years
		$ICTT_3$	Ratio of computer teachers
		$TYPE_3$	Teacher type ratio
		$LOAD_3$	Teaching load
		$OPENLN_3$	Planned use of ICT
		$OUTCOM_3$	Planned learning outcomes
		$ISSUES_3$	Teacher Implementation issues
		$EFFORT_3$	Teacher Beliefs about student work
		$SUPPORT_3$	Teacher Beliefs on schools support
		$COMMON_3$	Common hardware used by teachers
		$HOMUSE_3$	Home and general ICT use by teachers
		$CONFID_3$	General ICT teacher confidence
		$TEACH_3$	Teaching Practice using ICT
SET_1	SET_2	SET_3	Primary (0) or secondary (1) setting
OCC_1	OCC_2		Occasion (Occ1=0; Occ2=1; Occ3=2)
AGE_1	AGE_2		Student age
$NESB_1$	$NESB_2$		NESB students (English=0; NESB=1)
$HOMWK_1$	$HOMWK_2$		Student ICT-based homework
$ENTRMT_1$	$ENTRMT_2$		Student entertainment use
$HOMACC_1$	$HOMACC_2$		Student access to ICT at home
$SCHACC_1$	$SCHACC_2$		Student access to ICT at school
$ICTUSE_1$	$ICTUSE_2$		Student general ICT use
$ICTLIT_1$	$ICTLIT_2$		Student ICT literacy
$COMATT_1$	$COMATT_2$		Student computer attitude
$SCHATT_1$	$SCHATT_2$		Student school attitude
SEX_1			Student gender (Male=0; Female=1)
$SELFATT_1$			Student self-esteem

$_1$ = Level 1; $_2$ = Level 2; $_3$ = Level 3

Equation 11.13 $Y = \pi_0 + e$ Level 1

where:
- Y is the self-esteem of a student on any occasion in one of the six schools, specified as the outcome variable (n=4863);
- π_0 is the mean self-esteem of students for each school on each occasion, specified as the intercept; and
- e is a random within-student effect estimated by the deviation of that student's self-esteem score from their mean score over the three occasions.

The **Level 2** model, presented in Equation 11.14, places a schools' mean student self-esteem on each occasion, π_0, as an outcome varying randomly around the overall mean student self-esteem of the school.

Equation 11.14 $\pi_0 = \beta_{00} + r_0$ Level 2

where:
- π_0 is the mean self-esteem of students in each school for each occasion (n=18);
- β_{00} is the mean student self-esteem of the school; and
- r_0 is a random between-student effect determined by the deviation of that schools' mean student self-esteem score over the three occasions from the mean of all schools.

The **Level 3** model represents the variability between schools, where the school mean of student self-esteem, β_{00}, varies randomly around the grand mean measured across all schools, as is presented in Equation 11.15.

Equation 11.15 $\beta_{00} = \gamma_{000} + u_{00}$ Level 3

where: β_{00} is the overall mean student self-esteem in the school (n=6);
γ_{000} is the grand mean self-esteem across all schools; and
u_{00} is a random school effect estimated by the deviation of the average student self-esteem of a school from the grand mean across all schools.

The results of the fully unconditional three-level HLM school model are presented in Table 11.7.

Table 11.7 Null model estimations for the three-level HLM school model

Final estimation of fixed effects						
Fixed Effect	Coefficient	Std Error		t-ratio	Approx df	p-value
For INT1, π_0						
For INT2, β_{00}						
INT3, γ_{000}	-0.01	0.07		-0.16	5	0.883
Final estimation of Level 1, Level 2 and Level 3 variance components						
Random Effect	Reliability	Std Dev	Variance	Chi-square	df	p-value
Level 1, e		0.97	0.93 (σ^2)			
INT1, r_0	0.90	0.21	0.05 (τ_π)	57.71	12	0.000
INT1/INT2, u_{00}	0.49	0.13	0.02 (τ_β)	11.75	5	0.038
Statistics for current covariance components model					Deviance	13499.10
					Number of estimated parameters	4

INT is the intercept.

The final school model

The partition of total variance into its three components (see Equation 11.4) for the null model and computations at each developmental stage of the model (see Equation 11.5) are shown in Table 11.8. The first set of calculations given in Table 11.8 shows that nearly all of the available variance (93.8%) is estimated to be at Level 1, within students. The available variance remaining is portioned 4.6 per cent to Level 2, within schools, and 1.6 per cent to Level 3, between schools. The step-by-step addition of significant variables, also presented in Table 11.8, is seen to reduce the deviance and to increase the total variance explained, leading to the development of the final model.

Table 11.8 shows that the final school model has 24 per cent of the available within-student variance being explained, equivalent to 22.5 per cent of the total variance. At the within-school level, 24 per cent of the available Level 2 variance is accounted for, equivalent though to only 1.1 per cent of the total variance. Although only the smallest amount of variance between schools is available, the largest amount, some 99 per cent, is explained by Level 3, but this is estimated to be only 1.5 per cent of the total variance. Accordingly, the total amount of variance explained by the final school model is 25 per cent with a reduction in deviance of 1309 and an additional 40 degrees of freedom. With 25 per cent of variance explained, the Cohen (1992) recommendations rate the combined effect of the predictors as having a medium sized effect.

The final HLM school model is presented by Equation 11.16, Equation 11.17, and Equation 11.18. Variables that are centred around their grand mean are presented in italics, while those that are uncentred are not italicised.

Table 11.8 Development of the three-level HLM school model

	Variance			**Deviance**	**NEP**	**$L1_{4863}$**	**$L2_{18}$**	**$L3_{6}$**		**Conditions**
	σ^2	τ_π	τ_β			Variance available (%)				
Null	0.931	0.045	0.016	13499	4	93.8	4.6	1.6		Unconditional
						Variance explained (%)			Total (%)	
Level 1	0.920	0.045	0.017	13457	9	1.1	1.2	-5.3	1.0	SEX_1
	0.919	0.045	0.017	13454	16	1.2	1.1	-6.3	1.1	$NESB_1$
	0.917	0.045	0.017	13446	25	1.4	0.4	-7.4	1.2	$ENTRMT_1$
	0.880	0.042	0.015	13248	36	5.5	7.2	4.1	5.5	$COMATT_1$
	0.709	0.048	0.030	12230	49	23.8	-5.4	-90.4	20.6	$SCHATT_1$
Level 2	0.709	0.037	0.027	12220	57	23.8	17.6	-69.2	22.0	$SCHACC_2$
	0.708	0.037	0.028	12212	66	23.9	17.0	-76.5	22.0	OCC_2
Level 3	0.708	0.032	0.001	12200	67	23.9	28.3	92.1	25.2	$TEXP_3$
	0.708	0.033	0.001	12197	68	23.9	27.8	92.4	25.2	$OUTCOM_3$
	0.708	0.033	0.001	12194	69	24.0	26.1	92.5	25.2	SET_3
	0.707	0.034	0.001	12190	70	24.0	25.1	95.4	25.2	$TEACH_3$
Final	0.707	0.034	0.000	12190	44	24.0	24.4	98.6	25.2	a
Proportion of total variance explained						22.5%	1.1%	1.5%		
Total variance explained by final model									25.2%	
Reduction in statistics				1309	40					

NEP = Number of estimated parameters; a = Fixed coefficients with low reliability

Equation 11.16 Level 1 Model

$$SELFATT_1 = \pi_0 + \pi_1 SEX_1 + \pi_2 NESB_1 + \pi_3 \mathit{ENTRMT}_1 + \pi_4 \mathit{COMATT}_1 + \pi_5 \mathit{SCHATT}_1 + e$$

Equation 11.17 Level 2 Model

$$\pi_0 = \beta_{00} + \beta_{01} SCHACC_2 + r_0$$
$$\pi_1 = \beta_{10} + \beta_{11} OCC_2 + r_1$$
$$\pi_2 = \beta_{20} + r_2$$
$$\pi_3 = \beta_{30} + r_3$$
$$\pi_4 = \beta_{40} + r_4$$
$$\pi_5 = \beta_{50} + r_5$$

Equation 11.18 Level 3 Model

$$\beta_{00} = \gamma_{000} + \gamma_{001}\ TEXP_3 + u_{00}$$
$$^{a}\beta_{01} = \gamma_{010}$$
$$\beta_{10} = \gamma_{100} + \gamma_{101} OUTCOM_3 + u_{10}$$
$$^{a}\beta_{11} = \gamma_{110}$$
$$^{a}\beta_{20} = \gamma_{200} + \gamma_{201} SET_3$$
$$\beta_{30} = \gamma_{300} + u_{30}$$
$$\beta_{40} = \gamma_{400} + u_{40}$$
$$^{a}\beta_{50} = \gamma_{500} + \gamma_{501} TEACH_3$$

The results of the final three-level HLM school model are presented in Table 11.9. However, for a clearer understanding of the three-layered model, Figure 11.7 presents

[a] Fixed coefficients with low reliability.

a graphical interpretation of the equations comprising the three levels and includes the coefficient and standard error associated with each effect.

Table 11.9 Final estimations of the three-level HLM school model

Final estimation of fixed effects					
Fixed Effect	Coefficient	Std Error	t-ratio	Approx df	p-value
For INT_1, π_0					
For INT_2, β_{00}					
INT_3, γ_{000}	-0.077	0.05	-1.64	4	0.175
$TEXP_3$, γ_{001}	0.075	0.01	6.08	4	0.000
For $SCHACC_2$, β_{01}					
INT_3, γ_{010}	-0.769	0.31	-2.51	16	0.024
For SEX_1 slope, π_1					
For INT2, β_{10}					
INT_3, γ_{100}	-0.275	0.04	-7.87	4	0.000
$OUTCOM_3$, γ_{101}	1.956	0.58	3.39	4	0.039
For OCC_2, β_{11}					
INT_3, γ_{110}	0.117	0.03	3.55	16	0.003
For $NESB_1$ slope, π_2					
For INT2, β_{20}					
INT_3, γ_{200}	-0.138	0.05	-2.99	17	0.009
SET_3, γ_{201}	-0.186	0.08	-2.24	17	0.039
For $ENTRMT_1$ slope, π_3					
For INT2, β_{30}					
INT_3, γ_{300}	0.210	0.09	2.23	5	0.074
For $COMATT_1$ slope, π_4					
For INT2, β_{40}					
INT_3, γ_{400}	0.106	0.02	5.66	5	0.000
For $SCHATT_1$ slope, π_5					
For INT2, β_{50}					
INT_3, γ_{500}	0.436	0.03	15.72	17	0.000
$TEACH_3$, γ_{501}	-0.195	0.08	-2.32	17	0.033

Final estimation of Level 1, Level 2 and Level 3 variance components						
Random Effect	Reliability	Std Dev	Variance	Chi-square	df	p-value
Level-1, e		0.84	0.707(σ^2)			
INT_1, r_0	0.88	0.19	0.034(τ_π)	281.78	11	0.000
SEX_1 slope, r_1	0.29	0.07	0.005	21.18	11	0.031
$NESB_1$ slope, r_2	0.05	0.04	0.002	9.25	17	>.500
$ENTRMT_1$ slope, r_3	0.25	0.19	0.037	26.66	12	0.009
$COMATT_1$ slope, r_4	0.38	0.05	0.002	30.97	12	0.002
$SCHATT_1$ slope, r_5	0.70	0.10	0.010	86.50	17	0.000
INT_1/ INT_2, u_{00}	0.03	0.02	0.0002(τ_β)	1.11	4	>.500
SEX_1/ INT_2, u_{10}	0.09	0.03	0.001	3.08	4	>.500
$ENTRMT_1$/ INT_2, u_{30}	0.08	0.07	0.004	4.78	5	>.500
$COMATT_1$/ INT_2, u_{40}	0.11	0.02	0.000	2.06	5	>.500
Statistics for current covariance components model					Deviance	12189.90
					Number of estimated parameters	44

Note: INT = intercept.

By substituting Level 3 (Equation 11.18) into Level 2 (Equation 11.17) and then substituting these combined formula into Level 1 (Equation 11.16), the final model in expanded form is represented in Equation 11.19.

Equation 11.19 reveals that in the school model, student self-esteem can be viewed as a function of the intercept γ_{000}, seven main fixed effects, four cross-level interaction effects, and a random error (u_{00} + $u_{10}SEX_1$ + $u_{30}ENTRMT_1$ + $u_{40}COMATT_1$ + r_0 +

r_1SEX$_1$ + r_2NESB$_1$ + r_3*ENTRMT*$_1$ + r_4*COMATT*$_1$ + r_5*SCHATT*$_1$ + *e*). At the within-student level, five factors directly influence the outcome variable and include students' gender (SEX$_1$), language background (NESB$_1$), entertainment use (ENTRMT$_1$), computer attitude (COMATT$_1$), and school attitude (SCHATT$_1$). The only direct effect at the within-school level involves school computer access (SCHACC$_2$). At the between-school level, only teaching experience (TEXP$_3$) directly effects student self-esteem.

Equation 11.19 Final three-level school model

$$\begin{aligned} \text{SELFATT}_1 = {} & \gamma_{000} + \gamma_{001} TEXP_3 + \gamma_{010} SCHACC_2 + \gamma_{100}\text{SEX}_1 + \gamma_{101}\text{SEX}_1 OUTCOM_3 \\ & + \gamma_{110}\text{SEX}_1\text{OCC}_2 + \gamma_{200}\text{NESB}_1 + \gamma_{201}\text{NESB}_1\text{SET}_3 + \gamma_{300} ENTRMT_1 \\ & + \gamma_{400} COMATT_1 + \gamma_{500} SCHATT_1 + \gamma_{501} SCHATT_1 TEACH_3 \\ & + u_{00} + u_{10}\text{SEX}_1 + u_{30} ENTRMT_1 + u_{40} COMATT_1 + r_0 + r_1\text{SEX}_1 \\ & + r_2\text{NESB}_1 + r_3 ENTRMT_1 + r_4 COMATT_1 + r_5 SCHATT_1 + e \end{aligned}$$

The four cross-level interaction effects involve the interaction of student gender with learning outcomes (SEX$_1$OUTCOM$_3$) and occasion (SEX$_1$OCC$_2$), the school setting with students' language background (NESB$_1$SET$_3$), and students' attitude towards school with teaching practice (SCHATT$_1$TEACH$_3$).

Direct effects in the school model

In the school model, the direct effects on student self-esteem, presented in Equation 11.19, includes five factors at Level 1 (SEX, NESB, ENTRMT, COMATT, SCHATT), one factor at Level 2 (SCHACC), and one factor at Level 3 (TEXP).

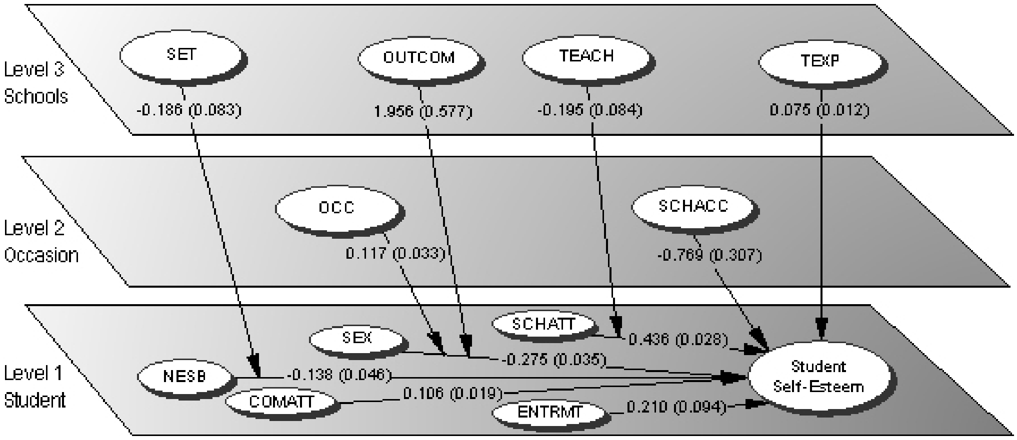


Figure 11.7 Diagramatic representation of the final three-level HLM school model showing the estimated regression coefficient and standard error associated with each effect

Student gender

At the within-student level, student gender (SEX, -0.28) significantly influences student self-esteem. The negative attribute suggests that male students maintain more positive views about themselves than their female peers.

NESB

Also at Level 1 in the school model, the influence of students' language background (NESB, -0.14) is significant. It supports the previous finding, resulting from the student model, that students from a non-English speaking background are more likely to report a lower self-esteem than their peers.

Entertainment used

Like the student model, students' entertainment use (ENTRMT, 0.21), at Level 1 in the school model, shows significant influence on student self-esteem. Accordingly, entertainment technology, like television and music players, used by students has a positive effect on their self-esteem.

Computer and school attitudes

The other Level 1 factors in the school model found to have direct and significant influences on student self-esteem are students' attitudes towards computers (COMATT, 0.11) and school (SCHATT, 0.44). Once again, the positive effects of both support the results obtained in the student model and suggest that those students who have positive attitudes towards computers and school are more likely to have higher self-esteem than their peers.

School computer access

At Level 2, a significant difference within the schools is apparent between occasions in the accessibility that students have to computers at school (SCHACC, -0.77). The general student perception of computer access in school negatively influences student self-esteem, so that those students who perceive their school to have good computer access are more likely to have lower self-esteem. This interesting finding could be interpreted as the so-called 'nerd effect', where academically-minded students place higher value on access to technology and make greater use of ICT, rather than, for example, playing sport at lunchtime. Such students, however, are often less sociable and tend to maintain lower self-esteem.

Teaching experience

At the school level, the average years of full-time teaching experience (TEXP, 0.08) is significantly different between schools. The positive attribute suggests that those students who are in schools with a greater proportion of experienced teachers are more likely to have positive self-esteem.

Interaction effects in the school model

Four cross-level interaction effects are present in the final school model. Isolating the variables involved in these cross-level interactions, by setting the inconsequential variables to zero, results in a simplification of the final school model (see Equation 11.19) into four separate expressions. These expressions are presented in Table 11.10 as Equation 11.20, Equation 11.21, Equation 11.22 and Equation 11.23. Following the same procedure as before, the variables in each expression were appropriately substituted to test the various conditions and determine the effects on students' self-esteem. Along with each expression, Table 11.10 indicates the values (given in brackets) that were used in the substitution process and presents the resulting measures of self-esteem based on the school model.

Plotting the self-esteem coordinates against the conditions prescribed in Table 11.10 produces graphical representations of the four expressions, presented in Figure 11.8, Figure 11.9, Figure 11.10, and Figure 11.11, respectively.

Table 11.10 Self-esteem interaction calculations for the school model

Equation 11. 20 $SELFATT_1$	$= \gamma_{000} + \gamma_{200}NESB_1 + \gamma_{201}NESB_1SET_3 + e$		
	$= -0.077 - 0.138\ NESB_1 - 0.186\ NESB_1SET_3$		
Language background	**School setting** SET		
NESB	Primary (0)	Secondary (1)	
Other (1)	-0.215	-0.401	
English (-1)	0.061	0.247	
Equation 11. 21 $SELFATT_1$	$= \gamma_{000} + \gamma_{500}SCHATT_1 + \gamma_{501}SCHATT_1TEACH_3 + e$		
	$= -0.077 + 0.436\ SCHATT_1 - 0.195\ SCHATT_1TEACH_3$		
School Attitude	**ICT-rich Teaching Practice** TEACH		
SCHATT	majority (1)	average (0)	minority (-1)
negative (-1)	-0.318	-0.513	-0.708
positive (1)	0.164	0.359	0.554
Equation 11. 22 $SELFATT_1$	$= \gamma_{000} + \gamma_{100}SEX_1 + \gamma_{110}SEX_1OCC_2 + e$		
	$= -0.077 - 0.275\ SEX_1 + 0.117\ SEX_1OCC_2$		
Student gender	**Occasion**		
SEX	Occ1 (0)	Occ2 (1)	Occ3 (2)
Male (-1)	0.198	0.081	-0.036
Female (1)	-0.352	-0.235	-0.118
Equation 11. 23 $SELFATT_1$	$= \gamma_{000} + \gamma_{100}SEX_1 + \gamma_{101}SEX_1OUTCOM_3 + e$		
	$= -0.077 - 0.275\ SEX_1 + 1.956\ SEX_1OUTCOM_3$		
Student gender	**Learning Outcomes** OUTCOM		
SEX	high (1)	average (0)	low (-1)
Male (-1)	-1.758	0.198	2.154
Female (1)	1.604	-0.352	-2.308

School setting and NESB

The first interaction, expressed by Equation 11.20 and shown in Figure 11.8, shows the impact on students' self-esteem of the interaction effect of school setting, namely, primary or secondary school, with their language background. Primary school students who came from a non-English speaking background presented a higher self-esteem than NESB secondary school students. However, the relationship is reversed for students where English is their first language. Secondary school students reported a higher self-esteem than their primary school peers.

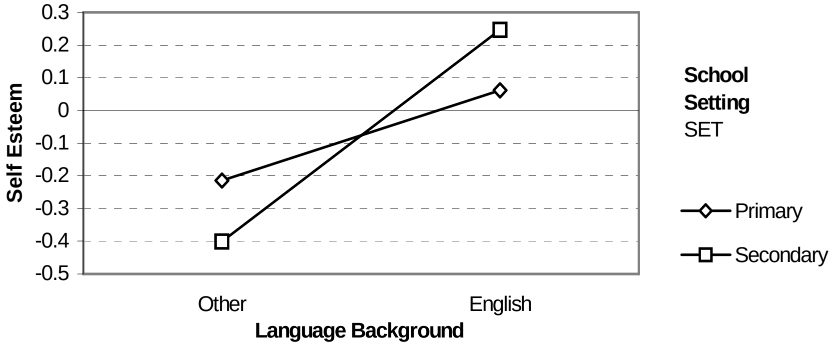


Figure 11.8 Impact on students' self-esteem of the interaction effect of school setting and students' language background

School-wide ICT-rich teaching practice and student school attitudes

Analysis of the second interaction, given in Equation 11.21 and plotted in Figure 11.9, shows the impact that the schools' climate of ICT-rich teaching practice in combination with students' attitudes towards school have on students' self-esteem. Those students who have a positive attitude towards school and who attend schools where the majority of teachers use ICT-rich teaching practices, present a positive but lower self-esteem than students who go to schools where ICT-rich teaching practice is not commonplace. In contrast, those students with a negative attitude towards school generally maintain a lower self-esteem but appear to improve in self-esteem in schools where ICT-rich teaching practice is increasingly used.

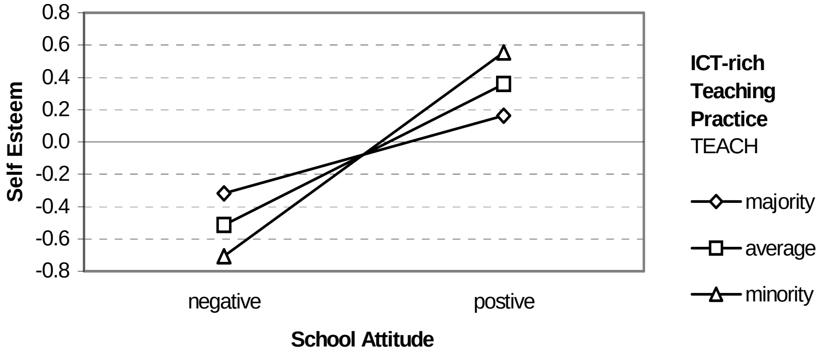


Figure 11.9 Interaction effect of the climate of ICT-rich teaching practice in schools and students' attitudes towards school on students' self-esteem

Gender and time

The third interaction is described by Equation 11.22 and featured in Figure 11.10. Analysis reveals the impact on a student's self-esteem of their gender and the changing school environment in which ICT is increasingly used. Male students clearly maintained higher self-esteem than their female peers. However, it appears that over the three occasions of the study, female students' self-esteem improved while male students' self-esteem declined. Arguably, change within the schools over the three years, which focused on increasing the use of ICT in learning, may be the cause of the change in self-esteem.

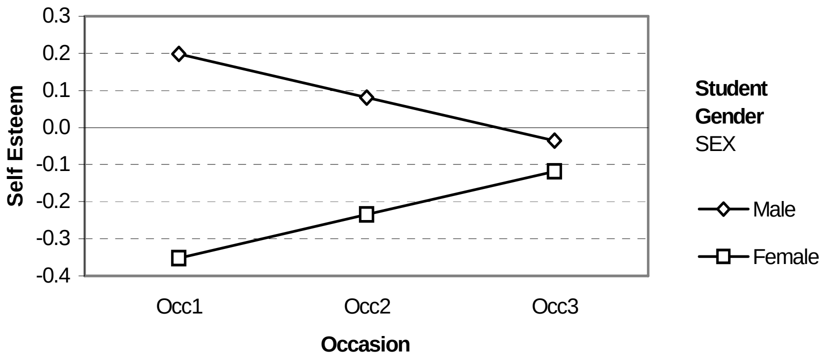


Figure 11.10 Interaction effect of gender on students' self-esteem over the three occasions

Gender and planned learning outcomes

The final cross-level interaction, expressed in Equation 11.23 and shown in Figure 11.11, reveals the interaction effect of gender and the schools' climate of teachers' planned learning outcomes on students' self-esteem. In schools where teachers were more likely to set higher-order learning objectives for their students, such as synthesising and presenting information, female students had a much higher self-esteem than their male peers. In schools where only a few teachers set challenging learning objectives, the trend was reversed with male students maintaining a higher self-esteem than female students. Schools that had an average number of teachers setting higher-order learning objectives resulted in male and female students having a similar level of self-esteem.

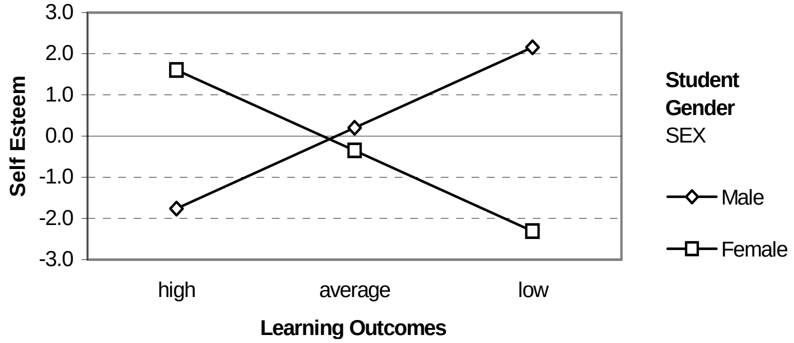


Figure 11.11 Interaction effect of gender and the schools' climate of teachers' planned learning outcomes on students' self-esteem

Even though the same variables that were used in the student model were also used in the school model, their alternative configuration in the school model has produced quite a different set of equations resulting in a very different model and set of findings. But do the models reveal similar effects on student self-esteem? The next section brings the results of both models together and briefly summarises the findings of the HLM analysis.

Summary

In this chapter, three-level HLM analyses are undertaken for two different models, namely the student model and the school model. Both proposed models place student self-esteem as the dependent variable, but the models differ in their approach. The first model examines change in students over time by nesting occasions within students within schools. The second model examines change in schools over time by nesting students within occasions within schools. In developing the models by using HLM procedures, a number of cross-level interaction effects and direct effects are examined. Summaries of both models are presented side by side in Table 11.11.

From the findings obtained from the three-level HLM analyses of the student and school models, a number of comparisons can be drawn.

1. Where factors are common to each model, their actions of influence on student self-esteem are similar. For example, student self-esteem increases over the three occasions, since in both models, the coefficient for occasion is positive.

2. The factors significant at the student level (Level 2) in the student model, namely students' language background, entertainment use, and attitudes towards computers and school, are also significant at the student level (Level 1) in the school model.

3. The only teacher factor to influence significantly change in students, presented in the first model, is teacher type, whereas in the second model, looking at change

in schools, several teacher factors are significant and include teaching experience, planned learning outcomes, and teaching practice.

Table 11.11 Summary of the estimated regression coefficients for the student and school HLM models

	Level 1		**Level 2**		**Level 3**	
Models:	Student	School	Student	School	Student	School
Intercept	-0.176	-0.076				
Occasion	0.206			0.117		
Student gender		-0.276	-0.098			
NESB students		-0.138	-0.170			
Student ICT-based homework					1.144	
Student entertainment use		0.212	0.348			
Student general ICT use					-0.325	
Student access to ICT at school				-0.773		
Student computer attitude		0.107	0.130			
Student school attitude		0.435	0.472		-0.065	
Primary or secondary school						-0.188
Teacher type ratio					0.491	
Teaching experience						0.075
Planned learning outcomes						1.939
Teaching Practice using ICT						-0.197
Variance explained	2.1%	22.5%	10.9%	1.1%	2.8%	1.5%
Total	Student Model = 15.8%			School Model = 25.2%		

More importantly, though, close examination and comparison of the student and school models, self-esteem is found to be supported for:

a) students in schools with an average to high proportion of permanent teachers;

b) students in schools that promote ICT-rich homework and study;

c) male students in schools where teachers predominantly set lower-order learning objectives, and female students in schools in which teachers mainly set higher-order learning objectives;

d) students in schools with a greater proportion of experienced teachers;

e) students who perceive their school to have low computer access;

f) students with a positive school attitude, regardless of the schools' climate of ICT-rich teaching practice, but particularly if they are male and a positive climate of school attitude prevails;

g) students who have a positive attitude towards computers;

h) students who use technologies like television and music players for entertainment;

i) primary school students who come from a non-English speaking background and secondary school students for whom English is their first language; and

j) female students, although lower than male students, increase in self-esteem over the three occasions of the study.

The results from the HLM analyses, then, can be used in conjunction with the path analyses results to understand better how a changing school environment, due to the increased use of learning technologies, impacts on students' self-esteem. It is in the last chapter that the research propositions are addressed and the conclusions are drawn.

12

Discussion, Conclusions and Implications

The overarching purpose of this study is to investigate longitudinal change in school climate through its influence on students and teachers, during a period of school-wide transition as ICT are embedded throughout mainstream curricula. In doing so, an assessment of the impact of ICT on student attitudinal outcomes is investigated. In particular, this study examines changes in students' attitudes towards computers and school and changes in self-esteem over a three-year period of school-wide ICT adoption. In addition, this study develops a theoretical and practical framework, DBRIEF, in which to design and conduct the research, and addresses the more technical issues involved in specifying appropriate methods of analysis, taking full advantage of the hierarchical and longitudinal nature of the data.

This chapter summarises and presents the findings of this study by responding to the propositions presented in Chapter 3. Conclusions are then drawn that lead to educational implications for administrators, school leaders and teachers, and equally importantly, complete the DBRIEF cycle by informing recommendations for ongoing and future research.

Discussion of Results: Testing the Propositions

In Chapter 3, following the discussion of the theoretical background to the study and development of the DBRIEF framework that guided the investigation, 10 propositions are advanced that provide a focus to the undertaking. In subsequent analyses, the majority of which are presented in Chapters 10 and 11, these general propositions are examined against the evidence obtained in the inquiry. Therefore, this section addresses and tests each proposition by drawing on the findings that result not only from the descriptive analyses of school, teacher and student, presented in Chapters 7, 8 and 9 respectively, but also from the path and HLM analyses, presented respectively in Chapters 10 and 11.

Proposition 1: School-wide adoption of ICT across the curriculum influences teachers' ICT-rich teaching

Recent years have seen a steady growth in the uptake of ICT by teachers in their classroom practice. Early research mainly reports on innovative teachers working independently and in isolation to bring ICT-rich learning experiences to their students (Reynolds et al., 2003). However, without wider support from the school community, teachers report that sustaining such practices is challenging, and generally revert to traditional behaviours. More recently, research shows that profound and permanent shifts in teaching practice, towards a student-centred constructivist style, is only possible when a school-wide approach to adopting ICT across the curriculum is present (Barnes et al., 2001; Housego and Freeman, 2000; Smeets and Mooij, 2001; Tearle, 2003).

The major impetus undertaken in the schools participating in this study over the three-year period was increasingly to embed learning technologies into the curriculum. The broad aim of this study, therefore, is to measure the impact that the changing school environment has on its teachers and students. However, it is not the focus of this study to determine how and to what extent teaching practice changed, only that it did change as evidenced by a change in student outcomes. Accordingly, the school model presented in Chapter 11 (see Figure 11.7 and Equation 11.19) provides evidence that, to differing degrees, schools underwent school-wide change during the three-year period of the study and that the existence of ICT-rich teaching practice as a significant factor at the school level is one indication of this.

In this study, teaching practice is measured by a variety of questions designed to touch on the broad range of activities and beliefs that comprise and inform a teacher's daily responsibilities. These aspects (defined by six manifest variables) involve teachers' views on focused learning applications, communication environments, behavioural learning objectives, the influence of ICT on teaching practice, and the importance of internet access and peripheral ICT. The influence of ICT on teaching practice provides the strongest measure of ICT-rich teaching practice, while internet access for use in general teaching practice and the planning of behavioural learning objectives are of lesser importance.

That said, this study finds that in an increasingly ICT-rich learning environment teachers frequently encourage students to use ICT, and value behavioural learning objectives that improve their students' computer skills and promote independent and collaborative learning.

Half the teachers in this study report that their teaching methods and goals are influenced by the use of ICT to at least a medium extent. Primary school teachers are less likely than their secondary school counterparts to report students' ICT use on a frequent basis, although they are more likely to be influenced by ICT in the way they organise their classroom. These results are not surprising since a greater focus on reporting is evident in secondary schools and the structure of secondary schools means that teachers generally have less control over the organisation of the space in classrooms.

What is overwhelmingly clear from this study, is that in order for teachers to embed ICT successfully into the curriculum, they require a computer with internet access for themselves with at least five computers in or near the classroom for their students. In planning their lessons, open-ended learning applications like spreadsheets and graphics packages are considered less important than the use of presentation software and data show facilities with their students. In most schools, however, web-browsers are the most frequently used and valued learning environments, while approximately half the teachers believe that the use of email and communicating electronically are important learning objectives.

In Chapter 10, this study also examines the influence of other factors impacting upon teachers' use of ICT in their teaching practice. Across all schools, teachers' ICT confidence, their beliefs about student work using ICT, the learning outcomes planned for their students, the issues arising using ICT, their use of common ICT, and computer ownership, all significantly influence teaching practice. The most influential of these factors is teachers' ICT confidence, reflected predominantly by their confidence in implementing ICT in the classroom. Accordingly, the findings of this study indicate that teachers more readily use ICT in their teaching practice if they own a computer, are confident ICT users, and believe ICT supports students' learning. In addition to these factors, which are common to teachers in primary and secondary settings, primary school teachers who are male and working full-time in a supportive school environment, and secondary school teachers with many years of teaching experience, are also more likely to adopt ICT-rich teaching practices.

Other between-school differences in the prevailing climate of teaching practice within each school are evident from this study. As a measure of the relative differences between school-wide teaching practices, the averaged teacher response along with the principal component scores (generated by combining the six manifest variables) are presented in Figure 12.1. Clearly, some schools (P4, S1 and S2) appear to be more effective in their school-wide adoption of ICT in teaching practice. Furthermore, this study provides evidence that such differences influence student outcomes.

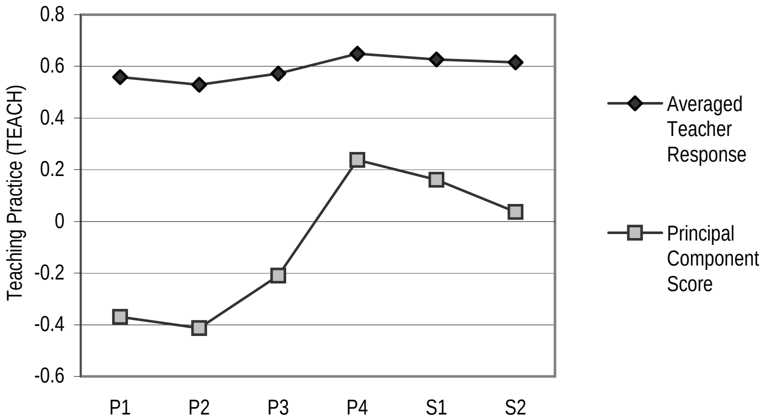


Figure 12.1 Averaged teacher response and principal component scores of school-wide teaching practice

In Chapter 11, results reveal the impact that a school's climate of ICT-rich teaching practice in combination with students' attitude towards school has on students' self-esteem. It finds that those students, who have a positive attitude towards school and who attend schools where the majority of teachers use ICT-rich teaching practices, present a positive but lower self-esteem than students who go to schools where ICT-rich teaching practice is not commonplace. In contrast, those students with a negative attitude towards school generally maintain a lower self-esteem but appear to improve in self-esteem in schools where ICT-rich teaching practice is increasingly used; in this case, primary school P4 and the two secondary schools.

Proposition 2: School-wide adoption of ICT across the curriculum influences students' self-esteem and the extent to which it changes

Only recently has there been research investigating the impact of ICT on student self-esteem. For instance, in a review of literature surrounding the evaluation of technology-rich initiatives in the compulsory schools sector in New Zealand and overseas, Boyd (2001a, 2001b) reports a number of studies (Chavers 1996; Derewetzky 1992; Jolly and Deloney, 1996) that found improvements in students' self-esteem using computers. Blackmore et al. (2003) reports in their survey of the literature that girls experienced a growing loss of self-esteem with respect to technology and schooling at Years 9–10 at a time when boys' self-esteem increased. In a project that examines computer assisted reading remediation, Scott (1990) found that improving self-esteem and confidence was one of the major benefits.

First and foremost, what is clear from the findings in this study is that an increasingly ICT-rich environment appears to be supportive of students' self-esteem.

A modified form of the Coopersmith Self-Esteem Inventory (1986) is used in the present study to provide important insight into the influences on students of embedding ICT into the curriculum. Adding further support to Blascovich and Tomaka's (1991) criticism of the Coopersmith Self-Esteem Inventory for its lack of a stable factor structure, factor analysis and cluster analysis conducted in this study results in a scale comprising only three components: general-self, social self-peer, and home-parents aspects of student self-esteem. Of these, student's self-attitude is best reflected by their general self-esteem in both the primary and secondary school settings.

The general-self component investigates students' feelings about themselves and ranges from not being easily bothered and having a high opinion of themselves to often wishing they were someone else and taking a long time to get used to anything new. This study reveals little difference between any of the schools, suggesting a robust measure of general-self-attitude. Moreover, with school-wide responses falling above the mid-position, the present study supports the work of Blascovich and Tomaka (1991) and others in finding that the measure, although consistent, is susceptible to socially desirable responding. Most measures of self-esteem are self-report, and it is difficult to obtain non-self-report measures of such a personal and subjective construct without some form of bias. However, as Blascovich and Tomaka (1991, p.123) argue, "an individual who fails to endorse Self-Esteem Scale items at least moderately is probably clinically depressed," suggesting that even the restricted range of self-esteem scores is useful among and representative of non-depressed individuals. In line with this argument, this study finds that two-thirds of students presented with an average general-self attitude, with all but a few of the remaining third reflecting a positive self-attitude. This finding indicates that approximately four per cent of the students participating in this study can be considered 'at risk' and clinically depressed, based on Blascovich and Tomaka's (1991) argument. Most importantly for these students, then, is that this study finds an increase in student self-esteem over time, attributable to the school-wide adoption of ICT. Accordingly, the use of ICT in learning appears to be beneficial to supporting students' general view of themselves, significantly so from the first to last years of the study.

The influence of ICT on peer and social relationships is an interesting but little studied area in relation to adoption research. The social self-peer component of students' self-esteem involves a selection of socially oriented statements that range from being popular with children their own age and not being shy, to finding it hard to talk in front of the class. This study finds clear differences between students in the primary and secondary settings, reflecting the dependency on age and being more self-conscious. Across all schools, students' social-peer self-esteem is lower than their general self-esteem, in all but one primary school (P2), which yields similar outcomes. Twice as many secondary students compared to primary students reflect a low social-peer attitude. Conversely, twice as many primary students as secondary students report positive social self-esteem. The combined outcome suggests that primary students have a generally positive self-esteem in the social-peer situation, while their secondary counterparts maintain a generally negative self-esteem. Moreover, in both the primary and secondary settings, students showed an improvement in social self-esteem, significantly so in the primary students, which reflects the effectiveness of the communication aspects of learning technologies.

Finally, students' self-attitude towards parents and in the home environment is characterised by a mix of items ranging from being considered and understood by their parents to wanting to leave home and being pushed too hard. This study reveals that students' acquisition of ICT skills and knowledge is equally shared between school and home, and so the influence of ICT on students' attitudes about parents and home is a worthwhile and relevant aspect of self-esteem to measure. Across all schools, the home-parent self-esteem component gains the most positive responses from students. In fact, only one per cent of primary and secondary students respond negatively to the statements, which suggests that students participating in this study maintain a positive self-attitude in their family environment. Compared to the other components of self-esteem, the use of ICT appears to have relatively little influence on students' attitudes towards parents and the home environment. Over the three-year period, however, an increase in students' attitudes towards their parents is experienced across the cohort, but not significantly so.

In Chapters 10 and 11, this study also examines the influence of other endogenous factors impacting upon students' self-esteem. Across all schools, ICT-based homework, general ICT use, and attitudes towards computers and school are found to influence student self-esteem significantly.

Further results suggest that positive self-esteem is strongly influenced by doing homework that involves using computers. That is to say, this study establishes that in an increasingly ICT-rich school environment, using a computer to study and do homework is more likely to promote positive self-esteem. That there are significant differences between schools in relation to the amount of ICT-rich homework being done by students, most likely reflects the general socio-economic background of the schools, often referred to in the literature as the so-called 'digital divide'. Although this relationship is not directly investigated in this study, the contextual and demographic information researched on each school suggests that those schools located in generally affluent suburbs (primary school P3 and secondary school S2) also report the highest levels of student computer use outside of school for homework (see Figure 9.3). Accordingly, those students in schools that promote ICT-rich homework are more likely to have positive self-esteem.

In addition to students using computers for homework, this study confirms the importance of the home environment to students' development and use of ICT skills, but indicates that moderation is equally important. Students' extra-curricula ICT usage, as defined in this study, broadly falls into the categories of internet, software, and hardware use, and has an indirect but negative influence on self-esteem. While low levels of extra-curricula ICT usage by the general student population maintain a positive self-esteem in conjunction with a positive computer attitude, this study shows that students in schools with average or high ICT usage outside of school are at risk of negative self-esteem.

Those students in schools that have a high level of student extra-curricula ICT usage and who have a positive computer attitude, have lower self-esteem than those students who have a poor attitude towards computers. Likewise, students with a positive computer attitude in schools that have an average or low level of student extra-curricula ICT usage, have higher self-esteem than those students who have a low computer attitude. As expected, there is a significant and positive relationship between a student's computer attitude and their self-esteem.

Findings from this study also indicate that positive self-esteem is strongly influenced by a positive school attitude, and is further promoted by having a positive attitude towards computers. However, the apparent stability of students' attitudes towards school and computers on self-esteem over the three-year period suggests that school-wide adoption of ICT has little effect on the way in which they influence self-esteem. Further analysis conducted in Chapter 11, provides additional understanding. Self-esteem is supported for students with a positive school attitude, but particularly if they are male and if a positive climate of school attitude prevails. That is to say, relative to male students, female self-esteem appears to improve as the climate of school attitude declines. One possible explanation is that female students feel more inadequate in an environment where the general school atmosphere is positive.

A final factor in this study that influences student self-esteem is teachers' planned learning outcomes (see Chapter 11, Figure 11.11). Students' self-esteem is found to be supported for male students in schools where few teachers set higher-order learning objectives and for female students in schools in which teachers mainly set higher-order learning objectives. Schools that have an average number of teachers setting challenging learning objectives result in male and female students having a similar level of self-esteem. Such a result suggests that when boys are challenged academically, their self-esteem declines, whereas girls appear to enjoy the challenge and gain self-esteem. However, upon closer examination of the results in Chapter 8, on average, only 70 per cent of primary school teachers set higher-order learning objectives, compared to 79 per cent of secondary school teachers. This finding indicates that male students may be less challenged in primary school, elevating their self-esteem, but find the more challenging objectives set in secondary school threatening, lowering their self-esteem. The reverse occurs for female students. An alternative more likely explanation can be that the nature of the learning objectives, while being of the higher-order, are more suited to male students in primary school and to female students in secondary school.

Proposition 3: ICT-rich teaching practice influences students' self-esteem

School-wide adoption of ICT is shown, in Proposition 1, to influence teaching practice, and in Proposition 2, to influence students' self-esteem. But is there a direct or indirect relationship between ICT-teaching practice and students' self-esteem? Findings from this study suggest there is.

In Chapter 11 (see Figure 11.9), results indicate that the schools' climate of ICT-rich teaching practice in combination with students' attitudes towards school influences students' self-esteem. Those students who have a positive attitude towards school and who attend schools where the majority of teachers use ICT-rich teaching practices, present a positive but lower self-esteem than students who attend schools where ICT-rich teaching practice is not commonplace. In contrast, those students with a negative attitude towards school generally maintain a lower self-esteem but appear to improve in self-esteem in schools where ICT-rich teaching practice is increasingly used.

Proposition 4: Teachers' planned use of ICT influences their adoption of ICT in teaching practice

One of the most surprising findings of this study was that teachers' planned use of ICT in their teaching does not influence, directly or indirectly, their ICT-rich teaching practice. In planning for their teaching, teachers were asked to indicate how many lessons they planned for their students to use a variety of open-ended software applications such as word-processing and reference CDs. Over 40 per cent of teachers did not explicitly plan to use these programs in their teaching, and only 10 per cent planned to do so for at least 10 lessons in the term. This finding suggests that teachers' planned use of ICT in their teaching does not result in them actually using it in their lessons. In other words, a teacher's intention to use ICT is not a reliable predictor that their teaching practice is ICT rich.

Proposition 5: An emphasis on ICT use in school influences students' access and use of ICT both inside and outside of school

In an increasingly ICT-rich school environment, a number of contextually important measures of change are used in this study to gauge students' access to ICT and usage at school and in the home.

One of the big surprises, reported in Chapter 10, is the apparent unimportance of school computer access as a factor influencing students' behaviours and attitudes. The removal of seemingly important variables is reassuring and suggests that the number of computers a school may or may not have for their students does not impact on their self-esteem, particularly since students increasingly and significantly believe over the three year period of the study that their schools do not have enough computers to access for their work. This drop may have resulted, not as a decline in the actual numbers of computers in the schools, but in response to the increased demand on a limited resource. Indeed, one of the secondary schools, boasts a 1:3 student to computer ratio. Therefore, it may be the case that it is more important how computers are used, rather than how many are available. In fact, almost 80 per cent of students indicate they regularly work individually or in pairs on a computer and do not disagree that their school has enough computers, suggesting that there are sufficient computers for students to use.

However, providing further insight, findings in Chapter 11 indicate that general student perception of computer access in school does influence student self-esteem, but negatively so. Those students who perceive their school to have good computer access are more likely to have lower self-esteem. That a significant decline in access to computers at school is reported by students, results in increased self-esteem over the duration of the study.

With 95 per cent of students having access to a computer at home, this study establishes that digital technologies outside of school are commonplace. The Microsoft Windows platform dominates the market with a Windows to Macintosh ratio of 7:1. Gaming systems such as Playstation are also a popular activity with half of the student population owning a system. Some influence in home computer ownership, particularly in the primary school sector, is also measured in this study.

In addition to computer access at home, access to other forms of mass-penetration technology such as television, videos, and music players, is also measured. It is found that these so-called 'entertainment' technologies have a positive effect on student self-esteem. This study also finds that male students, particularly if they are in a secondary school that has access to entertainment technologies, are more likely to have a computer in the home, and in turn, are more likely to use it. Secondary school students' general use of ICT, though, is found to be a reasonably stable quality, independent of their increased exposure to ICT in school, while primary school students' ICT use does appear to be influenced positively. Yet in Chapter 9, significant increases in students' use of the internet, and other computer software and hardware, outside of school, are evident over the three years of the study. Arguably, these changes outside of school can be attributed to the influence of school embedding ICT into the curriculum. Of greater concern, however, and also independent of the change within schools, is that male students are more likely to have access to a home computer than their female peers.

Proposition 6: Teacher and student presage characteristics influence students' self-esteem

Teacher and students presage factors include inter-personal characteristics brought to the learning context but independent of it. In this study, teachers' gender, type of teaching position, average teaching load, teaching experience, and ICT specialisation, along with students' non-English speaking background, age, and gender, are measured in the belief that these factors may influence directly or indirectly all other endogenous variables considered in this study, but in particular, that of student self-esteem. Only four presage characteristics, that of teacher type, teaching experience, student gender, and student language background, are found to influence students' self-esteem significantly.

In Chapter 11 (see Figure 11.4), this study finds that those students in schools with an average to high proportion of permanent teachers, show an increase in self-esteem over the three occasions, whereas those students in schools with a high proportion of temporary teaching staff (PAT and SSO), show a decline in self-esteem over the three occasions. If we examine the results presented in Chapter 7, it suggests that primary school P1, showing the lowest proportion of permanent staff of around 70 per cent (see Figure 7.6), is at greatest risk of declining self-esteem in the student population.

In further corroboration of the above finding and also reported in Chapter 11, is the impact on student self-esteem of teaching experience. Those students who are in schools with a greater proportion of experienced teachers are more likely to have positive self-esteem. Again, students in primary school P1, with the largest proportion of early-career teachers (see Figure 7.4), are at greatest risk of low self-esteem.

Findings in this study concur with those of previous research, that male students have higher self-esteem than female students. More interestingly, though, this study reveals a decline in the importance of gender on self-esteem over time, suggesting that the increased use of ICT in school may reduce the gender gap. This outcome is further supported by findings in Chapter 11 that suggest, independently of student gender, students' self-esteem improves over the three occasions.

Students' language background is also found to be an important factor in their self-esteem. Students from a non-English speaking background are more likely to have lower self-esteem than their English-speaking peers. Broken further down into primary and secondary cohorts, primary school students who come from a non-English speaking background present higher self-esteem than non-English speaking background secondary school students. However, the relationship is reversed for students in which English is their first language. Secondary school students maintain higher self-esteem than their primary school peers.

Figure 12.2 attempts to summarise the findings in this section parsimoniously. It presents in combination the outcomes of higher (+) and lower (-) self-esteem experienced under each presage condition. Therefore, male students for whom English is their first language in secondary schools with an experienced and permanent teaching population are more assured of maintaining high self-esteem. Conversely, Figure 12.2 also suggests that the group at greatest risk of having low self-esteem are seen to be female students from non-English speaking background in secondary schools with a large proportion of temporary and early-career teachers. While these combinations present the extreme in each case, Figure 12.2 also enables the tracing of other path ways as an aid to interpreting the complexity of results.

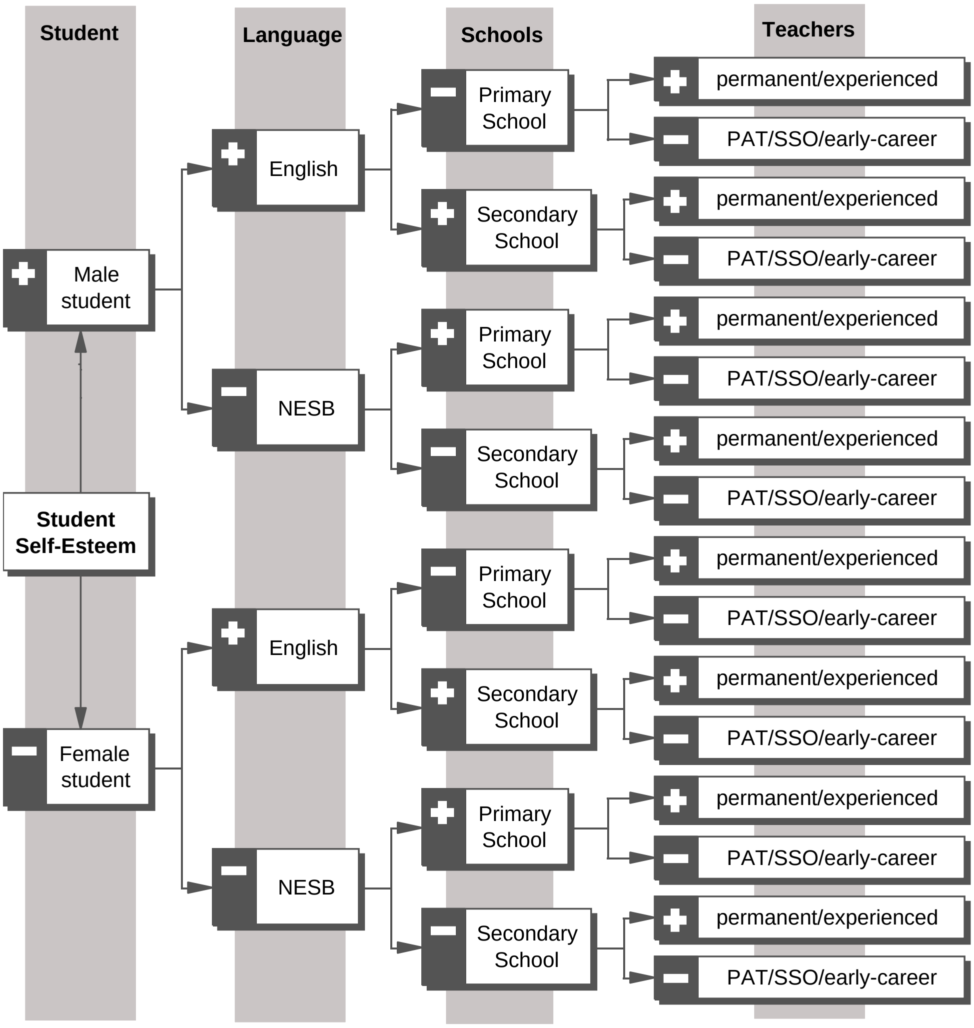


Figure 12.2 Summary of the influence of student presage factors on self-esteem by presenting in combination the outcomes of higher (+) and lower (–) self-esteem experienced under each presage condition

Proposition 7: Students' attitudes towards school and computers are influenced by their presage characteristics in different ways

As a measure of the process of deep change within students due to school-wide adoption of ICT in the curriculum, measures of attitudes towards computers and school are selected for this study. The existence of reliable survey tools also made this a feasible undertaking (Jones and Clarke, 1994; Keeves, 1974). How then, are these attitudes affected in response to the antecedent qualities of the students in an increasingly ICT-rich environment?

An adaptation of Keeves' (1974) questionnaires is used in this study to examine aspects of students' attitudes towards school. Five components include school enjoyment, staying at school, motivation to learn, motivation to achieve, and motivation to use effort in work. An additional factor, originating from the Coopersmith Self-Esteem Inventory (1967; 1986), examines the school-academic areas of attitudinal experience.

Findings show that students' enjoyment of school is twice as likely in younger students attending primary school than in older secondary school students. However, students in secondary school reveal improvements, though not significant, in their enjoyment of school. Over half the students in this study agree that they prefer to stay at school, a belief that is similarly held across the primary and secondary cohorts. Only this factor shows an increase in primary students' attitudes towards staying at school, though it is not significant over the three-year period. Across all schools, students' motivation to learn rates the lowest of any of the attitudinal measures. With items ranging from an enjoyment of working out difficult problems, to preferring to sit next to someone who worked hard all the time, responding positively to such items is considered 'uncool' by most students. Students in secondary school also show an improvement in their motivation to learn but it is not significant at the 0.05 level. Students' motivation to achieve academically is rated among the highest of the attitudinal measures, with over 60 per cent of primary students and just under half the secondary students reflecting a positive attitude. Showing the greatest difference between the primary and secondary settings, almost three times as many primary students compared to secondary students are academically motivated to put effort into their schoolwork. The final measure of school attitude used in this study, which examines academic self-esteem, finds that only eight per cent of students, irrespective of the setting, feel negatively towards their academic self.

In Chapter 10, the findings suggest that students from a non-English speaking background are more likely to report a positive attitude towards school, and that this attitude is not influenced by the changing learning environment over the three-year period.

Supported by previous research findings, it is no surprise to see that students' attitudes towards school are more positively held by female students. Though not significantly different in the direct effect, the primary and secondary settings differ in the total effects, suggesting that gender is a significantly stronger influence on the formation of school attitude in primary school. Furthermore, the apparent stability of student gender is evidenced by no significant change over the three years of the study. This finding suggests that independent of the level of ICT adoption in school, girls would probably maintain a consistently more positive view of school than boys.

Another finding supported by previous research is the influence of students' age on school attitude, whereby older students hold poorer attitudes towards school. Apparent only in the primary students, the drop-off of significance in the third year of the study suggests that students' age may be less influential in forming school attitude as ICT is increasingly adopted in schools, though the difference is not large enough to be significant. That age is not a significant factor at all in the secondary students, suggests that as students get older the influence of age may also diminish.

Figure 12.3 presents a summary of the presage factors and their direction of influence effecting students' attitudes towards schools. The findings suggest that female primary students from non-English speaking backgrounds are most likely to report positive attitudes towards school, while those at greatest risk of having poor school attitudes are male secondary school students with an English-speaking background.

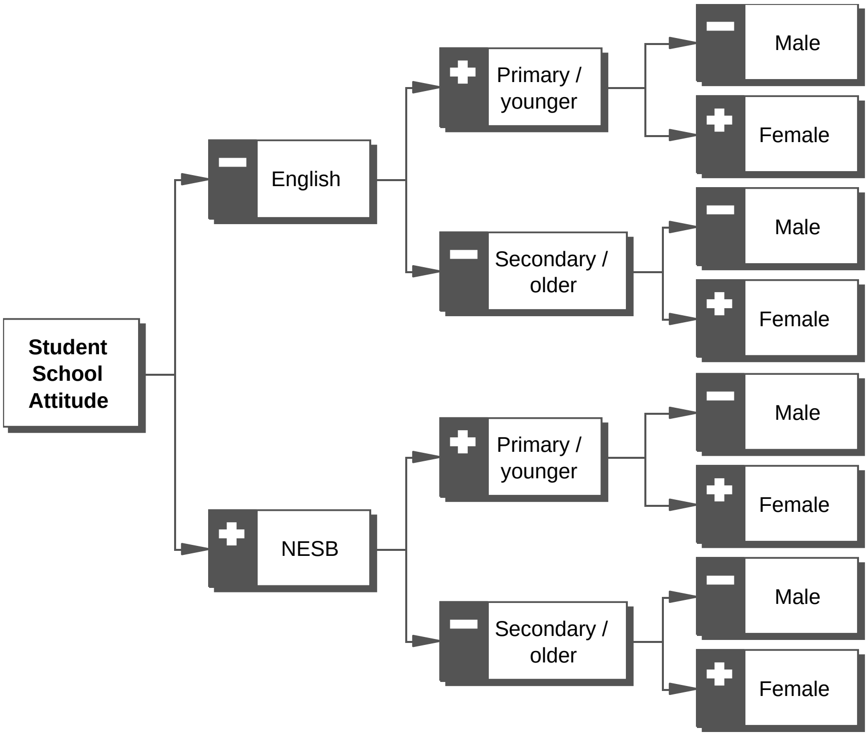


Figure 12.3 Summary of the presage factors and their direction of either positive (+) or negative (–) influence effecting students' attitudes towards schools

In order to examine aspects of students' attitudes towards computers, a modified version of the Jones and Clarke (1994) questionnaire is employed in this study. Three factors are resolved that identify with either the affective, behavioural or cognitive aspects of attitude and change in these attitudes over time is observed.

This study finds that of the three attitudinal components, the affective component most positively reflects students' attitudes towards computers, with only four per cent of students actually having negative affective attitudes. Items in the affective component range from, being highly intimidated and threatened by computers and feeling helpless when asked to perform new tasks on a computer, to being bored and frustrated with computers. In an environment where students are increasingly confronted about their feelings towards computers, the increase in students' affective attitudes towards computers is encouraging. This finding suggests that the increased use of ICT in learning is supportive to students computer attitudes in both the primary and secondary schools.

The behavioural component of computer attitude consists of positively worded items that range from, wanting to learn more about computers and use computers more often, to finding ways to use computers more efficiently and wanting to learn new tasks independently by trial and error. The behavioural aspect is generally the least positive reflector of computer attitude, with 13 per cent of students maintaining negative behavioural attitudes. In the changing school environment, students appear to find the increased use of ICT behaviourally more confronting, particularly in the older cohort. Primary students' behavioural computer attitudes show significant improvement over the three-year period. However, across the secondary cohort a decline in behavioural computer attitude, though not significant, is observed.

For the cognitive component, statements range from being creatively inhibited when using computers and believing computers to be a waste of time, to finding computers difficult to understand and isolating. Only five per cent of students agree with these statements, maintaining a negative cognitive attitude. In terms of change over the three years, findings from this study reveal a positive but non-significant improvement in primary students' cognitive computer attitude. More importantly, this study observes a positive and significant improvement in secondary students' attitude, possibly attributable to students' increased exposure to ICT.

Particularly for the affective and cognitive components of computer attitude, the relatively flat profiles across each school suggest that students in primary and secondary school hold similar attitudes towards computers. However, for the behavioural component of computer attitude, secondary school students are generally more negative, which may indicate increased pressure on access to computing resources. What is clear is that the increased use of ICT in schools over the duration of the study has a positive and significant impact on students attitudes towards computers.

In Chapter 10, findings indicate that male students maintain more positive attitudes towards computers than their female counterparts. However, a more noteworthy finding of this study is that this difference only becomes significant in secondary school students. Moreover, the increased use of ICT in schools appears to reduce the differences in male and female students' attitudes towards computers, although these differences are not large enough to be considered significant at the 0.05 level.

The other student presage characteristics of age and non-English speaking background present no influence over students' computer attitude, as Figure 12.4 shows.

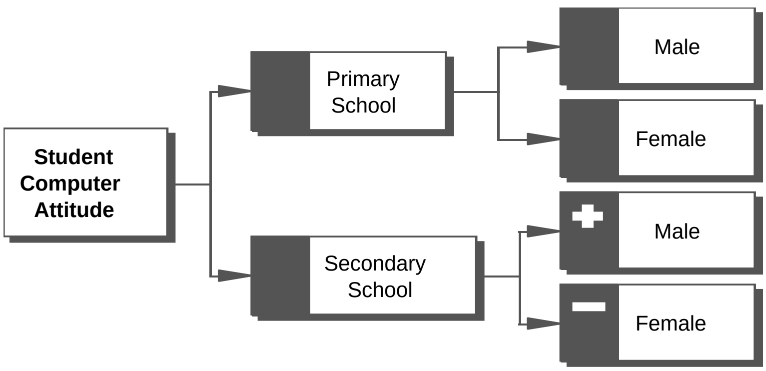


Figure 12.4 The influence of student presage factors on computer attitude, showing positive (+), negative (–), or no effect

Proposition 8: Teachers' presage characteristics influence their adoption of ICT in teaching practice

No presage factors are identified that are significant influences on teaching practice to teachers in both the primary and secondary settings, possibly reflecting the differences between teaching practices in the different settings.

However, results in Chapter 10 reveal that there are two factors significant to teachers in the primary schools and one factor significant to teachers in the secondary schools. It finds that primary school teachers are significantly influenced by their teaching load and gender, whereas secondary school teachers are influenced by their years of teaching experience. These findings suggest that male primary school teachers working full-time, and experienced secondary school teachers, are more likely to adopt ICT-rich teaching practices.

The other presage factors of ICT specialisation and type of teaching position present no influence over teachers' adoption of ICT in their teaching practice, as summarised in Figure 12.5.

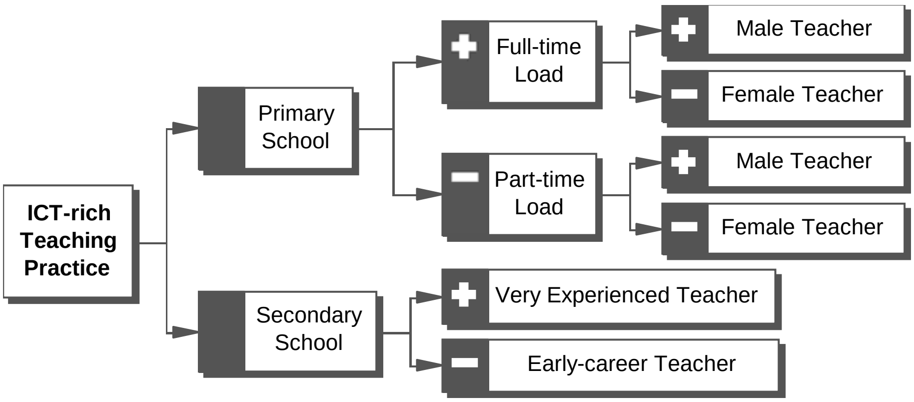


Figure 12.5 Teachers' presage factors influencing ICT-rich teaching practice, showing positive (+), negative (–), or no effect

Taking it further by considering all of the exogenous factors, this study finds that none of the factors is common to both primary and secondary teacher cohorts. While primary teachers reveal significant influences from teacher gender, type of teaching position, teaching load, and ICT teaching specialisation, but not teaching experience, the secondary teacher model finds that only teaching experience is a significant influence.

Proposition 9: Schools differ in how effectively they integrate ICT into the curriculum and how integration influences students

With six schools involved in this study faced with the task of embedding ICT curriculum-wide, the question begs, which school is most effective and why? By drawing together the findings from the path and HLM models developed in Chapters 10 and 11, and considering these findings in the light of the schools and their responses in Chapters 7, 8, and 9, a definitive diagram summarising the main findings can be developed. Figure 12.6 presents the school-level factors influencing students' self-esteem, their direction of influence, indicated by a positive or negative sign, and the predominating school in each case. Teacher-related factors are represented as darker boxes, while student-related factors are represented by lighter-coloured boxes. As a measure of the effectiveness and extent of change within the school, students' self-esteem is considered, not in terms of the school with the highest average level of self-esteem, but as the school in which the greatest amount of change has occurred over the three-year period. Although all schools make some form of representation of an optimal environment, there are some schools that clearly dominate.

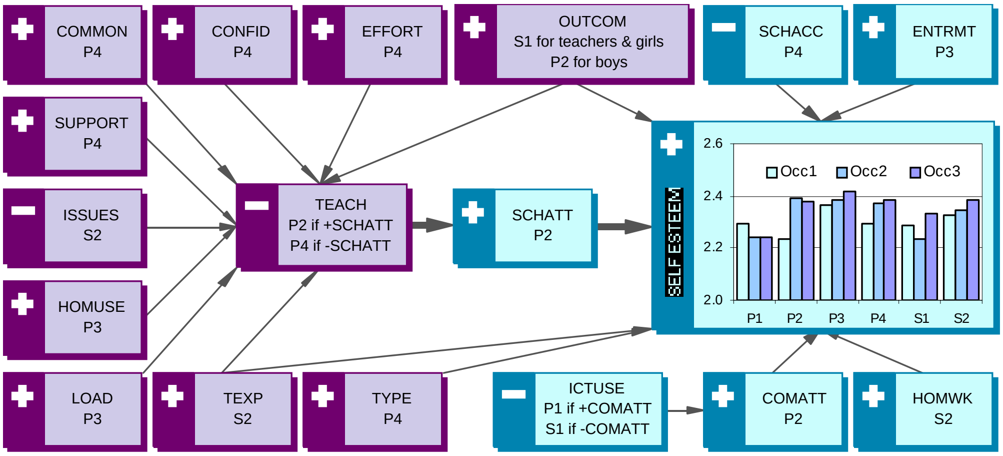


Figure 12.6 Teacher (darker-coloured boxes) and student (lighter-coloured boxes) factors influencing change in students' self-esteem over the three-year period (bar graph), their direction of influence (positive or negative), and the predominating school in each case (P1 to S2)

Explaining Figure 12.6 in detail, it can then be surmised that teachers' use of common ICT (COMMON), their level of confidence using ICT (CONFID), feeling supported by their school (SUPPORT), and their beliefs about the amount of effort students put into work when using ICT (EFFORT), are found to have a positive influence on their ICT-rich teaching practice (TEACH). In other words, teachers are more likely to adopt ICT-rich teaching practices if they regularly use mass-penetration technologies like television in their teaching, are confident ICT users who feel supported by their school, and believe students put more effort into work when using ICT. The school that reports the highest levels on these measures is primary school P4. In addition, schools with a higher proportion of full-time teachers (LOAD) who regularly use a computer at home (HOMUSE) are more likely to adopt ICT-rich teaching practices. Primary school P3 reports the highest proportion of full-time teachers and the greatest levels of home computer use. Another factor influencing teaching practice is teachers' beliefs about issues arising due to ICT integration (ISSUES). Indicated by the negative sign in this case, ICT-rich teaching practices increase as issues decline. Secondary school S2 optimised this factor by reporting the lowest levels of concern. Teaching experience (TEXP), also a significant positive influence on students' self-esteem, is best achieved in secondary school S2. The final factor influencing teaching practice, which is also found to influence students' self-esteem directly, is teachers' planned learning outcomes (OUTCOM). Due to an interaction effect it is found that secondary school S1, reporting the greatest proportion of teachers' who set higher-order learning objectives, is better for ICT-rich teaching practice and for girls' self-esteem. However, primary school P2, in which teachers mainly set lower-order objectives, provides an environment that is better for boys' self-esteem.

Although these nine factors are found to impact positively on ICT-rich teaching practice in schools, it is with some surprise, then, that ICT-rich teaching practice is found to have a negative impact on students' attitudes towards school. Hence, in

Figure 12.6, teaching practice (TEACH) is signified by a negative sign. Accordingly, students' with a positive attitude towards school, generally girls, are better off in a school with more traditional teaching practices. In this case, primary school P2 provides an optimal environment, since ICT-poor teaching practice is found to influence school attitude positively, which in turn positively influences self-esteem. As it happens, primary school P2 also reported the most positive attitudes towards school across the student sample and the greatest increase in students' self-esteem over the three-year period.

Figure 12.6 also presents the other six factors that are found to influence students' self-esteem directly or indirectly. Primary school P4 optimises two of these factors by having the greatest proportion of permanent teachers (TYPE) and the poorest perceived levels of computer access in school for students (SCHACC). Possibly as a reflection of an affluent community, primary school P3 excels on another factor by reporting the highest levels of entertainment technology access and usage (ENTRMT). Well known for its highly academic approach, secondary school S2 achieves the highest ranking on the amount of ICT-rich homework done by students (HOMWK). The last two factors that are found to influence students' self-esteem are those of students' use of ICT outside of school (ICTUSE) and attitudes towards computers (COMATT). Moreover, findings indicate that students' ICT use has a negative impact on their computer attitude. It is not surprising then that primary school P1, located in one of Adelaide's poorest suburbs, reports the lowest levels of students' out-of-school ICT use, ranking it as a better environment for promoting positive attitudes towards computers, while for students reporting poor computer attitudes secondary school S1 is better.

The school to report the highest levels of ICT-rich teaching practice is also the school that predominates in six of the 15 factors. Based on the measures selected for this study, primary school P4 demonstrates the widest integration of ICT across the curriculum. Yet, ranking as the most traditional in its teaching practice, primary school P2 provides an optimal environment for nurturing positive attitudes towards computers and towards school and presents the greatest increase in students' self-esteem. Based on these measures, primary school P2 demonstrates the most profound changes in students as a reflection of a changing environment over time. In response to the proposition then, schools clearly do differ in how effectively they integrate ICT into the curriculum and how this, in turn, influences students.

Proposition 10: School-wide adoption of ICT is change for the better

On the basis of whether school-wide adoption of ICT is a good thing, findings from this study, summarised in Figure 12.6, suggest that, for at-risk students, it is. This study establishes a strong positive relationship between students' attitudes towards school and their self-esteem. It also determines that an increasingly ICT-rich curriculum negatively influences students' attitudes towards school, and in turn, self-esteem. One possible explanation follows. In an increasingly ICT-rich learning environment, students are influenced by teachers' increased apprehension brought on by profound change – change within their school and to their teaching practices. For those students already with positive attitudes towards school, this change has a negative influence. In effect, the apprehension and uncertainty is passed on from teacher to student. Beresford (2000) provides a similar explanation:

> Where students are less clear about how they learn, they are more inclined to highlight personal shortcomings for their lack of success, which can impact upon both their motivation and their self-esteem as learners. (Beresford, 2000, p.4)

However, for those students already with negative attitudes towards school, seeing teachers out of their so-called 'comfort zone', and experiencing new and different ways of learning – this change has a positive influence on their attitudes towards school, and in turn, their self-esteem.

Accordingly, students considered to be at-risk with negative attitudes towards school, thus having a greater likelihood of low self-esteem, benefit from being in an increasingly ICT-rich learning environment. Although a more traditional teaching practice appears to support students' self-esteem, those students not considered at-risk with a positive attitude towards school, are less affected by an increasingly ICT-rich curriculum. In other words, the worst-case scenario for at-risk students, those having negative school attitude and low self-esteem, is an ICT-poor curriculum.

Meeting these considerations, primary school P4 provides greatest benefit to its students, but in particular, those considered at-risk. That this school, located in a low-socio-economic suburb characterised by high unemployment, still achieved the second highest increase in student self-esteem during the period (see Figure 12.6) is testimony to its success in undertaking school-wide adoption of ICT effectively.

Conclusions and Educational Implications

The broad aim of his study is to measure the impact that a changing school environment has on its students, and in particular, their self-esteem. This study has found that school-wide integration of ICT can promote significant changes in teaching practices and can have benefits for students, particularly those considered to be at-risk, in their attitudinal development. However, the findings are far more numerous than can be anticipated in the research propositions presented in Chapter 4 and addressed in the discussion of results. Therefore, in order to do justice to the depth and complexity of the study, a summary of the key research findings and their educational implications is listed. Accordingly, the major conclusions of this study, many of which are attributable to the school-wide adoption of ICT, include the following outcomes, not in any order of importance.

1. Changing what teachers understand as learning outcomes to be more broadly inclusive of affective outcomes such as improved motivation, self-esteem and changed attitudes towards school and computers is important in fostering an inclusive and supportive learning environment.
2. Teachers, particularly those in secondary school, need to be less resistant to change and more willing to embrace ICT-rich teaching practice. Moreover, effective integration of ICT in teaching practice requires a shift from teacher centred to student centred learning that promotes individual difference and need.
3. In order for teachers to embed ICT into the curriculum successfully, they require a computer with internet access for themselves with at least five computers in or near the classroom for their students, in addition to presentation software and data show facilities.
4. Teacher training needs to recognise the different needs of primary and secondary school teachers when developing their ICT skills and confidence. For primary school teachers, regular ICT tasks like managing files and searching the internet are important, whereas for secondary school teachers advanced administrative tasks are of additional importance. However, teachers' planned use of ICT in their teaching does not necessarily result in them having ICT-rich teaching practice.

5. Job security and in-school technical support are important factors, particularly in primary school, in encouraging teachers to own and use a home computer, and use mass-penetration ICT, like television and video players, within their teaching programs. The flow-on cyclical effect is that teachers become empowered, independent learners, better able to face the challenges and overcome issues arising from embedding ICT into their teaching practice. This in turn leads to increased confidence, the development of more challenging and inclusive curriculum, and further empowerment.

6. An increasingly ICT-rich learning environment benefits those students considered to be at-risk with negative attitudes towards school and low self-esteem. It also appears to be beneficial to girls, by potentially reducing the gender gap in which male students have traditionally maintained higher self-esteem.

7. Positive attitudes towards school and computers indicate a greater likelihood of positive self-esteem, and although integration of ICT significantly improves students' attitudes towards computers, it does not alter how students' attitudes towards school and computers influence self-esteem. In fact, as computers become the norm rather than a perceived highlight in daily school life, the influence of technology on students' attitude towards school diminishes.

8. Integration of ICT school-wide (for this study), increases computer usage during out-of-school hours by approximately 30 per cent in primary students and 25 per cent in secondary students, at the expense of time spent using entertainment technologies like television and radio. This better use of time has the potential to increase students' capacity through word-processing, drawing and presentation software to edit, revise, and ultimately produce higher quality work in a wider variety of formats. Students' academic efforts are further enhanced through a supportive school environment with good technical support and the experienced guidance of ICT specialist teachers.

9. Equitable home computer access and use becomes an issue of increasing importance as ICT are embedded in learning. Those students found to be at greatest risk of the so-called 'digital divide' are female and in primary school. Moreover, ICT-rich homework is beneficial to enhancing students' attitudes towards school, but particularly those of primary students.

10. At greatest risk of maintaining lower self-esteem, irrespective of the proliferation of ICT in learning, are female students from non-English speaking backgrounds in secondary schools with a large proportion of temporary and early-career teachers. This cohort of students is placed at further risk of declining self-esteem if the general school climate is optimistic, possibly due to a feeling of inadequacy in an environment where the general school atmosphere is positive.

11. School-wide adoption of ICT provides additional insight into understanding:
    a) the changing role that mass-penetration and entertainment technologies like music players and television play;
    b) the importance of moderating students' home usage of computer hardware and software;
    c) the positive impact of teacher permanency and experience;
    d) the benefits to girls' self-esteem of setting higher-order learning objectives, such as synthesising and presenting information, but at the risk of having a negative impact on boys' self-esteem; and

e) the value of promoting computers in schools as being a precious resource under high demand, but that the number of computers a school may or may not have for their students ultimately has little impact on self-esteem.

Clearly, all these outcomes have significant implications for creating a more diverse and inclusive ICT-rich curriculum that views the development of students, holistically, and recognises individual need and capacity.

Recommendations for Further Research

As with any study, there are design constraints, whether by choice or externally determined, that limit and focus the research. Furthermore, through reviewing the literature and conducting the research, in addition to addressing the research propositions, other shortcomings of the study emerge. Collectively, these limitations and delimitations serve as recommendations to inform future research. More importantly for this study, however, is that these recommendations address the final phase in DBRIEF (see Figure 3.7). The 'extended evaluation' phase of the DBRIEF cycle is designed to bring together the outcomes, findings and implications of the study in order to inform and promote ongoing research. Accordingly, some suggestions for further research are advanced.

Recommendation 1: Further testing of the path models

As useful and informative as the teacher and student path models are in this study, they may not be an accurate representation of the real world. In the models, each causal path is represented by an arrow and in actuality must be seen as a hypothesis. The causal links that are proposed in the model, and the model itself, must therefore be tested for adequacy. However, while the findings may support the acceptance of the model, they do not establish the truth of the model, and it must remain as adequate until a better explanatory model is proposed and tested.

Recommendation 2: Further model development using HLM

The focus of this study places students' self-esteem as the outcome variable in the HLM analysis. Clearly, there is additional understanding to be gained by developing alternative models that place students' attitudes towards computers and towards school as outcome variables. The richness of data also provides the opportunity to explore ICT-rich teaching practice by developing a two-level teacher model.

Recommendation 3: Follow-up study five years on

The three-year lifespan of this study was predetermined by the lifespan of the DECS*tech* Project, resulting in a longitudinal study that has yielded a rich tapestry of findings. However, to suggest that the schools undertaking this profound process of embedding ICT throughout the curriculum, actually achieved it in the three years, is likely to be unduly optimistic. Moreover, since each school participating in the study is autonomous in its decisions about undertaking the process of embedding ICT throughout the curriculum, the paths taken by each school to achieve this end are all different. Consequently, the degree and success of this adoption process cannot be measured directly or in an absolute way, and it may be that some schools changed very little over the time. Realistically, it is probably only now that the schools can claim to be effectively using ICT seamlessly in daily learning. What impact this has on teachers and students can make an important contribution as a follow-up study.

Recommendation 4: Analysis and comparison of the rural data

In addition to the six metropolitan schools participating in the project, three rural schools also responded to the annual questionnaires. However, due to the small samples, the data are not suitable for the statistical and modelling techniques employed for the metropolitan schools. Nonetheless, using methods appropriate for the data, analysis and comparison to the metropolitan data may yield valuable findings. A follow-up study in these remote schools can also be highly beneficial.

Recommendation 5: Studying the impact of ICT on junior primary and senior secondary students

This study is limited to those students in middle school, from Years 5 to 10. However, it does not mean that those students falling outside of this cohort are any less important. By targeting middle school students, both settings, primary and secondary, are involved in the study, maximising the transferability of results. However, by selecting schools in the public sector, only co-educational schools are involved, and there may be value in research conducted in private single-sex schools.

Recommendation 6: Further testing and refinement of DBRIEF as an effective educational research framework

At the heart of DBRIEF is the ‘enactment cycle’, where innovative programs of classroom intervention, such as the adoption of ICT in learning, are developed and evaluated in an iterative process of micro-cycles. Contextual factors along with teacher and student behaviours are measured to provide intermediate outcomes that support reflection and further development of proximal goals, and refinement of the intervention. Since it was not the focus of this study, no direct measures were made between teachers and students at the classroom level, nor of the specific ICT adoption processes undertaken in each school. Consequently, the potential of DBRIEF as a research framework, although conceptualised and proposed in this study, has not been fully tested and utilised.

Recommendation 7: Managing complex multi-level longitudinal data

This study poses many challenges in the collection and analysis of data, which operate at multiple levels and on multiple occasions, where appropriate methods of analysis are not widely known or well established. The management of these challenges, together with the practical and theoretical implications of the study, should re-inform original theory and design, with the underlying premise that change is sustainable and that innovation in classroom practice should be ever evolving. By doing so, this investigation provides a substantial and significant contribution to the field of educational innovation where research does inform practice.

References

Aaron, M. (2001). An exploration of the applicability and utility of fault tree analysis to the diffusion of technological innovation in educational systems. Unpublished doctoral dissertation. Concordia University, Montreal.

Aaron, M., Dicks, D., Ives, C. and Montgomery, B. (2004). Planning for integrating teaching technologies. *Canadian Journal of Learning and Technology*, 30 (2). [Online] http://www.cjlt.ca/content/vol30.2/cjlt30-2_art-3.html [8 September 2006].

Akbaba, S., and Kurubacak, G., (1998). Teachers' attitudes towards technology. In S. McNeil, J. D. Price, S. Boger-Mehall, B. Robin, and J. Willis (Eds), *Proceedings of the Society for Information Technology and Teacher Education 9th International Conference*. Charlottesville: Association for the Advancement of Computing in Education.

Alexander, S. (1995). Teaching and learning on the World Wide Web. *Proceedings of the AusWeb95 Conference*. [Online] http://www.scu.edu.au/ausweb95/papers/education2/alexander [30 November 2005].

Alexander, S. (1998). Internet-based teaching and learning: The past and the future. *Proceedings of University Science Teaching and the Web Workshop*, (pp.5-6), UniServe Science, Sydney April 1998. [Online] http://science.uniserve.edu.au/pubs/procs/wshop3/webws981.pdf [8 September 2006].

Alexiou-Ray, J.A., Wilson, E., Wright, V.H. and Peirano, A.M. (2003). Changing instructional practice: The impact of technology integration on students, parents, and school personnel. *Electronic Journal for the Integration of Technology in Education*, 2 (2). [Online] http://ejite.isu.edu/Volume2No2/AlexRay.htm [8 September 2006].

Amarasinghe, R. and Lambdin, D.V. (2000). Uses of computer technology in interdisciplinary mathematics learning. Paper presented at the *International Conference on Learning Technology*, Philadelphia, PA. [Online] http://l2l.org/iclt/2000/papers/185a.pdf [4 May 2000].

Anderson, J. (1984). Computing in schools: An Australian perspective. *Australian Education Review*, No. 21, ACER, Hawthorn.

Anderson, J. (1997). The Australian College of Education review: 1996 in retrospect (The Year of the Net). *Unicorn*, 23 (1), 3-15.

Anderson, J. (2005). IT, e-learning and teacher development. *International Education Journal*, 5 (5), 1-14. [Online] http://ehlt.flinders.edu.au/education/iej/articles/v5n5/anderson/paper.pdf [8 September 2006].

Anderson, L.W. (1999). *A revision of Bloom's taxonomy of educational objectives.* Seminar Hand-out, Flinders University, Adelaide.

Anderson, N., Baskin, C. and Halbert, M. (2002). Sustaining and supporting teacher professional development in ICT. *AARE*, Brisbane. [Online] http://www.aare.edu.au/02pap/and02399.htm [8 September 2006].

Arbuckle, J.L. and Wothke, W. (1999). *Amos.4 User's Guide*. Chicago: SmallWater Corporation.

Archer, L. (1999). Teachers' beliefs about successful teaching and learning in mathematics. *AARE Annual Conference Proceedings* [Online] http://www.swin.edu.au/aare/99pap/arc99491.htm [8 September 2006].

Ballard, A. (2001). Senior secondary IT programs in South Australia. *Australian Educational Computing*, 16 (1), 34-37. [Online] http://www.acce.edu.au/journal/journals/vol16_1.pdf [8 September 2006].

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. New York: Freeman.

Bannan-Ritland, B. (2003). The role of design in research: The integrative learning design framework. *Educational Researcher*, 32 (1), 21-24. [Online] http://www.aera.net/uploadedFiles/Journals_and_Publications/Journals/Educational_Researcher/3201/3201_Ritland.pdf [8 September 2006].

Barnes, A., Stewart, A., Filsell, J., Hazell, A. and Legge, W. (2001). *Embedding Learning Technologies in Teacher Practice: A Report on Innovations in the use of Learning Technologies by Teachers in the South Australian Discovery Schools*. Adelaide: DETE. [Online] http://www.education.unisa.edu.au/education/school/subjects/educ1066/Workshops/CaseStudies.pdf [8 September 2006].

Barrette, C.M. (2000). Preparing teachers for IT: Process, time and outcomes. *Compute-Ed*, 5. [Online] http://computed.coe.wayne.edu/Vol5/barrette.html [3 August 2000].

Bauder, D., Carr, D., Mullick, R. and Sarner, R. (1997). Making research count: Some guidelines for researchers. In J. Price, K. Rosa, S. McNeal and J. Willis (Eds), *Technology and Teacher Education Annual*. Charlottesville, VA: Association for the Advancement of Computing in Education.

Becker, H.J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research on Computing in Education*, 26(3), 291-321.

Becker, H.J. (2000). Findings from the Teaching, Learning, and Computing Survey: Is Larry Cuban right? *Education Policy Analysis Archives*, 8 (51). [Online] http://epaa.asu.edu/epaa/v8n51/ [8 September 2006].

Becker, H.J. and Riel, M.M. (1999). Teacher professionalism and the emergence of constructivist-compatible pedagogies. University of California, Irvine. Revised version of a paper presented at the *American Educational Research Association*, September 1999. [Online] http://www.crito.uci.edu/TLC/findings/special_report2/index.htm [8 September 2006]

Becker, H.J., Ravitz, J.L. and Wong, Y.T. (1999). Teaching and teacher-directed student use of computers and software. *Teaching, Learning and Computing 1998 National Survey: Report #3* [Online] http://www.crito.uci.edu/tlc/findings/computeruse/html/startpage.htm [8 September 2006].

Becta (2001). The 'Digital Divide': A discussion paper. Prepared for the DfES by the Evidence Team, Becta. Coventry, London: British Educational Communications and Technology Agency. [Online] http://www.becta.org.uk/research/reports/digidivide.html [8 September 2006].

Becta (2002). *Digital Divide: A collection of papers from the Toshiba/Becta Digital Divide Seminar*. February 2002. Coventry, London: British Educational Communications and Technology Agency. [Online] http://www.becta.org.uk/page_documents/research/digidivseminar.pdf [8 September 2006].

Becta (2003a). Identifying the Impact of ICT in Secondary Subjects. Coventry, London: British Educational Communications and Technology Agency. [Online] http://www.fischertrust.org/assets/ict/ConferenceReport_Final_2.doc [8 September 2006].

Becta (2003b). *Proving Effective Practice with ICT*. Summary report of the Becta 2003 Research conference. [Online] http://www.becta.org.uk/page_documents/research/conf2003/Conference2003Report.pdf [8 September 2006].

Becta (2004). Making a Difference with ICT in Primary Education. Coventry, London: British Educational Communications and Technology Agency. [Online] http://www.fischertrust.org/assets/ict/FinalConferenceReport.doc [8 September 2006].

Belanger, Y. (2000). Laptop computers in the K-12 classroom. ERIC Digest. [Online] http://www.ericdigests.org/2001-1/laptop.html [8 September 2006].

Bell, P. (2004). On the theoretical breadth of design-based research in education. *Educational Psychologist*, 39 (4), 243-253. [Draft Online] http://faculty.washington.edu/pbell/EPDBR_Bell.pdf [8 September 2006].

Bennett, D., Culp, K.M., Honey, M., Tally, B. and Spielvogel, B. (2000). It all depends: Strategies for designing technologies for education change. Paper presented at the *International Conference on Learning Technology*, Philadelphia, PA. [Online] http://l2l.org/iclt/2000/papers/265a.pdf [4 May 2000].

Beresford, J. (2000). Student perspectives on school improvement. Paper presented at the *British Educational Research Association Conference*, Cardiff University, September 7-10. [Online] http://www.leeds.ac.uk/educol/documents/00001529.doc [8 September 2006]

Bigatel, P.M. (2004). Exploring the beliefs and attitudes of exemplary technology-using teachers. Unpublished PhD Thesis. The Pennsylvania State University. [Online] http://etda.libraries.psu.edu/theses/approved/ WorldWideFiles/ETD-530/thesis.pdf [8 September 2006].

Biggs, J. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research and Development*, 8(1), 7-25.

Blackmore, J., Hardcastle, L., Bamblett, E. and Owens, J. (2003). Effective use of information and communication technology (ICT) to enhance learning for disadvantaged school students. Canberra: DEST. [Online] http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/documents/ictreport_pdf.htm [8 September 2006].

Blascovich, J. and Tomaka, J. (1991). Measures of self-esteem. In J.P. Robinson, P.R. Shaver and L.S. Wrightsman (Eds) *Measures of Personality and Social Psychological Attitudes, Volume I*. San Diego, CA: Academic Press.

Bloom, B.S. (1956). *Taxonomy of Educational Objectives*. McKay: New York.

Box, G.E.P. (1976). Science and statistics. *Journal of the American Statistical Association*, 71, 791-799.

Boyd, S. (2001a). Evaluating technology-rich ICT initiatives in schools: What does the literature tell us? A paper presented at the 23rd NZARE conference, Christchurch Polytechnic Institute of Technology, 6-9 December 2001. [Online] http://www.nzcer.org.nz/pdfs/10603.pdf [8 September 2006].

Boyd, S. (2001b). *Literature Review for the Digital Opportunities Projects*. Report to the Ministry of Education. Wellington: New Zealand Council for Educational Research. [Online] http://www.minedu.govt.nz/web/downloadable/dl6841_v1/digopps.pdf [8 September 2006].

Brand, G.A. (Winter 1997). What research says: Training teachers for using technology. *Journal of Staff Development*, 19 (1). [Online] http://www.nsdc.org/library/publications/jsd/brand191.cfm [8 September 2006].

Brick, J.M., Broene, P., James, P. and Severynse, J. (1997). *A User's Guide to WesVarPC*. Westat, Maryland: Rockville. [Online] http://www.westat.com/WESVAR/demo/downloads/weszip2.exe [8 September 2006].

Brick, J.M., Morganstein, D. and Valliant, R. (2000). *Analysis of Complex Samples Using Replication*. Westat, Maryland: Rockville. [Online] http://www.westat.com/WESVAR/techpapers/ACS-Replication.pdf [8 September 2006].

Brown, A.L. and Campione, J.C. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In R. Glaser (Ed.), *Innovations in learning: New Environments for Education*, (pp. 289–325). Mahwah, NJ: Erlbaum.

Brush, T. (1999). Technology planning and implementation in public schools: A five -state comparison. *Computers in Schools*, 15 (2), 11-23.

Bryk, A.S. and Raudenbush, S.W. (1992). *Hierarchical Linear Models*. Newbury Park, California: Sage.

Budin, H. (1999). The computer enters the classroom. *Teachers College Record*, 100 (3), 656-669. [Online] http://www.tcrecord.org/Content.asp?ContentID=10352 [8 September 2006].

Burnham, L., Miller, A. and Ray, L. (2000). Putting the pieces together. Paper presented at the *International Conference on Learning Technology*, Philadelphia, PA. [http://l2l.org/iclt/2000/papers/229a.pdf [4 May 2000].

Burns, R.B. (1998). *Introduction to Research Methods (3rd ed.).* Melbourne: Addison Wesley Longman.

Byrne, B.M. (2001). *Structural Equation Modeling With Amos*. New Jersey: Lawrence Erlbaum Associates.

California Department of Education (2004). The California K-12 education technology master plan: Recommendations. [Online] http://www.cde.ca.gov/la/et/rd/ctlmain.asp [8 September 2006].

Carr-Chellman, A.A. and Dyer, D. (2000). The pain and ecstasy: Pre-service teacher perceptions on changing teacher roles and technology. *Educational Technology and Society*, 3(2) [Online] http://ifets.massey.ac.nz/periodical/vol_2_2000/carr_chellman.html [8 September 2006].

Carroll, J.B. (1963). A model of school learning. *Teachers College Record*, 64, 723-733.

Cavanagh, R.F., Reynolds, P.S. and Romanoski, J.T. (2004). Information and communication technology learning in the classroom: The influence of students, the class-group, teachers and the home. Paper presented at the *2004 Annual Meeting of the Australian Association for Research in Education*: Melbourne. [Online] http://www.aare.edu.au/04pap/cav04445.pdf [8 September 2006].

Chalmers, C. and Price, P. (2000). Promoting gender equity in the information technology classroom. *Australian Educational Computing*, 15 (1), 13-16. [Online] http://www.acce.edu.au/journal/journals/vol15_1.pdf [8 September 2006].

Chavers, D. (Ed.) (1996). *Exemplary Programs in Indian education (2nd ed.)*. Albuquerque, New Mexico: Native American Scholarship Fund.

Christensen, R. (1998). Effects of technology integration education on the attitudes of teachers and their students. Unpublished Doctoral dissertation, University of North Texas, Denton. [Online] http://www.tcet.unt.edu/research/dissert/rhondac/index.htm [5 June 2000].

Clark, R.E. and Craig, T.G. (1992). Research and theory on multi-media learning effects. In M. Giardina (Ed.), *Interactive Multimedia Learning Environments: Human Factors and Technical Consideration*. New York: Springer-Verlag.

Clarke, B. (2001). Computer Studies in Western Australia. *Australian Educational Computing*, 16 (1), 48-50. [Online] http://www.acce.edu.au/journal/journals/vol16_1.pdf [8 September 2006].

Clarke, D.M. (1997). The changing role of the mathematics teacher. *Journal for Research in Mathematics Education*. 28 (3), 278-308.

Clarkson, B. (1998). 'I've never enjoyed teaching so much': Turning teachers on to learning technologies. In C. McBeath and R. Atkinson (Eds), *Planning for Progress, Partnership and Profit.* Proceedings of EdTech'98. Australian Society of Educational Technology. [Online] http://cleo.murdoch.edu.au/aset/confs/edtech98/pubs/articles/abcd/clarkson.html [7 June 2000].

Cobb, P., Confrey, J., diSessa, A., Lehrer, R. and Schauble, L. (2003). Design experiments in educational research. *Educational Researcher,* 32 (1), 9-13. [Online] http://www.aera.net/uploadedFiles/Journals_and_Publications/ Journals/Educational_Researcher/3201/3201_Cobb.pdf [8 September 2006].

Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112, 155-159.

Coley, R.J. (1997). Technology's Impact: A new study shows the effectiveness – and the limitations – of school technology. *Electronic School Online*, September: A30-A33. [Online] http://www.electronic-school.com/0997f3.html [8 September 2006].

Collins, A. (1991). The role of computer technology in restructuring schools. *Phi Delta Kappan*, 73, 28-35.

Confrey, J., Piliero, S.C., Rizzuti, J.M. and Smith, E. (1990). *High School Mathematics: Development of Teacher Knowledge and Implementation of Problem-Based Mathematics Curriculum using Multi-Representational Software*. ACOT, Report #11. California: Apple Computer. [Online] http://www.apple.com/education/k12/leadership/acot/library.html [8 September 2006].

Connell, M.L. (1997). Technology in constructivist mathematics classrooms. In J. Price, K. Rosa, S. McNeal and J. Willis (Eds), *Technology and Teacher Education Annual*, (pp.601-604). Charlottesville, VA: Association for the Advancement of Computing in Education.

Constantine, L.L. and Lockwood, L.A. (1999). *Software for Use: A Practical Guide to the Models and Methods of Usage-Centered Design*. Boston: Addison Wesley Professional.

Coopersmith, S. (1967). *The Antecedents of Self-Esteem*. San Francisco, CA: W.H. Freeman.

Coopersmith, S. (1986). *Self-Esteem Inventories*. New York: Consulting Psychologists Press.

Cox, M., Preston, C. and Cox, K. (1999a). What factors support or prevent teachers from using ICT in their classrooms? Paper presented at the British Educational Research Association Annual Conference. *Education-line* [Online] http://www.leeds.ac.uk/educol/documents/00001304.htm [8 September 2006].

Cox, M., Preston, C. and Cox, K. (1999b). What motivates teachers to use ICT? Paper presented at the British Educational Research Association Annual Conference. *Education-line* [Online] http://www.leeds.ac.uk/educol/documents/00001329.htm [8 September 2006].

Cox, M., Webb, M., Abbott, C., Blakeley, B., Beauchamp, T. and Rhodes, V. (2003). ICT and pedagogy: A review of the research literature. *ICT in Schools Research and Evaluation Series*, No.18. London: Becta.

Cradler, J. (1994). Summary of current research and evaluation findings on technology in education. Far West Laboratory, California. [Online] http://www.wested.org/techpolicy/refind.html [8 September 2006].

Crichton, S. and Kinsel, E. (2000). Communities in transition technology as a catalyst for change. Paper presented at the *International Conference on Learning Technology*, Philadelphia, PA. [Online] http://l2l.org/iclt/2000/papers/179a.pdf [8 September 2006].

Crook, C. (2001). Information and communication technologies in the A.C.T. *Australian Educational Computing*, 16 (1), 20-23. [Online] http://www.acce.edu.au/journal/journals/vol16_1.pdf [8 September 2006].

Cruickshank, D. (1985). Profile of an effective teacher. *Educational Horizons*, Winter, 90-92.

Cuttance, P. (2001). *School Innovation: Pathway to the Knowledge Society*. Canberra: DETYA. [Online] http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/school_innovation.htm [8 September 2006].

Cuttance, P. and Stokes, S. (2000). Monitoring progress towards the National Goals for Schooling: Information and communication technology (ICT) skills and knowledge - Report to the NEPMT. [Online] http://www.mceetya.edu.au/mceetya/default.asp?id=11971 [8 September 2006].

Czernezkyj, V., Fagan, K., Forster, M., Littler, M., Richards, A., and Watkins, Rhyll. (2001). Computing Studies in N.T. secondary schools. *Australian Educational Computing*, 16 (1), 24-27. [Online] http://www.acce.edu.au/journal/journals/vol16_1.pdf [8 September 2006].

Czerniak, C.M., Lumpe, A.T., Haney, J.J. and Beck, J. (1999). Teachers' beliefs about using educational technology in the science classroom. *International Journal of Educational Technology*, 1(2) [Online] http://www.ao.uiuc.edu/ijet/v1n2/czerniak/ [8 September 2006].

Darmawan, I.G.N. (2002). NORM software review: Handling missing values with multiple imputation methods. *Evaluation Journal of Australasia*, 2 (1), 20-24.

Dawes, L. (2001). What stops teachers using new technology? In M. Leask (Ed.), *Issues in Teaching Using ICT*, (pp. 61-79). London: Routledge.

Dawson, K.M. (1998). Factors influencing elementary teachers' instructional use of computers. In S. McNeil, J. D. Price, S. Boger-Mehall, B. Robin, and J. Willis (Eds), *Proceedings of the Society for In formation Technology and Teacher Education 9th International Conference*. Charlottesville: Association for the Advancement of Computing in Education.

Deacon, C.R. (1999). The effect of computer access and subject area on the level of teacher implementation of technology. Unpublished ED.D Thesis, Seton Hall University, United States.

Deaudelin, C., Dussault, M. and Brodeur, M. (2003). Human-computer interaction: A review of the research on its affective and social aspects. *Canadian Journal of Learning and Technology*, 29 (1). [Online] http://www.cjlt.ca/content/vol29.1/05_deaudelin_etal.html [8 September 2006].

Derewetzky, S. (1992). *Project Compugrafia.LEP. Final Evaluation Profile 1991–1992*. Brooklyn, New York: Office of Research, Evaluation, and Assessment, New York City Board of Education.

Design-Based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32 (1), 5-8. [Online] http://www.aera.net/uploadedFiles/Journals_and_Publications/ Journals/Educational_Researcher/3201/3201_DesignCollective.pdf [8 September 2006].

DETE (1999). *Learning Futures: DECStech 1997-2001 Making Connections*. Department of Education, Training and Employment. Adelaide, South Australia. [Online] http://www.decstech.nexus.edu.au/learn.htm [9 November 1999].

DETE (2001). *South Australian Curriculum, Standards and Accountability (SACSA) Framework*. Adelaide: South Australian Department of Education, Training and Employment (DETE).

DETYA (2001). Information and communication technology for teaching and learning. Department of Education, Training and Youth Affairs. *Schooling Issues Digest.* [Online] http://www.dest.gov.au/NR/rdonlyres/C251724A-1E09-4954-BFBE-FDA5836375E3/4508/technology.pdf [8 September 2006].

Dexter, S., Anderson, R.E. and Becker, H.J. (1999). Teachers' views of computers as catalysts for changes in their teaching practice. *Journal of Research on Computing in Education*, 31 (3), 221-239.

Dick, W. and Carey, L. (1990). *The Systematic Design of Instruction*. Glenview, IL: Scott, Foresman/Little.

Dirksen, D.J. and Tharp, D. (1997). Utilizing the concerns-based adoption model to facilitate systemic change. In J. Price, K. Rosa, S. McNeal and J. Willis (Eds), *Technology and Teacher Education Annual*, (pp.1064-1067). Charlottesville, VA: Association for the Advancement of Computing in Education.

Dix, K.L. (1999). Enhanced mathematics learning: Does technology make a difference? *Proceeding of the Twenty-second Annual Conference of the Mathematics Education Research Group of Australasia*, Adelaide, 192-199.

Dix, K.L. (2005). Are learning technologies making a difference? A longitudinal perspective of attitudes. *International Education Journal*, 5 (5), 15-28. [Online] http://ehlt.flinders.edu.au/education/iej/articles/v5n5/dix/paper.pdf [8 September 2006].

Dix, K.L. (2007). A longitudinal study examining the impact of ICT adoption on students and teachers. Unpublished PhD thesis. Flinders University: Adelaide.

Dix, K.L. and Anderson, J. (2000). Distance no longer a barrier: Using the internet as a survey tool in educational research. *International Education Journal*, 1 (2), 83-93. [Online] http://ehlt.flinders.edu.au/education/iej/articles/v1n2/ dix/dix.pdf [8 September 2006].

Dooley, K.E. (1999). Towards a holistic model for the diffusion of educational technologies: An integrative review of educational innovation studies. *Educational Technology and Society*, 2(4) [Online] http://ifets.massey.ac.nz/periodical/vol_4_99/kim_dooley.html [8 September 2006].

Dooley, L.M., Metcalf, T. and Martinez, A. (1999). A study of the adoption of computer technology by teachers. *Educational Technology and Society*, 2(4) [Online] http://ifets.massey.ac.nz/periodical/vol_4_99/ldooley.html [8 September 2006].

Downes, T., Fluck, A., Gibbons, P., Leonard, R., Matthews, C., Oliver, R., Vickers, M. and Williams, M. (2001). *Models of Teacher Professional Development for the Integration of ICT into Classroom Practice*. DETYA funded project. [Online] http://www.acce.edu.au/documents/store/1/ReportV4.doc [8 September 2006].

Dwyer, D., Ringstaff, C. and Sandholtz, J. (1992a). *Teacher Beliefs and Practices Part 1: Patterns of Change*. The evolution of teachers' instructional beliefs and practices in high-access-to-technology classrooms first - fourth year findings. ACOT Report #8. California: Apple Computer. [Online] http://www.apple.com/education/k12/leadership/acot/library.html [8 September 2006].

Dwyer, D., Ringstaff, C. and Sandholtz, J. (1992b). *Teacher Beliefs and Practices Part II: Support for Change*. The evolution of teachers' instructional beliefs and practices in high-access-to-technology classrooms first - fourth year findings. ACOT Report #9. California: Apple Computer. [Online] http://www.apple.com/education/k12/leadership/acot/library.html [8 September 2006].

Dwyer, D., Ringstaff, C. and Sandholtz, J.H. (1991) Changes in teachers' beliefs and practices in technology rich classrooms. *Educational Leadership*, 48(8), 45-52.

EdNA (2000). *Learning in an Online World, School Education Action Plan for the Information Economy*. Adelaide: Education Network Australia Schools Advisory Group. [Online] http://www.edna.edu.au/edna/file12665 [8 September 2006].

Education Information Center (1998). Is computer technology improving student achievement? [Online] http://www.ohioeic.org/computertechsept.html [19 September 2000].

Education Victoria (1998). *Learning Technologies in Victorian Schools: 1998-2001*. Community Information Service, Department of Education, Victoria.

Education Victoria (1998). *Rethinking Learning and Teaching: The Navigator Schools' Experience - Report 1 July 1998*. Victoria: Department of Education. [Online] http://www.sofweb.vic.edu.au/ict/research/navschls.htm [8 September 2006].

Edwards, B.S. (2000). The challenges of implementing innovation. *The Mathematics Teacher*, 93, 777-781.

Ehrenberg, R.G, Goldhaber, D.D, and Brewer, D.J. (1995). Do teachers' race, gender, and ethnicity matter? Evidence from the National Educational Longitudinal Study of 1988. *Industrial and Labor Relations Review*, 48 (3), 547-561.

Eng, T.S. (2005). The impact of ICT on learning: A review of research. *International Education Journal*, 6 (5), 635-650.

Entwistle, N. and Ramsden, P. (1983). *Understanding Student Learning*. London: Croom Helm.

Ferguson, G.A. and Takane, Y. (1989). *Statistical Analysis in Psychology and Education* (6th ed.). New York: McGraw Hill.

Filsell, J. and Barnes, A. (2002). Researching pedagogy and teaching methodologies that transform student learning in South Australian classrooms. In A. McDougall, J. Murnane and D. Chambers (Eds), *Proceedings of the WCCE2001 Australian Topics: Selected Papers from the Seventh World Conference on Computers in Education*, (pp.23-30). Copenhagen, Denmark: CRPIT, 8. [Online] http://crpit.com/confpapers/CRPITV8Filsell.pdf [8 September 2006].

Fisher, D. and Stolarchuk, E. (1998). The effect of using laptop computers on achievement, attitude to science and classroom environment in science. *Proceedings Western Australian Institute for Educational Research Forum 1998*. [Online] http://education.curtin.edu.au/waier/forums/1998/fisher.html [8 September 2006].

Fisher, S.C. and Dove, M.K. (1999). Muffled voices: Teachers' concerns regarding technological change. In J.D. Price, J. Willis, D.A. Willis, M. Jost, and S. Boger-Mehall, (Eds) *Proceedings of SITE 99*, (pp.1338-1343). The 10th International Conference of the Society for Information Technology and Teacher Education. Charlottesville, VA: Association for the Advancement of Computing in Education.

Forbes, S. (2005). Potential uses of longitudinal analyses to investigate education outcomes. *International Statistical Institute*, 55th Session. [Online] http://www.stat.auckland.ac.nz/~iase/publications/13/Forbes.pdf [8 September 2006].

Fouts, J.T. (2000). Research on computers and education: Past, present, and future. A report to the Bill and Melinda Gates Foundation. Seattle: Seattle Pacific University. [Online] http://www.esd189.org/tlp/documents/TotalReport3.pdf [8 September 2006].

Fuchs, T. and Wößmann, L. (2005). Computers and student learning: Bivariate and multivariate evidence on the availability and use of computers at home and at school. [Online] http://www.cesifo.de/pls/guest/download/Ifo%20Working%20Papers%20(seit%202005)/IfoWorkingPaper-8.pdf [8 September 2006].

Fullan, M.G. (1991). *The New Meaning of Educational Change*. New York: Teachers College Press.

Fuller, H.L. (2000). First teach the teachers: Technology support and computer use in academic subjects. *Journal of Research on Computing in Education*, 32 (4), 511-537.

Fulton, K. and Torney-Purta, J. (2000). How teachers beliefs about teaching and learning are reflected in their use of technology: Case studies from urban middle schools. Paper presented at the *International Conference on Learning Technology*, Philadelphia, PA. [Online] http://l2l.org/iclt/2000/papers/126a.pdf [4 June 2000].

Gage, N. and Berliner, D. (1992). *Educational Psychology (5th ed.).* Princeton, New Jersey: Houghton Mifflin.

Galbraith, P. and Haines, C. (1998). Disentangling the nexus: Attitudes to mathematics and technology in a computer learning environment. *Educational Studies in Mathematics*. 36, 275-290.

Galloway, J.P. (1997). How teachers use and learn to use computers. In J. Price, K. Rosa, S. McNeal and J. Willis (Eds), *Technology and Teacher Education Annual*, (pp.857-859). Charlottesville, VA: Association for the Advancement of Computing in Education.

Giddens, A. (1984). *The Constitution of Society*. Cambridge: Polity Press.

Glennan, T.K. (1998). *Elements of a National Strategy to Foster Effective Use of Technology in Elementary and Secondary Education*. A RAND Report. Santa Monica, CA: RAND. [Online] http://www.rand.org/pubs/testimonies/2005/CT145.pdf [8 September 2006].

Goddard, M. (2002). What do we do with these computers? Reflections on technology in the classroom. *Journal of Research on Technology in Education*, 35(1), 19-26. [Online] http://www.iste.org/Content/NavigationMenu/Publications/JRTE/Issues/Volume_351/Number_1_Fall_20021/Number_1_Fall_2002.htm [8 September 2006].

Godfrey, C. (2001a). Computer technologies: Scaffolding tools for teaching and learning. *Australian Educational Computing*, 16 (2), 27-29. [Online] http://www.acce.edu.au/journal/journals/vol16_2.pdf [8 September 2006].

Godfrey, C. (2001b). Computers in schools: Changing pedagogies. *Australian Educational Computing*, 16 (2), 14-17. [Online] http://www.acce.edu.au/journal/journals/vol16_2.pdf [8 September 2006].

Gould, E.W., Gurevich, M. and Pagerey, P.D. (1998). Conducting surveys over the World Wide Web. *Society for Technical Communication 45th Annual Conference Proceedings*, (pp.294-297). [Online] http://www.stc.org/confproceed/1998/PDFs/00037.PDF [8 September 2006].

Haertel, G. and Means, B. (2004). Evaluation strategies to support policymaking in learning technology. *The Evaluation Exchange*, IX (4). [Online] http://www.gse.harvard.edu/hfrp/eval/issue24/spotlight.html [8 September 2006].

Hair, J.F., Anderson, R.E., Tatham, R.L. and William, C. (1995). *Multivariate Data Analysis with Readings*. Englewood Cliffs, NJ: Prentice Hall.

Halsall, R. (1998). *Teacher Research and School Improvement: Opening Doors from the Inside*. Buckingham: Open University press.

Handal, B. and Herrington, A. (2003). Re-examining categories of computer-based learning in mathematics education. *Contemporary Issues in Technology and Teacher Educatio*n, 3(3), 275-287. [Online] http://www.citejournal.org/articles/v3i3mathematics1.pdf [8 September 2006].

Hannay, L.M. and Ross, J.A. (1997). Initiating secondary school reform: The dynamic relationship between restructuring, reculturing, and retiming. *Educational Administration Quarterly*, 33 (Suppl.), 576–603.

Harasim, L., Hiltz, S.R., Teles, L. and Turoff, M. (1995). *Learning Networks: A Field Guide to Teaching and Learning Online*. Cambridge, Mass: The MIT Press.

Harris, A. and Bennett, N. (2001). *School Effectiveness and Improvement: Alternative Perspectives*. London: Continuum.

Hennessy, S. and Deaney, R. (2004). *Sustainability and Evolution of ICT-supported Classroom Practice*. Final Report for Becta. Coventry: Becta. [Online] http://www.educ.cam.ac.uk/istl/SAE043.pdf [8 September 2006].

Hooper, S. and Rieber, L. P. (1995). Teaching with technology. In A.C. Ornstein (Ed.), *Teaching: Theory into Practice*. Needham Heights, MA: Allyn and Bacon.

Housego, S. and Freeman, M. (2000). Case studies: Integrating the use of web based learning systems into student learning. *Australian Journal of Educational Technology*, 16(3), 258-282. [Online] http://www.ascilite.org.au/ajet/ajet16/housego.html [8 September 2006].

Huitt, W. (2003). A transactional model of the teaching/learning process. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. [Online] http://chiron.valdosta.edu/whuitt/materials/tchlrnmd.html [8 September 2006].

Indiana Department of Education (2002). *Instructional Technology Projects*. Indiana: Office of Learning Resources. [Online] http://doe.state.in.us/olr/projects.html [8 September 2006].

Isaac, S. and Michael, W.B. (1990). *Handbook in Research and Evaluation: A Collection of Principles, Methods and Strategies Useful in the Planning, Design and Evaluation of Studies in Education and the Behavioral Sciences*. San Diego, CA: EdITs.

Janssen-Reinen, I. and Plomp, T. (1997). Information technology and gender equality: A contradiction in terminis? *Computers and Education*, 28 (2), 65-78.

Johnson-Gentile, K., Lonberger, R., Parana, J. and West, A. (2000). Preparing Preservice Teachers for the Technological Classroom: A School-College Partnership. *Journal of Technology and Teacher Education*, 8 (2), 97-11.

Jolly, D. and Deloney, P. (1996). Integrating rural school and community development: An initial examination. Paper presented at the Annual Conference of the National Rural Education Association, San Antonio, Texas, 11–14 October.

Jones, T. and Clarke, V.A. (1994). A computer attitude scale for secondary students. *Computers in Education*, 22 (4), 315-318.

Jones, T.H. and Paolucci, R. (1997). Putting educational technology in perspective: The question of learning effectiveness. *Proceedings of 8th International Conference of the Society for Information Technology and Teacher Education (SITE '97).*

Jones, T.H. and Paolucci, R. (1998). A research framework for investigating the effectiveness of technology in educational outcomes. In S. McNeil, J. D. Price, S. Boger-Mehall, B. Robin, and J. Willis (Eds), *Proceedings of the Society for Information Technology and Teacher Education 9th International Conference*. Charlottesville: Association for the Advancement of Computing in Education.

Keeves, J.P. (1974) *Some Attitude Scales for Educational Research Purposes.* Home Environment and School Study ACER Report, Melbourne: ACER.

Keeves, J.P. (1988a). Path analysis. In J.P. Keeves (Ed.) *Educational Research, Methodology and Measurement: An International Handbook,* (pp.723-731). Oxford: Pergamon.

Keeves, J.P. (1997). Models and model building. In J.P. Keeves (Ed.) *Educational Research, Methodology and Measurement: An International Handbook (2nd ed.),* (pp.386-394). Oxford: Pergamon.

Keeves, J.P. (2003). Design-based research. In J.P. Keeves, *Research Design and Evaluation*. Unpublished paper, Flinders University of South Australia, Adelaide. [Online] http://dev1.sturt.flinders.edu.au/ResearchDesign/presentasi/Design-Based%20Research_files/frame.htm [8 September 2006].

Keeves, J.P. (Ed.) (1986). Aspiration, motivation and achievement: Different methods of analysis and different results. *International Journal of Educational Research*, 10, 115-243.

Keeves, J.P. (Ed.) (1988b). *Educational Research, Methodology and Measurement: An International Handbook.* Oxford: Pergamon.

Kelly, A.E. (2003). Research as design. *Educational Researcher,* 32 (1), 3-4. [Online] http://www.aera.net/uploadedFiles/Journals_and_Publications/ Journals/Educational_Researcher/3201/3201_Kelly.pdf [8 September 2006].

Kimble, C. (1999). The impact of technology on learning: Making sense of the research [policy brief]. Aurora, CO: Mid-continent Regional Educational Laboratory. [Online] http://www.mcrel.org/PDF/PolicyBriefs/5983PI_PBImpactTechnology.pdf [8 September 2006].

Kline, R.B. (1998). *Principles and Practice of Structural Equation Modelling.* New York: Guilford Press.

Kulik, J.A. (1994). Meta-analytic studies of findings on computer-based instruction. In E.L. Baker and H.F. O'Neil (Eds) *Technology Assessment in Education and Training*. Hillsdale, N.J.: Lawrence Erlbaum.

Kulik, J.A., Bangert, R.L. and Williams, G.W. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology,* 75, 19-26.

Lagemann, E.C. (2002). *Usable Knowledge in Education: A Memorandum for the Spencer Foundation Board of Directors*. Chicago: Spencer Foundation. [Online] http://www.spencer.org/publications/usable_knowledge_report_ecl_a.htm [8 September 2006].

Lattimore, R. (1999). A note on the effective implementation of technology within the mathematics classroom. *Compute-Ed,* 5. [Online] http://computed.coe.wayne.edu/Vol5/Lattimore.html [4 August 2000].

Leggett, W.P. and Persichitte, K.A. (1998). Blood, sweat, and TEARS: 50 years of technology implementation obstacles. *Techtrends*, 43(3), 33-39.

Leonard, C., Bourke, S. and Schofield, N. (2004). Affecting the affective: Affective outcomes in the context of school effectiveness, school improvement and quality schools. *Issues in Educational Research*, 14(1), 1-28. [Online] http://education.curtin.edu.au/iier/iier14/leonard.html [8 September 2006].

Levine, T. and Donitsa-Schmidt, S. (1998). Computer use, confidence, attitudes, and knowledge: A causal analysis. *Computers in Human Behavior*, 14(1), 125-146.

Liao, Y. (1999). Gender differences on attitudes toward computers: A meta-analysis. In J.D. Price, J. Willis, D.A. Willis, M. Jost, and S. Boger-Mehall, (Eds) *Proceedings of SITE 99,* (pp.1388-1393). The 10th International Conference of the Society for Information Technology and Teacher Education. Charlottesville, VA: Association for the Advancement of Computing in Education.

Lietz, P., Miller, L. and Kotte, D. (2002). On decreasing gender differences and attitudinal changes: Factors influencing Australian and English pupils' choice of a career in science. *Psychology, Evolution and Gender,* 4 (1), 69-92.

Linn, M.C. and Hsi, S. (2000). *Computers, Teachers, Peers: Science Learning Partners*. Mahwah, NJ: Erlbaum.

Little, R.J.A. and Rubin, D.B. (1987). *Statistical Analysis with Missing Data.* New York: John Wiley.

Lupton, P.A. (1996). Factors influencing the integration of information technology into queensland's larger state primary schools. Unpublished Masters Thesis, University of New England.

Lynch, J. (1999). Introducing internet technologies: A study in four Victorian state secondary schools. *AARE Annual Conference Proceedings* [Online] http://www.aare.edu.au/99pap/lyn99492.htm [November 5, 2005].

MacDonald, R. (2005). What Counts as Information Communication Technology Integration? Toward a Better Theoretical Framework for Technology Integration. In P.L. Jeffery (Ed.) *Proceedings of the AARE International Education Research Conference 2004*. Melbourne: Australian Association for Research in Education. [Online] http://www.aare.edu.au/04pap/mac04222.pdf [November 4, 2005].

Machnaik, J. (2002). Investigating the effect(s) of technology integration on teaching practices that may lead to the development of a community of learners. *Occasional Papers in Educational Technology*. Educational Communications and Technology Program, University of Saskatchewan. [Online] http://www.usask.ca/education/coursework/802papers/machnaik/machnaik.pdf [November 8, 2005].

Macmillan, R.B., Timmons, V., and Liu, X. (1997). Teachers, computers, and the internet: The first stage of a community-initiated project for the integration of technology into the curriculum. *Alberta Journal of Educational Research*, 43 (4), 222-234.

Mandinach, E.B. and Cline, H.F. (1997). Methodological implications for examining the impact of technology-based innovations: The corruption of a research design. A paper presented at the annual meeting of the *American Educational Research Association.*

Marcinkiewicz, H.R. (1994). Computers and teachers: Factors influencing computer use in the classroom. *Journal of Research on Computing in Education,* 26(2), 220-237.

Marsh, H.W. (1986). Verbal and math self-concepts: An internal/external frame of reference model. *American Educational Research Journal,* 23, 129-149.

Maruyama, G. (1998). *Basics of Structural Equation Modeling*. London: Sage.

McDougall, A. (2001). Issues and challenges in information technology education in Australian schools. *Australian Educational Computing*, 16 (1), 18-19. [Online] http://www.acce.edu.au/journal/journals/vol16_1.pdf [8 September 2006].

MCEETYA (2003). *Learning in an Online World: Research Strategy*. Canberra: Ministerial Council for Education, Employment, Training and Youth Affairs. [Online] http://www.mceetya.edu.au/pdf/16aagenda.pdf [8 September 2006].

MCEETYA and EdNA (2001). *Learning in an Online World: The School Education Action Plan for the Information Economy*. Progress report 2001. Canberra: Ministerial Council for Education, Employment, Training and Youth Affairs. [Online] http://www.edna.edu.au/edna/file12663 [8 September 2006].

McIlrath, D. and Huitt, W. (December, 1995). The teaching/learning process: A discussion of models. Discussion paper. Valdosta, GA: Valdosta State University. [Online] http://chiron.valdosta.edu/whuitt/papers/modeltch.html [8 September 2006].

Meece, J.L. and Miller, S.D. (1996). Developmental changes in children's self-reports of achievement goals, competence, and strategy use during the late elementary years. Paper presented at *AERA Annual Conference*, New York.

Meredyth, D., Russell, N., Blackwood, L., Thomas, J. and Wise, P. (1999) *Real Time: Computers, Change and Schooling.* Canberra: Australian Key Centre for Cultural and Media Policy. [Online] http://www.dest.gov.au/archive/schools/publications/1999/realtime.pdf [8 September 2006].

Microsoft (2000). *Microsoft Excel for Windows*. Redmond, Washington: Microsoft Corporation.

Millea, J., Green, I. and Putland, G. (2005). *Emerging Technologies: A Framework For Thinking*. Canberra: ACT DET. [Online] http://www.det.act.gov.au/publicat/pdf/emergingtechnologies.pdf [8 September 2006].

Mok, M. and Flynn, M. (1997). Does school size affect quality of school life? *Issues in Educational Research*, 7(1), 69-86. [Online] http://education.curtin.edu.au/iier/iier7/mok.html [8 September 2006].

Moran, L., Thompson, L. and Arthur, P. (1999). *Strategic Analysis: Improving Teaching and Learning in Australian School Education Through the use of Information and Communications Technologies*. Paper for the EdNA Advisory Group. Curtin, ACT: Lifelong Learning Associates. [Online] http://www.edna.edu.au/edna/system/llreport/home.html [5 June 2000].

Morganstein, D., and Brick, J.M. (1996). WesVarPC: Software for computing variance estimates from complex designs. *Proceedings of the 1996 Annual Research Conference, Bureau of the Census*, pp. 861-866. [Online] http://www.census.gov/prod/2/gen/96arc/xbbrick.pdf. [8 September 2006].

Moseley, D., Higgins, S., Bramald, R., Hardman, F., Miller, J., Mroz, M., Tse, H., Newton, D., Thompson, I., Williamson, J., Hallian, J., Bramald, S., Newton, L., Tymms, P., Henderson, B. and Stout, J. (1999). Ways forward with ICT: Effective pedagogy using information and communication technology for literacy and numeracy in primary schools. *Education-line* [Online] http://www.leeds.ac.uk/educol/documents/00001369.htm [8 September 2006].

Moundridou, M. and Virvou, M. (2002). Evaluating the persona effect of an interface agent in a tutoring system. *Journal of Computer Assisted Learning*, 18 (3), 253-261.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Journal of Information Technology for Teacher Education*, 9 (3), 319-341.

Nash, J.B. and Moroz, P.A. (1997). An examination of the factor structures of the Computer Attitude Scale. *Journal of Educational Computing Research*, 17(4), 341-356.

National Research Council. (2002). Scientific research in education. In R.J. Shavelson and L. Towne (Eds) *Committee on Scientific Principles for Education Research*. Washington, DC: National Academy Press.

Newhouse, P. (1998). A model to assist in the understanding of teachers' responses to high access computing environments. *Proceedings Western Australian Institute for Educational Research Forum 1998*. [Online] http://education.curtin.edu.au/waier/forums/1998/newhouse.html [8 September 2006].

Noeth, R.J. and Volkov, B.B. (2004). *Evaluating the Effectiveness of Technology in our Schools*. ACT Policy Report. Iowa: American College Testing. [Online] www.act.org/path/policy/pdf/school_tech.pdf [8 September 2006].

Noonan, R.D. and Wold, H. (1988). Partial least square path analysis. In J.P. Keeves (Ed.) *Educational Research, Methodology, and Measurement: An International Handbook*, (pp.710-716). Oxford, Pergamon.

Noonan, R.D. and Wold, H. (1988). Partial least square path analysis. In J.P. Keeves (Ed.) *Educational Research, Methodology and Measurement: An International Handbook*, (pp.710-716). Oxford: Pergamon.

Norton, S. (1999). Secondary mathematics teachers' responses to computers and their beliefs about the role of computers in their teaching. *MERGA 22 Conference Proceedings*, 404-410.

OECD. (2004). *Learning for Tomorrow's World: First Results from PISA 2003.* Organisation for Economic Co-operation and Development. [Online] http://www.pisa.oecd.org/dataoecd/1/60/34002216.pdf [8 September 2006].

OECD. (2006). *Are Students Ready for a Technology-Rich World?: What PISA Studies Tell Us.* Organisation for Economic Co-operation and Development. [Online] http://www.pisa.oecd.org/dataoecd/28/4/35995145.pdf [8 September 2006].

Orrill, C.H. (2001). Building technology-based, learner-centered classrooms: The evolution of a professional development framework. *Educational Technology Research and Development*, 49(1), 15-34. [Online] http://www.designbasedresearch.org/reppubs/orrillpaper.pdf [8 September 2006].

Pajares, F. and Schunk, D.H. (2001). Self-beliefs and school success: Self-efficacy, self-concept, and school achievement. In R. Riding and S. Rayner (Eds), *Perception* (pp. 239-266). London: Ablex Publishing.

Pajares, M.F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62, 307-332.

Pallant, J. (2001). *SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS.* New South Wales: Allen and Unwin.

Pan, A.C. (1998). A need for technology-based teacher research. In S. McNeil, J. D. Price, S. Boger-Mehall, B. Robin, and J. Willis (Eds), *Proceedings of the Society for Information Technology and Teacher Education 9th International Conference*, (pp.867-870). Charlottesville: Association for the Advancement of Computing in Education.

Papert, S. (1980). *Mindstorms: Children, Computers and Powerful Ideas*. New York: Basic Books.

Passey, D. and Samways, B. (1997). *Information Technology. Supporting Change through Teacher Education.* IFIG TC3. Chapman and Hall: London.

Patton, M.Q. (1990) *Qualitative Evaluation and Research Methods.* Sage Publications, California.

Pea, R. (1998). The pros and cons of technology in the classroom. *Tapped In.* [Online] http://www.tappedin.org/info/teachers/debate.html [8 September 2006].

Pedhazur, E. J. (1997). *Multiple Regression in Behavioral Research* (3rd ed.). Orlando, FL: Harcourt Brace.

Pelgrum, W.J. and Plomp, T. (1991). *The Use of Computers in Education Worldwide: Results From The IEA 'Computers in Education' Survey in 19 Educational Systems*. Oxford: Pergamon Press.

Pelgrum, W.J. and Plomp, T. (Eds) (1993). *The IEA Study of Computers in Education: Implementation of an Innovation in 21 Education Systems*. Oxford: Pergamon Press.

Petty, R.E. and Cacioppo, J.T. (1986). The elaboration likelihood model of persuasion. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (Vol. 19, pp.123-205). New York: Academic Press.

Pohl, M. (2000). Bloom's (1956) Revised Taxonomy. Discussion paper. [Online] http://www.kurunjangsc.vic.edu.au/home/library/research/blooms.htm [8 September 2006].

Proctor, C. (1984). Teacher expectations: A model for school improvement. *The Elementary School Journal*, 469-481.

Raaijmakers, Q.A.W. (1999). Effectiveness of different missing data treatments in surveys with likert-type data: Introducing the relative mean substitution approach. *Educational and Psychological Measurement*, 59 (5), 725-748.

Raudenbush, S.W. and Bryk, A.S. (1994). A hierarchical model for studying school effects. *Sociology of Education*, 59(1), 1-17.

Raudenbush, S.W. and Bryk, A.S. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods*. Thousand Oaks, California: Sage Publications.

Raudenbush, S.W., Bryk, A.S. and Congdon, R.T. (2000). *Hierarchical Linear and Nonlinear Modelling*. Lincolnwood, IL: SSI Scientific Software.

Reeves, T.C. (1997). A model of the effective dimensions of interactive learning on the World Wide Web. Paper presented at the *Proceedings of Interaktiivinen Teknologia Koulutuksessa (ITK '97)*, Finland. [Online] http://it.coe.uga.edu/~treeves/WebPaper.pdf [8 September 2006].

Reynolds, D. (2001). ICT in education: The future research and policy agenda. Keynote Address. *Proceedings of the Building an ICT Research Network Conference*. 15 June 2001, Barbican Centre, London. British Educational Communications and Technology Agency: Coventry, London. [Online] http://www.becta.org.uk/page_documents/research/reynolds.pdf [8 September 2006].

Reynolds, D., Treharne, D. and Tripp, H. (2003). ICT – The hopes and the reality. *British Journal of Educational Technology,* 34 (2), 151-167.

Riel, M. and Fulton, K. (1998). Technology in the classroom: Tools for doing things differently or doing different things. In *Proceedings from the NeTech Forum on student learning and technology: Assessing the outcomes*. Paper presented at the Annual meeting of the American Educational Research Association, New York. [Online] http://www.gse.uci.edu/Vkiosk/Faculty/Riel/riel-fulton.html [8 September 2006].

Riel, M.M. and Becker, H.J. (2000). The beliefs, practices and computer use of teacher leaders. Report presented at the *American Educational Research Association*, New Orleans, April 2000. [Online] http://www.crito.uci.edu/tlc/findings/aera/aera_leaders.pdf [8 September 2006].

Ringstaff, C. and Kelley, L. (2002). *The Learning Return on our Educational Technology Investment: A Review of Findings from Research*. WestEd RTEC. [Online] http://www.wested.org/online_pubs/learning_return.pdf [8 September 2006].

Ringstaff, C., Yocam, K. and Marsh, J. (1996). *Integrating technology into classroom instruction: An assessment of the impact of the ACOT Teacher Development Center Project*. ACOT Report # 22. California: Apple Computer. [Online] http://www.apple.com/education/k12/leadership/acot/library.html [8 September 2006].

Robinson, V. (1998). Methodology and the research-practice gap. *Educational Researcher,* 27(1), 17–26.

Roblyer, M.D. and Edwards, J. (2000). *Integrating Educational Technology into Teaching* (2nd ed.). New Jersey: Prentice-Hall.

Rogers, E.M. (1995). *Diffusion of Innovations*. The Free Press, New York.

Romesburg, C. (2004). *Cluster Analysis for Researchers*. Lulu Press.

Rosenberg, M. (1965). *Society and the Adolescent Self-Image*. Princeton, NJ: Princeton University Press.

Rosier, M.J. and Ross, K.N. (1992). Sampling and administration. In J.P. Keeves (Ed.), *The IEA Technical Handbook* (pp. 51-90). The Hague: IEA.

Ross, J.A., Hogaboam-Gray, A. and Hannay, L. (1999). Predictors of teachers' confidence in their ability to implement computer-based instruction. *Journal of Educational Computing Research*, 21 (1), 75-97.

Rowe, H.A. (1996). I.T. is failing to revolutionise the curriculum, because to date we have failed to evaluate its benefits in context. *Proceedings of the Australian Computers in Education Conference*, Canberra. [Online] http://www.spirit.com.au/ACEC96/papers/rowe2.htm [28 September 1998].

Rubin, D.B. (2004). *Multiple Imputation for Nonresponse in Surveys.* New York: Wiley-IEEE.

Rudd, T. (2002). Looking into the digital divide(s) and seeing a content chasm. Discussion paper. Coventry, London: British Educational Communications and Technology Agency. [Online] http://www.becta.org.uk/page_documents/research/lookinginto.doc [8 September 2006].

Russell, G. and Bradley, G. (1997). Teachers' computer anxiety: Implications for professional development. *Education and Information Technologies*, 2 (1), 17-30.

Russell, T.L. (1997). The "No significant difference" phenomenon. [Online] http://teleeducation.nb.ca/nosignificantdifference/ [1999, March 31]. [Website] http://www.nosignificantdifference.org/ [8 September 2006].

Sandholtz, J.H., Ringstaff, C. and Dwyer, D.C. (1997). *Teaching with Technology: Creating Student Centred Classrooms.* New York: Teachers College Press.

Sandoval, W.A. (2004). Design-based research methods in education. *EDUCAUSE*. [Online] http://www.educause.edu/ir/library/powerpoint/NLI0462.pps [8 September 2006].

Sasseville, B. (2004). Integrating information and communication technology in the classroom: A comparative discourse analysis. *Canadian Journal of Learning and Technology*, 30 (2). [Online] http://www.cjlt.ca/content/vol30.2/cjlt30-2_art-1.html [8 September 2006].

Schafer, J.L. (1997). *Analysis of Incomplete Multivariate Data.* New York: Chapman and Hall.

Schafer, J.L. (1999). *NORM: Multiple Imputation of Incomplete Multivariate Data Under a Normal Model (Version 2). Software for Windows 95/98/NT.* University Park, PA: Department of Statistics, Pennsylvania State University. [Online] http://www.stat.psu.edu/~jls/misoftwa.html. [8 September 2006].

Schafer, J.L. and Olsen, M.K. (1998). Multiple imputation for multivariate missing-data problems: A data analyst's perspective. *Multivariate Behavioral Research*, 33, 545–571.

Schofield, J. (1995). *Computers and Classroom Culture*. New York: Cambridge University Press.

Schofield, J.W. (1995). *Computers and Classroom Culture*. Cambridge: Cambridge University Press.

Scott, W.J. (1990). Evaluation: Westcap Macintosh Computer Reading Program. *Aboriginal Child at School*, 18 (2), 44-50.

Sellin, N. and Keeves, J.P. (1997). Path analysis with latent variables. In J.P. Keeves (Ed.) *Educational Research, Methodology and Measurement: An International Handbook*, (pp.633-640). Oxford: Pergamon.

Shade, D.D. (1994). Computers and young children: Software types, social contexts, gender, age, and emotional responses. *Journal of Computing in Childhood Education*, 5 (2), 177-209.

Shavelson, R.J., Phillips, D.C., Towne, L. and Feuer, M.J. (2003). On the science of education design studies. *Educational Researcher*, 32 (1), 25-28. [Online] http://www.aera.net/uploadedFiles/Journals_and_Publications/ Journals/Educational_Researcher/3201/3201_Shavelson.pdf [8 September 2006].

Sheingold, K. (1991). Restructuring for learning with technology: The potential for synergy. *Phi Delta Kappan*, 73, 17-27.

Sheingold, K. and Hadley, M. (1990). *Accomplished Teachers: Integrating Computers into Classroom Practice*. New York: Bank Street College of Education, Center for Technology in Education.

Siann, G., McLeod, H., Glissov, P. and Durndell, A. (1990). The effect of computer use on gender differences in attitudes to computers. *Computers and Education*, 14, 183-191.

Sivin-Kachala, J. and Bialo, E.R. (2000). *2000 Research Report on the Effectiveness of Technology in Schools*, (7th ed.).Washington, DC: Software and Information Industry Association. [Online] http://www.siia.net/estore/REF-00-summary.pdf [8 September 2006].

Sloane, F.C. and Gorard, S. (2003). Exploring modeling aspects of design experiments. *Educational Researcher*, 32 (1), 29-31. [Online] http://www.aera.net/uploadedFiles/Journals_and_Publications/Journals/Educational_Researcher/3201/3201_Sloane.pdf [8 September 2006].

Smeets, E. and Mooij, T. (2001). Pupil-centred learning, ICT, and teacher behaviour: Observations in educational practice. *British Journal of Educational Technology*, 32 (4), 403-417.

Smyth, R. (2004). Exploring the usefulness of a conceptual framework as a research tool: A researcher's reflections. *Issues in Educational Research*, 14(2), 167-180. [Online] http://education.curtin.edu.au/iier/iier14/smyth.html [8 September 2006].

Snijders, T. and Bosker, R. (1999). *Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modelling*. London: Sage Publications.

Somekh, B., Mavers, D. and Lewin, C. (2003). Broadening access to the curriculum through using technology to link home and school: A critical analysis of reforms to improve educational attainment for all K-12 students. *The Curriculum Journal*, 14(1), 23-54. [Online] http://www.esri.mmu.ac.uk/respapers/k-12.php [8 September 2006].

Spady, W. (2001). OBE: Reform in search of a definition. [Online] http://www.schools.nt.edu.au/curricbr/cf/outcomefocus/Spady_OBE_intro.pdf [8 September 2006].

Spender, D. and Stewart, F. (2002). *Embracing e-Learning in Australian Schools*. Report sponsored by Commonwealth Bank of Australia. [Online] https://www.bssc.edu.au/public/learning_teaching/research/embracing%20e-Learning%20000-731.pdf [8 September 2006].

SPSS (2001). *Statistical Package for the Social Sciences*. Chicago: SPSS.

Stevens, J. (1996). *Applied Multivariate Statistics for the Social Sciences* (3rd ed.). New Jersey: Lawrence Erlbaum Associates.

Stevenson, D. (1997). *Information and Communications Technology in UK Schools: An Independent Enquiry*. London: The Independent ICT in Schools Commission.

Stevenson, I.J. (2004). *Measures for Assessing the Impact of ICT Use on Attainment*. A report to the DfES. School of Education, University of Leeds. [Online] http://www.becta.org.uk/page_documents/research/icta_report.pdf [8 September 2006].

Tabachnick, B.G. and Fidell, L.S. (1996). *Using Multivariate Statistics Sciences* (3rd ed.). New York: HarperCollins.

Tearle, P. (2003). ICT implementation: What makes a difference? *British Journal of Educational Technology*, 34 (5), 567-583.

Terashima, K., Yoshida, Y. and Ikai, R. (2003). Design based research on web-based learning: collaborative learning activity in multimedia production course. Paper and poster presented at 2003 KAEIB International Symposium and Conference on Educational Media in Schools, September 6, 2003, Seoul, Korea: Hanyang University. [Online] http://tera.cside.com/profile/down/kaeib-jaems.pdf [8 September 2006].

Thorndike, R.M. (1978). *Correlation Procedures for Research.* New York: Gardner Press.

Tolmie, A. (2002). Examining learning in relation to the contexts of use of ICT. *Journal of Computer Assisted Learning*, 17(3), 235-241.

Trochim, W. (2000). *The Research Methods Knowledge Base (2nd ed.).* Cincinnati, OH: Atomic Dog Publishing.

Turner, J.H. (1991). *The Structure of Sociological Theory (5th ed.).* California: Wadsworth.

Twisk, J.W.R. (2003). *Applied Longitudinal Data Analysis for Epidemiology*. Cambridge University Press.

Ulrich, K.T. and Eppinger, S.D. (2000). *Product Design and Development*. New York: McGraw-Hill.

UNESCO. (2003). *Developing and Using Indicators of ICT Use in Education*. UNESCO Asia and Pacific Regional Bureau for Education: Bangkok.

UNESCO. (2005). *ICT in Schools: A Handbook for Teachers or How ICT Can Create New, Open Learning Environments* (by A. Semenov and edited by J. Anderson and E. Khvilon). UNESCO: Paris.

Vaughan, W. (2002). Professional development and the adoption and implementation of new innovations: Do teacher concerns matter? *International Electronic Journal For Leadership in Learning*, 6 (5). [Online] http://www.ucalgary.ca/~iejll/volume6/vaughan.html [8 September 2006].

VCAA (2002). *E-merging: Perspectives on Information and Communications Technology – Teaching and Learning in the VCE*. Melbourne: Victorian Curriculum and Assessment Authority. [Online] http://www.springvalesc.vic.edu.au/elearning/newsletters/LT%20Newsletters%202003/E-merging%20VCAA.pdf [8 September 2006].

Volman, M. and van Eck, E. (1997). Gender-related effects of information and computer literacy education. *Journal of Curriculum Studies*, 29(3), 315-328.

Wartella, E., O'Keefe, B. and Scantlin, R. (2000). *Children and Interactive Media: A Compendium of Current Research and Directions for Future*. A Report to The Markle Foundation. [Online] http://academic.udayton.edu/RondaScantlin/CMM449_Fall2003/Comm449_Fall/2_Topic2/Full%20Compendium.pdf [8 September 2006].

Williams, D., Coles, L., Wilson, K., Richardson, A. and Tuson, J. (2000). Teachers and ICT: Current use and future needs. *British Journal of Educational Technology*, 31 (4), 307-320.

Williams, J.G., Sochats, K.M., Kiely, E. and Kyrish, S. (2000). Classroom utilization and impact of technology in Pennsylvania. Paper presented at the *International Conference on Learning Technology*, Philadelphia, PA. [Online] http://l2l.org/iclt/2000/papers/124a.pdf [4 May 2000].

Williamson, B. (2003). Bridging or broadening the digital divide: Interfacing the experience of learning for the next decade. British Educational Communications and Technology Agency: Coventry, London. [Online] http://www.becta.org.uk/page_documents/research/digidiv_williamson.pdf [8 September 2006].

Wolcott, H.F. (1988). *Contemporary Methods for Research in Education.* New York: Random House.

Wozney, L., Venkathes, V., Abrami, P.C. (2001). *Technology Implementation Questionnaire (TIQ): Report on Results*. Centre for the Study of Learning and Performance, Concordia University. [Online] http://doe.concordia.ca/cslp/assets/pdfs/tiqfinalreport_sept12.pdf [8 September 2006].

Wu, M.L. (2003). *The Impact of PISA in Mathematics Education – Linking Mathematics and the Real World*. [Online] http://www.fed.cuhk.edu.hk/~hkpisa/event/2003conference/download/paper/Margaret.pdf [8 September 2006].

Yang, Y. (2000). Multiple imputation for missing values: Concepts and new development. *SUGI Proceedings*: P267-25. [Online] http://support.sas.com/rnd/app/papers/multipleimputation.pdf [8 September 2006].

Zandvliet, D.B. (1999). The physical and psychological environment associated with classrooms using information technologies: A cross-national study. Unpublished Doctoral dissertation, Curtin University of Technology, Perth, Western Australia.

Shannon Research Press
Adelaide, South Australia
ISBN: 978-1-920736-30-9