

**Science and Mathematics Education Centre**

**The Physical and Psychosocial Environment Associated with Classrooms  
Using New Information Technologies - A Cross-National Study**

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## ABSTRACT

This research involved an in-depth and holistic investigation into the use of Internet technologies in high school classrooms. Specifically, it combined studies of the physical and psychosocial learning environments operating within these 'technological settings' and investigated interactions among the selected physical and psychosocial factors in influencing students' satisfaction with their learning. Further, the study described how both the physical and psychosocial domains may effectively enable, or alternatively, constrain the teaching methodologies used in these classrooms. The study involved two phases of investigation. The first phase involved a broad examination of the learning environment as measured with a questionnaire containing items measuring aspects of the psychosocial learning environment and with ergonomic site evaluations using a specially designed worksheet and inventory for computerised classrooms. In the second phase of the study, interactions among the physical and psychosocial variables in these measures were explored through the use of selected and detailed case studies from the original sample. Case studies included a more detailed assessment of the physical classroom environment in tandem with classroom observations and student/teacher interviews. The study was conducted in Australian and Canadian secondary schools and so, offers additional insights in the different approaches to technology implementation and teaching practice. The results of the study reveal a number of statistically significant and independent associations between physical and psychosocial factors and further, between psychosocial factors and students' satisfaction with learning. These findings were complemented by similar qualitative findings from the case studies. These quantitative and qualitative results were used to inform a model for educational productivity for computerised classrooms. The model includes a number of important physical and psychosocial factors which when considered together, may influence student attitudes (and potentially other outcomes) in emerging networked and computerised learning environments.

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# Chapter 1

## Background and Rationale

### 1.1 Introduction

Over the last 20 years, educational institutions have implemented a wide range of instructional technologies in the classroom. While some of these have proven useful for education, some may prove to be less so. While many attempts have been made to evaluate the effectiveness of technology use in classrooms (e.g. Sabelli & Barrett, 1993), few have looked at the issue from a sufficiently wide perspective. Now, recent innovations such as the world wide web (WWW) and computer-mediated communication (CMC) are promising to have even greater impacts on these classroom environments. Goumain (1989) has stated that, wherever new technologies are used, there is an increasing awareness that the social and physical working environments are changing concurrently and systematically. Still, few educational studies before this one have attempted to evaluate both the physical and psychosocial classroom environment, particularly as they are influenced by the use of new instructional technologies.

Many organisations have coped with widespread technological change in a reactive way by adapting to environmental problems only when they have become intolerable (Goumain, 1989). This is also probably true of educational organizations which have had to cope with the introduction of new technologies while being subjected to a variety of constraints. In considering the new technological classroom, many are advocating a closer integration of educational technologies, curriculum and instruction, and the design of suitable physical learning spaces (see Duggan 1994; Knirk, 1992; OECD, 1987). This implies a greater role for teachers in all of these varied processes. This study, and its proposed model for educational productivity, began this needed work. Further, the study combined knowledge about teaching and learning with other knowledge about the physical and psychosocial learning environment in computerised settings.

This chapter outlines the rationale for the current study in Section 1.2 and then follows with some background information in Section 1.3 before outlining the theoretical framework for the study in Section 1.4. The final section in this chapter provides an overview of the content of the other chapters in this thesis.

## **1.2 Rationale for the Study**

The increasing focus on information technologies in schools has manifested itself not only in an increase in the numbers of computers, but also in a diversification of their use. While several trends in educational reform are contributing to this focus on computers, the primary driving force can be seen as the technology itself. This explosive increase in the use of computers within our society can be summed up in the following quote by Chapanis (1996, p. 7):

Computers probably have had a more profound effect on society, on our ways of living, and on our ways of doing business than any other technological creation in this century. Computers help manage our checking accounts and our charge accounts. They help manufacture our goods, raise our crops, manage our farms, sort and distribute our mail, schedule our rail and air travel, book our theatre tickets, check out our groceries, diagnose our illnesses, teach our children and amuse us with sophisticated games ... To sum up, computers have become so intricately woven into the fabric of our daily lives that, if all the computers on earth were to vanish suddenly, our civilisation would be thrown into immediate chaos ...

Now, with the advent of localised computer networks and the rapidly expanding potential of the Internet, the computer revolution in our schools is headed into a second phase in which the need to implement information technology in our schools seems to have increased yet again. As many schools currently race to go on-line, and as millions of dollars are being spent, educators are again bracing themselves for some big changes

and possibly for a complete reworking of many aspects of teaching and learning. Such restructuring has already occurred in other professions and has only just begun for teaching.

With this ongoing second phase of technology implementation in schools, one might argue that the classroom of the future is rapidly approaching reality. Educational institutions, consistent with most organisations within society, continue to be profoundly affected by the implementation of new information technologies. Whether they are producing or using these technologies, there is an increasing awareness within all organisations that the social and physical working environments are also changing concurrently and systematically. The scope and nature of these changes are unprecedented in human history and are resulting in a series of complex organisational transitions (Goumain, 1989).

Goumain believes that many organisations have largely coped with these changes in a reactive way by adapting to environmental problems only when they have become intolerable. This is also probably true of educational organisations which also have had to cope with the introduction of new technologies while being subjected to a variety of constraints (budgetary and other). Goumain argued for a more proactive approach to planning and managing change in all organisations. To Goumain, this implies a closer integration of technology, management and design.

If this discussion is applied to the technological classroom of the future, a closer integration of technology, curriculum and instruction, and attention to the design of learning spaces, should be advocated for schools. Educators will need to be involved in both the design and implementation of new technologies, the devising of new curricula and teaching methods and, finally, the physical design of schools and of classrooms themselves. However, often teachers are left only to react to the new realities of teaching in increasingly technological settings with minimal input and preparation for the inevitable changes ahead.

Also, the development and advancement of the world wide web, or the so-called 'information highway', has seen unprecedented coverage in the popular media, both in print and on television. The rapid growth of this medium has been influenced by the development of a wide range of resources by various business, industry, government and educational concerns. However, while the Internet may hold great potential for schools, it is not a panacea. Still, at the time of writing this chapter, implementation programs to connect schools to Internet resources are proceeding at a furious pace in many jurisdictions and, in fact, many millions of dollars have been set aside solely for this purpose.

The exploding popularity of the world wide web, and the enthusiasm for this medium by governments abroad and in Australia, can be easily documented. Many state governments have highlighted several new initiatives aimed at moving their classrooms into the information age. For example, in New South Wales, the government has committed \$186 million dollars to be spent over four years (New South Wales Department of Training and Education Co-ordination, 1997). This has so far resulted in 22,000 new computers being delivered to public schools in that state, and each school having at least one Internet connection. Other Australian states are supporting technology initiatives with equal enthusiasm, with Victoria spending the sum of \$200 million (Victoria Department of Education, 1997) and Western Australia (the main location for this study) setting aside \$40 million (Education Department of Western Australia, 1997).

Independent schools are also touting their continued commitment to information technology as a marketing strategy to attract students. For example, at some schools, the use of a personal notebook computer is a mandatory requirement for students and teachers. It seems that the simple installation of Internet-capable computers is viewed by many parents as a prerequisite for innovative teaching and learning.

In the second country involved in this study, Canada, the implementation of Internet technology in schools is also proceeding on the fast track with large amounts of

government education funding increasingly being diverted into this area. This includes in part a special technology grant in the province of Ontario which pledges 60 million dollars to connect schools to the Internet (Ontario Ministry of Education and Training, 1997) and a similar program in Alberta pledging an additional 45 million dollars (Alberta Ministry of Education, 1997) to connect schools in a similar way. In the province of British Columbia (the jurisdiction for a portion of the present study), technology funding has been maintained at a yearly expenditure of 10.7 million dollars (British Columbia Ministry of Education, 1997), despite an economic climate characterised by fiscal restraint.

Finally, the initiatives outlined for Australia and Canada are not unique in the world. Governments in other countries, including the U.S. and U.K., are also implementing similar programs to wire their schools to the Internet. In the U.S., these educational initiatives are linked to the larger policy goal known as the National Information Infrastructure (Malhotra, Al-Sheri & Jones, 1995). In its statement of principles, this major government initiative aims to enhance the quality of education provided by educational institutions by facilitating the participation of individuals in what it terms 'electronic communities of learning'. It pledges that, by the year 2000, all individuals will be able to access information and learning resources available in their schools, colleges, universities, libraries and other community-based institutions. The scale of the project is immense, but its implementation period is extremely brief. Even so, similar programs continue to be proposed throughout the world and certainly involve the educational spending of billions of dollars.

Given the enormity of the task of connecting schools to the Internet, considerable thought must go into implementation strategies for this technology. Certainly, learning environments in both the physical and psychosocial sense will be profoundly impacted upon and the role of teachers will change substantially.

Similarly, with such huge outlays of money for the implementation of new information technologies in Canada and Australia (and throughout the world),

educational administrators and bureaucrats are hoping for large returns in the form of greater educational productivity from students. However, to date, success with the implementation of new information technologies has been largely related to the experience of dedicated teachers willing to experiment with new teaching methods. Despite the potential of the technology, there is currently little evidence that the many millions of dollars invested in these new technologies are returning a measurable change in the quality of education.

This research attempted to do two things in response to this situation. First, it aimed to describe the physical and psychosocial environments of classrooms which are currently using new information technologies. Second, it aimed to identify which environmental factors are most important in influencing student satisfaction (and hence providing an indication of the quality of their education) in these new learning environments. In the study, a range of important physical and psychosocial factors were combined to provide a revised model of educational productivity as it relates to the large-scale implementation of Internet technologies in all classrooms.

### **1.3 Background to the Study**

While the use of computers in educational settings has the potential to bring about large-scale and meaningful change in the way in which teaching and learning occurs, the degree to which new educational reforms are implemented will be influenced by the underlying principles accompanying them. If computers are indeed a tool, then the rationale for technology implementation becomes even more important. This study addressed this idea by investigating technology implementation in two different countries: Canada and Australia.

### **1.3.1 *Cross-national Studies***

Educational research which crosses national boundaries offers much promise for generating new insights for at least two reasons (Aldridge, Huang & Fraser, 1998; Fraser, 1998). First, there usually is greater variation in the variables of interest (e.g., teaching methods, student attitudes) in a sample drawn from multiple countries than from a one-country sample. Second, the taken-for-granted familiar educational practices, beliefs and attitudes in one country can be exposed, made 'strange' and questioned when research involves two countries. From the outset of the study, it was hoped that, by examining the implementation of information technology (IT) in two countries, variations in approach could be noted and comparisons of the nature of IT implementation, general use and classroom learning environments could be made.

### **1.3.2 *Framework for the Study***

A convenient framework for conceptualising all of the varied factors which might influence this technology implementation was provided in a general way by Gardiner (1989) and formed the conceptual model and framework used in this study. (This model is presented in Section 1.4 of this chapter.) Briefly, Gardiner's model consists of three spheres of influence, namely, the *technosphere* (influence of technology), the *ecosphere* (influence of the physical environment), and the *sociosphere* (influence of the social environment). In an educational setting, this model would imply the joint consideration of modern ideas about teaching with aspects of both physical and psychosocial learning environments.

The study is unique in that it used a holistic framework to study both the physical and the psychosocial learning environments associated with classrooms using new technologies. Importantly, it also explores the degree to which physical and psychosocial factors interact to influence students' satisfaction with their learning in these settings. When taken together, physical and psychosocial factors could form the framework for a new and revised model of educational productivity.



### **1.3.3 *Implementing New Technologies***

The expanding use of information technologies in schools has already been noted. There are probably many different factors precipitating this increased use of IT, which can be roughly categorised into two basic types: (1) the premise that the increasing use of technology in society alone justifies the greater implementation of information technology in our schools; and (2) the premise that the unique attributes of new information technologies in themselves offer great potential to increase the effectiveness of teaching and learning, and may enable current efforts for educational and curricular reforms (e.g. Adams, Carlson & Hamm, 1990; Dede, 1989; OECD, 1987). While two different pressures, they are related and aspects of each argument appear repeatedly in the literature.

Institutions have increasingly looked at information technologies as a technical aid in developing new models of teaching and learning. This aspect of the pressure to implement educational technologies is related to relatively new ideas about teaching and learning. This has been combined with trends towards greater individualisation in learning, the use of cooperative learning groups, integration of the subject areas, more concrete methods of instruction and an increasing focus on higher-order thinking skills (OECD, 1987).

Adams et al. (1990) state that the successful use of computers means involving students and educators in the learning process in new ways. As with any instructional medium, the vitality of computer use depends on good teaching. Professional knowledge about student learning, curricula and classroom organisation go hand in hand with other information on effective computer use. As with using any technology, the use of new information technologies has the potential to transform the physical and psychosocial learning environments in either negative or positive ways.

#### **1.3.4 *Psychosocial Learning Environments***

Studies of educational environments should be considered to include all of the relevant social-psychological contexts or determinants of learning. In the past, many educational studies focused only on the teacher or on specific teaching methodologies. Fraser (1998) has suggested that teaching is only one of many factors that affect the learning environment and that, arguably, teaching is itself affected by these factors. Fraser's summary of over two decades of learning environment research reveals that the methods used in the study of learning environments tend to be descriptive, multivariate and correlational.

A foundation for the study of classroom psychosocial learning environments was developed in the independent work of Herbert Walberg and Rudolf Moos (see Fraser, 1998). Many have built on this earlier work and applied its use to educational settings (Fraser, 1994). While the methods vary greatly in these studies, many useful instruments have been developed which measure the perceptions of students and teachers on a variety of aspects of the environment (Fraser, 1998; Fisher, 1994). Early examples of these instruments include the Learning Environment Inventory (Fraser, Anderson & Walberg, 1982) and the Classroom Environment Scale (Moos 1979; Moos & Trickett, 1987).

Other instruments have been developed which consider specific types of classrooms. These include the Individualised Classroom Environment Questionnaire (ICEQ; Rentoul & Fraser, 1979), the College and University Classroom Environment Inventory (CUCEI; Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986) and the Science Laboratory Environment Inventory (SLEI; McRobbie & Giddings, 1993). Two of the most recently developed learning environment instruments are the Constructivist Learning Environment Survey (CLES; Taylor, Dawson & Fraser, 1996) and the What is Happening in this Class? questionnaire (WIHIC; Aldridge, Huang & Fraser, 1998; Chionh & Fraser, 1998; Fraser, Fisher & McRobbie, 1996). All of these

instruments include scales which have proven to be effective predictors of student achievement, behaviours and attitudes (Fraser, 1998).

Fraser (1991) has also summarized the use of learning environment instruments and contrasted this approach with other methods such as direct observation, naturalistic inquiry, ethnography and case study. Fraser and Tobin (1991) have also identified the need for the development of new research models which combine these qualitative and quantitative methods together in a single study. Further, Walberg (1991) considered the learning environment found within schools as one of many factors operating within a broad concept of educational productivity which attempts to list important factors which can predict learning.

Learning environment research may take many forms (Fraser, 1998). These include (1) associations between student outcomes and environment, (2) use of environment dimensions as criterion variables (including the evaluation of educational innovations and investigations of differences between students' and teachers' perceptions of the same classrooms), (3) investigations of whether students achieve better when in their preferred environments and (4) action research involving teachers' own practical attempts to improve their classroom and school climates. Fisher (1994) has also summarised some other types of learning environment research, including studies of the differences in the learning environments among different schools, gender and cultural differences in the perceptions of learning environments, and studies jointly considering the learning environment as it relates to student motivation or student attitudes.

Finally, the development and validation of new instruments to measure learning environments continues in response to new areas of inquiry such as the potential use of computers to promote higher-level thinking or constructivist methodologies (Maor & Fraser, 1996; Taylor et al., 1996). More recently, learning environment instruments have been adapted by researchers for studies in networked computer classrooms (Churach & Fisher, 1998; Zandvliet & Fraser, 1998). This new and emerging type of

environment is the major focus of this study. A review of learning environment research relating to computerised environments is detailed in Chapter 4 (Section 4.5).

### **1.3.5 Physical Factors**

Technological change has affected many sectors of our society outside the educational field, including a wide variety of environments within business and industry. These changes were accompanied by the development of the science of *ergonomics*, which attempts to describe the physical, physiological and psychosocial factors which can influence worker productivity or health in a variety of settings (see Grandjean, 1988; Kroemer & Grandjean, 1997). While several scattered reports from a variety of disciplines have tentatively explored this idea in classrooms (e.g. Duggan, 1994; Knirk, 1992), few comprehensive studies have been realised. Applying the ergonomic approach to the classroom involves considering a wide range of physical and psychosocial factors and determining how they are influenced by the use of technology.

With the introduction of so much technological change in classrooms, the need to study the physical learning environment is probably greater than ever before. What is needed to accomplish this goal is a multidimensional research model which attempts to mirror the complexity of today's increasingly technological classrooms. The adoption and interpretation of some of the ergonomic standards developed for business and industry provides a good starting point for the categorisation of physical learning environments in schools (e.g. Knirk, 1992).

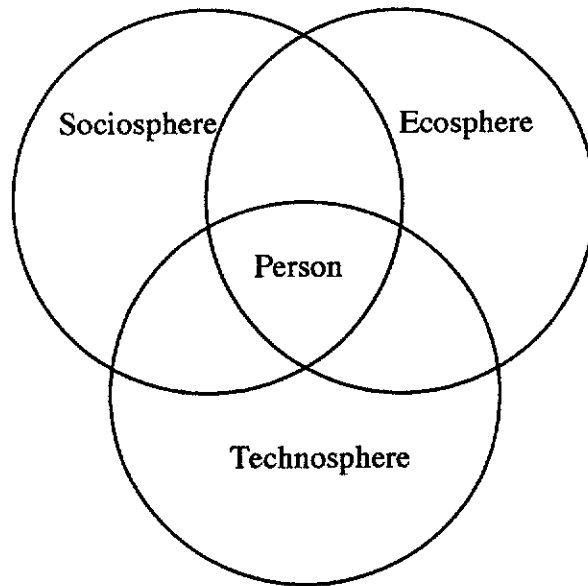
Most relevant in this argument is the need for researchers to consider aspects of both the psychosocial and physical environments in classrooms. This is important because a large amount of ergonomic research has shown that physical factors may influence psychosocial environments and therefore influence workplace productivity. It follows that, in schools and classrooms, psychosocial and physical variables may jointly influence outcomes such as student attitudes, achievement and satisfaction with learning.

Finally, to accomplish this task, a suitable conceptual model and framework combining an educational context for the implementation of IT with an evaluation of relevant physical (or ergonomic) factors and other more widely studied psychosocial factors was developed. The model provides a broader, more complete model of the learning environment for the emerging technological classroom. A description of the development of this model is described in the following section.

#### **1.4 Theoretical Framework**

Gardiner (1989) has described a framework for thinking about the pressures which may be driving change in our altogether human, though technological, environments. Gardiner's model consists of three overlapping spheres of influence which he describes as, respectively, the ecosphere, the sociosphere and the technosphere. The ecosphere relates simply to a person's physical environment and surroundings, whereas the sociosphere relates to an individual's net interactions with all other people within that environment. Finally, the technosphere is described as the total of all the person-made things (present and future) in the world. The model is presented as Figure 1.1.

Figure 1.1: A conceptual model for studying systematic change

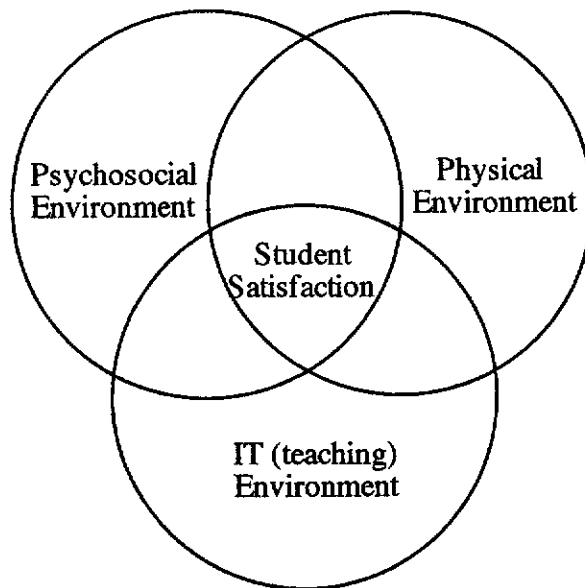


*Adapted from Gardiner (1989, p. 28)*

Gardiner described the individual person located in the centre of the model as the most complicated component in the system. Located at the intersection of these three spheres, people are subjected to all three influences.

Gardiner's (1989) model has been further adapted by this researcher to provide the theoretical framework used in this study. In an educational setting, Gardiner's model can be adapted so that the physical classroom environment represents the ecosphere, the psychosocial classroom environment represents the sociosphere, and finally the implementation of new educational technologies represents the technosphere component of the model. All of these are considered as they are associated with student satisfaction. This model is presented as Figure 1.2.

Figure 1.2: A conceptual model for studying educational change



*Adapted from Gardiner (1989, p. 28)*

The above conceptual model considers what are potentially the most important factors as they relate to technology use in schools. This model was used to organise several important aspects of this study, including directing the theoretical framework developed for the study, aiding in the selection and development of appropriate research methodologies and, finally, providing an organiser for categorising and presenting results. Importantly, this study uses this model to begin a holistic evaluation of the educational use of new information technologies .

In this study, important contextual information about the use of IT in schools and its associations with the physical and psychosocial environments was provided by detailed case studies in computerised classroom settings. These studies included environmental monitoring and classroom observations of a select group of classrooms. Further detailed information about important educational issues related to the use of information

technology is provided in Chapter 2, whereas a detailed description of the methodologies used in the case study portion of this study are described later in Chapter 5 (Section 5.5).

Complete and detailed information about the physical environment of computerised high school classrooms for this study was obtained by using a specially developed ergonomic worksheet and inventory. These instruments contained categories which rate important physical (or physiological) considerations in these classrooms including factors such as the qualities of workspace, lighting, equipment, spatial layout and air quality. Detailed information about these and other ergonomic considerations for schools (and other workplaces) is described in Chapter 3. Information about the development of the ergonomic worksheet and inventory is provided in Chapter 5 (Section 5.4).

Further, the psychosocial environment in a broad range of computerised high school classes was assessed with the use of a learning environment questionnaire. This instrument included scales which measure students' perceptions of a number of important psychosocial constructs of these classrooms including: student cohesion, cooperation, involvement, autonomy and task orientation. More detailed information on the development and current foci of this type of learning environment research is considered in Chapter 4, while the development of the questionnaire used in this study is described further in Chapter 5 (Section 5.3).

Finally, the key dependent variable of student satisfaction in these computerised settings was obtained using additional items included with the learning environment questionnaire. The satisfaction scale was modified from the Test of Science Related Attitudes (TOSRA; Fraser, 1981). In part, this study sought to address how student satisfaction in these settings might be jointly influenced by aspects of the physical and psychosocial environments.



In attempting an evaluation of the use of new information technologies in schools, this study addressed the following comprehensive set of research questions:

***The use of new information technologies for teaching and learning***

How are the new information technologies being used in the classroom? With what specific types of behaviours or tasks are students and teachers involved? Further, how do students and teachers allocate their time among these tasks? Are there differences between the observed Australian and Canadian situations?

***Relevant psychosocial factors operating in computerised classrooms***

How can the psychosocial environment in technological classrooms be validly measured? Are student perceptions positive? Further, which psychosocial factors are more closely associated with students' overall satisfaction with their learning? Are there differences between the observed Australian and Canadian situations?

***Relevant physical factors operating in computerised classrooms***

How have networked computer workstations been physically implemented or set up in schools? Do these installations meet published guidelines for workplace settings. Which physical (ergonomic) factors are more closely associated with student satisfaction?

***Issues concerning interactions among factors***

What types of interactions occur between physical and psychosocial factors in promoting student satisfaction in computerised learning environments? How do these interactions impact on teaching and learning? Are there notable differences between the observed Australian and Canadian settings?

## **1.5 Conclusion and Overview of Other Chapters**

This first chapter outlines the rationale and background for this study. It also presents a conceptual model for studying technological change which frames much of this work. Importantly, this study is uniquely relevant in two respects. First, it begins a much needed evaluation of Internet usage in schools at a time when a great deal of time and money is being allocated to this new teaching resource. Second, it does so in a comprehensive and holistic manner by jointly considering physical and psychosocial factors which may be influencing students' satisfaction (and hence productivity) in these environments. What follows is an overview of subsequent chapters in this thesis.

The next three chapters in this thesis complete the literature review which informs this study. Chapter 2 is related to the IT (teaching) environment and provides information about both the scope and rationale for using information technology from the perspective of educators. This is important in providing a context for this evaluation. Chapter 3 revisits the conceptual model presented in Chapter 1 but focuses on the physical or ergonomic environment of classrooms and outlines a number of important physical and physiological considerations for its effective implementation in classrooms. Chapter 4 completes consideration of the model and outlines studies of the psychosocial learning environment as a predictor of student productivity. The development of existing research instruments to assess psychosocial learning environments is also considered.

Chapter 5 in this thesis describes the development of research methodologies, techniques and instruments used in the current study including ergonomic worksheets and inventories, questionnaires, interviews, observation techniques and a detailed environmental monitoring methodology. It also describes the samples used for each part of the current study.

The three chapters following Chapter 5 present the results of the current study. Chapter 6 presents the results from the case study portion of this study. It describes

eight classrooms in detail (four each from Australia and Canada) and provides additional quantitative and qualitative data about each location. Chapter 7 presents the results of the learning environment questionnaire that was administered to students and teachers in these computerised settings and includes validity and reliability data about the scales in the questionnaire. It also provides information about associations between the psychosocial learning environment and student satisfaction. Finally, Chapter 7 presents the physical environmental data obtained from the completion of the ergonomic evaluations in a broad sample of computerised classrooms. It identifies strengths in these implementations but also discusses some common deficiencies. Last, it further describes associations between physical and psychosocial factors in influencing student satisfaction.

The final chapter in this thesis (Chapter 9) summarises and discusses all aspects of this study and proposes a revised model of educational productivity for use in networked computer learning environments that reflects the findings of this study. Limitations of the current study are discussed and also recommendations for further research on computerised learning environments are proposed.

## **Chapter 2**

### **Review of Literature on Educational IT Use**

#### **2.1 Introduction**

This chapter begins a review of the literature which informs this study of Internet use in school classrooms. (Chapter three and four continue this review by considering, respectively, physical and psychosocial classroom learning environments.) The need to study this massive implementation of information technology has been argued in Chapter 1 and is further described in Section 2.2 of this chapter. Specifically, this chapter outlines the IT (teaching) environment sphere of the conceptual model outlined at the end of chapter one (Section 1.4). It began by providing information related to both the scope and rationale for using IT from the unique viewpoint and perspective of educators (Section 2.2), then continues with a summary of current ideas about teaching and learning (including constructivism) in Section 2.3, and ends with a discussion about guidelines for the effective educational use of IT (Section 2.4). This chapter is particularly important in providing the relevant educational context for a study of information technology and its implementation in schools.

In particular, this study begins to explore the educational context of IT implementation by seeking to determine how new information technologies are currently being used by teachers in the classroom. Further, the study investigated specifically the types of behaviours (or tasks) in which students are involved as they work with these technologies and, further, how these types of interactions impact on teaching and learning. Finally, it investigated variations in approach in the use of technology by teachers in two countries (Canada and Australia) through a combination of qualitative and quantitative data collection methods. A complete description of the methodologies developed and used for this portion of the study follows later on in Chapter 5 and a summary of literature related to the other two spheres in the conceptual

model (the physical and psychosocial learning environments) are considered in detail in Chapters 3 and 4, respectively.

## **2.2 The Use of Information Technologies**

This section outlines a number of important considerations regarding the use of information technology in schools including their current scope and the rationale for its implementation.

### **2.2.1 *Scope of Educational Computing***

The current direction of educational change has precipitated an increase in the use of computers, whose range of educational uses continues to expand rapidly in schools. In the early 1980s, the use of computers in education had already reached a broad base and many researchers were advocating then for a comprehensive review into their effectiveness as tools in education and training (e.g. Percival & Ellington, 1984).

Computers are now used as a direct aid to the teaching process. The use of computer-assisted learning (CAL) has made a major contribution to education and training. Computers have also taken on an administrative function in education called 'Computer-Managed Learning' (CML). In CML, the computer acts as an administrative support to the teacher. Variations of CML provide individual guidance and assessment to students, while also providing clerical support by maintaining records and generating reports. Other important types of educational computer uses include Computer Administered Testing (CAT), computer simulations and games, word processors, databases and spreadsheets, and Computer Based Labs (CBLs).

While computer use continues to grow, the use of localised networks and the Internet are rapidly growing in popularity and importance to schools. Now, as in the past, a review into the overall effectiveness of computers as an educational tool must be attempted. This would need to include the impact of new information technologies (e.g. the Internet) on both the physical and psychosocial learning environments.

### ***2.2.2 Rationale for Implementing Technology***

In order to give a rationale and background for evaluating the educational use of information technologies, we need to consider the factors driving their increasing use in schools (i.e. Gardiner's influence of the technospere). While there are probably many different rationales for the use of new technologies, they can be roughly categorised into two basic types: (1) that the increasing use of technology in society alone justifies the more frequent use of information technology in our schools; and (2) that the unique attributes of new information technologies in themselves offer great potential to increase the effectiveness of teaching and learning, and to enable current implementations of educational and curricular reforms. While different pressures, the two are closely related and aspects of each argument appear repeatedly in the literature.

#### *Societal pressures*

The almost explosive increase in the use of computers within our larger society has also increased the need to implement computers in our schools. In response to the expanding use of information technologies, it is clear that the goals and contexts of schooling are undergoing a major redefinition. This general trend towards incorporating more technology is also, in part, evidenced by the need to include technology-focused components in the school curriculum (Layton, 1993). Such moves are seen in the development of technology education in Australia, Canada, the UK, the USA and many other countries. In response to this pressure, many jurisdictions have included technological education components across the curriculum, which is in keeping with the trend to make education more vocationally relevant. As most vocations are increasingly reliant on information technology, this trend would also imply a greater need for more information technologies.

There are several versions of the case for incorporating technology in the curriculum of general education by combining it with science. This wider role for science education is associated with science curricula that are context-based, and that give prominence to

applications and implications (Layton, 1993). In reviewing the variety of such science-technology-society (STS) courses, Layton distinguished between: (1) science-determined courses in which the sequence of knowledge is identical to that in traditional disciplinary science education, with the STS material added on; (2) technology determined courses in which the science content is determined by its relation to the technology or the socio-technological issue being studied; and (3) society-determined courses in which the science and technology to be studied are determined by their relevance to the societal problem under consideration.

Kings (1990) saw what he believed were the essential elements of successful curriculum change in the first option: the inclusion of technology education within science courses. Kings outlined a number of important factors which he believed were encouraging educational systems to implement technology. First, he noted a greater recognition of the social context of science and technology in the light of such contemporary issues as automation and genetic engineering. Kings believed that this heightened recognition could influence the nature of curriculum change by heightening awareness of society's need for a changing view of technology. This new viewpoint is embodied in those types of technology education which focus on problem solving and the need to draw on knowledge and skills from a range of disciplines. Even so, with this type of educational reform, the inclusion of a more technologically focused curriculum usually involves a greater inclusion of information technologies in the classroom as an integral part of its delivery.

Kings (1990) has also outlined the great need for science and technological expertise in many developed and developing countries. He saw that factors such as the recognition of low achievement levels, pressures from employer groups and ever increasing government expectations all work together to stimulate change. Kings described a variety of developments resulting in technology curricula being implemented throughout the world, especially in Australia, the U.S. and the U.K. The resulting curricula and their greater implementation of information technologies are

taken by many to reflect the needs of teachers and students while meeting society's expectations for change.

### *Educational pressures*

While already responding to external pressures for change, educational systems have a number of goals and problems of their own. Many schools face serious problems in helping students to obtain even a basic education (OECD, 1987). While these problems vary in their severity among countries, the OECD report included the following problems: (1) time pressures to cover an increasing amount of course material; (2) the widespread belief that standards have been lowered in response to these pressures; (3) gender differences in learning; (4) inadequate teacher training; and, finally, (5) difficulties in attracting skilled teachers to remote areas.

In response to these problems, institutions have increasingly looked at information technologies as an aid in developing new models of teaching and learning. This aspect of the pressure to implement educational technologies is in part related to relatively new ideas about teaching and learning. This has been combined with earlier trends towards individualisation, cooperative learning, integration of subject areas, more concrete methods of instruction and an increasing focus on higher-order thinking skills (OECD, 1987).

While the 1980s witnessed the beginning of widespread computer use in schools, increasingly, rich software and more advanced hardware are reaching a stage at which they have the potential to transform student ability, power and achievement (Adams, Carlson & Hamm, 1990). The indications are that the future will witness new relationships between technological tools, learners, teachers, the curriculum, and classroom organisation. For this to happen, teachers will need help from the research community in deciding how computers are best used. This study begins this process by describing problems that teachers currently face using IT.



Adams et al. (1990) believe that the successful use of computers may mean involving students and educators in the learning process in new ways. As with any medium, the vitality of computer use depends on good teaching. Also, professional knowledge about student learning, curricula and classroom organisation should go hand in hand with other information about effective computer use. For example, sharing with peers in a supportive small group is just as important for learning with computers as without. Finally, computers should not be considered simply as teaching machines for dispensing isolated learning but, instead, as instruments to help meet integrated curricular goals. As always, teaching will remain a very social endeavour. This philosophy is best described in the following statement made in the OECD (1987) report :

School, in some form or another, will always have a role in the education of young people and in the development of society. There can be no true education without contact between pupils and teachers and between pupils themselves. A major element of education, as opposed to the mere gathering of knowledge, lies in the social contacts and development of interpersonal relationships which occur within the structure of school life and which are an indispensable part of preparation for later life. (p. 38)

If computers are indeed simply a tool to further the pursuit of good teaching practices and to develop social relationships, then certainly a review of technology use needs to consider current and emerging views on teaching and learning.

### **2.3 New Ideas about Teaching and Learning**

Most educational researchers would now agree with the basic tenant that learning involves both activity and context. Such ideas may be traced back to the views of Skinner (1984) who argued that essentially what is reinforcing in the educational process is 'successful play'. In turn, compatible views have been espoused by other prominent thinkers such as Rousseau (1955) who argued that the senses were the basis

for intellectual development and that the child's interaction with the environment was the basis for understanding, and Dewey (see Rochelle, 1992) who emphasized that individual perturbations of the individual's understandings were the stimulus for learning. Of course, current views about teaching and learning share this common framework for learning as situated in activity. Modern terminology describes this approach as 'constructivist' which is in itself a broad term encompassing many different viewpoints about teaching and learning. Common to all of these is the emphasis on a changing role for the teacher to one of a manager, facilitator or coach for their students rather than as a vessel for knowledge (Duffy & Cunningham, 1996).

The following section considers new ideas about teaching and learning which may be summarised as the 'constructivist' teaching model. Current constructivist teaching methodologies are described as is the use of computers as a potential cognitive tool for the teaching and learning process.

### ***2.3.1 The Constructivist Teaching Model***

An important recent development in education has been the adoption of the 'constructivist' approach for teaching and learning, and for curriculum development in many school jurisdictions. Many educators believe that constructivism validates many current ideas about teaching and learning and that the needs of students using this model may be met by the use of IT. In order to describe fully the educational potential of information technologies, it is now important to provide a brief description of the constructivist perspective on teaching and learning. As it now exists, constructivism could be described as a new teaching model which has evolved out of the philosophies of Ernst von Glasersfeld (1995) and others and is supported by much research from cognitive science and science education. Cobb (1993) has outlined in broad terms two models for constructivism commonly written about in the literature: the cognitive perspective and the socio-cultural perspective. Similarities and differences between these two viewpoints are summarised below in Table 2.1.

Table 2.1

Contrasts between the individual cognitive and the sociocultural constructivist views

Idea	Cognitive Constructivist	Sociocultural Constructivist
The mind is located:	in the head	in the individual-in-social interaction
Learning is a process of:	active cognition reorganisation	acculturation into an established community
Goal is to account for:	the social and cultural basis of personal experience	constitution of social and cultural processes
Theoretical attention is on:	individual psychological processes	Social and cultural processes
Analysis of learning sees learning as:	cognitive self organisation	Acculturation
In looking at a classroom, we see:	an evolving microculture that is jointly constituted by the teacher and students	instantiation of the culturally organized practices of schooling

(adapted from Cobb, 1993)

The implementation of a constructivist model for teaching and learning implies significant changes in the way in which teachers teach and students learn and here lies the greatest potential of the Internet as a teaching tool. According to Zahorik (1995), the features of a constructivist perspective are as follows:

- Reality does not exist separately from the observer and there may be multiple constructions of reality.
- Knowledge consists of not merely facts and theories but also the ability to use the information in meaningful ways.
- The purpose of knowing is not to discover reality but rather to adapt to one's changing experiences.
- The role of the learner is not passive but instead should be to participate actively in the construction of new meaning.
- The role of the teacher is not simply to present information but rather to guide and facilitate students' new experiences.

Constructivist theories centre on the idea that knowledge is constructed by humans and is therefore not independent of the knower (Zahorik, 1995). Constructivists believe that human knowledge is not stable but rather conjecturable and fallible and that knowledge grows from exposure and experience. Also, constructivists believe that humans have internal knowledge structures that guide perception, understanding and action. They further believe that human learning is a matter of strengthening these internal structures.

In general, constructivist teachers emphasise thinking, understanding and self-control for their students, over behavioural approaches which centre on discipline and punishment or reward strategies (von Glasersfeld, 1995). Students are viewed as constructors of their own knowledge rather than reproducers of others' knowledge. Constructivist teachers believe that students' new experiences are received through their existing knowledge structures (termed assimilation) and that these structures must sometimes be reshaped to accept new experiences (termed accommodation).

Bauersfeld (1988) commented that constructivism is founded on the belief that individuals (and societies) construct their own knowledge in relation to past and present experience. He notes that alternative theories to explain phenomena are viewed as necessary and valid as they arise from different perspectives. Constructivists therefore believe that the resolution of widely-held scientific theories must arise naturally out of social interaction and reflection. Confrey (1990) states that the purpose of instruction (from a constructivist perspective) is to develop students' cognition rather than to teach them about constructions. She also suggests that the most fundamental quality of knowledge construction is that students must themselves believe in it. She asserts that personal autonomy is the backbone of the process.

Driver and Oldham (1986) have outlined a constructivist view for curriculum development. They state that children develop ideas and beliefs about the natural world long before they are formally taught and that these conceptions are important for learning. They further claim that the sense made out of any event or experience is

dependent not only on the situation but also on the individual's purposes and active construction of meaning. Because effort on the part of the learner is required, this implies that learners must hold considerable responsibility for their own learning. They outline a framework for curriculum development which includes not only decisions on content, but also factors such as students' prior ideas, different perspectives on the learning process and teachers' practical knowledge of students, schools and classrooms. Such ideas are important for this study as these varied factors may all influence the nature of student tasks and the overall learning environment while also providing a rationale for the greater use of IT in schools in that they provide students with a range of new experiences of which to make sense of or around which to 'construct' knowledge.

### **2.3.2 *Constructivist Methodology***

The methodology typically used in constructivist teaching has been summarised by many (e.g. Shapiro, 1994) and includes: (1) the selection of an appropriate experience embodying the concept to be taught; and (2) students attempting to explain this experience and evaluating each other's concepts against other students' ideas and with original experience. Teachers who have implemented constructivist teaching strategies have outlined their benefits. For example, Hand, Lovejoy and Balaam (1991) summarised the benefits to teachers as follows:

- Increased intellectual stimulation. Teachers often were impressed with the direction and depth that student discussions would take.
- Increased awareness of diversity. Teachers became more aware of the diversity of views held by students.
- Increased staff cohesion. Teachers in the case study reported that the teaching team had become more cooperative and sharing.

- More effective use of equipment. Teachers reported a clearer focus on outcomes as students were more responsible in laboratory settings.
- A better learning environment. The positive learning environment enabled students to gain self confidence and to enjoy science more.

In short, the constructivist teaching model validates many current ideas about teaching and learning. Many of the needs of students working in this model may potentially be met by the use of new information technologies.

### **2.3.3 *New Metaphors for Learning***

The current popularity of constructivist ideas about teaching and the growing use of computer networks is inspiring several new metaphors for learning. Many educators believe that common representations of information on the Internet (hypertext and multimedia) are similar to human long-term memory (eg. Eklund, 1995). With such a cognitive metaphor for memory, learners can create their own paths through a hypermedia environment and draw connections based on their own experiences.

Duffy and Cunningham (1996) have presented another metaphor for learning termed the Mind as Rhizome (MAR). Popularised by Italian author, Umberto Eco, this socio-cultural model blurs distinctions commonly made between environment/individual, inside/outside, and self/other and describes a system of knowledge which is interconnected in its 'total globality' while providing at the same time for parallel contextual realities.

Clearly, adopting any new metaphor for teaching and learning will be difficult. Still, the power and potential of new technologies may enable current reform efforts emphasising both sociocultural and cognitive constructivist ideas and potentially transforming the teaching and learning process in schools. Specifically, the implication in the adoption of constructivist metaphors for IT use is that it should ideally assist in

providing learning environments which emphasise greater learner control, exploration, expression, peer discussion, collaboration and a generally more facilitative or coaching role for the teacher in directing student learning.

#### **2.3.4 *Computers as a Tool for Learning***

Another perspective on the role of technology is simply as a tool for learning. Dede (1989) has noted that, despite the rapid pace and development of computing and telecommunications technologies, user demands for this power has increased as rapidly as it has become available. In order to understand how we can effectively use new and emerging technologies, Dede stressed that educators need to consider the concept of 'cognition enhancers'. He explains that two types of enhancers that are particularly important are: *empowering environments* and *hypermedia*. These ideas may relate well with the implementation of constructivist teaching methodologies.

Dede (1989) believes that many of the current educational uses for computers could be described as empowering environments as they free users from the more repetitive, machine-oriented tasks. This is the idea of computers being used as a time-saving tool. Users are free to spend more time in the uniquely human pastime of thinking. (An example of this would be the use of a spell-checker in a word processing environment.) The second type of cognition enhancer to which Dede refers can be described as hypermedia. Hypermedia is defined as a framework for creating interconnected representations of symbols (including text, graphics, sound) in a computer.

According to Dede (1989), the combination of widespread technological improvements and the concept of cognitive enhancers have the following implications for future curriculum design and content:

- Higher-order mental attributes such as creativity, decision making, evaluation and synthesis will become more important.

- Methods of assessment will shift from measuring mastery of descriptive knowledge to attainment of higher-order thinking skills.
- Learning while doing will become a more significant part of the learning process in schools.
- Group task performance, problem solving and collaborative learning will become increasingly important.

## **2.4 Learning as Mediated by Tools**

Yet another idea influencing the use of technology is the idea that learning is itself mediated or changed through the use of new technologies (such as the Internet). This idea was first espoused by Vygotsky (1978) who proposed two mediational means that could influence the nature or quality of an action: technical tools (eg. hardware) and semiotic tools (eg. symbols or text). The distinction between these two forms is difficult in the case of information technologies such as the Internet which incorporate both forms. Vygotsky's basic idea is that the invention or use of a tool doesn't simply facilitate forms of action that would occur anyway; instead it also could change the form, structure or character of the activity. In the case of learning as mediated by new information technologies, this idea could have positive or negative implications for computer use in schools. Clearly, this point underlines the need for clearer guidelines in the appropriate educational uses for networked computers.

This section outlines further important considerations in the development of educational guidelines for the use of IT from this perspective. It first describes the potential of the technology and follows with a consideration of software and physical design issues as they may alternatively facilitate or constrain student learning.

### **2.4.1 *The Educational Potential of IT***

Alexander (1995) has indicated that the world wide web (WWW) has developed into a popular and useful instructional medium for a number of reasons, including its



accessibility, flexible storage and display options, ability to support and display multimedia, and ease of use. However, Alexander maintains that all of these factors are largely technical considerations and that the instructional effectiveness remains unproven.

Another new development in schools has been the use of the Internet for what has been termed 'Computer-Mediated Communication' (CMC). This involves the use of e-mail, or other applications that enable human-to-human communication (e.g. conferencing software). In a study of school classrooms (Berge & Collins, 1995), many benefits of using CMC were reported including increased opportunities for cooperative learning, improved social interactions and increased cultural awareness on the part of students. This is important for this study because it indicates that the classroom learning environments may be positively improved through the use of IT.

Interestingly, new developments within the field of computing may enable new student-centred views about teaching to take hold if comprehensive guidelines specific to their educational use are developed. For example, the hypermedia format of the world wide web (WWW) gives this medium great potential as a learning tool. In particular, Eklund (1995) states that its power lies mainly in the types of learning that it can support. Eklund argues that it promotes student-centred learning, motivation, and exploration -- all factors linked to higher-order learning.

Many proponents of the use of the Internet or CMC see the principal value of this medium as an emancipatory communication medium, totally under the control of its users, for whatever purpose they deem useful (Romiszowski & Mason, 1996). This philosophy is witnessed in part by the growing number of Internet or 'Cyber-Cafes' appearing on street corners and institutions alike. In providing opportunities for greater learner control and autonomy through the use of technology, many educators see potential for a reversal in the traditional power and control structures prevalent in classrooms and in our larger society. In this, the Internet may at once be democratic and

anarchic in its offerings. However few would argue that this potential alone is a reason for its efficacy for education.

Other researchers cite examples where the Internet has potential to promote greater interactivity among students (Harasim, 1989) by allowing students to receive specific feedback of any length from other participants in their CMC discussions. Harasim (1990) states that CMC may be uniquely suited to collaborative study — providing students with opportunities for peer learning that would not be possible without the use of this technology.

The use of information technology in education in allowing students to develop strategies about 'learning how to learn' (metacognition). Burge (1993) used structured open-ended interviews to determine how students thought that they learned while engaged in their online learning environments. He found a set of learning strategies similar to those proposed by cognitive psychologists and adult educators as effective metacognitive strategies which included decision making skills, self expression, group interaction and methods for organising information. Eastmond (1993) found that students working in on-line environments were also better able to transfer these metacognitive strategies to other learning situations or contexts.

Importantly, while many factors point to the increasing use of computers as a powerful educational tool, computers (as machines) are themselves limited by their own technological needs (e.g. wiring, location of power supply, etc.) Care must be taken that these do not override the important sociocultural psychological and physiological human factors related to teaching and learning. Yet another important area where machine and human requirements must be balanced is in the area of software and interface design.

#### **2.4.2 *Software Considerations***

The issue of software design has been given much attention in the literature and a number of guidelines have been produced related to the development of software for

use in educational settings (e.g. Bowers & Tsai, 1990). These typically include a range of hardware and software requirements, human design factors, and the use of a simplified interface. Other important considerations include the need for adequate training in the use of the software. As a result of these guidelines, many educators have designed and developed useful educational applications for their students (e.g. Zandvliet & Farragher, 1997).

More recently, researchers have begun to study the design of software environments which more closely relate to current models of teaching and learning such as constructivism (e.g. Jonasson, 1994; Maor & Phillips, 1996). Jonassen (1994) suggests that students' construction of knowledge could be facilitated by software environments which: provide multiple representations of reality; avoid oversimplification; focus on knowledge construction; foster reflexive practice; and support collaborative construction of knowledge through social negotiation, not competition. Alternatively, it could be argued that software designs that do not incorporate these suggestions effectively could put constraints on the learning that might occur in those environments.

### **2.4.3 *Physical Design Considerations***

The physical layout of computerised classrooms and laboratories also could effectively constrain or optimise the types of learning activities and behaviours which are possible. In an international symposium which considered the use of new technology and its impact on educational settings (OECD, 1992), experts from many fields believed that future technologies might precipitate the following changes to the methods of education: (1) greater individualisation of learning; (2) more small-group work; (3) an opening up of the classroom to the outside; (4) greater autonomy for learners; and (5) greater responsibility on the part of learners. In forecasting the future needs of schools, the report summarised the following important points regarding physical learning areas:

- If most students are working as individuals or in small groups, noise reduction will be important within learning spaces.
- If open-plan spaces are used for individual or small-group learning, screening will be needed to avoid sound pollution.
- The trend away from 'whole-class' teaching will shift group structures and planned spaces will be needed to allow socialisation.
- Attention will be needed in the provision of furniture appropriate for different ages, but also to the 'security' of different students.
- Health and safety matters will need constant attention. This can be dealt with by referring to industrial and commercial experience.

All of the above points seem to indicate that, even within the unique vocational context of teaching, working and learning environments can be influenced by physical design factors and the psychosocial dynamics of the classroom. This study considered many of these interacting influences on the use of IT in our schools.

## **2.5 Summary**

Clearly, the development of educational guidelines for the implementation of new technologies such as the Internet is an important task. However, if these guidelines are to be effective, they must be comprehensive enough to take into account all of the factors considered in this chapter. In particular, they must consider the rationale and purposes for using information technology while also considering the influence of that technology on physical and psychosocial learning environments. These then would form an appropriate context for the use of IT in schools.

Importantly, some principles for the effective use of educational technology have already begun to be put in place (eg. Sabelli & Barrett, 1993). In a report for the National Science Foundation, Sabelli and Barrett also noted that technology itself is a

part of society and, so, should be tightly interwoven in education. They also stated three important principles for guiding its use: (1) technology is a neutral tool and its integration and educational progress go hand and hand; (2) technology provides educators with new and varied opportunities; and (3) learning should be engaging for students and technology can help to achieve this.

Clearly, the use of information technology in educational settings has the potential to bring about large-scale and meaningful change in the way in which teaching and learning occurs, and it could have a large role to play in influencing the current round of reforms. However, the degree to which these reforms are implemented will be largely influenced by the rationale and principles accompanying their implementation. This study investigated many of these considerations.

The next two chapters in this thesis continue the review of the literature by revisiting the conceptual model (from Section 1.4) and describing the degree to which IT implementation may influence the physical and the psychosocial learning environments in classrooms. Importantly, the degree to which these two aspects of learning environments interact to influence students' satisfaction is also explored.

## **Chapter 3**

### **Review of Literature on Physical Learning Environments**

#### **3.1 Introduction**

This chapter continues the review of literature relative to the implementation of IT in schools. While the rationale and potential for the educational use of IT was discussed in Chapter 2, the need for specific educational guidelines for its effective implementation was also noted. This chapter continues the description of the conceptual model first outlined at the end of Chapter 1 (Section 1.4) by describing the sphere described as the 'physical learning environment'. It is of particular importance to this study because the design of a physical space can facilitate or constrain the instructional use for that space, while at the same time impacting upon the psychosocial learning environment of the groups working within it.

Specifically, this chapter outlines a number of important physical considerations for the effective implementation of information technologies in school classrooms. It begins with an overview of early attempts at studying physical classroom environments (Section 3.2), outlines current thinking in the field of ergonomics and how this might be applied to the design and evaluation of computerised classrooms (Section 3.3), then gives a detailed consideration of the various ergonomic factors important for this study (Section 3.4) and, before closing, provides a brief summary of how these factors relate to other psychosocial issues in the field of ergonomics.

This study also explored the physical or ergonomic context of IT implementation by describing how a variety of networked computer workstations and laboratory facilities have been set up (or installed) in the studied schools. Further, it evaluated specifically how closely these set ups meet published guidelines used in the workplace (e.g. office settings). Finally, it investigated which of the physical factors considered are more

strongly associated with students' satisfaction with their learning. A description of the instruments and methodologies developed for this portion of the study is provided in Chapter 5 and a summary of literature related to the final sphere in the conceptual model (psychosocial learning environment) is considered in greater detail in Chapter 4.

### **3.2 The Learning Environment**

A growing amount of interest within the field of educational research has been focused on what is described as the classroom learning environment (Fraser, 1991, 1998; Fraser & Walberg, 1981; Moos, 1973; Walberg, 1979). This interest is also shared to some extent by researchers in other fields including those of psychology, sociology, physiology and engineering (Dugan, 1994; Knirk, 1992; Vasi & Laguardia, 1992; Walter & Jacobs, 1989; Weinstein, 1979). The interdisciplinary nature of such research points in part to the bewildering number of factors which ultimately can influence or determine learning.

As previously noted, the remaining factors which can influence learning can be grouped roughly into the categories corresponding to the physical and the psychosocial spheres in Gardiners' (1989) model. Physical factors might include such variables as classroom dimensions, classroom densities, and noise levels (what Gardiner termed the Ecosphere), while psychosocial factors would include the psychological and social aspects which could influence the quality or quantity of the interactions among individuals (what Gardiner termed the Sociosphere). It is important to note that physical and psychosocial factors are subtly and complexly inter-related. (This model was first presented in Section 1.4.)

This section looks specifically at aspects of research regarding the physical learning environment and evaluates how these are related to learning. Further, it attempts to summarise the background and development of the research methodologies which have been used in these areas in order to identify aspects of a research methodology that can facilitate the joint investigation of both physical and psychosocial learning

environments. This is important because the current study used this type of methodology in evaluating computerised classrooms associated with the use of new information technologies.

### **3.2.1 *Physical Classroom Environments***

While concerns about the physical environment and its effects on learning are not new, it remains a somewhat neglected component of teacher education and has been covered only sporadically in the literature. Still, early attempts at stimulating teachers to take stock of their physical teaching environments provide an important starting point for this type of study. Early concerns about the physical environment were limited to simple considerations of the spatial setting or to the quality and quantity of laboratory equipment.

Loughlin and Suina (1982) considered the physical learning environment as an important instructional tool for school teachers. They referred to classroom spatial organisation as an important vehicle for modifying or stimulating desirable learner behaviours. Loughlin and Suina distinguished between the overall fixed architecture of schools and what they termed 'the arranged environment'. They maintain that teachers could influence learning by carefully defining learner spaces within these existing constraints. The authors also provided a trouble-shooting guide which attempts to explain various disruptive behaviours in terms of environmental deficiencies.

Loughlin and Suina also stated that organising space in the learning environment would begin with furniture arrangement, which functions to divide the total area of the classroom into smaller spaces. While some spaces are designed by the teacher, others are created without intent and can be unnoticed. Because spatial organisation can influence actions and behaviours, these spaces can either support or contradict the teacher's purposes and expectations. Of particular interest are the dynamics of classroom movements which Loughlin and Suina maintain provide opportunities for meaningful (or disruptive) student interaction.



With the large-scale implementation of computer equipment and its associated furniture in classrooms, there is the potential for the physical environment to be either positively or negatively influenced by its installation. This is related to both the technological needs of the equipment itself and the equipment's relationship to the physical environment.

In a comprehensive review of earlier work, Weinstein (1979) described how the earliest studies of the physical environment of schools were concerned primarily with the establishment of minimum standards for size, acoustics, lighting and heating. This practice seemed to assume that, as long as these basic requirements were met, learning would depend solely on pedagogical, psychological and social variables. Weinstein also reviewed research on the impact of the classroom's physical environment on student behaviour, attitudes and achievement. This area of inquiry has generally been referred to as *environmental psychology*. According to Weinstein, work within this field is credited with giving rise to the controversial open space schools popularised during the 1970s (see Educational Facilities Laboratories, 1965).

Further, Weinstein noted that, because investigators studying educational environments come from a variety of disciplines (e.g. architecture, sociology, psychology and education), their reports are scattered and difficult to locate. Weinstein identified two basic approaches that had been used in the earlier research. The first method attempted to isolate a single environmental variable such as seating position, classroom design, student density, amount of privacy, noise or existence of windows and to measure its effect on learning or behaviour. The second type of research focused on 'ecological studies' which did not attempt to isolate the effects of any single variables but, instead, attempted to describe the educational 'habitat' of students.

### **3.2.2 *Review of Earlier Research***

Weinstein (1979) described several early studies in which environmental variables such as classroom design and furniture arrangement were studied and an attempt was made to measure their effects on learning. These included studies of correlational relationships between design and behaviour in third grade open classes (Zifferblatt, 1972), an experimental model with changing furniture arrangement in third grade classrooms (Weinstein, 1977), and a correlational study of alternative learning facilities with college students (Horowitz & Otto, 1973). Weinstein summarised by suggesting that design factors, such as the arrangement of furniture, use of modular panels, lighting, etc. could have an influence on students' general behaviour and on their attitudes towards the class and other students. In general, Weinstein believes that these variables did not have an impact on student achievement. Other studies which attempted to isolate other physical variables, such as classroom density and noise levels, were inconclusive.

Weinstein further noted several ecological studies which attempted to describe classroom behaviours in a general way and noted that this method was commonly used as an evaluation tool. The largest single body of research in the area relates to studies of open space schools (e.g. Educational Facilities Laboratories, 1965). Weinstein's summary of the literature on these schools suggests that they enhanced students' feelings of autonomy and that this in turn affected many of the non-achievement behaviours and attitudes of students (e.g. attendance, participation and motivation). However, following the widespread study of this type of school, Weinstein assumed that much of this information was not readily generalisable to other educational settings. Much of this initial problem was related to possible problems in the research methodologies used for these studies.

### 3.2.3 *Reworking a Research Methodology*

Weinstein had much to say about the quality of the research on physical learning environments, which mostly was either inconclusive or deemed to be methodologically flawed. Weinstein suggested a number of recommendations which she believed were needed to further this type of research, including: (1) the need to study other variables, such as noise levels and classroom density, which at that time had received only minimal attention; (2) the need to explore the relationship between physical design, educational program and teaching methodology; (3) acknowledgment of the complexity of environment-behaviour relationships; and (4) the need for carefully-designed research and interpretation which could reflect this inherent complexity.

Weinstein also stated that the frequent methodological flaws noted in this type of research were partly due to the extensive reliance on data from field-based observations in classrooms. She noted that, as in all field research, true experimentation was not possible because of factors such as the non-random assignment of subjects, lack of control of extraneous variables, and the need to take non-intrusive measurements constraining the methods used by researchers. Weinstein concluded by describing a variety of suitable methodologies including several types of correlational studies and single-unit interventions which would be appropriate for use in subsequent studies of physical learning environments.

The problems inherent in this type of research are not unique to the field of education. For solutions, educational researchers can look to research models and guiding principles from other areas of expertise. One area well suited to this type of interdisciplinary inquiry is the field known as *ergonomics*. The present study has borrowed extensively from ergonomic models in its consideration of the learning environment. The following section outlines the main principles from the field of ergonomics and describes how they may be applied to computerised classroom settings.

### **3.3 General Ergonomic Principles**

This section describes, in a general way, some important considerations in studying working or learning environments wherever they may be. It begins by giving an overview of ergonomics as it is generally applied in workplace settings, then details an approach that has been used in the design of computerised classrooms. Finally, this section lists some important considerations for evaluating the suitability of computerised environments in educational settings using an ergonomic approach and describes briefly the type of ergonomic evaluation adopted for use in the current study.

#### **3.3.1 *Workplace Ergonomic Considerations***

In the absence of a broad base of research on the subject of physical learning environments, educational researchers have had to rely heavily on research from other disciplines to guide the physical design of classrooms and institutional buildings. Increasingly, this type of research has become more influenced by interdisciplinary *ergonomic* or *human factors* studies. Here, ergonomics can be defined as the science that attempts to maximise worker productivity and safety by manipulating aspects of the physical environment. Chapanis (1996, p. 11) gives a broader view:

‘Human factors’ have been defined in many ways. One simple definition is designing for human use. Another simple definition is humanizing technology. Human factors or ergonomics is concerned with designing systems or working environments to accommodate human users. The aim of ergonomists is to provide individuals with tools and environments which are safe, comfortable and maximize productivity.

In examining general ergonomic principles, it is important to consider the broad scope of research which has occurred within commercial settings. Several comprehensive works have summarised a wide range of ergonomics studies in the workplace (e.g. Diberardinis, Gatwood, Baum, Groden, First & Seth, 1987; Goumain, 1989; Grandjean, 1987,1988; Kroemer & Grandjean, 1997; Osborne & Gruneberg,

1983; Stocker, 1991; Peterson & Patten, 1995). These summaries include extensive and broad reviews of literature in the areas of anthropometry (human anatomical dimensions in design), indoor climate, lighting levels, noise levels, and spatial seating arrangements. A detailed consideration of these factors is undertaken in Section 3.4. These factors are often considered as they relate to measures of worker productivity and safety.

### **3.3.2 *Ergonomics and Classroom Design***

Obviously, the science of ergonomics provides many factors to consider in attempting to study all aspects of the physical working environment. To a limited extent, some educational researchers have attempted to apply this approach to the study of physical learning environments within computerised school classrooms. These attempts have been largely related to the design process or to ongoing evaluations of the physical space.

In one report (Duggan, 1994), the concerns of microcomputer laboratory designers were emphasised. This included attention to areas such as the design of furnishings, access for the disabled, and type of teaching media in use in technologically equipped classrooms. The report also considered issues such as hardware and software security. Where these are often important areas to consider in designing a facility, the study ignored other important physical environment variables such as lighting, noise or measures of indoor climate.

In a more detailed consideration of environmental design, Knirk (1992) outlined an ergonomic approach to considering the physical environment for an integrated learning system (ILS). Knirk argues that educational institutions should work at applying ergonomic principles in order to adapt learning environments better to the needs of the teacher and learner. The author justifies the approach by summarising a number of findings from engineering, physiology and psychology which demonstrate that, when learning environments are well designed, a higher level of learning occurs.

Knirk (1992) maintains that the premise behind the application of ergonomic principles in the classroom is that, when the learning environment is not optimal, learners find themselves thinking about the more disturbing aspects of their environment, rather than concentrating on the learning tasks at hand. In his plan for the design of an integrated learning system, Knirk considered a variety of physical factors influencing the use of the technology in classrooms, including (1) lighting, (2) furniture, (3) wiring, (4) space, (5) security, (6) storage, (7) materials accessibility, (8) ambient noise, (9) room temperature and (10) relevant codes and laws pertaining to safety, fire and student density. While many of these recommendations closely resemble those listed in Section 3.3.1, they are unique in that they were derived from experience in educational settings.

### ***3.3.3 Ergonomic Evaluations of Classrooms***

Several evaluative reports have involved ergonomic principles and have further clarified the issues for the use of instructional technology in classrooms. While these issues again closely mirror those outlined in the previous sections, they are important as they were derived from evaluations of functioning learning environments rather than as a component in a design process.

In one such report, Walter and Jacobs (1989) reiterate that maintaining a productive learning environment could involve the manipulation of a variety of physical factors such as furniture, lighting, acoustics, air circulation, wall surfaces and floor coverings. In considering the findings from this diverse ergonomic research, the authors have made a number of important recommendations regarding the health, safety, comfort and productivity of students in computerised environments. Section 3.3.4 outlines how these and other important ergonomic factors, when considered together, are relevant to both the design and evaluation of productive working and learning environments.

### **3.3.4 Overall Performance of Physical Environments**

Goumain (1989) notes that, for occupants using a space, what counts is the combined performance of all the factors operating there. In technological environments, this complexity is compounded. For example, when considering lighting, the aspects of illumination, luminance, quality of lighting, glare and possibly even the colour and reflectance of a surface need to be considered together in order to evaluate the suitability of this particular environmental dimension. While many of these variables have been considered separately in the past, Goumain advocates the simultaneous evaluation of many physical measures as the most suitable approach to future ergonomic evaluations. Goumain describes this concept as the 'overall performance' of a space and recommends that combined standards be developed so that this new approach might be facilitated.

This concept has been reflected in the development of the methodology and instruments used in the current study. In particular, one instrument -- the Computerised Classroom Ergonomic Inventory (CCEI) -- was developed to measure the total suitability of groups of environmental dimensions considered together (e.g. the 'visual environment' for the example outlined in the preceding paragraph). With this instrument, several related physical factors were grouped together for consideration. These items were listed hierarchically -- with minimum requirements listed first and with subsequently listed items moving towards an increasingly optimal condition for the overall performance of that dimension.

The environmental groupings listed on the CCEI consist of five measures: workspace environment, computer environment, visual environment, spatial environment and air quality. In this manner, the ergonomic inventory incorporated many of the physical design aspects and environmental qualities considered important by ergonomists in maintaining or creating productive working/learning environments. A complete description of the development and use of this instrument is provided in Chapter 5. This review now continues with a detailed description of the various

ergonomic factors considered important in evaluating computerised classrooms. Many of these have been incorporated into the ergonomic inventory just described.

### **3.4 Ergonomic Factors in Working and Learning Environments**

This section gives a summary of the areas which proved useful in investigating the physical environment found in computerised classrooms. Sections 3.4.1 and 3.4.2, respectively, consider workspace and equipment design, and then Sections 3.4.3 and 3.4.4 consider aspects of lighting and colour use in working/learning environments. Section 3.4.5 deals with aspects of the spatial arrangement, while Section 3.4.6 describes important concerns relating to air quality in these environments. Finally, Section 3.4.7 completes this portion of the review by outlining ergonomic research regarding noise effects in computerised (and other) classrooms.

#### **3.4.1 *Engineering Anthropometry and Workspaces***

In order to avoid the constrained postures common at computer workstations in commercial or industrial settings, and to guarantee easy control of computerised tasks, the design of computer workstations must be adapted to several elements of body size. Here, ergonomists are faced with a problem because of the great variation in body size among individuals, the sexes and ethnic groups (Kroemer & Grandjean, 1997). This would also hold true in computerised school classrooms.

The science which deals with the measurement of size, weight and proportions of the body is termed *anthropometry*. Many countries have developed extensive databases of anthropometric measures and have made these available to furniture and equipment designers. Typically, ergonomists are concerned that the design of computer workstations minimally accommodates 90% of the population (normally the 5th to 95th percentiles). The two types of measurements typically used are static measures and functional measures which take into account joint flexibility and practical reach during normal movement.



Grandjean (1987, 1988) has proposed ergonomic guidelines for the design of computer workstations in general office settings. These parameters were developed in relation to both functional anthropometric measurements and the preferred settings of computer operators themselves. It is assumed that these recommendations would also be suitable for use with computer workstations located in school classrooms. These minimal design guidelines are presented in Table 3.1. In interpreting these, ergonomists would rate non-compliance with a guideline as a potential deficiency in the physical design of the workspace. Aggregated deficiencies might contribute to a loss of productivity or, more acutely, potential safety hazards.

Table 3.1

Acceptable computer workstation dimensions

Measure	Acceptable Range
Keyboard height (floor to home row)	700-850 millimetres
Screen centre above floor	900-1150 millimetres
Screen inclination to horizontal	88-105 degrees
Keyboard (home row)	100-260 millimetres
Screen distance to table edge	500-750 millimetres

Adapted from Grandjean (1988, p. 76)

In addition, Grandjean also made the following recommendations regarding workstation design:

- The furniture (and equipment) should be conceived as flexibly as possible. A computer workstation should be adjustable to a range of users.

- A workstation without adjustable keyboard height and distance of the screen is not suitable for continuous work.
- The controls for adjusting the dimensions should be easy to handle, particularly at workstations with rotating shiftwork.
- At knee level, the distance between the front table edge and the back wall should be not less than 600 mm and at least 800 mm at foot level.
- Flat keyboards which can be shifted are best. The centre row should be positioned no more than 30 mm above desk to avoid wrist stress.

Knirk (1992) has outlined a number of important considerations in the design of furnishings for computer workstations used in schools. He notes that the space, furniture and equipment requirements of learners (as opposed to workers) are particularly worthy of consideration. Of central importance is the need for computer tables or desks that include a separate adjustment for the keyboard. He notes that, when learners work at a computer, their forearms should be relatively horizontal and at a comfortable level. Further, the table should be large enough to allow room for text or other student materials and should be finished with a light colour. He also notes that the learner's chair should be ergonomically designed with an easily adjustable pad to support the lower back and that the front of the chair should be rounded with no sharp edges to cut into the learner's legs. He believes that these standards, commonly practised in office environments, should equally apply to computerised classrooms.

Any evaluation of furniture design in educational settings should critically consider the furniture types and arrangements currently used with computers. In one such evaluation, Walter and Jacobs (1989) made a number of important recommendations, including the use of recessed keyboards and the use of ergonomically designed chairs and tables for workstations. They recommend that the keyboard be adjusted so that the user has a natural arm position (i.e. the upper arm hanging vertically and the forearm/wrist positioned parallel to the floor). Further, they discuss how chairs should

be easily adjustable for seat and backrest height and should be equipped with castors for easy gliding. They note further that seat edges should be rounded to avoid interference with blood flow to the lower legs. Finally, they suggest that computer tables be adjustable when needed for proper screen and keyboard heights and for adequate leg room. Many of these recommendations agree closely with those proposed by Knirk (1992).

Another evaluative report (Vasi & Laguardia, 1992) echoes similar recommendations about furniture design but adds a number of special recommendations regarding the design and placement of CD ROM workstations in resource centres or libraries. In particular, the report suggests that special consideration be given to the placement of this type of work station, noting that ample room should be allocated to allow teachers or librarians to move around the workstation and to provide assistance to students when needed. They also stress that books and other reference materials should be conveniently located nearby.

Vasi and Laguardia also recommended that, in general, multimedia workstations should be provided with a two-level working surface. They noted that keyboards would ideally be placed at a lower level for ease of typing and that monitors should be placed at a higher level to allow for comfortable viewing. Also, the overall work surface should be large enough to accommodate other peripherals such as printers, scanners, etc. and that there should be sufficient additional space allocated for materials such as workbooks or texts to be used at the workstation. The authors noted that this could be accomplished by providing a moveable keyboard or by offsetting the keyboard to one side.

In this study, many of the concerns about furnishing in computerised classrooms were incorporated through the use of a descriptor defined as the 'workspace environment.' This factor formed the first of five categories evaluated by a special ergonomic inventory developed and used in this study. (The development and use of this inventory is described in Section 5.4.) The variable 'workspace environment'

encompasses a variety of factors including the amount and depth of workspace in addition to the range of adjustments in seating, keyboard and screen heights. The results of this evaluation of computer workspaces in schools is presented in Chapter 7. Importantly, the workspace environment was considered in relationship with another important ergonomic concern -- the design of the computer hardware and software itself.

### **3.4.2 *Computer Hardware and Software Considerations***

Many researchers have considered the design aspects of software and hardware interfaces used in learning environments. In a summary of the research in this area, Helander and Palanivel (1992) point to the need for the development of comprehensive design standards -- stressing a need for consistency in dialogue design, regular feedback to the user and a high degree of error tolerance as important considerations in software design. They also stress that careful consideration of the previous experience and training of the end user should also inform the design of new software. In many ways, the authors felt that the development of the direct manipulation interface, which was first developed by Xerox and later popularised by Apple, could positively influence these standards.

Knirk (1992) considered the equipment interface requirements of work stations in educational settings and recommended that the keyboard should be designed to be detachable so that the user can move it around into a comfortable position. He states that colour monitors have generally been found to be better than monochrome monitors as they allow for more effective cueing and highlighting in the software. He discusses how so called 'user-friendly' features of software such as windowing, pull down menus, search patterns and help features have been shown to help students perform better. Generally, he supports their use in classroom learning environments.

Sarti (1992) has also reviewed the architecture of educational applications and of the human-machine interface. He notes a general trend towards easy-to-use,

ergonomically-designed interfaces such as those using the object-oriented paradigm (whereby computer users click on objects on the screen rather than typing commands). Sarti identified a number of advantages in using window-managed computer systems and stated that the combination of these aspects contributed to the shorter time required for training individuals in the use of these types of programs. Many of these ideas have been successfully incorporated into most of the educational software now available. Indeed, with the increasing convergence of software and system designs across a variety of platforms (i.e. the graphical interfaces in Macintosh, Windows, etc.), the software interface is much less of an issue than previously thought.

With only small variations in currently available software designs and the limited availability of different Internet browsing applications, software interface issues were of only minimal concern in this study. Nonetheless, they are considered in this review as they have the potential to influence learning environments in either positive or negative ways.

Computer hardware and software issues taken together were considered under a descriptor defined as the 'computer environment' in this study. This factor formed the second of five categories evaluated by the special ergonomic inventory noted in the previous section and its development and use is described in Section 5.4. The variable 'computer environment' encompasses factors such as monitor and keyboard adjustments, and the presence of a graphical user interface (GUI) and colour monitor with reverse display (dark text on light background.) The results of this evaluation of computer hardware and software are presented in Chapter 7. This review of physical environmental factors continues below with a consideration of other relevant concerns which were incorporated into the research methodology for this study, including the amount of lighting and its quality and positioning.

### **3.4.3 *Illumination, Luminance and Glare***

Both the quality and quantity of lighting have been shown by ergonomists to be very important in maintaining worker productivity and health. Ergonomic recommendations in this area relate to the physiological requirements of the human eye in adapting to different levels of illumination and luminance, and in dealing with excessive glare. Inadequate lighting or excessive glare can cause eye fatigue and annoyance, which contribute to a reduction in attention to working tasks.

Illumination is described as a measure of the stream of light falling on a surface. The light can come from the sun, bright lamps or any other bright surface in a room. The unit of measurement of illumination is the lux (lx). Reflected light is measured as luminance (i.e. the brightness of a surface). Its unit of measurement is the candela per m<sup>2</sup> (cd/m<sup>2</sup>). Glare can be described as an overloading of the adaptation processes of the eye which is brought about by overexposure of the retina to light. Relative glare is caused by excessive brightness contrasts between different parts of an individual's visual field.

The ergonomic considerations for lighting are based on physiological and psychological requirements and should include the maintenance of a suitable level of illumination, a spatial balance of surface luminances, a temporal uniformity of lighting, and an avoidance of glare (i.e. with appropriate lights). Also, where artificial lighting is used, the following should also be considered: the reflectivity (i.e. colour and material) of working materials and surroundings; the extent of the difference from natural light; and whether it is necessary to use daytime lighting (Grandjean, 1988; Kroemer & Grandjean, 1997). Further, recommendations for illumination and the elimination of glare in computerised offices have been proposed (Grandjean, 1987, 1988) and are summarised in Table 3.2.

Table 3.2

Recommended luminance levels for computerised offices

Type of task	Lighting (horizontal measure)
For conversational tasks with well-printed source documents	300 lux
For conversational tasks with reduced readability of documents	400-500 lux
For data entry tasks	500-700 lux

Adapted from Grandjean (1987, pp. 265-269)

In addition, Grandjean noted the following considerations related to glare:

- The most effective preventative measures are the adequate positioning of the screen with respect to lights and windows.
- To avoid dazzle effects, all important surfaces within the visual field should be of the same order of brightness.
- The general level of illumination should not fluctuate rapidly because pupil and retinal reactions are a relatively slow process.
- The effect of relative glare is greater the nearer the source of dazzle is to the optical axes, and the larger its area.
- A bright light above the line of sight is less dazzling than one below or to either side.
- The risk of dazzle is greater in a dim room because the retina is then at its most sensitive.

These types of recommendations are of course equally relevant to the use of computers in educational settings. Failure to meet guidelines of this nature can severely impact learning environments and the overall productivity of students. In considering the lighting in educational settings, Knirk (1992) states that measurable increases in learning have been made by manipulating both lighting levels and the amount of lighting contrast in the learning environment (e.g. Woodson, 1987). He believes that glare from computer monitors is a major distracter to learning as are extreme contrasts in brightness between background or ambient lighting and the illumination of the computer screen. The reasoning is that high contrast levels force students to adapt to variations in the lighting level. To avoid this, Knirk recommended that lighting levels be maintained within the range 440-755 lux.

Walter and Jacobs (1989) note that one of the most important physical factors in any evaluation of computer usage is background lighting. Here, the authors cite research indicating that lower lighting levels are recommended in rooms where computers are being used. The benefit of lower light levels are that (1) they minimise the contrast between the lighting levels in the room and the monitor, thereby making screen characters easier to read, and (2) they reduce screen glare created by bright lighting. Walter and Jacobs suggest that all lighting sources in rooms where computers are used should be indirect and come from below the waist (never overhead). In some situations, the use of glare screens fitted over monitors could lessen the problem.

Walter and Jacobs also state that another common source of screen glare comes from unprotected windows; they suggest as a solution that all windows be fitted with coverings that control the angle of incidental light. They acknowledge further that a growing body of physiological research has shown the benefits of using full-spectrum lighting as opposed to other types (e.g. fluorescent lighting) in workstation design. Citing a study by the Austrian Centre for Sports Medicine, Walter and Jacobs suggest that the use of full spectrum lighting can improve work capacity, decrease heart rate, and increase oxygen intake. In contrast, the use of fluorescent lighting has been linked



to headaches, eyestrain and fatigue. It is reasonable to assume that these research findings can also apply within classroom learning environments.

The considerations of illumination, luminance and glare were jointly considered in this study under a descriptor defined as the 'visual environment'. This factor formed the third category evaluated by the ergonomic inventory developed and described in Section 5.4. The variable 'visual environment' encompasses factors such as the absence of glare, presence of natural lighting, extent of lighting contrast (due to differences in finishing materials), and overall illumination and luminance in a setting. The results of this evaluation of lighting are presented in Chapter 7. Another important and related ergonomic issue in evaluating physical learning spaces was the use of colour. This important issue is raised in the following section.

#### **3.4.4 *Psychological Effects of Colour***

The use of colour in providing psychological cues has also been widely studied by ergonomists. The use of special colours in warning systems has been implemented in a variety of systems (i.e. traffic lights, emergency vehicles, controls, etc.). In addition, the use of colour schemes in workplace design can have more subtle effects (Grandjean, 1988) where they can effectively enhance or constrain a person's psychological perceptions of the physical space. These findings can also be associated with the degree of reflectivity of different colours, as well as their effects on an individual's mood. A summary of colour effects is presented in Table 3.3. This consideration is equally important for this study as many behaviours are the result of subtle perceptions of that environment by a group or individual rather than of physical or physiological responses to environmental stressors. For example, the use of light blue and green hues in the finishing of a room can give individuals the perception that the room is larger than it actually is. Further, the use of darker colours such as brown or orange can make the same space appear smaller or more confined.

Table 3.3

## Psychological colour effects

Colour	Distance effect	Temperature effect	Mental effect
Blue	Further away	Cold	Restful
Green	Further away	Cold to neutral	Very restful
Red	Closer	Warm	Very stimulating
Orange	Much closer	Very warm	Exciting
Yellow	Closer	Very warm	Exciting
Brown	Much closer	Neutral	Restful
Violet	Much closer	Cold	Aggressive; tiring

Adapted from Grandjean, (1988, p. 336)

Knirk (1992) points to a standard regarding the use of colour in learning spaces, because research has shown that the use of colour can influence a person's behaviour and physiology (Sanders & McCormick, 1987). For example, studies have shown that colour can affect our ability to differentiate between objects in addition to affecting a learner's attention span, blood pressure and respiratory rate (Kwallek & Lewis, 1990). He summarised by stating that cooler, softer colours used with visible hardware, paper products and computer screens tend to foster contemplation. He notes that computer equipment is usually light in colour to match the paper and text materials commonly used at workstations.

In the current study, references to colour were imbedded in many of the variables described by the ergonomic inventory, including (1) the use of colour for cueing in computer software (Computer Environment), (2) minimised contrast through the use of neutral finishes (Visual Environment) and, (3) overall room finish (Spatial Environment). This review of ergonomic factors continues now with a consideration of the different spatial requirements for working and learning spaces.

### 3.4.5 *Spatial Arrangements*

In addition to other factors, minimum safety guidelines have been proposed for the design and layout of teaching laboratories (Diberardinis, Gatwood, Baum, Groden, First & Seth, 1987). According to these guidelines, a teaching laboratory should be designed and constructed to provide a safe working and learning area for groups of students. In high schools, the number of students in a laboratory should not exceed 30 students. The authors state that teaching laboratories should be designed to demonstrate and encourage safe practices while allowing easy movement throughout the laboratory. In general, the guidelines state that peninsula arrangements do not permit such movement but that wall and island benches do.

Criteria have also been developed for the design of individual laboratory work areas (Diberardinis et al., 1987). These have been developed from detailed time/motion efficiency studies and relate to optimal dimensions for the standard laboratory aisle. The authors define a laboratory aisle as a space, usually flanked by an array of work surfaces, equipment, benches and utilities, where individuals spend their working day. The guidelines state that an aisle between benches, work surfaces or equipment should be a minimum of 152 centimetres wide so that a person can pass behind another person working at a bench. The maximum clearance should be 183 centimetres as the authors noted that aisles wider than this tend to get clogged with free standing equipment and other obstructions.

In addition to these minimal guidelines, spatial arrangements are often part of the fixed design of classrooms and often are not adjustable to suit the instructional needs of individual teachers. It becomes obvious that these arrangements can profoundly affect the nature of the teaching methodologies employed and hence the range of possible student tasks or behaviours in a given setting. In this study, the issue of minimum spatial environments was considered by the ergonomic inventory variable *spatial environment*. Further consideration to the different types of spatial arrangements in classrooms is described by a case study methodology presented in Chapter 5. This

review now continues with another important issue which was jointly considered by the ergonomic inventories and case studies -- indoor climate.

#### **3.4.6 *Monitoring Indoor Climate***

Another important area of ergonomic enquiry is that of indoor climate, which can be described as the physical conditions under which work (or study) is undertaken. Its principal components are air temperature, the temperature of the surrounding surfaces, air humidity, air movements and air quality. One hardly notices the internal climate of a room as long as it is comfortable. However, the more it deviates from a comfortable standard, the more it attracts attention as the body must work actively to heat or cool itself. Further, discomfort with climate can bring about physiological changes which affect the entire body. Overheating can lead to weariness, loss of performance and increased errors. Conversely, overcooling induces restlessness, which reduces alertness and concentration, particularly on mental tasks. Therefore, the maintenance of a comfortable climate indoors is essential for well-being and maximum efficiency (Grandjean, 1988).

In response to this information, Kroemer and Grandjean (1997) have proposed the following guidelines which can also be suitable for use in school settings:

- The air temperature should be between 20 and 24 degrees Celcius.
- Adjacent objects should be at temperatures within 2-3° C of the air.
- The relative humidity should be maintained between 40% and 60%.
- Draughts at the levels of head and knees should not exceed 2 m/s.

Some educational researchers also include the factors of temperature, humidity and overall air quality as important considerations for physical learning spaces. Research has shown that these factors to have an effect on learning, information handling, and human performance (Sanders & McCormick, 1987). Knirk (1992) states that the ideal

air temperature for young adults should range between the equivalent of 20-22 degrees Celsius at 30 inches from the floor (with the relative humidity kept between 30% and 60%). Outside of these limits, the body must work to heat or cool itself, and this impacts on student performance as errors increase and accuracy decreases. Further, Knirk notes that, if humidity levels rise above 70%, it impairs human performance and can further lower the quality of the learning experience.

Finally, a positive learning environment would also be one in which, minimally, the air would be free of pollutants such as carbon dioxide, carbon monoxide and ozone. Such air-borne pollutants have significant health and safety implications and even trace amounts of these substances can have deleterious effects on human attention and performance (Grandjean, 1987). It is important to note that some pollutants (e.g. carbon dioxide) occur naturally and can accumulate to problem levels in areas without adequate ventilation. Importantly, minimum safety guidelines for carbon dioxide (and other pollutants) have been published by a variety of organisations (e.g. Occupational Safety and Health Administration, 1997) and can be easily monitored by qualified occupational health and safety personnel.

The environmental monitoring of classroom temperature and humidity, as well as the measurement of carbon dioxide levels, formed an important part of the methodology used in this study and is described in Section 5.5. Extremes or fluctuations in these environmental measures could certainly constrain students' productivity and comfort and therefore influence the learning environment. As with other ergonomic concerns, these outcomes can involve a combination of psychological or physiological responses. This consideration of ergonomic factors continues with a description of a final physical factor -- noise effects.

### **3.4.7 Monitoring Noise Levels**

An important area of ergonomic inquiry is the study of noise effects. As with some of the other ergonomic measures, this is a difficult area of study as the human perception of sound has both a physiological and psychological component. In simple terms, a noise is any disturbing sound. In practice, we call it 'sound' when we don't find it unpleasant and 'noise' when it annoys us. The perception of sound is related to both pressure (intensity) and pitch (frequency). The human ear detects sound within a range of 20 to 20,000 hertz (Hz). A logarithmic unit, the decibel (dB), measures a wide range of audible signals.

Excessive background noise levels or frequent modulation or fluctuation of noise levels and pitch have been shown to distract individuals, thereby impairing concentration, communication and, in extreme cases, even causing permanent injury. The apparent loudness of a sound has also been shown to depend on its pitch or frequency; often, low pitched sounds seem much quieter than do higher pitched ones (Grandjean, 1988; Kroemer & Grandjean, 1997).

Personal experience also shows that many noises can arouse in individuals feelings and sensations that are strongly subjective. These psychological effects relate to an individual's unique background and experience. So, for concentrated mental work or jobs which emphasise speech or communication, even low noise levels can be disturbing. Therefore, the monitoring of sound levels in computerised classrooms should also be considered important.

The equivalent noise level ( $L_{eq}$ ) is the most commonly used unit to assess noise loads. This measure expresses the average level of sound energy during a given period of time. It effectively compares the disturbing effect of fluctuating noises within a continuous noise of steady intensity. Measures of mean and peak noise levels are also used. In order to protect workers from the effects of noise, Grandjean (1987, 1988) has proposed the guidelines in Table 3.4 for noise levels in large open offices.

Table 3.4

## Recommended noise levels in large offices

Type of measure	Recommended range
Equivalent noise level	54-59 dB(A)
Mean noise level	50-55 dB(A)
Peak noise levels	60-65 dB(A)

Adapted from Grandjean (1987, p. 273)

Researchers have also studied ambient noise levels in school classrooms and have attempted to relate these to their effect on learning. Ergonomic standards stress that noise levels above 70 dB have been shown to influence heart rate and blood pressure, and can decrease performance. Also, many researchers have noted that even lower intensity background noise may be annoying or result in distraction from the learning task (Sanders & McCormick, 1987). Some researchers have suggested that the highest level of background noise in a learning environment should be 45 dB, with 30 dB being optimal (Woodson, 1987). Excessive noise can be controlled by the use of carpeting, by having fewer windows, or by the addition of drapes. It is important to note that few studies have indicated noise levels in excess of 70 dB in classrooms, and that often louder classrooms are a product of more active and lively discussion and are therefore considered a positive attribute by many teachers.

The monitoring of noise levels in computerised classrooms did form a part of the methodology used in this study and is further described in Section 5.5. This measure was considered particularly important because excessive amounts of noise can illicit both psychological and physiological responses which can distract individual learners. In addition, variations in tone, amplitude and frequency (possibly from working equipment in a room or from human interactions) could provide further concerns --

potentially affecting student productivity and influencing the psychosocial learning environment.

Up to this point, this review of the ergonomic literature has considered mainly physical variables which can be considered in evaluating the implementation of IT in workplaces and in schools. However, it is important to note that ergonomists also concern themselves, to some extent, with the psychosocial aspects of the technological working and learning environments. This component of their research is focused on limiting what they term 'occupational stress' on individuals by carefully monitoring and controlling the nature of their tasks. This area is considered in the next section.

### **3.5 Psychosocial Issues in Ergonomics**

Ergonomists seek to limit the 'occupational stress' experienced by workers. In this, occupational stress could be defined as the emotional state (or mood) which results from a discrepancy between the level of demand in a situation and an individual's ability to cope. Ergonomists believe that this stress is a subjective phenomenon and exists in people's recognition of their inability to cope with the demands of a job or workplace. This inability could be based on any number of physical or psychosocial variables.

Research on occupational stressors has also defined the concept of 'person-environment fit' (Grandjean, 1987, 1988; Kroemer & Grandjean, 1997). The assumption is that the degree of fit between individuals and their environment can determine their well-being. Environment is used here in a broad sense -- including the social and physical environments. Factors that could affect the degree of stress include (1) degree of task control, (2) amount of social support, (3) task performance demands, (4) the physical environment and (5) task complexity. In general, a lack of autonomy could produce emotional and physiological strain and increasing social support could lessen these effects. Other aspects of the environment could either increase or decrease these perceptions of stress.



Interestingly for this study, many of the psychosocial constructs considered by ergonomists as being important in the workplace have also been shown to be important in educational settings (e.g. degree of autonomy, task orientation, cooperation and support). This point reinforces the idea that learning and working environments can be jointly influenced by both physical and psychosocial factors as they are associated with the use of new information technologies.

### **3.5 Summary**

While scholars in a wide variety of disciplines have attempted to categorise and study the physical learning environment inside school classrooms, their reports remain largely scattered and lacking in a cohesive framework or research methodology. In fact, many early studies of physical learning environments demonstrate serious flaws in research methodology or have findings which are not considered applicable to a wide range of educational settings. The most successful studies are those which have taken an ecological approach and attempted to include the widest variety of physical factors in some type of correlational model.

Here, researchers can also benefit from a broad body of ergonomic research which has illuminated many important physical considerations such as the type of furnishings and equipment present, the nature and amount of lighting, spatial room arrangements, air quality and noise levels. Ergonomists have demonstrated that all of these factors can influence human productivity in workplace settings. Further, a small number of educational studies has begun to explore these considerations as they apply to educational settings. Still, most ergonomic studies involve only a limited number of factors and consider few factors outside of the physical learning environment. While ergonomists also consider psychosocial factors such as 'occupational stress', what is most problematic for ergonomists in this respect is that the vast differences in goal structures between the different classroom and workplace environments can largely invalidate this approach for research in schools.

Still, with the introduction of so much technological change in classrooms, the need to study the physical learning environment is probably greater than ever before and the field of ergonomics has much to offer in this. What is needed is a multidimensional research model which mirrors the complexity of today's increasingly computerised classrooms. Because the adoption and interpretation of the ergonomic standards developed for business and industry provide a good starting point for the study of physical learning environments in schools, this was the approach taken in this study. However, this information was also combined with other more widely studied psychosocial factors and with additional information about the educational context for its use. This final point leads to a consideration of the final sphere of influence needed to evaluate IT use in classrooms. This area has been identified as the 'psychosocial learning environment' and is discussed in the next chapter.

## Chapter 4

### Review of Literature on Psychosocial Learning Environments

#### 4.1 Introduction

This chapter completes the review of literature relating to the implementation of IT in schools begun in Chapters 2 and 3 by focusing on the psychosocial learning environment. It continues the description of the conceptual model first outlined in Section 1.4 by outlining the final sphere of influence in the model. Psychosocial learning includes all the social interactions and communications among teachers and their students. Ultimately, as teaching at its very core remains primarily concerned with managing these social interactions, the psychosocial environment would seem to be crucial in evaluating the use of new information technologies in teaching and in shaping the maintenance of effective physical learning environments. As such, this line of research is of particular importance to this study.

The chapter outlines important psychosocial factors related to the implementation of information technologies in classrooms. It begins with a general description of this type of learning environment research (Section 4.2), then describes the historical perspective in its development (Section 4.3). The chapter continues by describing a number of important learning environment instruments developed by researchers (Section 4.4) and then ends by describing a variety of recent learning environment studies including those conducted in computerised classrooms in Section 4.5.

The current study used a modified version of a recently developed learning environment instrument -- the What is Happening in this Class (or WIHIC). This instrument (described in Section 4.4.8) was used to aid the description of the psychosocial learning environment in the studied classrooms. Further, it was used to investigate which of the described psychosocial factors are more closely associated with students' satisfaction with learning in these settings. This information is considered jointly with other information about the educational context of these settings and other

important information about the physical learning environment. A detailed description of modifications to the WHIC instrument and the methodology developed for its use are provided in Chapter 5.

## **4.2 Psychosocial Learning Environments**

In an overview of research on classroom and school climate, Fraser (1994) noted that Herbert Walberg (1976) and Rudolf Moos (1973) independently laid the foundations for the initial work on educational environments in the late 1960s. Studies now conducted by educators on classroom learning environments owe much to this earlier work and its application to educational settings. Fraser described research on learning environments as being both descriptive of the classroom and potentially predictive of student learning.

A great variety of approaches has been used in the study of educational environments. These methods range from so-called subjective measures, such as students' and teachers' perceptions of the learning environment, to so-called objective measures, such as the frequencies of certain observed behaviours. These different approaches have also been categorised as, respectively, 'high' and 'low' inference measures. Work still needs to be done in determining the appropriate context for each type of methodology.

While discussing the attributes of these different types of research, Fraser (1994) also identified a number of other methods which have been employed in describing classroom learning environments, including naturalistic, ethnographic and behaviouristic approaches. He noted that still other studies had taken an interdisciplinary approach which included either an ecological or ergonomic focus in the analysis of learning environments. Before considering the methodologies and instruments currently used in classroom environment studies, it is important to consider the historical background and context to this type of research, including the development of current research methodologies (Section 4.3.5).

### **4.3 Historical Perspective**

In some of the earliest work on human environments, Rudolf Moos (1973) stated that interest in the physical and social aspects of planning human environmental systems such as towns, workplaces or public institutions, was increasing. Moos eventually saw this growing concern as being responsive to the technological changes which were (and are) effecting large-scale change in society. He suggested that this created a need for a model to conceptualise and assess these environments.

Moos presented six major indices of human functioning which could focus this assessment, namely, (1) ecological dimensions, which include geographical and physical design features, (2) behaviour settings, which include both ecological and behavioural factors, (3) dimensions of organisational or administrative structure, (4) dimensions identifying collective personal and behavioural characteristics, (5) dimensions related to psychosocial and organisational climates, and finally (6) variables relevant to the functional and reinforcement analyses of these environments.

Moos stressed that this conceptualisation of human environments was incomplete and that each of the dimensions was interrelated and non-exclusive of other dimensions. He suggested that the six categories were not rigid and that certain measures could be as easily placed in one dimension as another. In short, Moos recognised the interdisciplinary nature of the study of human environments. Throughout, he referred to research in other disciplines, including engineering (ergonomics), psychology (behavioural ecology) and sociology. In another early work on human environments, Walberg (1976) reviewed three models for conceptualising the psychology of learning environments: a behavioral model; a structural model; and a perceptual model. While he described the underlying assumptions of each, Walberg criticised the behavioural model which had dominated much of educational research and advocated a shift to perceptual research models.

Walberg described perception as a broad, complex subject of psychological inquiry. He summarised how perceptions of environment could account for considerable variation in classroom learning but also considered some of the research complexities that investigators of educational perceptions faced. One such problem was described in terms of the 'unit of analysis' question (whether perceptions should be considered at the individual or class level). Walberg noted that psychological research favoured the use of group means.

Walberg claimed that the evaluation of teaching based on structural and behavioural theories required perceptual measures of what he termed the 'feel of the class'. He indicated that such measures might include perceptions of factors such as cohesiveness, level of participation, and feelings of adequate achievement. Finally, he noted that the multivariate analysis of behavioural complexes with educational perceptions may eventually begin to characterise some important aspects of the social learning environment.

#### ***4.3.1 Developing the Context***

In subsequent work on classroom learning environments, a research context began to develop and common themes began to emerge. Several reviews of the literature attempted to identify these trends and identify new areas for research. One of the more important reviews (Walberg 1979) introduced the concept of 'educational productivity' discussed later in this section. Walberg (1979) characterised educators essentially as environmentalists because they design and bring about environmental contexts, processes and interventions which they hope would maximise learning. While acknowledging the difficulty in measuring the effects of these actions, Walberg noted the inherent importance of attempting to do so.

Walberg also discussed the difficulty in finding causal effects within educational settings. He attributed the problem to several factors, including variance in the goals held for education, variance in the methodologies employed by researchers, and finally

the inherent difficulty in measuring some of the more subtle environmental factors.

Walberg also noted that many of these measures were uncalibrated and that many were simply not comparable across the wide variety of educational settings.

#### **4.3.2 *Productivity Models***

Walberg's own work attempted to illuminate an area which he called 'educational productivity'. As in other professions, such as medicine, agriculture or engineering, educators were searching for answers to empirical questions of causality, such as "Which environmental factors tend to maximise student achievement?" It followed that, if such questions could be answered with some clarity, new practices could be recommended to educators.

Walberg, Fraser and Welch (1986) further tested this model of educational productivity. According to Walberg, the nine factors which work together to increase student achievement are (1) ability, (2) age, (3) motivation or self concept as measured by personality tests, (4) quantity of instruction, (5) quality of the instructional experience, (6) the home environment, (7) the classroom environment, (8) the peer group, and (9) the mass media (especially television viewing).

In this research, Walberg et al. studied aspects of ability, motivation, quantity and quality of instruction, and the environments of the home and class using a set of 11 predictors. When these individual predictors were regressed on achievement and attitude, the educational productivity model was generally supported. The study found that most factors were positively related to either student achievement or attitudes. The exception was the amount of television viewing which had a negative relationship with achievement and attitude. They concluded that no single factor emerged to be dominant in determining learning.

A later use of Walberg's model of educational productivity (Walberg, 1991) included three groupings of nine factors to be analysed. These factors were student aptitude (as measured by student ability, development and motivation), instruction (as

measured by amount of time and instructional quality), and finally psychological environments (including home, classroom, peer group and television). Walberg considered many of these factors as being at least partially influenced by educators.

Around the same time that the model of educational productivity was being developed, a number of other ideas were taking shape, including the identification of a variety of different goal structures commonly employed by teachers in maintaining a positive learning environment in their classes.

#### **4.3.3 *Social Goal Structures***

In an important discussion of psychosocial factors in the learning environment, Johnson and Johnson (1979) state that, for whatever reason, student-to-student interactions had not previously been emphasised in the development of curriculum and in the preparation of teachers. Instead, the role of the teacher had been emphasised and student interaction with the instructional materials had been stressed. They argued that student interaction had powerful effects on learning. Johnson and Johnson described the attributes of three goal structures which had been used by educators: *cooperative* (positive goal interdependence); *competitive* (negative goal interdependence); and *individualistic* (no interdependence). They stated that, in the ideal classroom, each of these goal structures would be used at appropriate times. The authors noted further that the way in which teachers structure their learning goals would determine how students interact and, ultimately, what they learn.

The authors also discussed the practical nature of using the three goal structures appropriately. They argued that cooperative strategies should be used more frequently than competitive or individualistic structures as they provide the best overall context for learning. Finally, they noted that the importance of cooperative learning experiences went beyond improving instruction to include other important social and attitudinal competencies essential to the functioning of any social environment. Other work on



classroom environments explored tentative relationships between the learning environment and the curriculum.

#### **4.3.4 *Curricular Links***

Kuert (1979) summarised what he believed to be the empirical relationship between the subject matter (curriculum) and various environmental variables. He indicated that much of this research was based on a 'needs-press' model which stressed the need to view behaviour as a product of both the person and the environment. This view of the learning environment had considerable influence in the literature and eventually led to the development of a variety of different instruments attempting to measure it.

Kuert reported that the two most popular ways of assessing classroom environments were observational systems and self-report questionnaires. Observational models were characterised by discrete 'category systems' which attempted to quantify certain classroom behaviours as viewed by an external observer. In contrast, the use of self-report questionnaires tended to rely on high inference responses.

Finally, Kuert stated that the self-report questionnaire had been the most frequently used method for assessing aspects of the psychosocial learning environment. A list of the important instruments which had been developed at that time included the High School Characteristics Index (HSCI), Classroom Environment Scale (CES), Class Activities Questionnaire (CAQ), and Learning Environment Inventory (LEI). These instruments were used in a variety of studies as determinants of the learning environment. A comprehensive summary of current instruments still in use is detailed by Fraser (1998) and described in Section 4.4.

#### **4.3.5 *Developing Methodologies***

In one review of the research, Fraser and Walberg (1981) summarised three distinct methodologies for assessing and studying classroom environments: naturalistic inquiry; interaction analysis; and the measurement of perceptions of the psychosocial characteristics of the classroom. They indicated that the measurement of perceptions had a number of important advantages over these other methods in that they were simple to administer, were based on experiences over a longer period of time, and had been shown to account for considerable variance in student learning. A detailed description of the methodology used to describe the psychosocial learning environment in this study is outlined later on in Chapter 5. This review continues with a description of some popular learning environments instruments, including the What is happening in this Class (WIHIC) questionnaire used in this study.

#### **4.4 Learning Environment Instruments**

Recently, Fraser (1998) overviewed the instruments used in research on learning environments, including the Learning Environment Inventory (LEI), Classroom Environment Scale (CES), Individualised Classroom Environment Questionnaire (ICEQ), My Class Inventory (MCI), College and University Classroom Environment Inventory (CUCEI), Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CES) and, finally, What is Happening in this Class (WIHIC) questionnaire. Fraser states that these instruments have been shown to be reliable in extensive field trials. What follows is a brief description of each instrument and some information about its validation. A summary of each instrument's scales and the grade level is also provided in Table 4.1.

#### **4.4.1 *The Learning Environment Inventory (LEI)***

The initial development and validation of the LEI began in the late 1960s as part of an evaluation and research program related to Harvard Project Physics (Fraser, Anderson & Walberg, 1982). The final version of this instrument contains a total of 105 statements (grouped into seven scales) which are descriptive of typical school classes. Respondents express their position of agreement or disagreement with each statement using the four response alternatives of Strongly Disagree, Disagree, Agree and Strongly Agree. The scoring direction (sometimes termed polarity) is reversed for some items which have been negatively worded. A typical item in the Cohesiveness scale for this instrument is “All students know each other very well” while a typical item in the Speed scale is “The pace of the class is rushed”.

#### **4.4.2 *Classroom Environment Scale (CES)***

The CES was developed by Rudolf Moos at Stanford University (Fisher & Fraser, 1983; Moos, 1979; Moos & Trickett, 1987) and grew out of comprehensive research program involving perceptual measures of a variety of human environments including hospitals, prisons, university residences and work environments (Moos, 1973). The final version of the instrument contains nine scales – each with 10 items with a True-False response format. The published materials included with this instrument include a test manual, answer sheet and transparent hand scoring key. Typical items in the CES are “The teacher takes a personal interest in the students” (from the Teacher Support scale) and “There is a clear set of rules for students to follow” (from the Rule Clarity scale).

#### **4.4.3 *Individualised Classroom Environment Questionnaire (ICEQ)***

The ICEQ describes those dimensions which distinguish individualised classrooms from conventional ones. Its initial development (Rentoul & Fraser, 1979) was guided by literature on individualised, open and inquiry-based methods in education and extensive interviews of teachers and secondary school students. During the drafting of the ICEQ, selected experts, teachers and junior high school students were consulted for their reactions. The final published version of the instrument (Fraser, 1990) contains 50 items divided equally into five distinct scales. Each item is responded to using a five-point response scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. As with the LEI, the scoring direction is reversed for many of the items. Typical items are “The teacher considers students' feelings” (from the Personalisation scale) and “Different students use different books, equipment and materials” (from the Differentiation scale).

#### **4.4.4 *My Class Inventory (MCI)***

The MCI is basically a version of the LEI (described in the previous section) which has been simplified for use in primary schools (Fisher & Fraser, 1981; Fraser, Anderson & Walberg, 1982; Fraser & O'Brien, 1985). Although the MCI was developed for use among younger children (aged 8–12 years), it also has been found to be very useful with students in the junior high school, especially those who might experience reading difficulties with other instruments. The final form of the MCI contains 38 items in five scales (reduced from seven). The MCI contain simplified wording and a simple Yes-No response format. Typical items in the instrument are “Children are always fighting with each other” (Friction) and “Children seem to like the class”(Satisfaction).

#### **4.4.5 *Collegel/University Classroom Environment Inventory (CUCEI)***

Until the development of the CUCEI, surprisingly little work had been done in describing the learning environment in higher education classrooms (Fraser, 1998). While this type of instrument is not particularly useful for large lecture-based courses, smaller 'seminar-type' classes could be considered parallel to the traditions of classroom environment research at the secondary and primary school levels. The CUCEI was developed for use in small classes of up to 30 students (Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986). The final form of the CUCEI contains 49 items divided equally among seven scales. Each item has four responses (Strongly Agree, Agree, Disagree, Strongly Disagree) and the scoring is reversed for approximately half of the items. Typical items in the instrument are "Activities in this class are clearly and carefully planned" (Task Orientation) and "Teaching approaches allow students to proceed at their own pace" (Individualisation).

#### **4.4.6 *Science Laboratory Environment Inventory (SLEI)***

The SLEI is an instrument which recognises the importance and uniqueness of laboratory settings in science education. The instrument is specifically suited to assessing the environment of science laboratory classes at the senior high school or higher education levels (Fraser, Giddings & McRobbie, 1995). The SLEI has 35 items divided equally among five scales. In a similar way to other learning environment instruments, it employs a five-point response scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. Typical items in the scale are "I use the theory from my regular science class sessions during laboratory activities" (Integration) and "We know the results that we are supposed to get before we commence a laboratory activity" (Open-Endedness). The last example shows a response scored with reverse polarity.

#### **4.4.7 *Constructivist Learning Environment Survey (CLES)***

According to the constructivist view, meaningful learning is an active and cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed. Constructivism was discussed earlier in Chapter 2 (Section 2.3). This social process involves active negotiation and consensus building among students and between students and teacher. The CLES (Taylor, Dawson & Fraser, 1996) was developed to assist researchers and teachers to assess the degree to which a particular classroom's environment is consistent with constructivist ideas, and to assist teachers to reflect on and reshape their teaching practice. The most recent version of this instrument consists of 30 items divided equally into five scales. Respondents use the same five-point response format used in the SLEI and other instruments. A typical item from the CLES is "In this class I get the chance to talk to other students" (Negotiation).

#### **4.4.8 *What Is Happening In This Class (WIHIC) Questionnaire***

The WIHIC questionnaire is one of the more recent instruments to be used in learning environment research and was the one that was adapted for use in this study. The WIHIC was developed by combining modified versions of the most salient scales from a wide range of earlier questionnaires with additional scales formulated to accommodate contemporary educational concerns (e.g., equity and constructivism). Also, the WIHIC is unique in that it has a separate 'class form' (which assesses a student's perceptions of the class as a whole) and a 'personal form' (which assesses a student's personal or individual perceptions of his or her role in a classroom).

#### **4.4.9 Validation of Instruments**

Fraser and Walberg (1981) described a strategy that has been used in the development and validation of many classroom environment instruments. This strategy consists of four steps: (1) the identification of a list of the individual dimensions characterising these environments; (2) development of an initial item pool by researchers and educators; (3) administration of the items to a sample of students followed by item analysis to remove faulty items; and (4) the estimation of overall statistics measuring the validity of each scale.

Often, the scales in a learning environment instrument are validated in the following manner. First, the internal consistency of each of the scales is enhanced by removing any items whose correlation with others in the same scale is low or negative. Factor analysis can be used to assist in determining whether the structure of scales on the instrument should be altered by removing individual items from a scale or by combining or removing scales from an instrument. The Cronbach's alpha coefficient is then used as a measure of the internal consistency of each of the refined scales. Second, the discriminant validity of each scale is calculated by determining the mean correlation of a scale with all other scales in the instrument (discriminant validity estimates the distinctness of each variable measured by a scale). Typically, both of these measures are determined at the levels of the individual respondent and the class mean. As a final measure, an ANOVA is performed for each scale with class membership as the independent variable. The resulting  $\eta^2$  statistics and significance levels indicate the ability of the scales to differentiate between the perceptions of students in different classes.

Similar procedures were used for the current study with a factor analysis performed on the questionnaire items followed by further statistical tests regarding the internal consistency reliability of each scale (Cronbach's alpha coefficient), Discriminant validity of scales (mean correlation of a scale with other scales) and the ability of a scale

to differentiate among different classes (the  $\eta^2$  statistic). These procedures are described fully in Chapter 5.

The following pages provide additional information about the WIHIC and other learning environment instruments described in this section. An overview of the scales provided in each instrument is outlined in Table 4.1, whereas reliability and validity data for each of the described instruments is provided in Table 4.2 .



**Table 4.1: Overview of scales contained in a eight classroom environment instruments (LEI, CES, ICEQ, MCI, CUCEI, SLEI, CLES and WIHIC)**

<b>Instrument</b>	<b>Level</b>	<b>Items per scale</b>	<b>Scales</b>	
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Speed Diversity Friction Difficulty Formality Favouritism Competitiveness	Material environment Cliqueness Satisfaction Goal direction Apathy Disorganisation Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Task orientation Order and organisation Affiliation	Competition Teacher support Rule clarity Teacher control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Independence Differentiation	Participation Investigation
My Class Inventory (MCI)	Elementary	6	Cohesiveness Difficulty Friction	Competitiveness Satisfaction
College and University Classroom Environment Inventory (CUCEI)	Higher Education	7	Personalisation Task orientation Innovation Involvement	Individualisation Student cohesiveness Satisfaction
Science Laboratory Environment Inventory (SLEI)	Upper Secondary / Higher Education	7	Student cohesiveness Open endedness Rule clarity	Integration Material environment
Constructivist Learning Environment Survey (CLES)	Secondary	7	Personal relevance Critical voice	Uncertainty Shared control Student negotiation
What Is Happening In This Classroom (WIHIC)	Secondary	8	Student cohesiveness Investigation Equity	Task orientation Teacher support Cooperation Involvement

**Adapted from Fraser (1998, p. 56)**

Table 4.2: Alpha reliability, discriminant validity (mean correlation of a scale with other scales) and ANOVA results ( $\eta^2$  statistic) for scales of selected instruments (using individual as the unit of analysis).

Scale	Alpha reliability	Discrim. validity	ANOVA $\eta^2$
<i>Classroom Environment Scale (CES) (N=1,083 students)</i>			
Involvement	0.70	0.40	0.29*
Affiliation	0.60	0.24	0.21*
Teacher Support	0.72	0.29	0.34*
Task Orientation	0.58	0.23	0.25*
Competition	0.51	0.09	0.18*
Order and Organisation	0.75	0.29	0.43*
Rule Clarity	0.63	0.29	0.21*
Teacher Control	0.60	0.16	0.27*
Innovation	0.52	0.19	0.26*
<i>Individualised Classroom Environment Questionnaire (ICEQ) (N=1,849 students)</i>			
Personalisation	0.79	0.28	0.31*
Participation	0.70	0.27	0.21*
Independence	0.68	0.07	0.30*
Investigation	0.71	0.21	0.20*
Differentiation	0.76	0.10	0.43*
<i>My Class Inventory (MCI) (N=2035 students)</i>			
Cohesiveness	0.67	0.20	0.21*
Friction	0.67	0.26	0.31*
Difficulty	0.62	0.14	0.18*
Satisfaction	0.78	0.23	0.30*
Competitiveness	0.71	0.10	0.19*
<i>College and University Classroom Environment Inventory (CUCEI) (N=372 students)</i>			
Personalisation	0.75	0.46	0.35*
Involvement	0.70	0.47	0.40*
Student Cohesiveness	0.90	0.45	0.47*
Satisfaction	0.88	0.45	0.32*
Task Orientation	0.75	0.38	0.43*
Innovation	0.81	0.46	0.41*
Individualisation	0.78	0.34	0.46*
<i>Science Laboratory Environment Inventory (SLEI) (N=3,727 students)</i>			
Student Cohesiveness	0.77	0.34	0.21*
Open-Endedness	0.70	0.07	0.19*
Integration	0.83	0.37	0.23*
Rule Clarity	0.75	0.33	0.21*
Material Environment	0.75	0.37	0.21*
Innovation	0.52	0.19	0.26*
<i>Constructivist Learning Environment Survey (CLES) (N= 1,081 students)</i>			
Personal Relevance	0.88	0.43	.016*
Uncertainty	0.76	0.44	0.14*
Critical View	0.85	0.31	0.14*
Shared Control	0.91	0.41	0.17*
Student Negotiation	0.89	0.40	0.14*
<i>What Is Happening In This Classroom (WIHIC) (N= 1,081 students)</i>			
Student Cohesiveness	0.81	0.37	0.09*
Teacher Support	0.88	0.43	0.15*
Involvement	0.84	0.45	0.10*
Investigation	0.88	0.41	0.15*
Task Orientation	0.88	0.42	0.15*
Cooperation	0.89	0.45	0.12*
Equity	0.93	0.46	0.13*

\* $p < 0.05$

Adapted from Fraser (1998, p. 56)

## **4.5 New Developments in Learning Environment Research**

This section considers a number of important new developments in the field of learning environment research. These areas include the development and validation of new instruments, the investigation of learning environments in new or emerging classroom environments and, also, the combination of learning environment variables with other types of methods including qualitative techniques derived from ethnographic or interview data.

### **4.5.1 *Revision, Development and Validation of New Instruments***

The development and validation of new forms to measure learning environments has continued in response to many developments in educational thinking such as constructivism and the potential use of computers to promote higher-level thinking (Maor & Fraser, 1996; Taylor, Dawson & Fraser, 1996) and also in an effort to describe unique classroom environments such as science laboratories (Fraser, Giddings & McRobbie, 1995; Wong & Fraser, 1995) and distance learning environments (Jegede, Fraser & Fisher, 1998). Also, the new 'personal' form of questionnaires continues to respond to suggestions that individual students may hold differing perceptions of the same classroom environment (see Fraser, Giddings & McRobbie, 1996).

#### *Revision and cross-validation of instruments*

The development of a revised version of the Constructivist Learning Environment Survey (CLES; Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991) was accomplished in an attempt to monitor the development of innovative constructivist approaches to teaching school science. The revised form of the instrument (Taylor, Dawson & Fraser, 1995) includes the scales Personal Relevance, Student Negotiation, Shared Control, Critical Voice and Uncertainty. The researchers reported that this revised CLES was suitable for monitoring systemic constructivist-oriented reforms in science education (Dryden & Fraser, 1998).

Wong and Fraser (1995) reported the cross-validation of the Science Laboratory Environment Inventory (SLEI) for use in Singapore. This study used both the 'actual' and 'preferred' forms of this survey with a sample of 1,592 students in 56 Year 10 chemistry classes. The instrument was comprised of five scales: Student Cohesiveness, Open-endedness, Integration, Rule Clarity, and Material Environment. Validation procedures determined that this instrument (originally developed in Australia) was suitable for measuring the students' perceptions of the science laboratory environment in Singaporean schools.

#### *Development of new instruments*

Maor and Fraser (1996) developed and validated a new instrument called the Computerised Classroom Environment Inventory (CCEI). In a study which examined the perceptions held by 120 students and seven teachers in their inquiry-based classrooms, this instrument included the development and use of five scales, namely, Investigation, Open-endedness, Organisation, Material Environment and Satisfaction. The instrument was developed in order to measure changes in the learning environment in these classes after a computerised database was implemented as a new teaching strategy. Validation procedures for the instrument suggested that it would be widely applicable for use in evaluating inquiry-based computer learning.

More recently, Jegede, Fraser and Fisher (1998) described the development, validation and use of a learning environment instrument for use in university distance education settings. This new instrument, called the Distance and Open Learning Environment Survey (DOLES), includes the five core scales of Student Cohesiveness, Teacher Support, Personal Involvement, Flexibility, Task Orientation and Material Environment and the two optional scales of Communications Technology Resources and Student Centre Environment, which measure the adequacy of these resources if they have been provided with the course. Validation procedures confirmed that this new instrument has potential for measuring student perceptions of the learning environment

in distance education settings, but that further cross-validation with other samples is needed.

#### **4.5.2 *Selected Current and Recent Research in Learning Environments***

Fraser (1998) describes the current types of research that have used classroom environment instruments as including (1) associations between student outcomes and environment, (2) use of environment dimensions as criterion variables (including the evaluation of educational innovations and investigations of differences between students' and teachers' perceptions of the same classrooms), (3) investigations of whether students achieve better when in their preferred environments and (4) action research involving teachers' own practical attempts to improve their classroom and school climates. This section samples some recent research in learning environments.

In a recent study assessing middle grade classroom environments (Sinclair & Fraser, 1998), students' perceived and preferred classroom environments were investigated using an instrument called the Science Classroom Inventory. This sample consisted of 10 middle grade teachers and 43 classes. The scales in the instrument are Cooperation, Teacher Empathy, Involvement and Task Orientation. These measures were combined with other qualitative measures (such as student interviews). The intent of this study was to provide teachers with opportunities to improve the classroom environment for their students through the adoption of reflective teaching practices. The study was important in that it considered an area (middle school classrooms) where few learning environment studies have been reported previously.

Henderson, Fisher and Fraser (1998) reported a study of associations between student attitudes and perceptions of the learning environment in high school classrooms. The study used scales modified from the Science Laboratory Environment Inventory (SLEI) and What is Happening in this Class? (WIHIC) instrument. The scales included those of Student Cohesion, Integration, Involvement, Material Environment and Task Orientation. The sample consisted of 100 students in seven

environmental science classrooms. The study was important in that it further demonstrated that aspects of the learning environment (in this case, Student Cohesion, Involvement and Task Orientation) are linked with positive attitudinal outcomes.

In a study of associations between student outcomes and the computer laboratory environments of university students, Newby and Fisher (1998) used an instrument known as the Computer Laboratory Environment Inventory. This instrument included the scales Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy and Laboratory Availability. The study found that all of these variables except Laboratory Availability were associated with the attitudinal measures of Anxiety, Enjoyment, Usefulness of Computers and Usefulness of the Course. Further, the variable Student Cohesion was shown to be significantly associated with achievement. The study is important in that it considered aspects of the learning environment in computerised classrooms and linked this to a variety of student outcomes.

Churach and Fisher (1998) considered the learning environment of a sample of 431 students in five high schools using the Internet in secondary science classes. They used the Constructivist Learning Environment Survey (CLES) in combination with a number of other quantitative and qualitative methods to investigate whether the use of Internet technologies impacted on the classroom environment in a positive way. The CLES includes the five scales of Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. The study found that student attitudes, as well as individual feelings of self-control and personal relevance, seem to be enhanced by the use of the Internet in these classrooms.

### **4.5.3 Research using the WIHIC**

In the current study, five scales from the What is Happening in this Classroom (WIHIC) were used to describe the learning environment in Internet high school classrooms. (The WIHIC instrument was summarised in Section 4.4.8 and in Tables 4.1 and 4.2 earlier in this chapter.) This questionnaire was chosen for use in the study as it incorporated many of the more salient scales from earlier learning environment instruments. Originally, the WIHIC had 90 items categorised into nine scales (Fraser, 1998). This initial version was refined by both factor and item analyses using data from 355 junior high school science students, and extensive interviewing of students about their views of their classroom environments in general (Fraser, Fisher & McRobbie, 1996). Only 54 items in seven scales survived these procedures. However, this item set was later expanded to include a total of 80 items in eight scales.

Another version of the WIHIC (with the Autonomy scale excluded) was used in a study which involved junior high school science classes in Australia and Taiwan. Whereas the Australian sample of 1,081 students in 50 classes responded to the original English version, a Taiwanese sample of 1,879 students in 50 classes responded to a Chinese version that had undergone careful procedures of translation and back translation (Huang & Fraser, 1997). This field testing procedure led to a final form of the WIHIC containing 56 items in seven scales.

The WIHIC has been used successfully in its original or modified form in studies involving 250 adult learners in Singapore (Khoo & Fraser, 1997) and 2,310 high school students in Singapore (Chionh & Fraser, 1998). Also, more recently, it was used in a study of high school chemistry classes in Brunei (Riah & Fraser, 1998) and a cross-national study of science classrooms in Taiwan and Australia (Aldridge, Huang & Fraser, 1998). These and other studies have pointed to the ability of learning environment instruments such as the WIHIC to describe the learning environment of a wide variety of classrooms and in a wide variety of contexts.

Fraser (1994) has also discussed the predictive validity of psychosocial environment measures (such as the WIHIC), noting that a large number of studies support the predictive validity of using classroom perceptions in accounting for variance in learning. Current findings from early research in computerised learning environments seem to replicate these earlier findings (Churach & Fisher, 1998; Newby & Fisher, 1998). Finally, it is important to note that a correlational model for the analysis of psychosocial dimensions also allows the inclusion of other factors (e.g. physical/ergonomic factors) for comparison with the important psychosocial factors operating in classrooms.

#### **4.6 Summary**

It seems that the introduction of information technologies into classrooms and the creation of so-called 'computerised learning environments' has the potential to present new and different social and physical environments to which students and teachers must adapt. Successful adaptation may require a shift of the focus of teaching from the computer as a technological innovation towards greater attention to the learning process (Maor & Taylor, 1995). Important in this, is the development of new instruments (such as the WIHIC) which aim to measure aspects of the psychosocial environment in new classroom environments such as those employing constructivist teaching ideas (Fraser, Fisher & McRobbie, 1996; Maor & Fraser, 1996). These new forms consider many unique factors associated with learning.

In formulating methodology, Fraser (1991) has stated that teaching is only one of many factors that affect the learning environment and that teaching may itself be influenced by the environment. This chapter has summarised a variety of methods and instruments for considering students' perceptions of learning environments, and contrasted these with other methods such as direct observation, naturalistic inquiry, ethnography and case study. In particular, it has also described the development and validation of learning environment questionnaires (such as the WIHIC used in this study). Finally, this review has further outlined the need for the development of new



research models which (1) combine a variety of qualitative and quantitative methods together in a single study (e.g. Fraser & Tobin, 1991) and (2) have a cross-national component in them (e.g. Aldridge, Huang & Fraser, 1998). These aspects are considered in further detail in Chapter 5.

Finally, Walberg (1991) focused on the need to consider the psychosocial learning environment found within schools as one of many factors operating within a broader concept of educational productivity (i.e. student outcomes). This study attempts to broaden this productivity model to include other factors (i.e. the physical factors covered in chapter 3) which could work together in providing a methodology which can enable a more complete description of learning environments as they are influenced by the use of IT. The next chapter outlines the methodology used for this study.

## Chapter 5

### Research Methodology

#### 5.1 Introduction and Overview

This chapter provides an overview of the research methodologies, research questions, and instruments used for this study. It begins by outlining the framework used in the selection of these methodologies and the sample characteristics for each portion of the study (Section 5.2). The chapter continues by outlining the development and use of the various methodologies and instruments, including teacher and student questionnaires (Section 5.3), ergonomic worksheets and inventories (Section 5.4), and detailed case studies (Section 5.5). Each of these techniques is discussed as it relates to the research questions outlined in Chapter 1 and to each sphere of the conceptual model -- namely, the physical, psychosocial and IT (teaching) environments (Section 1.4).

The type of classrooms identified for the purposes of this study could be described as 'technologically-rich' classrooms. This type of classroom was defined for this study as those having a number of networked computers installed, with the general availability of Internet resources for students and their substantial use in the delivery of curriculum. For each classroom, an attempt was made to construct a general profile of the learning environment by evaluating a number of selected psychosocial and physical factors for each setting. The results were pooled in an attempt to generalise these descriptions and to identify some trends. Also, these statistical results were further validated, interpreted, clarified and described by intensely investigating a subset of the original sample of classrooms using qualitative case studies. This research methodology was developed from an ergonomic (or human factors in the workplace) model used in a variety of business and industry settings. The study encompassed learning environments in the two different jurisdictions of Western Australia and British Columbia, Canada.

## 5.2 Selection of Methodologies

In selecting and developing the type of research methods to use in an interdisciplinary study of this nature, a variety of different models from ergonomic and educational research was examined. In a discussion of the range of possible ergonomic research methodologies, Charlton (1996) has described the wide variety of ergonomic test issues, measurement methodologies and analysis paradigms which present themselves to any investigation of human factors. These can range from the use of checklists, critical incident report forms, interviews, questionnaires and environmental monitoring to, more recently, computer modelling. Historically, the selection of appropriate ergonomic test issues and measures has been a matter of the expertise and experience of individual researchers.

Charlton (1996) described alternatively a framework known as SITE which was used in selecting the appropriate methodology used in this study. The acronym, SITE, stands for Situation, Individuals, Task and Effectiveness. Charlton described this model as a guideline in selecting the appropriate instruments for the ergonomic evaluation of any technological setting. With SITE, evaluators are urged to consider together the design aspects, who is using the equipment, how it is being used and, finally, user satisfaction with the results. A summary of each consideration is given in Figure 5.1.

Figure 5.1: The SITE framework for selecting research methodologies

Situation	Individuals	Tasks	Effectiveness
The setting of interest or the system function involved	The persons using the equipment or operating within this setting	How is the system or specific equipment intended to be used	The success, productivity or satisfaction with the result

*Adapted from Charlton (1996, p. 28)*

If the SITE model is applied to this study, the situation to be investigated essentially would be the use of networked (Internet) computers in school settings. The individuals using the equipment would be secondary high school students in years 10, 11 or 12. The tasks to be completed by these students in these settings would be determined by their teachers. In the case of school settings, effectiveness, and therefore productivity, might be measured in a number of different ways, including behavioural measures (What are the students doing and what percentage of the total time do students spend on each type of task?), perceptually (How do students feel about the environment in which they are working?) and objectively (What physiological and physical changes are occurring within each classroom setting?). In brief, a number of different methodologies was selected including student and teacher questionnaires, ergonomic inventories, student and teacher interviews, classroom observations and environmental monitoring.

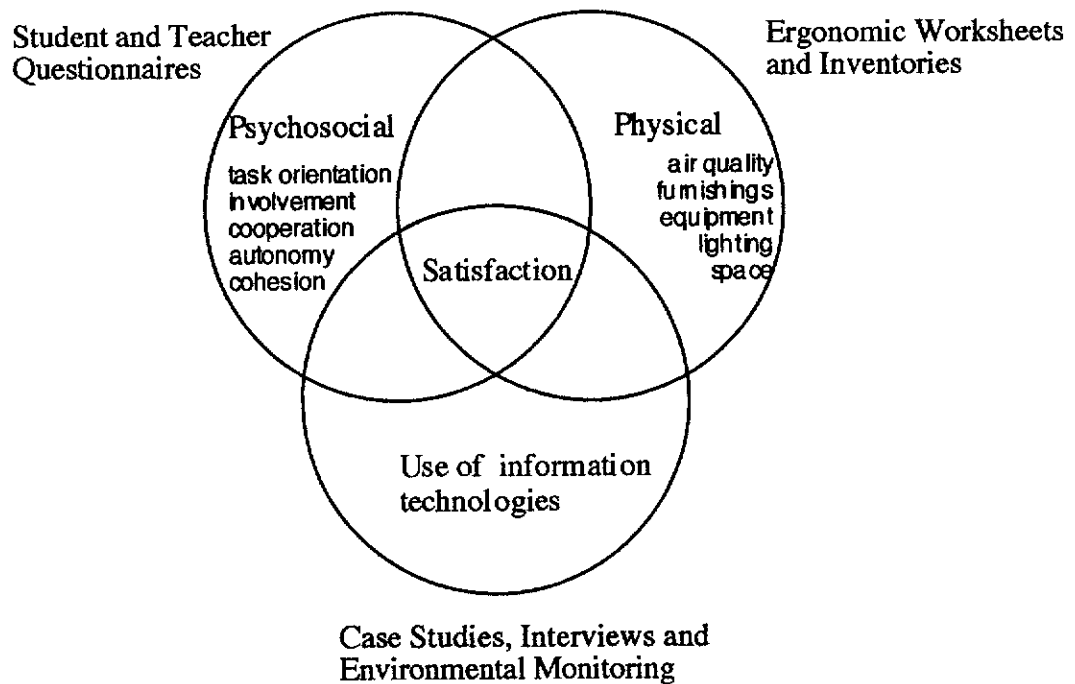
### **5.2.1 *Revisiting the Conceptual Model***

The conceptual framework for considering learning environments in this study was adapted from a model developed by Gardiner (1989) and outlined first in Chapter 1 (Section 1.4). In this model, the intended use of information technologies (within an educational context), as well as the physical and psychosocial environments, are considered together as they influence students' satisfaction in that environment. Figure 5.2 revisits this idea and outlines the relationship of each methodology to the model.

In this study, information about the psychosocial environment was obtained by the use of student and teacher questionnaires. Information about the physical environment in these classrooms was obtained by using a number of ergonomic worksheets and inventories developed specially for this purpose. Finally, detailed information about the use of these technologies and the relationship of this use to the physical and

psychosocial environment was obtained through a combination of classroom observation, student and teacher interviews, and detailed environmental monitoring.

Figure 5.2: Conceptual model of potential factors influencing student satisfaction



*Adapted from Gardiner (1989)*

In addition to showing how the various spheres of influence included in this study are related to each other, the model in Figure 5.2 lists specific psychosocial and physical factors described by this methodology as they may be associated with students' satisfaction with learning. What follows is a summary of how and when the various research methodologies were used in this evaluation of technological classrooms.

### ***5.2.2 Research Questions and the Conceptual Model***

In attempting to evaluate technological classroom settings, a comprehensive set of research questions was outlined in Chapter 1. They are reviewed here as they relate to Gardiners's conceptual model and to the methodologies used in researching them.

#### ***The use of new information technologies for teaching and learning***

To answer questions related to how the new information technologies are being used, a detailed case study methodology was selected for use in a small sub-sample of classrooms involved in the questionnaire survey. This involved detailed task analysis of student and teacher behaviours followed by student and teacher interviews. This methodology is outlined in Section 5.5.

#### ***Relevant psychosocial factors operating in computerised classrooms***

To describe adequately, perceptions about the learning environment in computerised classrooms and to obtain a rating of their overall satisfaction in that environment, students and their teachers were asked to complete a questionnaire. This methodology is outlined in section 5.3.

#### ***Relevant physical factors operating in computerised classrooms***

In evaluating the physical implementation of computers in schools, many classrooms and laboratories were evaluated using a specifically-designed ergonomic inventory which compared how these implementations compared with guidelines proposed from business and industry settings. This methodology is described in Section 5.4.

#### ***Issues concerning interactions among factors***

In order to describe interactions between physical and psychosocial factors in promoting student satisfaction, care was taken to link the different methodologies used in the study. Also, care was taken in ensuring that the samples used in the study were

representative of typical schools, but would also allow for some cross-national comparisons. Sample characteristics for each portion of the study are described next.

### **5.2.3 Sample**

The target population for this study consisted of students in suburban high schools in Western Australia and British Columbia, Canada (specifically years 10, 11, and 12). The study involved investigations conducted in technological (Internet) classroom settings as identified by teachers in those settings. In total, 24 schools were selected for inclusion in the study, with a total of 81 classes and 1404 students located in 43 computerised classroom settings. The majority of these locations were in Western Australia as this was the main location for the study. However, four Canadian schools were selected for the purposes of making some cross-national comparisons. From the larger sample approximately 30% of the locations (8 schools) served as sites for the more detailed case study portion of this research.

#### *Australian sample*

The Australian sample was selected following a mail-out of information to schools in the metropolitan area of Perth, Western Australia. Of the approximately 100 schools canvassed, 20 schools were selected for participation in the study (1329 students in 75 classes). The resulting sample consisted of a wide range of public and independent schools located in a number of areas of varying socioeconomic levels. This sample was taken as the main population for the study which involved the administration of questionnaires and ergonomic inventories. Of these 20 schools, four locations were also selected for case study. The Australian schools and classes could be considered typical and representative of suburban high schools in Western Australia.

### *Canadian sample*

The Canadian sample was also selected following a mail-out of information to schools in the south coast region of British Columbia, Canada. Of the approximately 200 schools canvassed, 4 schools (75 students in 6 classes) were selected for comparison with the main Australian sample. These schools were also subjected to the more detailed and descriptive case study. The Canadian schools could be considered typical and representative of suburban high schools in British Columbia.

### **5.3 Student and Teacher Questionnaires**

As outlined in the model presented in Figure 5.2, the study investigated students' and teachers' perceptions of the learning environment in their computerised classrooms. This information was also related to a key dependent variable for this study -- students' satisfaction with their learning. Information about each of these measures was obtained using a questionnaire administered to both students and teachers.

#### **5.3.1 *Assessing Psychosocial Learning Environments Using the WIHIC***

A variety of learning environment instruments including the WIHIC were discussed in Chapter 4. In the present study, the psychosocial measure used consisted of five scales selected and adapted from a recent learning environment instrument called the What is Happening in This Class (Fraser, Fisher & McRobbie, 1996). This instrument has been shown to have high reliability and validity in educational settings. Specifically, the scales of Student Cohesiveness, Involvement, Autonomy/Independence, Task Orientation and Cooperation were included in the questionnaire. These scales have been adapted from those used in previous instruments which have been shown to be predictors of student learning outcomes and attitudes (see Fraser, 1998).

Importantly, the selected scales also attempt to measure psychosocial factors in classrooms that are consistent with the goals of current reform efforts aimed at individualising curriculum and instruction and increasing the amount of student



interaction experienced by students. Such goals have been articulated by many advocating the use of technology in reforming curriculum (Layton, 1993; Sabelli & Barrett, 1993) and have been given increased importance by those espousing constructivist teaching strategies (see von Glasersfeld, 1992). Also, all of the constructs included in the questionnaire are consistent with variables considered important by ergonomists in workplace environments (e.g. Grandjean, 1987).

The first version of the WIHIC instrument included 90 items in the following nine psychosocial scales, each scale consisting of 10 items: Student Cohesiveness, Teacher Support, Involvement, Autonomy/Independence, Investigation, Task Orientation, Cooperation, Equity and Understanding. The instrument employs a five-point response scale with the alternatives of Almost never (1), Seldom (2), Sometimes (3), Often (4) and Almost always (5). Importantly, the most recent version of the survey omitted the scale Understanding, as it proved unreliable in field trials. This instrument has been used in a variety of recent studies of classroom learning environments in Australia, Taiwan and Singapore (see Aldridge, Huang & Fraser, 1998; Chionh & Fraser, 1998; Huang & Fraser 1997; Khoo & Fraser, 1998).

The five psychosocial scales selected from the WIHIC for this study were Student Cohesiveness, Involvement, Autonomy/Independence, Task Orientation and Cooperation. As previously noted, these scales were selected for this study as they are consistent with the goals of current reform efforts aimed at individualising curriculum and instruction and increasing student interactions, and they are also consistent with variables considered important by ergonomists. Other important scales such as Teacher Support, Understanding and Equity were omitted from the questionnaire to clarify for teachers that it was the teaching medium and the classroom environment that were being evaluated and not their teaching. While the questionnaire form was headed *What is happening in this class?*, the sub-heading (*while we are using computers*) was added in order to highlight that respondents were reflecting mainly on their computer usage in

that setting. In total, the resulting form included five psychosocial scales with 50 items. A copy of the version of the WIHIC used is included as Appendix A.

### **5.3.2 *Measuring Student Satisfaction***

Students' satisfaction with their learning is increasingly being included as a tool to help evaluate educational programs or innovations as an example of a student outcome. In an interesting parallel, job satisfaction has often been used as a key indicator variable in evaluations of workplace productivity (Kroemer & Grandjean, 1997). Therefore, a key dependent variable for this study was student satisfaction, and a further questionnaire was used to assess this outcome in the each of the different classroom environments.

The Satisfaction scale was adapted from the Enjoyment of Science Lessons scale in the Test of Science Related Attitudes, TOSRA (Fraser, 1981). The eight items included in the questionnaire for this study were modified in their wording so that the statements could apply equally to any subject discipline (as the original items had a science area orientation). The inclusion of a Satisfaction scale provided a dependent variable to correlate with the other physical and psychosocial measures obtained in the study (refer to research questions). As with the other scales, students and teachers responded to these items using a five-point response scale (Almost never, Seldom, Sometimes, Often and Almost always).

### **5.3.3 *Administration of Questionnaires***

Each of the participating schools was mailed class sets of the WIHIC and Satisfaction questionnaires to be completed by students at their school. The class sets of questionnaires were coded with school, class and student number on the top right-hand corner of each form. This was done for the purposes of confidentiality and to facilitate data entry. Detailed instructions were also included with each mailing to ensure consistency in its administration. For each of the classes, teachers were asked to

administer the questionnaire to students as they worked in their usual computerised setting, and also to complete a copy of the questionnaire themselves.

The in-class time required for the administration of these questionnaires was estimated at approximately 30 minutes. Following their completion, teachers noted the physical location where the questionnaires had been completed on a cover page for each class set. This allowed the questionnaire data to be later linked to the physical (ergonomic) data to be collected. In the following section, the development of a methodology for evaluating complementary information about the physical classroom environment for these students is described.

## **5.4 Evaluating the Physical Learning Environment**

This section outlines the methodology used to evaluate the physical learning environment in computerised classrooms. Section 5.4.1 describes the ergonomic instruments developed for this purpose, while Section 5.4.2 outlines their development and Section 5.4.3 outlines the procedures followed in their use.

### **5.4.1 *Ergonomic Worksheets and Inventories***

The study investigated a selection of physical environmental factors through the use of two instruments, the Computerised Classroom Ergonomic Inventory (CCEI) and the Computerised Classroom Ergonomic Worksheet (CCEW). Both of these instruments were developed specifically for this study and worked together to describe the physical environment in classrooms. The CCEI employed a rating scale (scored out of five) which gave an estimate of a classroom's degree of 'fit' within a composite of currently published ergonomic guidelines. For example, many ergonomists have published recommendations regarding desirable working conditions for computerised office environments (Grandjean, 1988; Kroemer & Grandjean, 1997). These guidelines are typically stated as an acceptable range of measures rather than as single values. If a given classroom measure (e.g. aisle width) fell within the acceptable range, it was scored a point on that item in the inventory.

Importantly, while the CCEI included a variety of general physical variables discretely measured or noted by the researcher, these factors were not considered separately but instead grouped with other distinct but related factors into overall physical domains such as Workspace environment or Computer environment. The inventory includes those factors considered most important in evaluating the physical working environment (see Grandjean, 1987; Knirk, 1992; Kroemer & Grandjean, 1997; OECD, 1992; O'Brien 1996). The rating scale used was hierarchical in that a location complying with more of the published ergonomic guidelines received a higher score. In order to ensure consistency in the measures, the CCEI and CCEW were completed by the same observer in each of the computerised classroom settings studied.

#### ***5.4.2 Development of Ergonomic Worksheets and Inventories***

A discussion of the ergonomic factors which may influence learning was considered earlier in Chapter 3. In discussing physical workspace factors in ergonomic studies, O'Brien (1996) has stated that the measurement of these and other features of a system design is best performed in conjunction with a design checklist. It is also important to note that the use of checklists in schools is a common practice. For example, science teachers historically have held responsibilities for maintaining and informally evaluating laboratory equipment and spaces in addition to their teaching responsibilities. In order to facilitate this function, many organisations have published laboratory facilities checklists for use by classroom teachers. An early example of such an evaluative tool was provided by the Biological Science Curriculum Study and reprinted in many teacher sourcebooks (e.g. Troyer & Kellogg, 1972). Such evaluative checklists typically consider aspects such as the fixed architecture of a facility and the quantity and quality of its laboratory equipment. Often, common laboratory spatial arrangements are discussed.

In keeping with this technique, an ergonomic inventory, the Computerised Classroom Ergonomic Inventory (CCEI), and an accompanying worksheet, the Computerised Classroom Ergonomic Worksheet (CCEW), were developed specifically

for use in this study. These instruments provided a research aid for collecting the relevant ergonomic data. Specifically, the inventory employs a rating scale (scored out of five) which gives an estimate of a classroom's degree of 'fit' within a composite of current, published ergonomic guidelines (classrooms complying with more of the guidelines typically score higher on the scale). The inventory itself includes a variety of general physical variables discretely measured or noted by a researcher and then it groups them into the overall domains of Workspace environment, Computer Environment, Visual Environment, Spatial Environment, and Overall Air Quality. The accompanying worksheet provides a convenient form on which to record relevant workspace, lighting, spatial dimension and air quality measures. A copy of the worksheet and inventory are included as Appendix B.

#### ***5.4.3 Procedure for Completion of Ergonomic Inventories***

Consultative visits were organised to each of the participating schools for the purpose of conducting the physical and ergonomic evaluations of students' computerised learning environments. These evaluations were conducted in the same settings where the questionnaires had been administered. Generally, each evaluation required 45-60 minutes to complete for a given setting. To facilitate the variety of measurements and tests, most school visits were scheduled outside normal class times (i.e. during teaching breaks, lunch hours or after school). This scheduling technique also allowed greater participation of teachers in the evaluation process as they were less frequently distracted by students during these consultations. However, in order to ensure consistency in all measurements and tests, the ergonomic inventories and worksheets were completed by the same researcher in each of the computerised settings involved.

The ergonomic evaluations generally adhered to the following procedure. Initially, the worksheet (CCEW) was completed for each of the environmental measures before completing the associated ergonomic inventory (CCEI) for a given setting. This involved first measuring the variability and range of adjustments of furnishings and

workspace arrangements and the ambient light levels and reflectance values for a range of positions throughout each workspace. The latter two light measures were taken using a lux meter sampling from a variety of locations within each setting. Further, a sketch of the general room layout was made noting the number, placement and position of computers, windows, doors and other major defining features. Spatial measurements related to aisle width, positioning of desks, workstation dimensions or other features were also noted. Finally, room dimensions were recorded for calculations of room volume, and airflow readings were used to measure ventilation or to detect drafts. Space was provided to record all of these measures on the CCEW (see Appendix B).

The completion of the ergonomic worksheets (CCEW) was also accomplished with the assistance of a variety of specialised equipment. In the measurement of the workspace environment, tape measures (in centimetres) and goniometers (for measuring the inclination of monitor angles) were used in obtaining the data. In measuring illumination and luminance in each setting, a digital light meter was used (with measurements recorded in lux). Tape measures (in centimetres) were again used in obtaining measures of aisle widths and overall room dimensions. Finally, a digital airflow meter (recording in metres/second) was used to measure ventilation rates at air ducts or to detect excessive draft conditions. As previously noted, most of these measures were taken in unoccupied classroom settings so as not to interfere with normal classroom activities. The precise dimensions and locations are indicated clearly on the diagrams provided on the CCEW template. Also, where variation in any of these measures existed within a given setting, multiple worksheets were completed for that location. However, for most of the observed settings, the completion of one worksheet was sufficient to record all relevant data.

Following completion of the ergonomic worksheets, this information was used in combination with other observations in completing the ergonomic inventory (CCEI) for each of the observed computerised settings. The inventory form was completed while the researcher remained in that computerised setting. On the inventory, the presence or

absence of a number of conditions were noted, and a point was scored for each statement that was considered true. Following completion of the inventory, scores on each of the five domains were summed and noted in the space provided on the inventory. This resulted in scores (out of five) for each of the noted physical domains of Workspace Environment, Computer Environment, Visual Environment, Spatial Environment and for the estimate of Overall Air Quality. In cases where multiple worksheets were used, weighted averages were calculated and these resulted in some fractional scores transferred to the CCEI. Details of this calculation are provided on the reverse of the CCEI and CCEW forms (see Appendix B).

## **5.5 Describing the Educational Context for IT**

The study also undertook a contextual description of the learning environment in typical computerised classrooms in both Western Australia and British Columbia, Canada. (The merits of this cross-national approach was argued in Section 1.3.1.) Also, many researchers have argued the merits of combining quantitative and qualitative methods in a single study (e.g. Fraser & Tobin, 1991; Tobin & Fraser, 1998). This section describes how the study combined these approaches through the use of case studies.

### **5.5.1 Case Study Methodologies**

Detailed information about the context for IT use in this study was considered in relationship to its ability to influence the psychosocial and physical learning environments. This portion of the study involved the use of case studies which employed a number of different methodologies covered in the following sections, including classroom observations (Section 5.5.2) and environmental monitoring of physical variables (Section 5.5.3), followed by a series of student and teacher interviews (Section 5.5.4). Also, the inventory and questionnaire portions of the study provided additional quantitative information which complemented the case studies. As such, the case studies involved a combination of quantitative and qualitative methods

and were important in allowing a number of cross-national comparisons and in interpreting the quantitative findings regarding the physical and psychosocial environments.

A number of settings was selected from the original sample for more intense case studies. These included detailed classroom observations of in-class student behaviours, complemented by environmental monitoring of selected physical variables taken during these classroom observations. This procedure was followed by focused student and teacher interviews. The purpose of the interviews was to explore, qualitatively, questions and trends which arose in the earlier quantitative portion of the study. Four schools and eight classes each from British Columbia and Western Australia were involved. An attempt was made to balance the representation of government and independent schools and to ensure a cross-section of different socio-economic regions. The intent of the case studies was to provide further descriptive information about the relevant psychosocial and physical factors under consideration and also to provide some cross-national comparisons regarding the educational implementation of information technologies.

### ***5.5.2 Classroom Observation Techniques***

Many different techniques have been used by researchers in completing psychosocial observations in technological environments. Chapanis (1996) has described a method of observation termed 'activity analysis' which involves an observer periodically sampling the activities being performed in a given environment. The activities are then classified into a set of categories such as 'moving about the room' and 'entering data into a computer.' These data can then be aggregated over a certain time period so that activity frequency tables and graphs can be created. Chapanis has noted that this method is particularly useful if a variety of tasks are performed by individuals in no particular order. He noted that the products of an activity analysis include any of the following:

- an estimate of, or verification of, personnel (i.e. teaching) requirements on the job



- an assessment of the skill levels required by individuals working in that environment
- an assessment of the consequences of reallocating system (i.e. workstation) functions
- an indication of where changes in procedure/system design will improve performance.

The methodology selected for use in this study included a combination of the 'activity analysis' technique described by Chapanis (1996) and traditional sociological observation methods (e.g. Bakeman & Gottman, 1986). This technique was used for each of the 16 case studies. In each selected location, the researcher chose two students at random and observed their activities and behaviours throughout the first 50 minutes of a lesson. Similarly, the actions and behaviours of the teacher were monitored. Observations for each individual were recorded at one-minute intervals throughout the lesson and the resultant frequencies of teacher and student behaviours were recorded and categorised separately on a coded observation sheet. A copy of the observation sheet is provided in Appendix C.

### **5.5.3 *Environmental Monitoring Techniques***

Detailed environmental monitoring was also undertaken simultaneously with the classroom observations in each of the case study locations and an ergonomic evaluation procedures were used (O'Brien, 1996). These included monitoring factors such as noise, air temperature and humidity, in addition to ambient lighting and carbon dioxide levels. A number of specialised pieces of equipment was needed for this phase of the study and these varied with the methodology used in the two different jurisdictions. The inclusion of these and other measures with the data provided by the ergonomic inventory and worksheet served to complete a detailed profile for the physical environment in the selected classrooms. This information was combined with the other data to provide a more detailed account of these settings. The case studies and detailed environmental monitoring helped to explain associations between the physical and psychosocial environments and students' satisfaction with their learning.

### *Monitoring physical environments*

Many important physical environmental factors can only be measured in a working classroom while students and teachers are present (because their presence and activity levels contribute to variation in these measures). Importantly, eight locations (four from each country) were subjected to more intense environmental monitoring. The factors selected for inclusion in this portion of the study were noise level, temperature, humidity and air quality. While some of these measures were more practically estimated using the ergonomic inventory with the large sample, more direct measures were made for monitoring the physical environment in each selected location. This involved the use of several additional pieces of specialised equipment. Due to the different availability of equipment in each country and different physical environmental concerns, there was some variation in the methodology across countries for this portion of the study.

During the Australian portion of the study, a decision was taken to measure noise, temperature, humidity and carbon dioxide levels. The following procedure for environmentally monitoring the selected classrooms was completed simultaneously with the classroom observation techniques described in Section 5.5.2. Equivalent noise levels ( $L_{eq}$ ) were measured using a noise dose meter fitted with a microphone and an octave band filter set. Prior to each classroom observation, the noise dose meter was set so that it would run throughout the lesson, with final readings being taken after the class had ended. Second, dry bulb and wet bulb temperature readings were taken using the RSS-214 Wibget monitoring device (to assess room humidity). Air temperature readings were recorded at five-minute intervals throughout a lesson. Finally, carbon dioxide readings were taken using a Drager pump fitted with gas detection tubes. A sample of air was taken on one occasion near the end of each lesson to measure the ambient carbon dioxide level.

During the Canadian portion of the study, a decision was made to modify the original monitoring methodology in the following manner. First, noise levels were not monitored as only zero levels had been measured in the Australian sample and, also,

comparable noise monitoring equipment was not available in the Canadian setting. Further, the measures of temperature and humidity were taken using a different monitoring device, specifically, the Q-Trak (model 8550) IAQ Monitor, instead of the Wibget. Finally, due to the increased functionality of the Q-Trak device, carbon dioxide levels were continually monitored in the Canadian locations. This decision was made in part due to the increased importance of carbon dioxide levels in the typical closed working spaces common in colder climates such as those in Canada. As for the Australian sample, the environmental monitoring of selected classrooms in Canada was completed simultaneously with the classroom observation techniques described in Section 5.5.2.

As in the earlier Australian portion of the study, the environmental monitoring equipment was set up prior to commencement of a lesson. The measures of temperature, relative humidity (calculated from dry and wet bulb readings; Geshwiler, 1996) and the carbon dioxide levels were recorded at five-minute intervals throughout the lessons at each of the chosen case study locations. The resulting battery of environmental measures taken at both the Australian and Canadian locations complemented the full range of other physical measures taken previously when using the ergonomic inventories (CCEW and CCEI). These data, when combined with these other measures, constituted a more complete physical evaluation for each of the selected case study locations.

#### **5.5.4 *Student and Teacher Interviews***

The classroom behavioural observations and physical measures described in the Sections 5.5.2 and 5.5.3 were closely followed by focused student and teacher interviews. The purposes of these interviews were to explore, qualitatively, questions and trends which developed in the quantitative portion of the study. In framing the questions used in this part of the study, the conceptual framework was once again referenced and questioning was first focused on clarifying the actual tasks performed in a class (and the teachers' objectives), and this was followed by questioning relating to

the psychosocial and physical environments experienced by students within these settings. All questions included in the teacher and student interviews were open ended and designed to encourage respondents to elaborate on the area in question.

For each of the selected sites, student interviews were conducted immediately following the 50-minute classroom observation sessions. Interviews were generally conducted outside of the classroom, in a teacher's office, and were tape recorded for later reference. In order to encourage students to respond, the interviews were conducted with both students present and each individual was encouraged to elaborate on or clarify the other's statements. Similarly, teachers were generally interviewed during a teaching break, recess or lunch periods. This technique minimised disruption of classroom activities during the interview process and allowed the researcher to clarify any issues and activities observed during the classroom observations which were not clearly evident. Generally, each of these interviews took approximately 15 minutes to complete.

## **5.6 Summary of Methodologies**

This chapter has provided an overview of the research methodologies, research questions, and instruments used in this study, and related them to the conceptual model first described in Section 1.4. Further, it has outlined the development and use of the various methodologies and instruments, teacher and student questionnaires (the WHIC psychosocial scales of Student Cohesiveness, Autonomy/Independence, Involvement, Task Orientation and Cooperation and TOSRA Satisfaction scale), ergonomic worksheets and inventories (which provided an evaluation of the physical classroom environment), and a detailed case study methodology (which provided contextual information about these computerised settings). Each of these methodologies relate directly back to the conceptual model -- namely, the overlapping, physical, psychosocial and IT (teaching) environments -- and provides relevant information for potentially describing how the physical and psychosocial environments can influence students' satisfaction with learning.

The next three chapters present the results from the use of the various methodologies described in this chapter. Chapter 6 presents the qualitative and quantitative information obtained during the case study methods of this study. This information is useful in the interpretation of data related to both the physical and psychosocial learning environments and their influence on student satisfaction. Chapter 7 describes the *information obtained for the questionnaires. It includes the validation of the psychosocial learning environment and satisfaction scales and it outlines a number of important associations between the psychosocial learning environment and students' satisfaction with learning.* Finally, Chapter 8 details the results of the investigation into the physical learning environment in computerised classrooms using the ergonomic worksheets and inventories. It provides summary information about the suitability of these environments and it further describes relationships between these physical factors and the psychosocial factors as they jointly influence students' satisfaction with learning.

## Chapter 6

### Results -- Case Study Data

The detailed case studies of computerised learning environments in schools yielded much descriptive information about the educational context of these settings. Also, because these studies were conducted in two countries (Australia and Canada), they provide additional qualitative information about the approach taken to the implementation and use of IT in these two jurisdictions. The methodologies employed for these case studies were described in Chapter 5 and include classroom observations with task analysis, detailed monitoring of physical environmental factors and, finally, focused interviews with students and teachers.

Additionally, further information about these environments is given by the questionnaire and ergonomic data obtained in the other portions of the study (presented in Chapters 6 and 7). In total, eight locations (or roughly 30% of the total sample) were selected for this detailed study (four locations from each country). Of these, two from each jurisdiction were government schools and two were independent schools. This chapter describes these locations in detail (Section 6.1), provides a synthesis of the data and makes some comparisons between countries (Sections 6.2 and 6.3, respectively). Finally, this chapter describes links between these data and other parts of this study (Section 6.4). The following section outlines the types of information collected about each of the study locations.

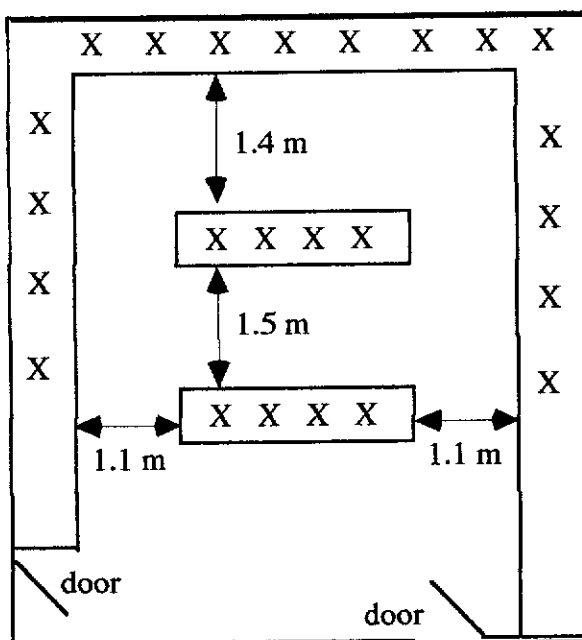
#### 6.1 Description of Settings

In order to organise the diverse data recorded for each of the study locations and to facilitate discussion about the relationships among these data, the use of a case study 'template' is used to present this descriptive and contextual data. This template (repeated for each location) gives some categorical information about the study location (e.g. government or independent school, country and school identification number), and then it continues to detail the data collected about each setting.

Each case study template contains a number of sections including: a general diagram illustrating the layout of a setting (transferred from ergonomic worksheets completed in school settings); a summary of the task analysis done during classroom observations; detailed environmental data about that location; and, finally, a list of relevant comments made by teachers and students during focused interviews in these locations. Further physical and psychosocial data (provided by ergonomic inventories and questionnaires) are also noted for each study location.

The following pages of case study information concisely describe each of the studied locations in a systematic way. This section is followed by an overall synthesis of the behavioural, physical and anecdotal data obtained in these case studies, followed by a section which makes some cross-national comparisons between the two jurisdictions (British Columbia, Canada and Western Australia). Finally, an attempt is made to link these data to important information obtained in other portions of this study. Together, these data provide the context for a more complete description of the physical and psychosocial environments of classrooms associated with the use of new information technologies.

### 6.1.1 Case Study One



#### School 4 -- Lab D3 -- Peripheral

School Location: Western Australia

School Type: Independent

#### Physical and Environmental Measures

Lighting: (475 -- 490 lux)

No. of Workstations: (24)

Carbon dioxide: (1000 ppm)

Mean Temperature: (22.4 C)

Relative humidity: (75 %)

#### Ergonomic Inventory :

(max. score = 5)

Workspace Environment (1)

Computer Environment (5)

Visual Environment (5)

Spatial Environment (4)

Overall Air Quality (3)

#### Task Analysis Summary:

(based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(13.0 mins.)
Moving about room :	(25.0 mins.)
Interacting with others :	(25.0 mins.)
Reading print material:	(1.0 mins.)
Browsing (computer):	(8.0 mins.)
Entering data (computer):	(26.0 mins.)
Miscellaneous (off task):	(2.0 mins.)

	<i>Students</i>
Listening to teacher:	(10.0 mins.)
Moving about room :	(5.0 mins.)
Interacting with others:	(7.0 mins.)
Reading print material:	(6.6 mins.)
Browsing (computer):	(32.6 mins.)
Entering data (computer):	(34.8 mins.)
Miscellaneous (off task):	(4.0 mins.)

#### Questionnaire Responses:

(max. score =5):

Social Cohesion	(3.7)
Involvement	(3.3)
Autonomy / Independence	(1.9)
Task Orientation	(3.8)
Cooperation	(3.2)
Satisfaction	(3.6)

#### Interview comments:

##### *Student IT Tasks*

Students described their tasks as finishing off their current projects and assignments. One of these projects was the design of a personal home page. The teacher described that the intent of the project was for students to learn how to use another application (eg. Netscape). Students are rewarded for completing their projects with further work on the Internet.

##### *Psychosocial environment*

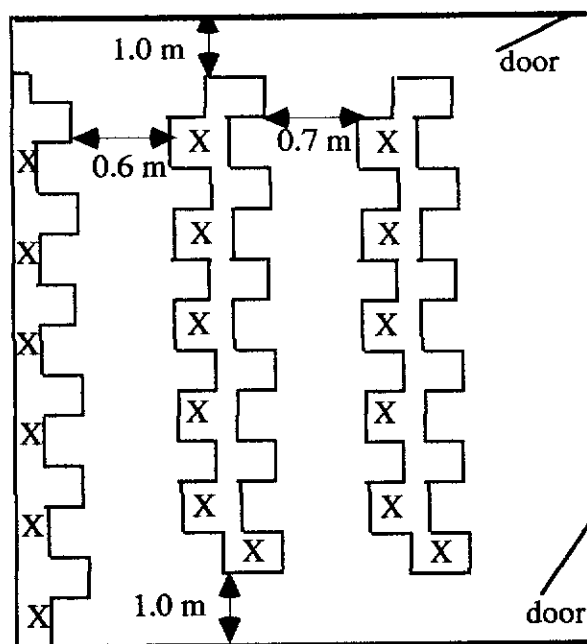
The teacher characterised the class as having a good psychosocial climate. Students said that they often work together (by choice) on their assigned projects.

##### *Physical environment*

Students believed that the classroom layout was great, although they thought that the position of the projection panel should be changed. The teacher also liked the physical layout of the room because students' screens could easily be seen while they were working. Students and teachers both agreed that it would be better to have a climate controlled setting in the classroom.



### 6.1.2 Case Study Two



#### School 11 -- Lab 62 -- Linear

School Location: Western Australia

School Type: Government

#### Physical and Environmental Measures

Lighting: (504 -- 550 lux)

No. of Workstations: (18)

Carbon dioxide: (600 ppm)

Mean Temperature: (18.4 C)

Relative humidity: (80 %)

#### Ergonomic Inventory :

(max. score = 5)

Workspace Environment	(1)
Computer Environment	(5)
Visual Environment	(2)
Spatial Environment	(3)
Overall Air Quality	(2)

#### Task Analysis Summary:

(based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(12.0 mins.)
Moving about room :	(34.0 mins.)
Interacting with others :	(32.0 mins.)
Reading print material:	(8.0 mins.)
Browsing (computer):	(0.0 mins.)
Entering data (computer):	(0.0 mins.)
Miscellaneous (off task):	(14.0 mins.)

	<i>Students</i>
Listening to teacher:	(12.0 mins.)
Moving about room :	(0.6 mins.)
Interacting with others:	(13.2 mins.)
Reading print material:	(17.4 mins.)
Browsing (computer):	(23.4 mins.)
Entering data (computer):	(13.4 mins.)
Miscellaneous (off task):	(20.0 mins.)

#### Questionnaire Responses:

(max. score =5):

Social Cohesion	(3.8)
Involvement	(3.2)
Autonomy / Independence	(2.2)
Task Orientation	(4.1)
Cooperation	(3.3)
Satisfaction	(3.7)

#### Interview comments:

##### *Student IT Tasks*

The teacher indicated that the concepts in the course are quite difficult to master. Students related that a typical class involved them working on assignments/design exercises. Students were often allowed to listen to music on CDs while working.

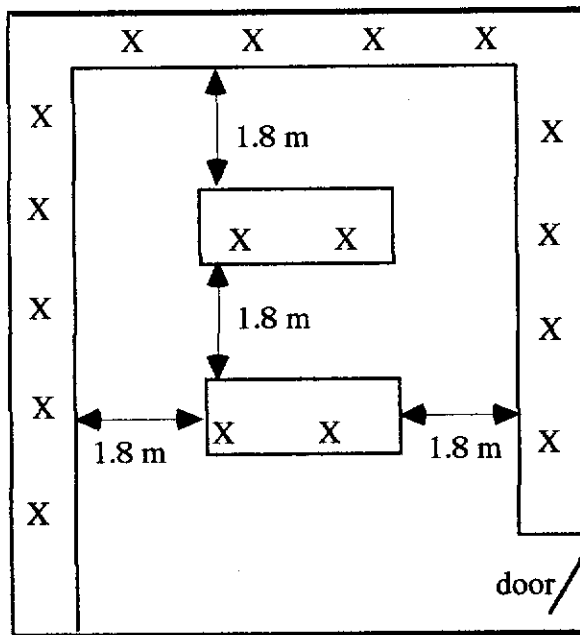
##### *Psychosocial environment*

The teacher saw the psychosocial climate as positive in the class and that students 'get along pretty well -- but keep pretty quiet'. Students indicated that the class segregates itself into two cliques (by row) and is not very social -- students not working well together. The teacher noted that students worked better when the teacher sat next to them. Some students are not comfortable asking others for help (eg. from other row).

##### *Physical environment*

Students indicated that the laboratory layout was not that good because students can not move around or talk to other people. The teacher would like to change the classroom layout and would like students to work in groups 'but can't here'.

### 6.1.3 Case Study Three



#### School 17-- Lab D2 -- Peripheral

School Location: Western Australia

School Type: Government

#### Physical and Environmental Measures

Lighting: (550-600 lux)

No. of Workstations: (17)

Carbon dioxide: (1000 ppm)

Mean Temperature: (22.7 C)

Relative humidity: (75 %)

#### Ergonomic Inventory :

(max. score = 5)

Workspace Environment (2)

Computer Environment (5)

Visual Environment (4)

Spatial Environment (5)

Overall Air Quality (3)

#### Task Analysis Summary:

(based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(9.0 mins.)
Moving about room :	(28 mins.)
Interacting with others:	(45.0 mins.)
Reading print material:	(0.0 mins.)
Browsing (computer):	(5.0 mins.)
Entering data (computer):	(11.0 mins.)
Miscellaneous (off task):	(2.0 mins.)

	<i>Students</i>
Listening to teacher:	(7.6 mins.)
Moving about room :	(15.0 mins.)
Interacting with others:	(26.8 mins.)
Reading print material:	(0.6 mins.)
Browsing (computer):	(24.4 mins.)
Entering data (computer):	(22.4 mins.)
Miscellaneous (off task):	(7.2 mins.)

#### Questionnaire Responses:

(max. score =5):

Social Cohesion	(3.4)
Involvement	(3.5)
Autonomy / Independence	(2.2)
Task Orientation	(3.6)
Cooperation	(3.2)
Satisfaction	(3.2)

#### Interview comments:

##### *Student IT Tasks*

Students indicated that they were working on assignments and projects. An example of a recent assignment was the drafting of a newspaper article using the Internet for source material. The teacher indicated that the class assignments were open-ended -- with students working on themes.

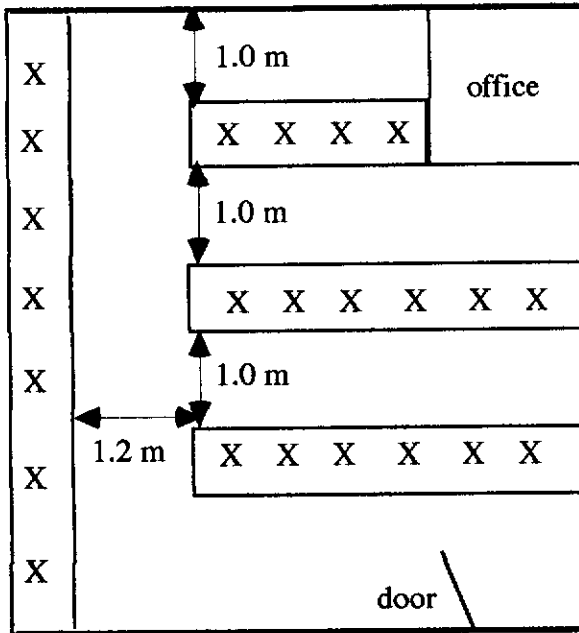
##### *Psychosocial environment*

Students indicated that the environment was positive and that students often moved around talking to people. Students reported working well together. The teacher indicated that the class was organised into 'learning teams'. They were encouraged to get help from other students and teachers.

##### *Physical environment*

Students reported that the room set-up was perfect and that they wouldn't change anything (except perhaps more blinds). The teacher noted that students were encouraged to work together by this layout. There are (purposely) fewer computers than students available in this classroom.

### 6.1.4 Case Study Four



#### School 20 -- Lab 21 -- Linear

School Location: Western Australia

School Type: Independent

#### Physical and Environmental Measures

Lighting: (504-550 lux)

No. of Workstations: (22)

Carbon dioxide: (600 ppm)

Mean Temperature: ( 21.5 C)

Relative humidity: (70 %)

#### Ergonomic Inventory :

(max. score = 5)

Workspace Environment (0)

Computer Environment (5)

Visual Environment (3)

Spatial Environment (3)

Overall Air Quality (3)

#### Task Analysis Summary:

(based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(15.0 mins.)
Moving about room :	(26.0 mins.)
Interacting with others:	(32.0 mins.)
Reading print material:	(3.0 mins.)
Browsing (computer):	(18.0 mins.)
Entering data (computer):	(8.0 mins.)
Miscellaneous (off task):	(0.0 mins.)

	<i>Students</i>
Listening to teacher:	(12.0 mins.)
Moving about room :	(6.0 mins.)
Interacting with others:	(10.0 mins.)
Reading print material:	(1.0 mins.)
Browsing (computer):	(45.0 mins.)
Entering data (computer):	(17.6 mins.)
Miscellaneous (off task):	(8.4 mins.)

#### Questionnaire Responses:

(max. score =5):

Social Cohesion	(3.2)
Involvement	(3.3)
Autonomy / Independence	(2.2)
Task Orientation	(3.4)
Cooperation	(3.0)
Satisfaction	(3.5)

#### Interview comments:

##### *Student IT Tasks*

Students and teachers described a new course 'Industrial technology'. Typical assignments involved project work (e.g. students creating personal web pages).

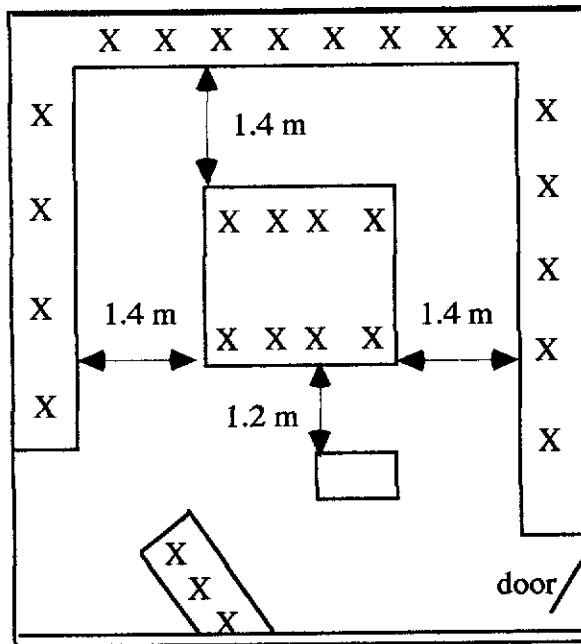
##### *Psychosocial environment*

Students (all boys) believed that they were good achievers and that the social climate was positive in the class. They further indicated that interaction was mostly limited to asking a neighbour for help. The teacher characterised the class as being several different 'groups of mates' and indicated that more interaction in the class was needed. Students were described as ordinary workers -- not terribly productive.

##### *Physical environment*

Teacher and students indicated that the monitors were too high (standing height) and that a peripheral lab would encourage more interaction as the benches restricted movement. The need for fresh air and climate control was also noted.

### 6.1.5 Case Study Five



### School 21-- Lab 117 -- Peripheral

School Location: Canada  
School Type: Government  
Physical and Environmental Measures

Lighting: (200-387 lux)  
No. of Workstations: (30)  
Carbon dioxide: (675 ppm)  
Mean Temperature: (21.2 C)  
Relative humidity: (33.1 %)

### Ergonomic Inventory : (max. score = 5)

Workspace Environment	(3)
Computer Environment	(4.7)
Visual Environment	(2)
Spatial Environment	(5)
Overall Air Quality	(5)

### Task Analysis Summary: (100 minutes total)

	<i>Teacher</i>
Presenting or lecturing:	(19.0 mins.)
Moving about room :	(24.0 mins.)
Interacting with others:	(38.0 mins.)
Reading print material:	(6.0 mins.)
Browsing (computer):	(4.0 mins.)
Entering data (computer):	(9.0 mins.)
Miscellaneous (off task):	(0.0 mins.)

	<i>Students</i>
Listening to teacher:	(15.0 mins.)
Moving about room :	(7.0 mins.)
Interacting with others:	(22.0 mins.)
Reading print material:	(6.0 mins.)
Browsing (computer):	(28.0 mins.)
Entering data (computer):	(26.0 mins.)
Miscellaneous (off task):	(3.0 mins.)

### Questionnaire Responses: (max. score =5):

Social Cohesion	(3.5)
Involvement	(2.7)
Autonomy / Independence	(2.2)
Task Orientation	(3.6)
Cooperation	(3.0)
Satisfaction	(3.1)

### Interview comments:

#### *Student IT Tasks*

Students and teachers described a new course (IT 11). Students related that much of the course is spent working on project or design work intended to give students practical (hands on) experience. The teacher's role was as 'coach' and to choose order of tasks and to collect resources.

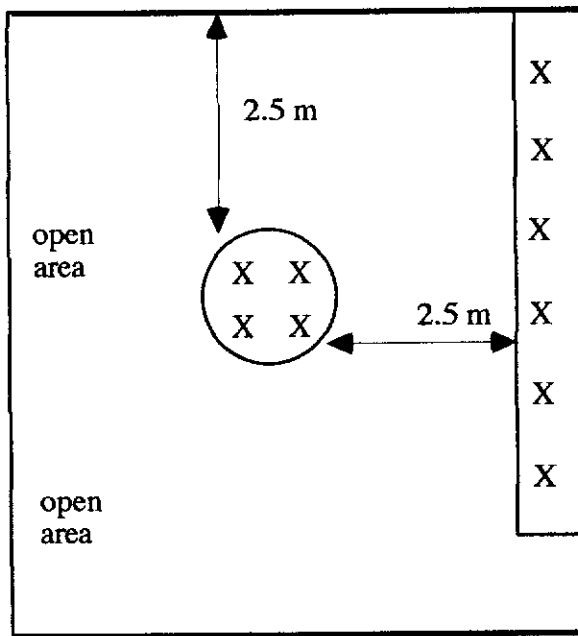
#### *Psychosocial environment*

Students described the psychosocial environment as positive. The teacher indicated that some students prefer to work alone/ but that many work together. This lab was an open lab and the teacher indicated that this allows for interactions among subject disciplines.

#### *Physical environment*

The teacher reported this layout as good because it is easy to monitor student work and allowed for groupwork / peer helping. Students indicated that an empty work space in the middle of the room was needed. The teacher indicated that the viewing height of the monitors needed adjustment.

### 6.1.6 Case Study Six



#### School 22 -- Lib. Lab -- Cluster

School Location: Canada

School Type: Government

#### Physical and Environmental Measures

Lighting: (400-800 lux)

No. of Workstations: (10)

Carbon dioxide: (794 ppm)

Mean Temperature: (21.0 C)

Relative humidity: (28.5 %)

#### Ergonomic Inventory :

(max. score = 5)

Workspace Environment (1)

Computer Environment (4.5)

Visual Environment (3)

Spatial Environment (4)

Overall Air Quality (5)

#### Task Analysis Summary:

(based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(4.0 mins.)
Moving about room :	(33.0 mins.)
Interacting with others :	(34.0 mins.)
Reading print material:	(14.0 mins.)
Browsing (computer):	(0.0 mins.)
Entering data (computer):	(0.0 mins.)
Miscellaneous (off task):	(15.0 mins.)

	<i>Students</i>
Listening to teacher:	(5.4 mins.)
Moving about room :	(13.0 mins.)
Interacting with others:	(18.0 mins.)
Reading print material:	(15.4 mins.)
Browsing (computer):	(18.0 mins.)
Entering data (computer):	(18.2 mins.)
Miscellaneous (off task):	(12.0 mins.)

#### Questionnaire Responses:

(max. score =5):

Social Cohesion	(n/a)
Involvement	(n/a)
Autonomy / Independence	(n/a)
Task Orientation	(n/a)
Cooperation	(n/a)
Satisfaction	(n/a)

#### Interview comments:

##### *Student IT Tasks*

Students were working on a research project at library stations. (The teacher refused an interview). Librarian reported that most students use the Internet for research and that some use it (after school) for e-mail or browsing. Librarian indicated that new skills are needed (e.g. ability to question / search skills). She noted that the curriculum states that 'students be aware of the technology'.

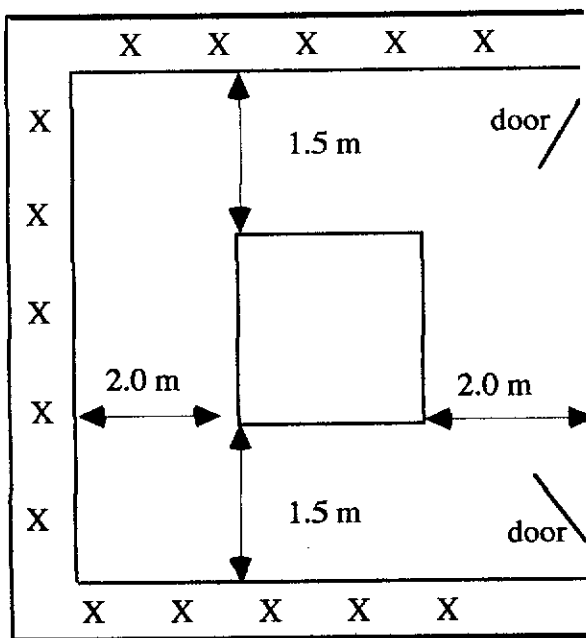
##### *Psychosocial environment*

As noted above, the teacher refused to be interviewed. However, some students reported that they found the internet motivational, while others did not. Many students felt frustrated working individually -- believing that they need more instructions on how to use the internet.

##### *Physical environment*

Some students did not access the Internet because of too few stations. The librarian also commented that more physical space was needed. Some students felt that better chairs were needed and were unhappy being forced to stand at some stations.

### 6.1.7 Case Study Seven



**School 23 -- Lab -- Peripheral**  
 School Location: Canada  
 School Type: Independent  
Physical and Environmental Measures

Lighting: (342-500 lux)  
 No. of Workstations: (15)  
 Carbon dioxide: (675 ppm)  
 Mean Temperature: ( 23.5 C)  
 Relative humidity: (32.3 %)

Ergonomic Inventory :  
 (max. score = 5)

Workspace Environment	(1)
Computer Environment	(5)
Visual Environment	(3)
Spatial Environment	(5)
Overall Air Quality	(2)

Task Analysis Summary:  
 (based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(6.0 mins.)
Moving about room :	(40.0 mins.)
Interacting with others :	(36.0 mins.)
Reading print material:	(8.0 mins.)
Browsing (computer):	(4.0 mins.)
Entering data (computer):	(6.0 mins.)
Miscellaneous (off task):	(0.0 mins.)

	<i>Students</i>
Listening to teacher:	(1.0 mins.)
Moving about room :	(15.0 mins.)
Interacting with others:	(24.0 mins.)
Reading print material:	(14.0 mins.)
Browsing (computer):	(23.0 mins.)
Entering data (computer):	(12.0 mins.)
Miscellaneous (off task):	(11.0 mins.)

Questionnaire Responses:  
 (max. score =5):

Social Cohesion	(3.3)
Involvement	(2.7)
Autonomy / Independence	(2.6)
Task Orientation	(2.8)
Cooperation	(2.9)
Satisfaction	(3.1)

Interview comments:

*Student IT Tasks*

Students and teacher described a business management class. The course generally involves students working on projects such as promotional / marketing research, etc. Students reported using the internet to research business plans and business ideas.

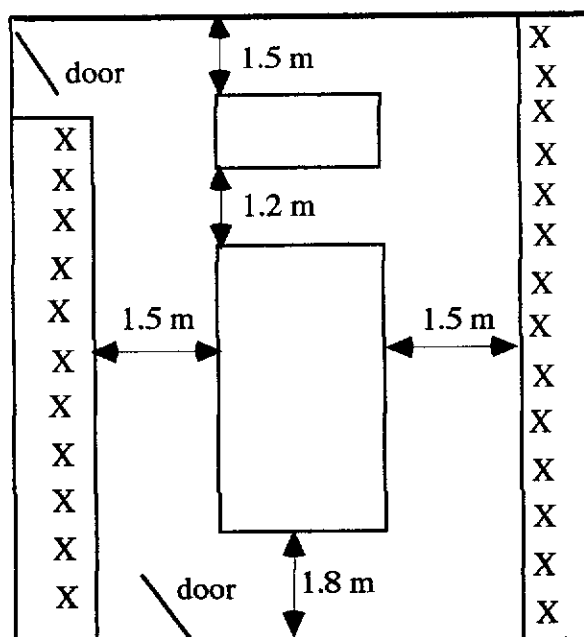
*Psychosocial environment*

Students reported a positive environment where it was common for them to work together or alone. They indicated that they could get help from the teacher individually or when approached in small groups. The teacher described the class as a small close-knit group with lots of interaction and cooperation among the students.

*Physical environment*

Students believed that the lab was too small, hot and stuffy and that the corners were crowded. The teacher agreed, but indicated that the general room layout works well. Teachers and students also indicated the need for more table space for their work.

### 6.1.8 Case Study Eight



#### School 24 -- Lab111 -- Peripheral

School Location: Canada  
School Type: Independent  
Physical and Environmental Measures

Lighting: (500-600 lux)  
No. of Workstations: (24)  
Carbon dioxide: (1006 ppm)  
Mean Temperature: (22.8 C)  
Relative humidity: (42.4 %)

#### Ergonomic Inventory : (max. score = 5)

Workspace Environment	(3)
Computer Environment	(5)
Visual Environment	(4)
Spatial Environment	(5)
Overall Air Quality	(4)

#### Task Analysis Summary: (based on 100 minutes)

	<i>Teacher</i>
Presenting or lecturing:	(28.0 mins.)
Moving about room :	(30.0 mins.)
Interacting with others :	(40.0 mins.)
Reading print material:	(0.0 mins.)
Browsing (computer):	(0.0 mins.)
Entering data (computer):	(0.0 mins.)
Miscellaneous (off task):	(2.0 mins.)

	<i>Students</i>
Listening to teacher:	(16.0 mins.)
Moving about room :	(5.0 mins.)
Interacting with others:	(9.0 mins.)
Reading print material:	(4.0 mins.)
Browsing (computer):	(37.6 mins.)
Entering data (computer):	(25.0 mins.)
Miscellaneous (off task):	(3.4 mins.)

#### Questionnaire Responses: (max. score =5):

Social Cohesion	(3.9)
Involvement	(2.8)
Autonomy / Independence	(2.6)
Task Orientation	(3.5)
Cooperation	(3.3)
Satisfaction	(3.8)

#### Interview comments:

##### *Student IT Tasks*

Teacher described a typical computer applications unit with most course time set aside for project work. In this described 'paperless' setting all notes/assignments are posted on internet. Students reported reading old work posted as e-mail, working on projects (e.g. GIS projects). The teacher described assignments as individual and freeform -- but based on common themes.

##### *Psychosocial environment*

Students reported that the class was a cooperative group which allowed individuals to help each other. The teacher described that the class allowed natural peer grouping with no assigned seating. This was reported as being occasionally noisy but the teacher indicated that "peer pressure usually controls this".

##### *Physical environment*

The teacher reported a good layout with tables in the centre. The cooling system was seen as unpredictable with significant down drafts. Students indicated the need for additional (non-computing) workspace.

## **6.2 Synthesis of Case Studies**

This section provides a summary of the types of information collected in the case studies presented in the previous section. Section 6.2.1 provides information about typical room layouts in the study, while section 6.2.2 summarises the results of the task analyses conducted in these locations. Finally, section 6.2.3 summarises the information obtained by environmental monitoring during working classes and section 6.2.4 summarises the interview data.

### **6.2.1 Room Layouts**

The eight locations selected for case study varied greatly in size, shape and number of computers. They included computer laboratories with many computers, classrooms with several computer workstations installed and one library setting. Overall, the number of computers in these locations ranged from a minimum of 10 machines in one library setting to a maximum of 30 in a computer laboratory setting. The average number of computers per study location was 20.

Throughout the larger study, a number of different, though typical, room layouts was noted during the completion of ergonomic evaluations (see Chapter 5). These layouts are represented in these case studies and are so defined here. Diagrams of typical layouts are provided in the top left-hand corner of each case study template. The most common layout has been labelled a 'peripheral' laboratory in this thesis (case studies 1, 3, 5, 7 and 8). This type of laboratory is characterised by computer workstations positioned along the outer wall of a room, with students facing away from the centre of the room and towards these outer walls. The second most common layout is termed a 'linear' laboratory in this study (case studies 2 and 4). This type of laboratory is characterised by rows of computer workstations positioned so that most students face towards the front of the room. One location (case study 6) shows a minimal setting where computers have been clumped together in different areas of a



learning space (in this case a library). This type of arrangement is described as a 'cluster lab' in this study.

Other aspects of the size and spatial environment in these computerised settings are described in the completed ergonomic inventories as discussed in another portion of this study (Section 6.4.2).

### 6.2.2 Task analysis

Each of the eight case study locations was subjected to a task analysis completed by this researcher sampling teacher and student behaviours. The methodology for this task analysis is described in Chapter 5. Each classroom analysis involved two observation sessions of 50 minutes each when the tasks and behaviours of both students and teachers were noted and categorised on an observation sheet. When these data are tabulated and summed across the eight cases, a time analysis of the types of activities typically occurring in these computerised classrooms can be described. A list of possible activities was determined by the researcher (in consultation with teachers) prior to these observations. The summed data are presented as Figure 6.1 and 6.2.

Figure 6.1: Time spent on student tasks in computerised classrooms (all cases)

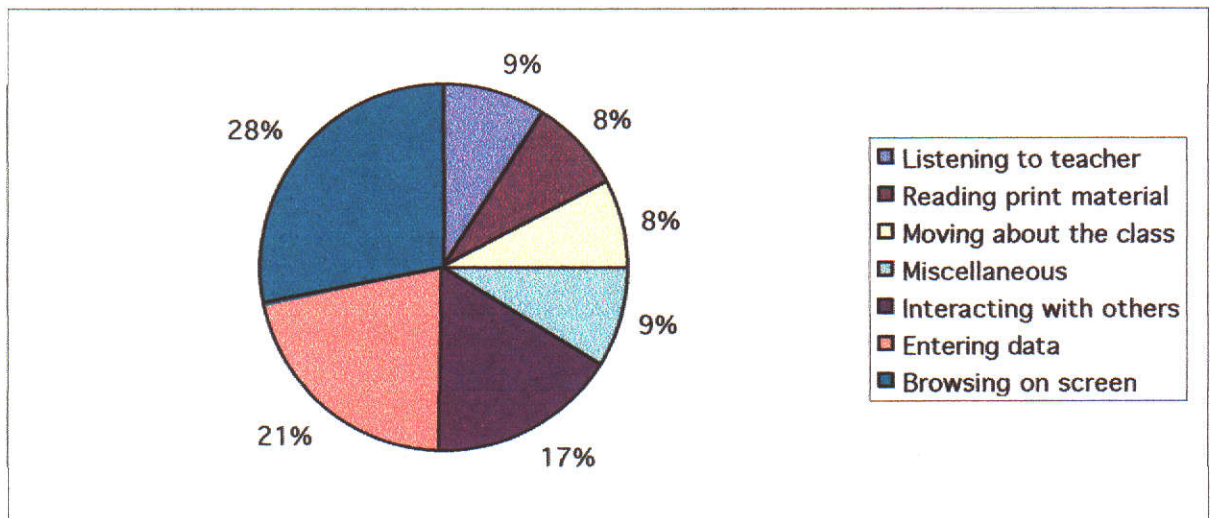
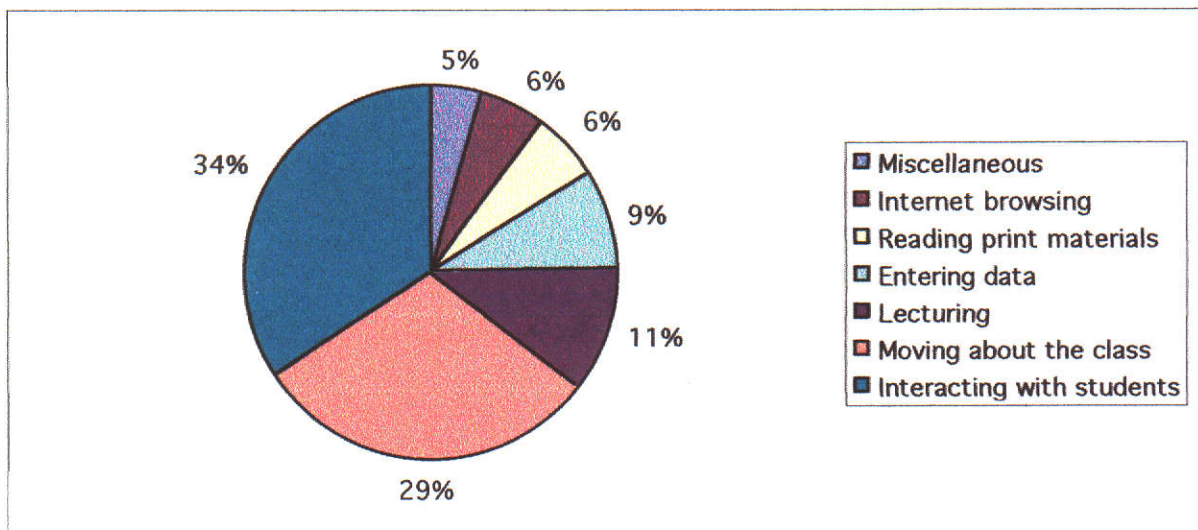


Figure 6.2: Time spent on teacher tasks in computerised classrooms (all cases)



An interpretation of the chart presented in Figure 6.1 indicates that, overall, students spent most of their time interacting directly with the computer (with the tasks of 'browsing on screen' and 'entering data' together accounting for nearly 50% of the total time spent in class). Interacting with other students was also an important portion of a class -- occupying about 18% of the total time. Miscellaneous or off-task behaviours occupied on average 9% of class time. Finally, students spent the least amount of their time listening to the teacher lecture, reading print or moving about the class.

The manner in which teachers spend their time in computerised settings was also of interest. An interpretation of the chart presented in Figure 6.2 is that, overall, teachers spent most of their time interacting one-on-one with students as they worked on computers (with the tasks of 'moving about the room' and 'interacting with students' accounting for fully 63% of a teacher's total time in class). Of next importance in teacher tasks was lecturing, but this activity occupied only 11% of a teacher's time. The remainder of time was spent doing a number of different tasks including entering data into computers, reading print materials or browsing on the internet. Interestingly,

teachers were also observed in miscellaneous off task behaviours and these on average occupied 5% of their time.

### **6.2.3 Environmental monitoring**

Environmental monitoring of a number of important physical variables was undertaken for each of the case studies simultaneously with the task analysis described in the previous section. A description of the methodology used is presented in Chapter 5. Environmental measures included noise load, lighting levels, temperature, relative humidity and carbon dioxide levels. These factors are considered by many ergonomists to be the most relevant in impacting on human work environments. As such, they also have the potential to enhance or detract for the learning environment. These data, in addition to ergonomic inventory scores, are provided in the top right-hand corner of each of the templates.

#### *Noise Load*

Noise load was monitored for the four Australian cases, but only zero level readings were recorded for each of these settings. Following these data, this measure was discontinued for the Canadian sample cases. Even though the levels of sound were not measurable, the noise factor is nevertheless important as the detection of 'noise' (undesirable sound) also has a psychological rather than physiological component. However, this factor was not an issue in any of the studied settings.

#### *Lighting Levels*

Over the eight locations, lighting levels remained at or near recommended levels (500-700 lux) with the exception of case study 5, which had fairly deficient lighting levels. However, all of these locations used unshielded fluorescent lighting which is not recommended (qualitatively) despite lighting levels being generally adequate.

### *Temperature and Humidity*

Mean classroom temperatures for most schools were close to or slightly higher than the recommended 20 degrees C. One location (case study 2) experienced fairly low temperatures with a mean value of only 18.4 degrees Celcius, while another (case study 7) was fairly warm with a mean value of 23.5 degrees C. Also, many settings (4) experienced high relative humidity (at or near 80%). Temperatures more than a few degrees above or below 20 degrees Celcius and relative humidities greater than 75% should be regarded as significant environmental deficiencies that could distract learners from attention to their tasks. It is important to note that many of these extremes in temperature and humidity are due to seasonal changes in the climate. Nevertheless, the existence of climate controlled environments would lesson their effects.

### *Carbon Dioxide Levels*

This measure also varied considerably among the eight case study locations -- ranging from a low of about 600 parts per million (ppm) to a high of 1006 ppm. Three case study locations showed carbon dioxide levels at or near 1000 ppm (case studies 1, 3 and 8) which, if consistently maintained, would be problematic (Occupational Safety and Health Administration, 1997). These data suggest that some settings may not be adequately ventilated with fresh air. This would have potentially serious consequences for both learner productivity and health.

#### **6.2.4 Interview Data**

A number of trends may also be noted from a synthesis of the comments provided in the student and teacher interviews. While individuals were asked questions directly related to the use of IT in that setting, they were also asked to comment on aspects of their physical and psychosocial environments. These data were the last type to be considered in the case study portion of this research.

### *Student IT Tasks*

The type of course delivered in each of the settings varied and included information technology courses, science courses, a humanities course and a business management course. Despite the range of curricula, most teachers had assigned to their students project or assignment work in which information or ideas were to be derived from browsing or searching on the internet. In one location (case 8), course information, assignments and other resources were also provided on-line. In some locations, the assignments given were individualised or open-ended (or based on a theme). One teacher (from case study 1) allowed students to browse the internet as a reward for completing other course work.

### *Psychosocial Environments*

Many of the described settings had teachers and students who reported a positive learning environment in the class. These environments were characterised by cooperative groups of students who were permitted to interact freely with others during class periods. Both students and teachers described a need to work sometimes independently and at other times in small groups. Importantly, the 'peripheral' type layouts were those which had the fewest number of negative comments regarding the learning environment, although they were described as noisier by one teacher. Conversely, 'linear' layouts studied seemed to be characterised by comments from students or teachers indicating a desire for more interaction during classes.

### *Physical environments*

Over the eight case study locations, students and teachers clearly had a preference for the 'peripheral' layout described in earlier sections. Teachers preferred this arrangement as it allowed them to monitor student work and move about the room more easily (a large percentage of their tasks in these settings). Students also preferred this type of arrangement as it allows for easy movement and interaction among students as they work on individual projects or assignments. In one 'linear' type layout (case study

2), students indicated that they were restricted from moving around and talking to other people. Their teacher expressed a desire to change the layout as it prevented students from working in groups. In a second 'linear' layout (case study 4), the teacher also believed that the arrangement of benches restricted movement and believed that a 'peripheral' layout would encourage interaction.

Another factor which was an issue for some locations was the number of workstations present in that setting. In one location (case study 6), the number of computers (10) was considered insufficient by students and contributed to some frustration as students were denied opportunities to access the internet. In another location (case study 3), the number of workstations was deliberately limited (to 17) in an attempt to stimulate more cooperation and interaction among students while they worked (despite more machines being readily available at the school).

Also, concerns about monitor height were described in two locations (case studies 4 and 6) where some monitors were placed to be viewed by students from a standing position or from an elevated stool rather than seated in a chair. Half of the locations further described inadequacies in the ventilation or climate control of settings, with three settings being hot and stuffy (cases studies 1, 4 and 7) and one setting having a ventilation system with excessive down drafts (case study 8).

### **6.3 Cross-national Comparisons**

While the synthesis of data presented in the previous section outlined some clear trends in the case study data, some important qualitative differences exist between data collected separately in British Columbia and Western Australia. These differences are outlined in the following sections. Because of the small number of case studies, no statistical tests were performed on these data and differences are presented in descriptive rather than quantitative terms.

### **6.3.1 *Comparison of Room Layouts***

A quick survey through the layout diagrams for the case studies reveals that, of the four Australian locations (case studies 1 through 4), two locations featured variations on the 'peripheral' layout considered as preferable according to interview comments, while two locations were variations on the less desirable 'linear' arrangement. Of the Canadian locations (case studies 5 through 8), three locations were variations of the 'peripheral' layout, while one was a minimal 'cluster' arrangement in a school library. The mean number of computers in the two jurisdictions was comparable at 19.8 (Canada) and 20.3 (Australia). However the number of workstations in each location varied more in the Canadian settings (ranging from 10 to 30) while remaining more uniform in Australia (17 to 24). No other differences in room layout or numbers of computers were noted in either setting.

### **6.3.2 *Comparison of Task Analyses***

A comparison of the task analyses conducted for students and teachers in each jurisdiction also reveals some subtle differences in the tasks and behaviours in which students and teachers were involved in computerised settings. Comparative time analyses for students in the two settings are presented in Figures 6.3 and 6.4, while similar analyses for teachers are presented in Figures 6.5 and 6.6.

*Comparing Student Tasks and Behaviors*

Figure 6.3: Time spent on student tasks in computerised classrooms (Australian cases)

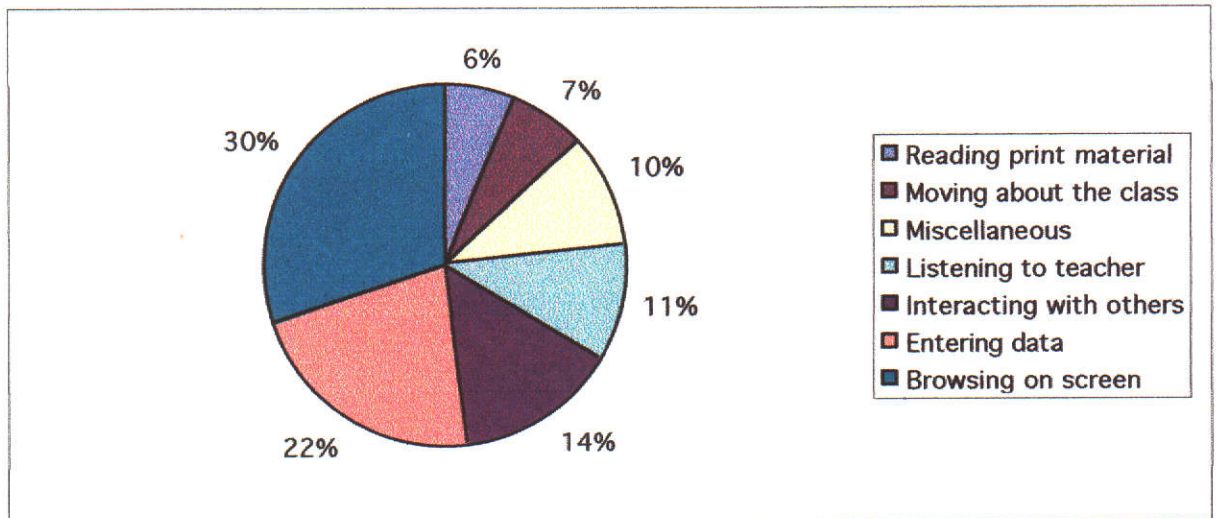
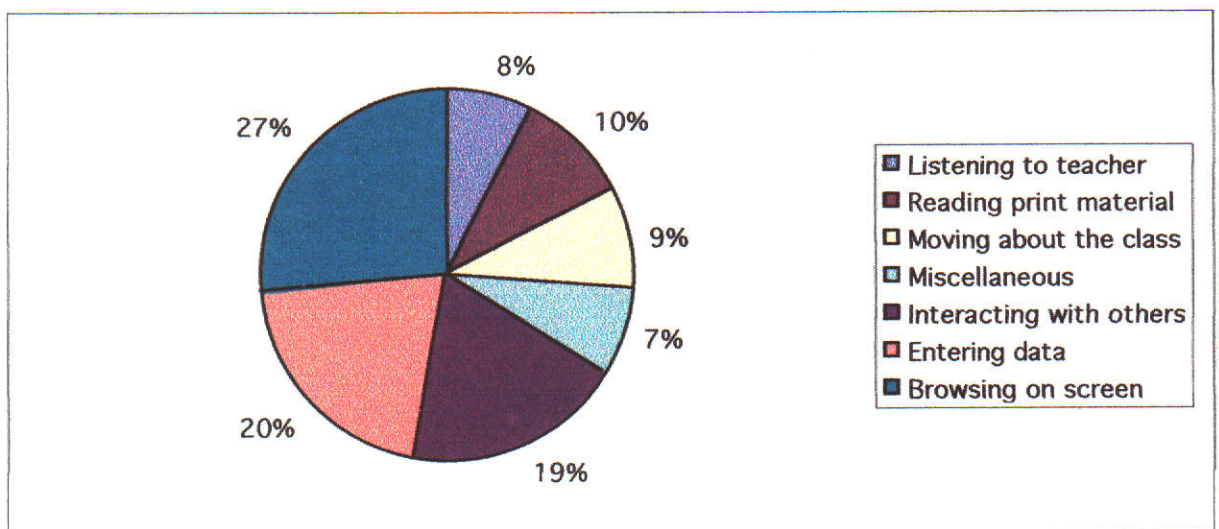


Figure 6.4 - Time spent on student tasks in computerised classrooms (Canadian cases)





A comparative interpretation of the task analyses presented in Figures 6.3 and 6.4 reveal that, although the data from the Australian and Canadian cases revealed a similar pattern of behaviours, Canadian students seemed to spend more time interacting with others than did the Australian students. This additional 'socialising' on the part of Canadian students seems to be at the expense of time spent working directly on the computer (either for entering data or browsing on screen).

### *Comparing Teacher Tasks and Behaviors*

Figure 6.5: Time spent on teacher tasks in computerised classrooms (Australian cases)

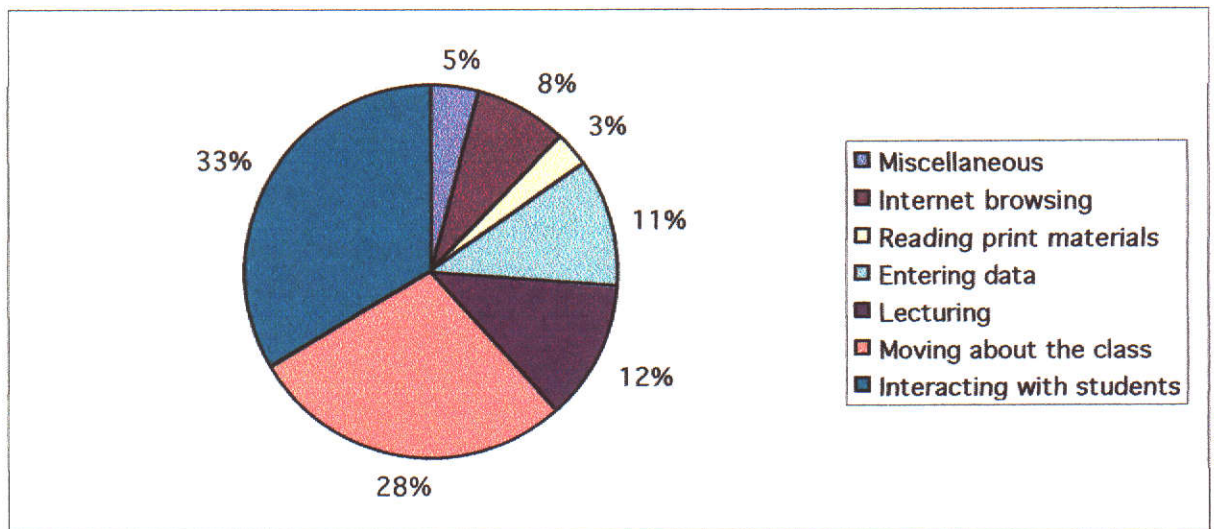
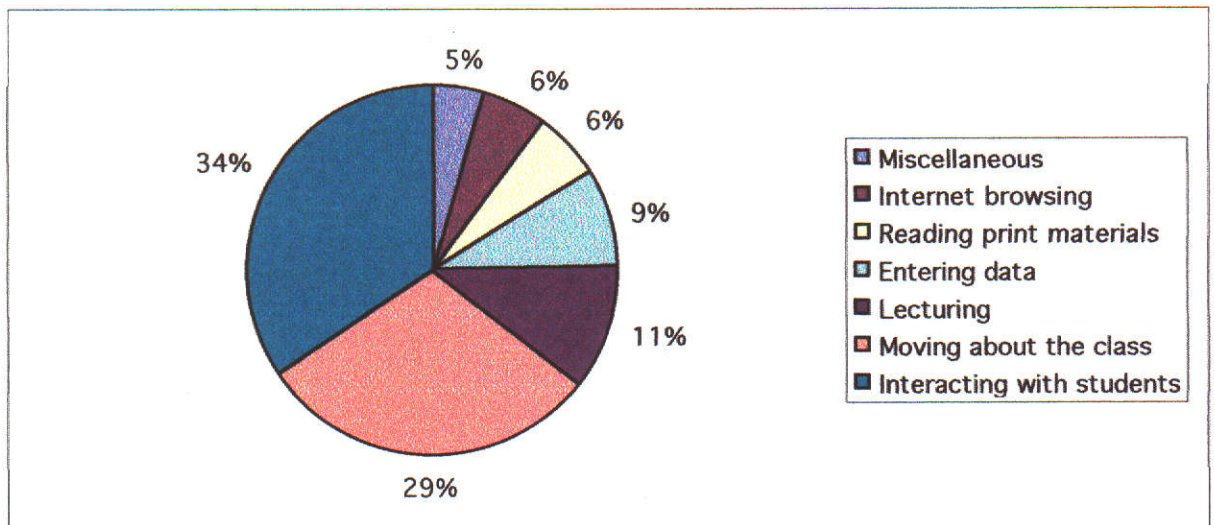


Figure 6.6: Time spent on teacher tasks in computerised classrooms (Canadian cases)



A comparative interpretation of the task analyses presented in Figures 6.5 and 6.6 reveals that the data from the Australian and Canadian cases describe a similar pattern of behaviours on the part of teachers in these two jurisdictions. However, unlike the task analyses of student behaviours, there do not seem to be notable between-country differences in the percentages of time that teachers allot to these different behaviours. Clearly, the tasks of 'moving about the class' and 'interacting with students' as they work are of equal and primary importance in both settings, with lecturing as a secondary task.

### 6.3.3 Comparisons of Environmental Factors

As described in the previous section, a number of physical environmental factors were monitored for the case studies and some important trends and deficiencies emerged from the synthesis of these data. Subtle qualitative differences also emerged when the factors of lighting, temperature, humidity and carbon dioxide levels are considered between the two jurisdictions.

### *Lighting Levels*

Although the mean lighting levels were acceptable for the overall sample of case studies, the Canadian cases yielded most of the lowest values within their range. Three of these studies yielded lighting levels in a portion of their setting that were below the recommended lower threshold of 500 lux. In comparison, none of the Australian case studies fell below this threshold value. Therefore it can be said that, in the locations studied, *Australian classrooms had a more optimal level of lighting.*

### *Temperature and Humidity*

There were considerable fluctuations in these related measures across the eight case study locations. However, it is useful to note that the lowest recorded mean temperature (18.4 degrees C) was taken at an Australian location which did not possess a localised heating system. Similarly, the highest recorded temperature (23.5 degrees C) was taken in a Canadian setting which was serviced by a centralised (rather than localised) heating system. Finally, the Australian cases were recorded as having a mean relative humidity of 75% (exceeding a recommended upper threshold of 60%). In comparison, Canadian cases yielded a mean relative humidity of only 34% (less than half that of the Australian sample). For both countries, these readings were taken during the autumn.

### *Carbon Dioxide Levels*

Although carbon dioxide readings recorded at both locations were problematic, no differences were noted between the *Canadian and Australian settings.*

## **6.4 Relationship to Other Data**

The preceding case study data reveal a great deal about the educational contexts for this study using a variety of quantitative and qualitative methods. These data, synthesised and compared in this chapter, also complement the more quantitative portion of this study involving measures of the psychosocial and physical learning environments in computerised classrooms. Before moving on to a more detailed

description of these results in the following two chapters, an attempt is made here to link the case study data from this chapter to results found with the larger study sample.

#### 6.4.1 *Psychosocial Data*

While the case study data provided important information about the psychosocial environments in the case study locations (and their context), they may also be considered typical of the broader range of locations studied in the larger study. These other data involved the administration of questionnaires measuring student perceptions of the psychosocial environment to a sample of 81 classes and 1404 students. Data for the questionnaire portion of the study are presented in Chapter 7.

A comparison of mean scores from each questionnaire scale between the case study group and the larger sample is presented as Table 6.1. The close similarity of these mean scores strengthens the argument for linking the case study data described here and other questionnaire data obtained in this study. Where differences between means exists, they are not statistically significant ( $p > .05$ ).

Table 6.1

Comparison of means on psychosocial environment scales between the case study and larger samples (data obtained from scales on the WHIC questionnaire)

Sample	Student Cohesiveness	Involvement	Autonomy / Independence	Task Orientation	Cooperation
Case study	3.5	3.1	2.3	3.5	3.1
Overall	3.6	3.2	2.3	3.6	3.4

### 6.4.2 Physical Data

The case study data not only provided important information about the physical (or ergonomic) environments of the case study classrooms, but also they should be considered typical of the broad range of locations in the larger sample. These other data involved the ergonomic evaluation of 43 computerised settings in 24 schools. Data for the physical or ergonomic portion of the study are presented in Chapter 8.

A comparison of mean scores from each factor in the ergonomic inventories between the case study locations and the larger sample is presented as Table 6.2. The close similarity of these means also strengthens the argument for linking the case study data here with other ergonomic data obtained in this study. Again, where differences between means exist, they are not statistically significant ( $p > .05$ ).

Table 6.2

Comparison of means on ergonomic factors between the case study and larger samples (data obtained from completion of the CCEW and CCEI forms)

Sample	Workspace Environment	Computer Environment	Visual Environment	Spatial Environment	Air Quality
Case study	1.5	4.9	3.3	3.6	3.4
Overall	1.6	4.7	3.0	4.1	3.2

### 6.4.3 Interview Data

The interview data collected following classroom observations from teachers and students authenticates many of the findings of other methodologies used during this study in a qualitative way. While these comments and views cannot be linked directly, comments made by teachers will form a part of the discussion in later chapters. As the case study locations are typical of many of the studied locations, it is likely that the ideas and concerns of those working and learning in these environments can be considered typical.

## 6.5 Summary of Case Study Findings

These detailed case studies of computerised learning environments have yielded much descriptive information about the educational context of these settings. Interviews with teachers and students indicated that the internet medium is being used largely to assist with projects, research and individualised (thematic) assignments. Also, students and teachers largely felt positively about their learning environments, but they expressed a number of concerns about physical factors such as room layout, workstation height and the temperature and air quality in these working settings. Overall, teachers indicated a preference for 'peripheral' laboratory arrangements as they believe that they encourage more student interaction.

Task analysis during observations in the computerised settings revealed that students were involved mainly with task-oriented behaviours such as browsing for information and entering data on computers, rather than teacher-centred activities such as listening to lectures. This point was further reflected in the observed tasks of teachers who focused mainly on facilitative tasks such as interacting one-on-one with students and moving around the room to help with individual problems. A qualitative comparison of the Canadian and Australian settings also revealed that the Canadian settings exhibited slightly more interaction for students than the Australian settings.

The environmental monitoring of computerised classrooms revealed potential problems including inadequate lighting levels, fluctuations in temperature and humidity and, finally, problematic levels of carbon dioxide. These findings suggest a number of areas which are in need of serious attention in many computerised learning environments. It is important to note that, because these environmental measures were taken during the autumn in both locations these environmental problems are likely to be further exacerbated at certain times of the year (e.g. during the Canadian winter or Australian summer). In the following chapters, a broader consideration is given to psychosocial and physical learning environments in similar settings.

## Chapter 7

### Results -- Psychosocial Learning Environments

As previously described in the methodology for investigating psychosocial learning environments (discussed in Section 5.3), a total of five scales from the 'class form' of the What is Happening in this Class (WIHIC) instrument and one attitude scale -- Satisfaction (adapted from the TOSRA) -- were administered to a sample of 1404 high school students in 81 classes. In addition, a sample of 23 teachers also completed the form. Students and teachers were instructed to reflect on their actual rather than preferred learning environments while completing these forms. This version is therefore referred to as an 'actual' form. The responses were subjected to statistical analysis using the SPSS (version 6.1) statistical package. The unit of analysis for this study was the class mean (with the exception of a factor analysis conducted on the individual questionnaire responses).

The intent of the questionnaire was to encourage teacher and student responses regarding their perceptions of the learning environment in their computerised classrooms. However, before these results may be considered, some initial data are presented regarding the factor structure of the questionnaire and each scale's internal consistency reliability, discriminant validity, and ability to distinguish among the different class groupings. Together, these statistical measures give an indication of the suitability of this questionnaire in describing the psychosocial environment in the studied classrooms.

## **7.1 Questionnaire Reliability and Validity**

### **7.1.1 *Validation of WIHIC Scales***

Using questionnaire data obtained from 1,404 students, factor and item analyses were conducted in order to identify faulty questionnaire items which could be removed in order to increase the reliability of each of the five psychosocial scales from the WIHIC instrument. A principal components factor analysis resulted in the factor loadings presented in Table 7.1. As a result of this analysis, all of the 50 items from the WIHIC scales were retained in the original questionnaire and the five scales of Student Cohesion, Involvement, Autonomy/Independence, Task Orientation and Cooperation were retained as independent measures of the psychosocial learning environment.

In order to estimate the internal consistency reliability of each of the scales from the WIHIC, a Cronbach alpha coefficient was calculated. The discriminant validity of each scale was determined by calculating the mean correlation of a scale with other scales. These two analyses were performed at both the individual and the class levels. Finally, an ANOVA and the eta<sup>2</sup> statistics were used to determine the ability of each scale to differentiate between classes. A summary of these statistics is presented in Table 7.2. Interpretation of these statistics show that the internal reliability (Cronbach alpha) for each scale was high (ranging between 0.86 and 0.89 at the individual level of analysis). This internal reliability increased at the level of class mean (ranging between 0.92 and 0.93). Values greater than 0.70 are considered acceptable by most researchers for this measure.



Table 7.1

## Factor loadings for WHIC questionnaire items

Item Number	Factor Loading				
	Student Cohesion	Involvement	Autonomy/ Independence	Task Orientation	Cooperation
1	0.61				
2	0.48				
3	0.71				
4	0.64				
5	0.58				
6	0.75				
7	0.71				
8	0.74				
9	0.69				
10	0.75				
11		0.70			
12		0.71			
13		0.62			
14		0.74			
15		0.50			
16		0.71			
17		0.68			
18		0.69			
19		0.65			
20		0.67			
21			0.68		
22			0.75		
23			0.64		
24			0.40		
25			0.45		
26			0.40		
27			0.48		
28			0.68		
29			0.72		
30			0.41		
31				0.67	
32				0.65	
33				0.67	
34				0.67	
35				0.68	
36				0.59	
37				0.74	
38				0.67	
39				0.70	
40				0.71	
41					0.40
42					0.70
43					0.67
44					0.75
45					0.73
46					0.68
47					0.76
48					0.71
49					0.66
50					0.68

Factor loadings smaller than 0.40 have been omitted.

Table 7.2

Internal consistency (Cronbach alpha coefficient), discriminant validity (mean correlation with other scales) and ability to differentiate between classes (ANOVA) for scales from the 'What is Happening in this Classroom' questionnaire (WIHIC)

WIHIC Scale	Unit of Analysis	Cronbach Alpha	Discriminant Validity	ANOVA $\eta^2$
Student Cohesiveness	Individual	0.86	0.46	0.27*
	Class Mean	0.94	0.47	
Involvement	Individual	0.86	0.51	0.23*
	Class Mean	0.92	0.50	
Autonomy / Independence	Individual	0.77	0.25	0.27*
	Class Mean	0.86	0.16	
Task Orientation	Individual	0.87	0.44	0.27*
	Class Mean	0.95	0.48	
Cooperation	Individual	0.89	0.50	0.24*
	Class Mean	0.94	0.52	

\* $p < .0001$

Calculations of the discriminant validity of the scales (mean correlation of a scale with other scales) were in the range of 0.44 to 0.51 for most scales at the individual level and slightly higher for the level of class mean. This indicates that these scales measure distinct though somewhat overlapping aspects of the psychosocial environment in these classrooms. One exception to this was the scale Autonomy / Independence yielded a lower discriminant validity score (0.25 at the individual level and 0.16 at the class mean level). The discriminant validity of the Autonomy / Independence scale is greatest at the level of the class mean (the unit of analysis for this study). However, the factor analysis results in Table 7.1 strongly support the five-factor a priori structure of the WIHIC.

### 7.1.2 *Validation of the Satisfaction Scale*

In order to estimate the internal reliability of the Satisfaction scale, Cronbach's alpha coefficient was calculated for this scale at two levels of analysis. A summary of these statistics is presented in Table 7.3. Interpretation of these values indicate that the adapted *Satisfaction* scale has good internal reliability.

Table 7.3

Internal consistency (Cronbach alpha coefficient) for satisfaction scale (TOSRA)

Attitude Scale	Unit of Analysis	Cronbach alpha
Satisfaction	Individual	0.70
	Class Mean	0.74

### 7.1.3 *Suitability of the Instruments*

The statistical analyses for the WIHIC learning environment scales and the TOSRA Satisfaction scale support the validity and reliability of these instruments for obtaining information about aspects of the psychosocial environment and students' level of satisfaction in the studied settings. It is assumed that these questionnaires were also suitable for use in obtaining teachers' perceptions of these classroom environments, although reliability and validity data for this small sample were not computed. Overall, student and teacher perceptions of these environments are considered in the following two sections as are differences between the perceptions of Canadian and Australian students. However, due to large difference in sample sizes for these comparisons, this information is included for descriptive purposes and care should be used by the reader in interpreting the results.

## 7.2 Questionnaire Responses

### 7.2.1 Student Questionnaire Responses

Questionnaires were distributed in class sets to teachers who were working in computerised settings (according to the methodology outlined in Chapter 5). The resulting sample consisted of a total of 1,404 high school students grouped in 81 classes. Individual scores for each scale were obtained by averaging the responses to the items in each. Mean scores for each class were then calculated using individual scale scores and aggregating the data by class. This analysis yielded a number of descriptive statistics for the psychosocial learning environment in the studied classes. Similarly, the class means on the student Satisfaction scale were also calculated. These data are presented in Table 7.4.

Table 7.4

Descriptive statistics for learning environment scales (WIHIC) and student satisfaction (TOSRA) for student responses

Questionnaire and Scale	Mean Score	Standard Deviation	Minimum Score	Maximum Score
<i>WIHIC</i>				
Student Cohesiveness	3.56	0.33	2.84	4.32
Involvement	3.24	0.32	2.62	3.98
Autonomy / Independence	2.29	0.30	1.65	2.98
Cooperation	3.35	0.35	2.51	4.24
Task Orientation	3.61	0.34	2.72	4.43
<i>TOSRA</i>				
Satisfaction	3.49	0.26	2.95	4.13

N=1404

Respondents were asked to rate how frequently practices related to each of these scales occurred using the response key: 1=Almost never, 2=Sometimes, 3=Often (neutral), 4=Often, 5=Almost always.

Interpretation of the student questionnaire data presented in Table 7.4 yields one perspective on the learning environment in computerised classrooms. Mean scores of greater than 3 are considered positive and indicate that the majority of respondents perceived practices related to this psychosocial variable to be occurring more than *sometimes* and in the direction of *often* or *almost always*. Conversely, scores of less than three are considered negative as these practices were viewed by students as happening less frequently than *sometimes* and in the direction of *seldom* or *almost never*. Overall, students perceived most aspects their learning environments to be positive and characterised them higher in Student Cohesiveness and Task Orientation than other scales. The scale measuring Autonomy/Independence scored lowest (less than three) of the five learning environment scales. Finally, students rated their level of Satisfaction with learning in these environments as generally positive.

### **7.2.2 Teacher Questionnaire Responses**

As mentioned in the previous section, teachers administered the questionnaire to their classes working in computerised settings. Further, these teachers were themselves asked to fill out the same form of the questionnaire. This questionnaire data was collected for comparison with the student questionnaire data. The resulting sample consisted of 23 teachers working in a variety of different settings. Scale calculations for each individual teacher and as well as the mean and range for the five psychosocial scales and Satisfaction scale are presented in Table 7.5.

Interpretation of the teacher questionnaire data indicates that, overall, though scores vary considerably for some scales, teachers perceived that their IT classes had a fairly positive learning environment (scores greater than 3.0) and that the learning environment in these classrooms is characterised by higher levels of Student Cohesiveness and Task Orientation than other scales and lower levels of Autonomy / Independence (negative). Further, teachers rated the Satisfaction scale highly in these learning environments. While the sample size is not sufficiently large to draw conclusions, it provides a useful descriptive comparison with the student data presented

in the previous section. A graphical representation of this comparison is also provided in Figure 7.1.

Table 7.5

Teacher responses for five learning environment scales and student satisfaction

Teacher	Scale					
	Student Cohesion	Involvement	Autonomy / Independence	Task Orientation	Cooperation	Satisfaction
1	4.1	2.8	1.6	4.3	2.9	5.0
2	4.3	3.7	1.2	4.5	2.4	5.0
3	3.1	2.8	2.2	4.1	3.1	3.5
4	3.7	3.3	3.0	4.4	3.8	4.6
5	3.7	3.7	1.6	4.3	3.6	4.0
6	4.0	3.6	3.2	4.2	4.5	3.4
7	4.5	4.6	3.4	4.6	4.0	3.3
8	3.9	3.8	2.4	4.1	5.0	4.1
9	3.6	3.9	2.9	3.5	3.9	4.9
10	3.7	3.3	2.4	3.6	3.5	4.1
11	3.4	3.3	2.5	3.8	2.8	3.4
12	3.4	3.4	3.3	3.8	3.6	3.3
13	4.3	4.4	4.1	4.7	4.9	5.0
14	3.9	2.8	2.6	3.6	2.4	4.4
15	3.7	3.4	2.1	4.2	2.7	3.4
16	3.9	4.1	2.9	3.6	3.8	4.4
17	3.0	3.2	1.0	4.2	1.6	3.8
18	3.6	2.7	1.4	4.3	2.8	4.5
19	4.0	3.7	2.3	4.5	4.1	4.0
20	3.9	3.0	1.4	4.5	3.0	3.0
21	3.5	3.2	2.5	3.0	3.1	2.9
22	4.2	4.1	3.2	4.5	3.9	4.8
23	4.0	3.4	2.3	4.3	3.7	4.0
range	3.1-4.5	2.8-4.6	1.0-4.1	3.0-4.7	1.6-5.0	2.9-5.0
mean	3.8	3.5	2.4	4.1	3.4	4.0

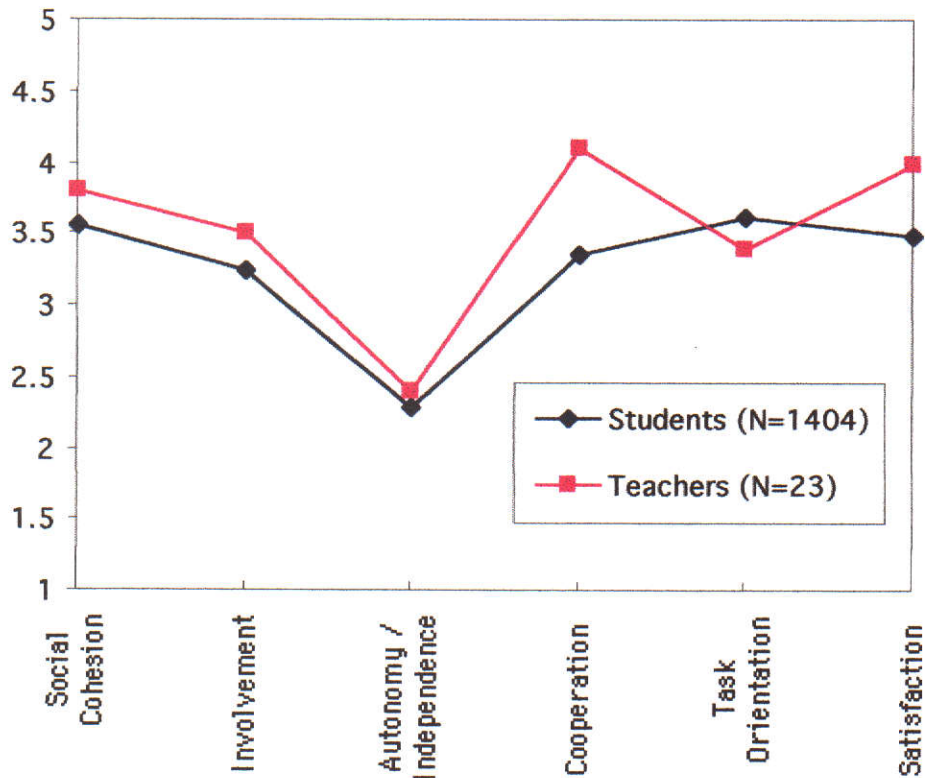
N=23

This section has provided descriptive information about how students and teachers generally view their psychosocial learning environment in their computerised classrooms. Interestingly, similar patterns in these responses are apparent and these are the topic of the next section.

### 7.3 Comparison of teacher and student responses

It is interesting to compare the mean scores on each of the questionnaire scales. A comparative plot of means scores on each scale for student and teacher respondents to the questionnaire is provided as Figure 7.1. However, due to differences in sample size this is done for descriptive purposes and no statistical comparisons are made.

Figure 7.1: Mean scale scores for teacher and student responses on five psychosocial scales (from the WIHIC) and satisfaction (from the TOSRA)



An interpretation of the information presented in Figure 7.1 is that, in general, teachers perceived the learning environment to be more positive than did students in their classrooms for most scales. The tendency of teachers to rate attributes of the

psychosocial environment more favourably than do their students is commonly reported in the learning environment literature (see Fraser, 1998). The exception to this was the scale mean of Task Orientation, which students perceived as being more favourable than did the teachers. Importantly, students and teachers agreed closely with their ratings of Autonomy / Independence, which both groups ranked as occurring with a low frequency (less than 3). This indicates that both groups considered this to be a somewhat negative attribute of the learning environment.

On the attitudinal measure of student Satisfaction (from TOSRA), students and teachers also similarly ranked this key outcome measure. Both groups rated this measure positively with teachers scoring these items higher than did their students. Overall, students and teachers agreed that their computerised learning environments were characterised by a high degree of satisfaction with learning. However, as large differences in sample size exist between the teacher and student samples, care should be taken in interpreting any differences between groups.

This section has compared two different perspectives on the learning environment and student satisfaction and shown a similar pattern of responses between teachers and their students. However, as this study had a cross-cultural component, another important comparison is the difference in responses between countries. The following section continues the consideration of the questionnaire data by comparing student responses on the WIHIC and TOSRA scales between Australian and Canadian samples.

#### **7.4 Comparison of Australian and Canadian Samples**

Although the main portion of the study occurred in Australia, a small sub-group of Canadian students (75) also answered the questionnaire. Descriptive statistics were calculated for both of these groups and t-tests comparing scores on each of the psychosocial scales (from WIHIC) and the outcome measure (Satisfaction from TOSRA) were computed. These data are presented in Table 7.6. However, as large differences in sample size exist, care must be used in interpreting these results. The data



demonstrate that, for the most part, mean scores and standard deviations for the scales from the WIHIC for each country were similar. However, Involvement and Cooperation showed a statistically significant difference between the samples, with Australian students scoring higher. Also, a statistically significant difference in students' rating of Satisfaction was noted, with Australian students also scoring higher on this measure.

Table 7.6

Comparison of means and standard deviations for learning environment scales (WIHIC) and student satisfaction (TOSRA) between Australian and Canadian samples

Scale	Mean		Difference	Standard Deviation	
	Australia	Canada		Australia	Canada
<i>WIHIC scales</i>					
Student Cohesion	3.55	3.60	0.05	0.63	0.57
Involvement	3.25	2.78	0.47**	0.67	0.79
Autonomy/ Independence	2.28	2.37	0.09	0.59	0.61
Task Orientation	3.61	3.54	0.07	0.64	0.75
Cooperation	3.36	3.05	0.31**	0.75	0.74
<i>TOSRA scale</i>					
Satisfaction	3.49	3.32	0.17*	0.57	0.81

\*p < 0.05, \*\*p < 0.01 N (Australia) = 1329 N (Canada) = 75

Where small differences may exist in the psychosocial learning environment and students' ratings of Satisfaction between the Canadian and Australian samples, great care should be made in interpreting these differences. Also classroom observations made in the two countries did indicate that there were variations in the learning environment and students' levels of satisfaction with learning in the study locations. However, these variances could be attributed to many factors including subtle cultural differences or differences in curriculum and teaching methodologies. More importantly,

relationships between the psychosocial learning and student satisfaction with their learning can be explored using a common approach in both of these locations. The following section describes associations between aspects of the psychosocial environment (as measured by the WIHIC scales) and student satisfaction (as measured by the TOSRA Satisfaction scale).

### **7.5 Associations Between Psychosocial Factors and Satisfaction**

The key dependent variable in this study is the measure Satisfaction, and associations were explored between this attitudinal variable and various psychosocial and physical factors (see research questions in Section 1.4). Both the psychosocial measures and the measure of student Satisfaction were obtained using student questionnaires and descriptive statistics regarding these measures were presented in the previous section. This section describes associations between the psychosocial environment and students' satisfaction with learning.

Questionnaire data were analysed for associations between the outcome variable student Satisfaction and the five psychosocial scales in the WIHIC questionnaire. To accomplish this, simple correlations and multiple linear regressions were performed at the level of the class mean using the SPSS (version 6.1) statistical package. In this analysis, Satisfaction was identified as the dependent variable and the other five psychosocial scales were identified as independent variables. These regression statistics are presented as Table 7.6.

Table 7.7

Associations between five WIHIC scales and student satisfaction in terms of simple correlations ( $r$ ) and standardised regression coefficients ( $\beta$ ) using the class mean as the unit of analysis

WIHIC Scale	$r$	$\beta$
Student Cohesion	0.35*	0.13
Involvement	0.35*	0.00
Autonomy / Independence	0.35*	0.32*
Task Orientation	0.53*	0.46*
Cooperation	0.31*	0.11
Multiple correlation (R)		0.61*

N=81 classes

\* $p < .01$

The results show that the simple correlations with Satisfaction was statistically significant for all five WIHIC scales. When all five environment scales are considered together, the multiple correlation of Satisfaction with the set of five psychosocial scales was high (0.61), indicating that approximately 36% of the variation in the Satisfaction scores was explained by psychosocial environmental variables. In addition, the  $\beta$  weights shown in Table 7.6 suggest independent, strong associations between Satisfaction and each of the psychosocial scales of Autonomy / Independence and Task Orientation when the influence of other factors are controlled. Of these associations, Task Orientation had the strongest individual association with student Satisfaction.

## 7.6 Summary of results

Overall, the administration of the questionnaire to 1,404 high school students yielded good reliability and validity data for each of the five learning environment scales of Student Cohesion, Involvement, Autonomy / Independence, Task Orientation and Cooperation (contained in the WIHIC). In addition, the attitudinal scale Satisfaction was also confirmed to have sound internal consistency reliability.

Students' perceptions of the psychosocial learning environment and Satisfaction were generally positive with the exception of the scale *Autonomy / Independence*, which yielded low scores. Overall, positive scores on most attributes of the learning environment seem to support the ideas outlined in Chapter 2 (Section 2.4.1) which outlined the potential of Internet supported environments in promoting collaboration, and *interaction among students*. Low ratings on the *autonomy* scale seem to indicate that students required greater freedom in managing their own learning and were perhaps frustrated in this regard. Similar perceptions of the learning environment were also held by the teachers in these settings who also ranked *Autonomy / Independence* in these classrooms as being low. In general, teachers perceived the learning environment and student satisfaction in these settings more favourably than did their students, which is consistent with past research (Fraser, 1998). The exception was the degree of *Task Orientation* was rated more highly by students than by their teachers.

Comparisons of mean scale scores for the WIHIC and Satisfaction scale were also made between Australia and Canada. However, scores for most aspects of the psychosocial environment (as measured by the WIHIC) were similar with the exception of the scales of *Cooperation* and *Involvement*, which showed statistically significant, higher scores in the Australian sample. In addition, there was a statistically significant difference in the mean scores for the outcome measure of *Satisfaction*, with the Australian sample again scoring higher than the Canadian sample. However, caution is advised in interpreting these differences because of the difference in sample size from the two countries.

Most important in these findings are the strong associations between *Satisfaction* and the psychosocial factors of *Autonomy / Independence* and *Task Orientation* (at the class level). These associations suggest a positive relationship between the degree of autonomy allowed to students and their overall satisfaction with learning in that environment. Further, the degree of task orientation in a class could similarly influence satisfaction. The next chapter presents further quantitative information about physical

(or ergonomic) factors influencing satisfaction, and further explores their associations with the psychosocial learning environment.

## Chapter 8

### Results -- Physical Learning Environments

The physical or ergonomic evaluation of study settings was undertaken using the methodology and instruments outlined in Chapter 5. In all, 43 computer settings were evaluated in 24 study schools for 81 class groupings. These settings included school classrooms, computer laboratories and library resource centres. The procedure involved primarily the completion of the Computerised Classroom Ergonomic Worksheet (CCEW) and Computerised Classroom Ergonomic Inventory (CCEI) for each of the study's physical locations. The intent of this portion of the study was to describe in a general way the physical settings where students spend their time working and to indicate to what extent these settings are appropriate by comparison with published guidelines used in other settings (e.g. Kroemer & Grandjean, 1997).

Information about the physical computerised classroom was also linked to student questionnaire data pertaining to the psychosocial learning in these settings. The intent in this was to consider and describe relationships among physical and psychosocial factors and their influence upon student satisfaction in each class. These data also complement the detailed and contextual information about physical and psychosocial learning environments described in the case study portion of this study described in Chapter 6.

#### 8.1 Ergonomic Evaluations Using the CCEI

A general description of each physical learning environment was completed by undertaking school visits to conduct evaluations of their computerised settings (using the instruments and methodology outlined in Section 5.4). On average, these evaluations took 45-60 minutes to complete and were done outside normal class time to facilitate the various physical measures needed for completion of the ergonomic worksheets (CCEW) and ergonomic inventories (CCEI).

In total, 43 evaluations were completed for this portion of the study. Each evaluation yielded scores of between 0 and 5 on each of the dimensions of Workspace Environment, Computer Environment, Visual Environment, Spatial Environment and Overall Air Quality for that setting as noted on the CCEI instrument (described earlier in Section 5.4). In addition, the number of computers in each setting and the type of room layout were also noted. A summary of this information, in addition to means for the overall sample, are provided as Table 8.1.

Interpretation of the ergonomic data presented indicates that schools rated as high their choice of computer equipment (as measured by Computer Environment) and the proper arrangement of this equipment throughout the room (as measured by Spatial Environment). On average, the studied schools rated lowest the individual workspaces where their computer equipment was being used (as measured by Workspace Environment). Other measures (Visual Environment and Overall Air Quality) varied widely by location. Lastly, the evaluation of computerised classrooms also indicated that, on average, these settings consisted of 22 computer work stations. The most common room layout was a peripheral laboratory (27 out of a total 43 settings) which featured computers located along the peripheral walls of a classroom with working students facing away from the centre of the room. Next in frequency was the linear layout (9 settings) which had students seated in rows with students facing the front of the room.

Table 8.1

Summary of ergonomic data from 43 classroom evaluations using the CCEI  
(Workspace Environment, Computer Environment, Visual Environment, Spatial  
Environment, Estimate of Air Quality, Number of Workstations and Room Layout)

School ID	Room ID	Workspace	Computer	Visual	Spatial	Air Quality	No. Stations	Layout
1	8	1	4	2	3	3	21	Peripheral
1	30	3	5	3	5	3	24	Peripheral
1	31	2	5	3	5	3	32	Peripheral
2	3.03	1	3.5	3	4	3	24	Peripheral
2	3.04	0	3	2	3	2	32	Peripheral
3	D1	0	5	1	3	3	18	Peripheral
3	Library Lab	1	5	1	5	3	18	Cluster
4	D2	1	5	5	4	3	24	Linear
4	D3	1	5	5	4	3	24	Linear
5	LRC	3	4	4	5	5	24	Cluster
5	Sc.2.11	2	5	4	5	3	25	Peripheral
6	C. Lab	1	5	4	3	4	22	Peripheral
6	US 10	2	5	4	5	3	22	Peripheral
7	B1.15	2	4	3	4	3	14	Peripheral
7	F 37	2	5	3	5	3	16	Peripheral
8	Lab 03	1	4.5	2	5	3	20	Peripheral
9	C. Lab	1	5	1	4	3	21	Peripheral
10	G16	1	5	2	5	3	21	Peripheral
10	G17	2	5	2	5	3	20	Peripheral
11	Old Lab	0	2	2	3	2	36	Peripheral
11	New Lab	1	5	2	3	2	18	Peripheral
12	T8	3	5	5	3	5	28	Linear
12	G8	3	5	4	3	3	27	Linear
12	M7	2.33	4.33	4	5	3	15	Cluster
13	C1	2	5	4	2	3	24	Cluster
13	C2	3	5	2	5	3	24	Peripheral
14	IT IM	2	4	2	5	2	11	Peripheral
15	F35	2	5	4	5	5	29	Peripheral
16	Bus. 3	1	5	3	5	2	16	Cluster
16	Bus. 2	1	5	2	3	2	26	Linear
16	Bus. 1	2	5	2	3	2	26	Linear
17	Lab 02	2	5	4	5	3	18	Peripheral
17	Lab 03	2	5	4	5	3	17	Cluster
18	IT 5	2	4	3	3	3	15	Peripheral
19	G33	1	5	3	4	4	21	Peripheral
20	G32	1	5	4	4	5	21	Peripheral
20	Lab 21	0	5	3	3	3	23	Linear
21	Lab 22	1	5	3	3	3	21	Linear
21	Lab 117	3	4.7	2	5	5	30	Peripheral
21	Lab 124	2.6	4.6	3	5	4	27	Linear
22	Library Lab	1	4.5	3	4	5	10	Cluster
23	Lab	1	5	3	5	2	15	Peripheral
24	Lab 111	3	5	4	5	4	24	Peripheral
Mean		1.6	4.7	3.0	4.1	3.2	22	-

Each variable provided a composite score for a set of five environmental conditions which were scored one point for each condition that was true for that setting. The maximum score on each variable was 5.

After first considering the ergonomic data from the assessed classrooms, further statistics were computed in order to describe potential relationships among the physical



environmental variables noted on the CCEI. A correlation matrix for the five variables from the CCEI is provided as Table 8.2.

Table 8.2

Correlations among physical or ergonomic factors as measured by the CCEI

Physical Factor (CCEI)	Workspace Environment	Computer Environment	Visual Environment	Spatial Environment	Overall Air Quality
Workspace environment	-				
Computer environment	0.48**	-			
Visual environment	0.35**	0.31**	-		
Spatial environment	0.41**	0.40**	0.11	-	
Overall air quality	0.45**	0.40**	0.50**	0.17	-

$p < .01$ ,  $N = 43$

The correlations presented in Table 8.2 indicate that, although the different physical factors measured discrete aspects of the physical environment in the studied computerised classrooms, there were a number of statistically significant correlations among the different measures. To a limited extent, classrooms which scored highly on one variable also tended to score highly on others. Conversely, classrooms which scored lower on an ergonomic measure also tended to score lower on other physical measures. This chapter now continues with a comparison of mean scores on the CCEI from the two jurisdictions in this study, namely, Perth in Western Australia and the South coast region of British Columbia, Canada. However, due to the differences in sample sizes, care must be taken in interpreting the results of these comparisons.

## 8.2 Cross-national Comparisons of Physical Factors

Because 5 of 43 computerised classroom settings evaluated in this study were in Canadian schools, there were two sub-samples which could be compared for differences. Descriptive statistics were calculated for each of the five factors rated by the CCEI and for an additional measure recorded on the form, Number of Workstations. Further, t-tests were calculated to compare the mean scores between the Canadian and Australian settings. These statistics are presented as Table 8.3.

Table 8.3

Descriptive statistics and comparison of means for physical factors (CCEI) and number of workstations between Australian and Canadian samples

Factor	Mean			Standard Deviation	
	Australia	Canada	Difference	Australia	Canada
Workspace Environment	1.50	2.00	0.50	0.89	1.15
Computer Environment	4.60	4.80	0.20	0.87	0.23
Visual Environment	3.20	3.20	0.00	1.20	0.84
Spatial Environment	4.00	4.80	0.80*	0.88	0.45
Overall Air Quality	3.20	4.00	0.80	0.87	1.22
Number of Workstations	23.3	20.6	-2.70	5.65	6.32

\* $p < 0.05$ , N (Australia) = 38 N (Canada) = 5

Interpretation of the data presented in Table 8.3 show that, on average, the Canadian locations fared slightly better on all scores of the CCEI and had a fewer number of computer workstations. However, due to large differences in sample size, care should be taken in drawing conclusions from these results. In particular, the statistical tests performed lack power and therefore, there is a need to examine the size of the

differences that are not statistically significant. For two measures an identical difference in mean scores yielded differences that were significant for one and not the other. On the measure, Spatial Environment, the Canadian locations scored higher than the Australian locations. On another measure, Overall Air Quality, Canadian schools scored higher than Australian schools but this difference was not statistically significant. The next section in this chapter will give further consideration to the measure Number of Workstations and demonstrate important associations with learning environments.

### 8.3 Associations between Number of Work Stations and Other Factors

After considering the overall suitability of the computerised settings in question, an effort was made to explore associations between the number of computers in each setting and other (physical or psychosocial) data. Statistical techniques similar to those described in Chapter 7 were used. Simple correlations and multiple linear regression statistics were computed (using SPSS Version 6.1) as measures of association between the set of five physical variables obtained from the CCEI (Workspace Environment, Computer Environment, Visual Environment, Spatial Environment and Overall Air Quality) and the measure Number of Workstations as recorded on the CCEI. These statistics are presented as Table 8.4. Further, similar analyses were carried out for the set of five psychosocial variables scales derived from the WIHIC questionnaire for this same measure -- Number of Workstations (from the CCEI). These statistics are presented as Table 8.5.

Table 8.4

Associations between physical variables (from CCEI) and number of workstations in terms of simple correlations ( $r$ ) and standardised regression coefficients ( $\beta$ )

Physical factor	$r$	$\beta$
Workspace environment	-0.26*	-0.02
Computer environment	-0.60**	-0.65**
Visual Environment	-0.02	0.12
Spatial Environment	-0.36**	-0.13
Overall Air Quality	-0.05	0.19
Multiple correlation (R)		0.66**

N= 43 locations, \* $p < .05$ , \*\* $p < .01$

The statistics in Table 8.4 show three statistically significant (negative) correlations between the number of computers and the variables of Workspace Environment, Computer Environment and Spatial Environment. Further, interpretation of the multiple regressions demonstrates a fairly strong (negative) independent association between increasing numbers of computers workstations and the Computer Environment (suitability of computing equipment) in each location. As the number of workstations increases, the overall suitability of this equipment decreases. No further significant associations between physical environmental factors and number of computer workstations were noted.

Table 8.5

Associations between five psychosocial scales (WIHIC) and number of workstations in terms of simple correlations ( $r$ ) and standardised regression coefficients ( $\beta$ )

WIHIC Scale	$r$	$\beta$
Autonomy / Independence	-0.27*	-0.21
Cooperation	0.01	0.16
Involvement	-0.15	-0.38**
Social Cohesion	0.09	0.15
Task Orientation	0.03	0.22
Multiple correlation (R)		0.40*

N= 81 classes

\* $p < .05$ , \*\* $p < .01$

Interpretation of the data presented in Table 8.5 indicates that the psychosocial scale *Involvement* had a statistically significant independent (negative) association with increasing numbers of computer workstations in a setting also there was a statistically significant (though weaker) negative association evident in the simple correlation between the scale *Autonomy/Independence* and Number of Workstations. That is, increasing the number of workstations seems to have a negative effect in terms of decreasing student *Autonomy / Independence* and *Involvement*. While other analyses were performed, no positive associations were demonstrated between increasing numbers of computers and the psychosocial factors described by the WIHIC scales.

Therefore there was no evidence suggesting that increasing the number of computers in a classroom would impact the psychosocial learning environment in a positive way.

Further, an effort was also made to explore associations of the physical environmental variables with the other data collected in the questionnaire portion of the study. The following two sections consider further associations between the Psychosocial environment and Satisfaction scales with other aspects of the physical (ergonomic) environment assessed using the CCEI. To do this, the class mean data for the five psychosocial scales and Satisfaction were linked by using the cover sheets completed by teachers indicating the location where each class completed the questionnaires. The relevant physical data were then added to the questionnaire data for the statistical analyses which followed.

#### **8.4 Associations between Ergonomic Variables and Satisfaction**

Because an important area for this study was exploring the role of both physical and psychosocial factors in influencing students' satisfaction with learning (see research questions in Section 1.4), associations between the five physical environmental variables with student satisfaction were first considered. Simple correlations and linear regression statistics were calculated (using SPSS Version 6.1), with Satisfaction as the dependent variable and with each of the physical factors identified as independent variables. These data are presented as Table 8.6. The results of this analysis at the class level failed to indicate any statistically significant associations between Satisfaction and the physical variables of Workspace Environment, Computer Environment, Visual Environment, Spatial Environment and Overall Air Quality, as measured by the CCEI. It also revealed a relatively weak multiple correlation ( $R=0.16$ ) in the relationship between the set of physical environmental variables and student satisfaction.

Table 8.6

Associations between physical variables (from CCEI) and satisfaction (TOSRA) in terms of simple correlations ( $r$ ) and standardised regression coefficients ( $\beta$ )

Physical factor	$r$	$\beta$
Workspace environment	.11	.12
Computer environment	.08	.06
Visual Environment	.10	.06
Spatial Environment	-.04	-.12
Overall Air Quality	.06	-.02
Multiple correlation ( $R$ )		.16

N= 81 locations

While no statistically significant associations emerged from this analysis of student satisfaction and physical (or ergonomic) factors, it is important to note that such associations were apparent between student satisfaction and psychosocial factors measured by the WIHIC (see Section 7.5). To explore other possible relationships, the study next searched for links between the physical and psychosocial environmental variables.

### 8.5 Associations between Physical and Psychosocial Factors

To establish possible associations between physical and psychosocial environmental variables, further simple correlations and linear regression statistics were computed to describe associations with each psychosocial scale (e.g. Student Cohesion or Involvement) from the WIHIC instrument. Each of these were individually identified as the dependent variable and its relationship was estimated with the set of five physical variables obtained from the CCEI (Workspace Environment, Computer Environment, Visual Environment, Spatial Environment and Overall Air Quality). These physical factors were identified as the independent variables for these comparisons. In total, this technique resulted in five sets of correlation and regression statistics calculated (one for each scale). These results are presented as Table 8.7.

Table 8.7

Associations between physical variables and psychosocial variables in terms of simple correlations ( $r$ ) and standardised regression coefficients ( $\beta$ )

Physical variables	Student Cohesion		Autonomy Independence		Involvement		Task Orientation		Cooperation	
	$r$	$\beta$	$r$	$\beta$	$r$	$\beta$	$r$	$\beta$	$r$	$\beta$
Workspace Environment	0.08	0.26	0.28*	0.30*	0.17	0.15	0.22	0.28*	0.38**	0.43**
Visual Environment	0.27*	0.31*	0.12	0.36**	0.22	0.24	0.31**	0.38**	0.05	-0.10
Spatial Environment	0.03	-0.03	0.04	0.13	0.04	-0.03	0.07	0.05	0.17	0.06
Computer Environment	0.00	-0.14	0.18	0.10	0.09	0.01	-0.08	-0.29*	0.06	-0.18
Overall Air Quality	0.03	-0.19	0.22	0.25	0.05	-0.13	0.04	-0.05	0.18	0.06
Multiple correlation (R)		0.37		0.44*		0.27		0.45**		0.42*

N=81 classes

\*\*p < .01 \*p < .05

Results of the regression analysis between the physical factors on the CCEI and the psychosocial variable revealed that, overall, relatively strong and statistically significant multiple correlations exist between the set of physical variables and the psychosocial scales of Autonomy/Independence (.44), Task Orientation (.45) and Cooperation (.42). These associations were much stronger than those between student satisfaction with the physical variables. Also, while simple correlations and standardised regression coefficients at the class level revealed no statistically significant associations for the Involvement scale, a number of other important and unexpected associations between the physical (ergonomic) factors and psychosocial factors were found. In the first instance, a number of statistically significant independent associations between Workspace Environment and student Autonomy, Task Orientation and Cooperation were noted. Further, statistically significant independent associations between the Visual Environment and student Autonomy, Student Cohesion and Task Orientation were also noted, and an additional negative association between Computer Environment

and the scale Task Orientation was evident. These data suggest that the physical attributes of a learning space indeed can influence the psychosocial environment operating within it.

### 8.6 Associations of Psychosocial and Physical Factors with Satisfaction

The statistical relationships so far described indicate that the original model which hypothesised that physical and psychosocial environmental factors could jointly influence students' satisfaction with learning may be flawed. A commonality analysis of the relationships between the set of five physical and five psychosocial variables and student satisfaction is summarised as Table 8.8.

Table 8.8

Commonality analysis of the  $R^2$  statistic showing unique contributions to variance in satisfaction scores for psychosocial factors (WIHIC) and physical factors (CCEI)

Variance component	$R^2$
Psychosocial factors	0.40
Physical factors	0.06
Common variance	-0.03
Total variance	0.43

N=81 classes  
 \*\* $p < .01$  \* $p < .05$

Interpretation of the results confirm many of the findings outlined elsewhere in this chapter by describing associations between the physical and psychosocial environments and student satisfaction. Table 8.8 shows that the psychosocial factors contribute uniquely to forty percent of the variance in satisfaction, whereas physical factors uniquely account for only six percent of the variance. Nevertheless, although the direct association between the physical environment and students' satisfaction is weak, a number of statistically significant associations between the physical and psychosocial environments was noted in the previous section. This suggests that the physical environment could influence student satisfaction indirectly through its influence on the



psychosocial environment. This idea is explored further in the final chapter of this thesis (Section 9.4). The following section summarises the various data presented in this chapter.

## **8.7 Summary of Results**

The completion of ergonomic evaluations using the Computerised Classroom Ergonomic Inventory (CCEI) provided much descriptive information about computerised settings in schools. Overall, schools tended to be rated highly on the quality of the computer equipment selected and for the quality of the spatial environment. However, ratings of Workspace environment in these settings were rated as fairly low. Further, correlational data showed that, while the factors measured in the ergonomic inventories were conceptually distinct, they were empirically related in that locations scoring higher on a given scale also scored highly on other scales.

Cross-national comparisons between mean scores on the physical factors evaluated by the inventory also revealed that the Canadian locations scored higher on the Spatial Environment, with all other measures (including Number of Workstations) showing no statistically significant differences. Further, associations of the physical variables with the number of computers were also interesting. A statistically significant negative association was noted between the number of computers in a setting and the measure Computer Environment (the quality of equipment). A further negative association was noted between the number of computers and the psychosocial scale, Involvement. This last relationship may indicate that increasing the number of computers in a classroom may be associated with students being less involved in the lessons.

Finally, while there were weak associations between Satisfaction and the physical variables considered in this study, strong associations between physical factors and the psychosocial learning environment scales were noted. These include associations between: Autonomy / Independence with the variables Workspace Environment and Visual Environment; Cooperation with Workplace Environment; Student Cohesion with

Visual Environment; Task Orientation with Workspace Environment and Visual Environment; and, Computer Environment. (negatively) with Task Orientation.

In summary, analysis of the quantitative physical data obtained with the ergonomic inventories of classrooms revealed some interesting relationships -- especially after they were linked to other data (such as psychosocial factors). These results indicate that there are tentative and emerging links between the physical and psychosocial learning environments associated with the use of new information technologies. While the hypothesis that these physical and psychosocial factors jointly influence students' satisfaction was not supported, physical factors were shown to be important in influencing the psychosocial learning environment (and so may affect student satisfaction in an indirect way). This final chapter of this thesis summarises and discusses the results presented in these last three chapters.

## Chapter 9

### Discussion and Conclusions

This thesis has presented a unique theoretical framework in a study of a new learning environment -- the networked, computerised classroom. Holistically, the study has interpreted information from three realms of influence relating to Gardiner's (1989) model of conceptual change in technological environments (namely, the technosphere, the sociosphere and the ecosphere). This model was presented originally in Chapter 1 (Section 1.4) and was embodied in this study by considering jointly the educational context of technology use in schools, relevant ergonomic information about the implementation of computer technology, and the psychosocial learning environment of these new educational 'habitats' for students. All of these factors were considered in relationship to how they influenced a key outcome variable -- students' satisfaction with learning in these environments.

This study combined qualitative and quantitative methods in its case studies, and also, combined ergonomic and educational strategies in its description of physical and psychosocial learning environments. Finally, the study had a cross-national component in that it considered these computerised, internet classrooms in two different countries, Australia and Canada. This chapter summarises and discusses the results from all of these approaches (Sections 9.1- 9.3), proposes a model of educational productivity (Section 9.4), and ends by considering the limitations of the study, areas for further research and conclusions (Sections 9.5 through 9.7). To begin this discussion, the case studies results are reviewed in the next section.

## **9.1 Discussion of Case Study Results**

The case study data presented and synthesised in Chapter 6 described a great deal about the educational context of this holistic study of internet classrooms. First, it described a range of ways in which these settings were being used by teachers across a range of subject disciplines. Second, it highlighted variations and potential deficiencies found in these environments (in both the physical and psychosocial sense). Third, the inclusion of qualitative data from this portion of the study complemented the largely quantitative description of the psychosocial and physical learning environments of computerised classrooms presented in Chapters 7 and 8. A synthesis and discussion of the findings from the eight locations involved in the case study portion of this study occurs in the following sections.

### **9.1.1 Review of Case Study Findings**

The case studies of computerised learning environments yielded descriptive information about the educational context of these settings. Interviews with teachers and students indicated that the internet medium is being used largely to assist with projects, research and individualised (thematic) assignments. Also, students and teachers largely felt positively about their learning environments, but expressed a number of concerns about physical factors such as room layout, workstation height and the temperature and air quality in these settings. Overall, teachers indicated a preference for 'peripheral' laboratory arrangements (i.e. arrangements where computers were placed along the periphery of a room) as they believe that they encourage further student interaction.

Further, task analysis during observations in the computerised settings revealed that students were involved mainly with task-oriented behaviours such as browsing for information and entering data on computers, rather than teacher-centred activities such as listening to lectures. This point was further reflected in the observed tasks of teachers who focused mainly on facilitative tasks such as interacting one-on-one with students and moving around the room to help with individual student problems. A qualitative

comparison of the Canadian and Australian settings also revealed that the Canadian settings exhibited slightly more interaction for students than the Australian settings.

Finally, the environmental monitoring of computerised classrooms revealed a number of potential problems including inadequate lighting levels, fluctuations in temperature and humidity and, finally, problematic levels of carbon dioxide in the observed settings. These findings suggest a number of areas which are in need of serious attention in many computerised learning environments.

### **9.1.2 *Spatial Arrangements***

The common link that teachers drew between the physical environment of a classroom setting (in particular its layout) and the teaching and learning environment within it suggests that the way a room in which is arranged or 'laid out' is an important (and often overlooked) consideration. Many case studies were characterised by room layouts which were conducive to, or conversely restrictive of, the activities performed in those settings. Teachers and students (in both countries) consistently preferred 'peripheral' layouts and expressed the need for adequate workspaces and for freedom for individuals to move around a room.

### **9.1.3 *Teaching and Learning***

Task analyses conducted in the case study locations revealed a pattern of tasks and behaviours which should be familiar to teachers working in computerised settings. Students were largely involved in individual or small-group project work with their teachers constantly moving about the room and interacting with the students. Such patterns of behaviour indicate a largely student-centred approach to teaching and learning with an emphasis on process and problem solving. In such settings, teachers more closely resemble 'project facilitators' rather than their traditional role as 'providers of information'. This has implications for the types of methodologies employed by teachers.

#### **9.1.4 Differences Between Countries**

Importantly, a number of differences were noted among the case study data collected in the Australian and Canadian settings. In this approach, four classrooms from Canada and four classes from Australia were compared across a number of different dimensions including task analyses, environmental monitoring of temperature and humidity, and lighting levels. However, the noted differences are most easily explained by reference to differences in the physical and or climatic settings of these classrooms rather than to national, cultural or curricular differences.

In accounting for the difference presented in the task analyses of student behaviours (Section 6.3.2), variation is probably accounted for by the differing physical layouts, rather than by differences in teaching or other (e.g. curricular) constraints. Whereas it was previously noted that the Canadian locations consisted of a greater number of 'peripheral' layouts, this factor may account for the slight greater degree of student interaction noted for the Canadian sample.

Further, the reported extremes of temperature and humidity and variations in lighting level in case study schools (Section 6.3.2) can also be accounted for in reference to the common architectural and design practices found in each jurisdiction (which no doubt have been influenced by the climate in each location).

In Western Australia (a warm climate), most schools are built with classrooms opening to the outside environment. Buildings are constructed of brick to minimise the heat in summers and, typically, central heating is not provided. These factors contributed to the low temperatures and high humidities recorded in the Australian locations during the autumn season. As the classrooms are connected to the outside, this may also account for the better lighting observed as they would have a greater amount of natural light.

In British Columbia (a cooler climate), most schools are airtight and built of timber frames. Classrooms typically open into enclosed corridors with little direct access to the

outside environment to minimise the heating costs for these larger, centrally-heated buildings. These factors contributed to the warmer (and drier) classroom climates experienced in the Canadian locations. Again, as there is less opportunity in these classrooms to let in ambient light, this may account for their lower levels of lighting.

#### **9.1.5 *Environmental Problems***

Finally, it is most important to restate that a number of important physical environmental measures taken during the case studies revealed potential deficiencies in the working environment of students and teachers (and were common in both countries). These included problems with lighting and workspace requirements in addition to concerns about air quality (carbon dioxide levels) of a classroom setting. *These deficiencies are most likely due to the limited consideration on the part of schools to the physical classroom environment when implementing computer technology (i.e. many classrooms were originally designed for another purpose prior to the advent of information technologies).* Such concerns related to working environments are often overruled by decisions regarding the type or quantity of equipment purchased for schools, its cost-effective set-up, and ongoing security concerns. Failure to attend to physical environmental factors when implementing IT in schools may ultimately negate the potentially positive aspects of its use.

#### **9.1.6 *Combining Qualitative and Quantitative Data***

While the case study data provided important, detailed information about the psychosocial and physical environments in the case study locations, they were also linked to the broader range of class groupings and physical settings studied in the larger sample. While the case study data can be considered typical of this wider sample, apparent associations between physical and psychosocial factors in the qualitative case study data confirmed findings in the other more quantitative consideration of physical and psychosocial factors. Next, the findings regarding the psychosocial environment in the larger sample of 81 classes (1,404 students) and its influence on student satisfaction

in computerised classrooms are discussed. These data were obtained through the administration of the questionnaire.

## **9.2 Discussion of Questionnaire Results**

The findings from the questionnaire portion of this study (presented in Chapter 7) *gave further quantitative data to complement the findings of the detailed case studies.* Further, they provided an opportunity to verify statistically some of the links between physical and psychosocial factors noted qualitatively in the studied classrooms. Finally, they demonstrated that the psychosocial environment had a strong influence on students' satisfaction with learning in these settings.

### **9.2.1 Review of Questionnaire Results**

Overall, the administration of the questionnaire to 1,404 high school students yielded *good reliability and validity data for each of the five learning environment scales of Student Cohesion, Involvement, Autonomy / Independence, Task Orientation and Cooperation, and the attitudinal scale of Satisfaction was also confirmed to have sound internal consistency reliability.*

Students' perception of the psychosocial learning environment attributes and *satisfaction were generally positive with the exception of the scale Autonomy / Independence which yielded low scores.* Similar perceptions of the learning environment were also held by the teachers in these settings, but teachers also ranked *Autonomy / Independence in these classrooms as being low.* In general, teachers perceived the learning environment and student satisfaction in these settings higher than did their students.

Comparisons of mean scale scores for the WIHIC and TOSRA scales were also made between the Australian and Canadian samples. However, scores for most aspects of the psychosocial environment were comparable with the exception of *Involvement, which had higher scores in the Australian sample.* In addition, the outcome measure of



Satisfaction also showed a statistically significant difference in mean scores between countries, with the Australian sample again scoring higher than the Canadian sample.

Most important in the questionnaire findings were the strong independent associations between Satisfaction scores and the psychosocial factors of Autonomy / Independence and Task Orientation (at the class level). These associations indicated a positive relationship between the degree of autonomy allowed in a class, and students' overall satisfaction with their learning in that environment. Further, the degree of task orientation perceived by a class could potentially influence satisfaction by a larger amount. A discussion of these questionnaire findings follows.

### ***9.2.2 Psychosocial Learning Environments***

Overall, the study indicates that students and teachers both viewed their learning environments positively and that these environments were characterised by relatively high levels of student cohesion, involvement, task orientation, cooperation and satisfaction. Students and teachers also rated the amount of autonomy and independence in these settings as low. This may be in part due to any number of constraining factors, including noted physical (ergonomic) factors, curriculum constraints, or perhaps the inexperience of teachers in this relatively new teaching context.

### ***9.2.3 Associations Between Psychosocial Factors and Satisfaction***

As has been previously noted, students' satisfaction with learning in computerised settings was rated as high by both teachers and students. However, this study also indicates that students' satisfaction may be further influenced in a positive way by a variety of psychosocial factors. In the first instance, strong associations are indicated between the factor of Autonomy / Independence and student Satisfaction. As Autonomy / Independence was rated as less than optimal in these settings, this association becomes an important one. Further, a stronger association was noted between Task Orientation and Satisfaction. Together, these factors may influence students' satisfaction (and hence productivity) with learning.

#### **9.2.4 *Associations Between Physical and Psychosocial Factors***

While the questionnaire data revealed a great deal about student and teacher perceptions of their computerised learning environments, this information was also linked with other important ergonomic evaluations of the physical learning spaces where these teachers and students worked. This linking of ergonomic information about the physical setting with the questionnaire data about the psychosocial environment revealed a number of interesting associations which suggest that the physical attributes of a learning space may influence the psychosocial environment within it and, further, may indirectly influence students' satisfaction with learning (perhaps through the psychosocial environment). These ideas are discussed in the following sections.

### **9.3 Discussion of Physical Factors**

The ergonomic evaluation of computerised classrooms presented in Chapter 8 complemented the information presented by the case study and questionnaire data. These evaluations completed the holistic view of classroom environments attempted by this study. A review and discussion of the ergonomic findings are presented here.

#### **9.3.1 *Review of Physical (Ergonomic) Results***

The completion of ergonomic evaluations using the Computerised Classroom Ergonomic Inventory (CCEI) revealed much information about computerised settings in schools. Overall, they tended to be rated highly on the quality of the computer equipment selected and for the quality of the spatial environment. However, ratings of Workspace Environment in these settings were fairly low. Further, correlational data showed that, while the factors measured in the ergonomic inventories were conceptually distinct, those environments rated highly for one physical variable also tended to be rated highly for other ergonomic variables.

Cross-national comparisons between mean scores on the physical factors also revealed that the Canadian locations scored higher on the measure *Spatial Environment*,

with all other measures (including Number of Workstations) showing no statistically significant between-country differences. Further, associations between physical factors and Number of Computers were also interesting. A statistically significant and negative association was noted between the number of computers in a setting and the measure Computer Environment (the quality of equipment). A further negative association was noted between Number of Computers and the psychosocial scale, Involvement. This suggests that increasing the number of computers in a classroom may lead to the use of less suitable equipment and, further, that this could also lead to a lower level of involvement on the part of students.

Finally, while there were only weak associations between Satisfaction and the physical variables considered in this study, many interesting associations between physical factors and the psychosocial learning environment scales were noted. These included associations between: Autonomy / Independence with the variables Workspace Environment and Visual Environment; Cooperation with Workplace Environment; Social Cohesion with Visual Environment; and Task Orientation with Workspace Environment and Visual Environment.

In summary, analysis of the quantitative physical data obtained with the ergonomic inventories of classrooms revealed some interesting relationships -- especially after they were linked to other data (such as the noted psychosocial factors). The results indicated that there are tentative and emerging links between the physical and psychosocial learning environments associated with the use of new information technologies and that, in particular, psychosocial factors may influence students' satisfaction with learning in these settings. As many associations between the physical and psychosocial environments have been noted, many ergonomic deficiencies may need more careful consideration by educators if the potential of information technology in improving classroom learning environments is to be realised.

### **9.3.2 *Workspace Environments***

As noted, the completion of the ergonomic evaluations using the Computerised Classroom Ergonomic Inventory (CCEI) revealed much descriptive information about computerised settings in schools. Overall, they tended to rate high on the quality of the computer equipment selected and for the quality of the spatial environment. However, the Workspace Environment in these settings was rated as fairly low. This would seem to indicate that this feature of computerised classrooms is in need of further attention -- particularly as it was associated with many aspects of the psychosocial learning environment. Student workspaces should be designed so that students may adequately adjust them to suit their individual needs as well as to provide adequate workspace for students to work productively in groups or individually on their assignments.

### **9.3.3 *Number of Workstations***

As many educational organisations have pushed towards the goal of 'a computer for every student', associations of physical and psychosocial factors with the number of computers in a classroom were also interesting. A statistically significant and negative association was noted between the number of computers in a setting and the measure Computer Environment (the quality of equipment). This association probably reveals a common sense economic relationship in the purchase of computer equipment. For example, if a school with a fixed amount of funding for computers buys more equipment, then the quality of that equipment would be lower.

Also, a further negative association was noted between the number of computers and the psychosocial scale, Involvement. It seems to suggest that increasing the number of computers in a setting (beyond some optimal number) is probably counter-productive. This idea gains greater importance when it is considered that, in this study, no positive associations among the number of computers in a setting and measures of the psychosocial learning environment were noted quantitatively or qualitatively. This brings into question the common practice of purchasing large numbers of computers

with little concern for the physical environment in which these computers are to be used.

#### **9.3.4 *Links Between Physical and Psychosocial Factors***

Finally, because of the many interesting and positive associations noted between physical and psychosocial learning environments, more consideration needs to be given to these important physical considerations as 'educational' improvements rather than as simply health or safety issues. Associations such as those between the psychosocial factor *Autonomy / Independence* and the ergonomic consideration of *Workspace or Visual Environment* indicate that there are tentative and emerging links between the physical and psychosocial learning environments which may allow educators to further enhance the productivity of their students. The significance of this line of thinking is considered and a tentative model is outlined in the next section.

### **9.4 *Significance of the Study***

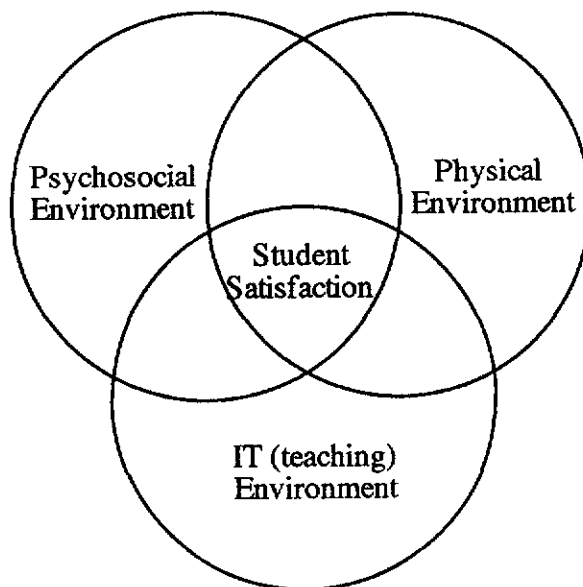
This study is important because it jointly considered the physical and psychosocial learning environments in a single study while combining qualitative and quantitative methods. The research is distinctive because of its holistic and ecological approach to the study of an important new learning environment: the technological classroom. By including questionnaire data with case studies and laboratory evaluations, its approach mirrors ergonomic methods which have proven effective in a wide variety of research in other settings, including technological settings within business and industry. Finally, this study has identified some important physical and psychosocial factors for inclusion in a new and developing model of educational productivity.

#### **9.4.1 *Review of the Conceptual Model***

In the first chapter of this thesis, a conceptual model for this study was presented which hypothesised that students' satisfaction (and hence productivity) with learning

might be jointly influenced by the use of IT and by a combination of physical and psychosocial environmental variables. This model is presented here as Figure 9.1.

Figure 9.1: Initial conceptual model for the study



*Adapted from Gardiner (1989, p. 28)*

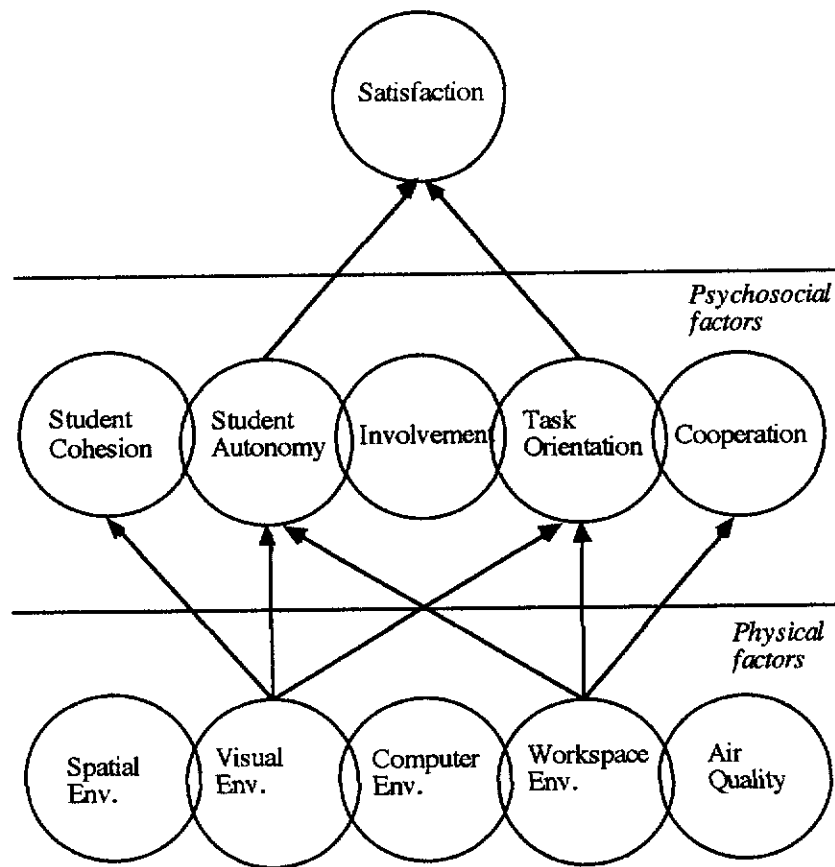
While the IT classroom environments in this study were characterised by high levels of student satisfaction, aspects of this initial model appeared flawed in that stronger associations were demonstrated between student satisfaction and the psychosocial measures than were evident between student satisfaction and the physical (ergonomic) measures in this study. Nevertheless, many strong associations were demonstrated between aspects of the physical and psychosocial environments in these classrooms. These findings were used to inform the development of the new model proposed in the following section.

#### **9.4.2 *An Emerging Productivity Model***

The variety of data involved in the various parts of this research (including the case study, questionnaire and ergonomic data) have contributed to an emerging productivity model presented here as Figure 9.1. This model outlines the noted associations between psychosocial factors in computerised settings and students' satisfaction in these settings. Further, it also proposes that physical factors in classroom environments may also contribute to satisfaction (through the noted psychosocial associations) by subtly influencing these important aspects of the learning environment. Finally, the manipulation of physical factors (such as lighting and workspace) should also be considered as a positive and practical method of influencing the overall learning environment of a class and for increasing the general educational productivity of a classroom setting.

Figure 9.2 presents a summary of all the statistically significant independent associations determined through the regression analyses performed as part of the study (marked with arrows). It differs from the original model by illustrating how student satisfaction was shown to be associated with individual psychosocial factors in this study. Further, it shows how individual physical factors in this study may indirectly influence student satisfaction through associations with these psychosocial environmental variables. As a tentative model, this schema attempts to describe relationships which emerged from quantitative and qualitative methodologies used throughout this study to describe how the variety of variables may work to influence student satisfaction in these technological environments. Further research is needed to confirm or adjust this model appropriately.

Figure 9.2: Schematic representation of a model for educational productivity



### 9.5 Limitations to the Study

While this study has taken a detailed, holistic and cross-national approach to the study of classrooms associated with the use of new information technologies, a number of important limitations to the study must be stated. First, this study involved only students in years 10, 11 and 12 as its study group. Because the instruments designed and the methodologies employed during this study reflect this fact (i.e. reading level for the WIHIC and TOSRA questionnaires and anthropometry guidelines for the ergonomic measures for the CCEI), the relationships described by this study may not apply to other groupings. Second, whereas the research attempted to study a wide range of settings in considering the implementation of IT, there no doubt exists other types of



implementations that were not considered in this study, Therefore, the data in this study should not be considered as 'complete' or exhaustive. Finally, care should be taken in interpreting the cross-national comparisons made in this study as there were large differences in sample sizes and differences can be attributed to variations in any number of extraneous factors.

## **9.6 Recommendations for Future Research**

Despite the limitations noted above, this study has broken new ground in describing a new learning environment in schools -- the technological classroom. It has used a combination of quantitative and qualitative measures while adopting methodologies from science (ergonomics), sociology and education to accomplish this. Finally, it has compared and contrasted the educational implementation of IT in two different countries, Canada and Australia. This study recommends that further work be done in two distinct areas: the first relates to the unique combination of methodologies employed by this study; the second relates to the computerised learning environments which were investigated. These ideas are considered in the following sections.

### **9.6.1 *Further research involving a combination of methodologies***

The combination of research methods used in this study contributed uniquely to the description of the learning environments. While many recent studies have combined interviews and questionnaires in their design, this study is unique in including ergonomic measures in its approach (checklists/inventories and environmental monitoring). This study recommends that further research consider physical (ergonomic) factors and their potential influence on the psychosocial environment of a classroom as another method of making 'educational' improvements. These studies might take place in other technological settings such as science laboratories or learning centres. Further studies are needed to confirm that ergonomic factors can have a tangible effect on students' learning. To this end, future studies might incorporate other outcome measures, such as student achievement in the research model or, alternatively,

refine or revise the model proposed in this chapter (Section 9.4.2) using other physical / psychosocial factors.

### **9.6.2 Further research on technological classrooms**

Importantly, this research has only begun the much needed study of today's emerging internet classrooms. Whereas many millions of dollars continue to be spent on the implementation of networked computer laboratories and workstations in schools throughout the world, relatively few comprehensive studies have been undertaken which support its continued use, or can inform its implementation. Further, more studies are needed to reveal the contextual nature of technology use. These studies could involve the use of internet technologies by students in other countries (including developing ones) or in other cultural settings (such as Aboriginal communities within Australia or First Nations communities within Canada). Finally, research must be done which will inform teachers in all settings about how technology will potentially impact their jobs, so that they may begin to develop the skills and practices required of them now and in the future.

## **9.7 Conclusions**

As stated in the first chapter of this thesis, educational institutions have continued to implement a wide range of instructional technologies in the classroom over the years. With the advent of internet technologies, the pace of this technological change has become quickened and its implementation become more costly. Meanwhile, societal pressures to implement these technologies have also continued to increase. In considering the new technological classroom, this study makes a case for the closer integration of information technology, curriculum and instruction, and the design of suitable physical learning spaces. In future, all educators will need to be more involved in both the design and implementation of new technologies, the devising of new curricula and teaching methods and, finally, the physical design of schools and of classrooms themselves.

In conclusion, this study describes the learning environment in computerised classrooms as being a complex system in which many competing and interrelated physical, psychosocial and contextual factors are at work which need to be fully considered in shaping good instruction. While many aspects of the computerised and networked classrooms in this study were evaluated as being positive, many physical factors such as workspace environments, lighting levels, and air quality showed marked deficiencies, while students also perceived their degree of autonomy and independence as being less than ideal. All of this points to the fact that educational implementations of IT can and should be improved. This may involve diverting some of the resources currently allocated for equipment purchase towards other neglected areas.

Finally, if the considerable potential of the new information technologies (such as the World Wide Web and E-mail) is finally to be realised, coherent guidelines must be developed to ensure the technology's effectiveness as a learning tool. Minimally, such guidelines should include consideration of physical and psychosocial factors (with their potential ability to influence outcomes) and give concrete suggestions for the suitable installation and configuration of this equipment in classroom environments. Optimally, such guidelines would also include a detailed consideration of the professional development needs of teachers, in response to the new duties and responsibilities expected of them as they continue to shape the physical and psychosocial environments in their classrooms associated with the use of new information technologies.

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## **Appendices**



## **Appendix A**

Student/Teacher Questionnaire

*(WIHIC and TOSRA Scales)*

## What is Happening in this Class (while we are using computers)

### Directions

This questionnaire contains statements about practices which could take place in this class while it is using computers. You will be asked how often each practice takes place. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Think about how well each statement describes what this class is like for students. Then, draw a circle around:

<b>1</b>	if the practice takes place	<b>Almost Never</b>
<b>2</b>	if the practice takes place	<b>Seldom</b>
<b>3</b>	if the practice takes place	<b>Sometimes</b>
<b>4</b>	if the practice takes place	<b>Often</b>
<b>5</b>	if the practice takes place	<b>Almost Always</b>

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

### Practice Example

Suppose that you were given the statement: "Students choose their partners for group discussions." You would need to decide whether you thought that students in this class choose their partners 'Almost Never', 'Seldom', 'Sometimes', 'Often' or 'Almost Always'. For example, if you selected 'Often', you would circle the number 4 on your questionnaire.

SC		Almost Never	Seldom	Some- times	Often	Almost Always
1.	Friendships are made among students in this class.	1	2	3	4	5
2.	Students in this class know each other.	1	2	3	4	5
3.	Members of this class do favours for one another.	1	2	3	4	5
4.	Members of the class are friends.	1	2	3	4	5
5.	Students help each other with homework.	1	2	3	4	5
6.	Students help each other in this class.	1	2	3	4	5
7.	Class members work well with each other.	1	2	3	4	5
8.	Students help other class members who are having trouble with their work.	1	2	3	4	5
9.	Students in this class like each other.	1	2	3	4	5
10.	In this class, students are able to depend on each other for help.	1	2	3	4	5

IN		Almost Never	Seldom	Some- times	Often	Almost Always
11.	Students discuss ideas in class.	1	2	3	4	5
12.	Students give their opinions during class discussions.	1	2	3	4	5
13.	The teacher asks students questions.	1	2	3	4	5
14.	Students' ideas and suggestions are used during classroom discussions.	1	2	3	4	5
15.	Students ask the teacher questions.	1	2	3	4	5
16.	Students explain their ideas to one another.	1	2	3	4	5
17.	Students discuss with each other how to go about solving problems.	1	2	3	4	5
18.	When starting a new topic, students discuss what they already know about it.	1	2	3	4	5
19.	Students are asked to explain how they solve problems.	1	2	3	4	5
20.	Students discuss different answers to questions.	1	2	3	4	5

AI		Almost Never	Seldom	Some- times	Often	Almost Always
21.	Students have a say in how their class time is used.	1	2	3	4	5
22.	Students have a say in deciding what activities they do.	1	2	3	4	5
23.	Students have a say in deciding how their learning is assessed.	1	2	3	4	5
24.	Students are told how to do their work.	1	2	3	4	5
25.	The teacher decides when students are to be tested.	1	2	3	4	5
26.	The teacher decides how much movement and talk students are allowed.	1	2	3	4	5
27.	The teacher decides when the class moves on to a new topic.	1	2	3	4	5
28.	Students are given a choice of topics for assignments.	1	2	3	4	5
29.	Students are given a choice in which investigations they do.	1	2	3	4	5
30.	Students work at their own pace.	1	2	3	4	5

**Please continue on to the next page ...**

TO		Almost Never	Seldom	Some- times	Often	Almost Always
31.	Students know what has to be done in this class.	1	2	3	4	5
32.	Getting a certain amount of work done is important to this class.	1	2	3	4	5
33.	Class assignments are clear so everyone knows what to do.	1	2	3	4	5
34.	Students do as much as the class sets out to do.	1	2	3	4	5
35.	Each student knows the goals for this class.	1	2	3	4	5
36.	Students are ready to start this class on time.	1	2	3	4	5
37.	Students know what they are trying to accomplish in this class.	1	2	3	4	5
38.	Students pay attention during this class.	1	2	3	4	5
39.	Students try to understand the work in this class.	1	2	3	4	5
40.	Students know how much work they have to do.	1	2	3	4	5

CO		Almost Never	Seldom	Some- times	Often	Almost Always
41.	Students cooperate with each other when doing assignment work.	1	2	3	4	5
42.	Students share books and resources with each other when doing assignments.	1	2	3	4	5
43.	When students work in groups in this class, there is teamwork.	1	2	3	4	5
44.	Students work with each other on projects in this class.	1	2	3	4	5
45.	Students learn from each other in this class.	1	2	3	4	5
46.	Students work with each other in this class.	1	2	3	4	5
47.	Students cooperate with each other on class activities.	1	2	3	4	5
48.	Students work with each other to achieve class goals.	1	2	3	4	5
49.	Students work in groups in this class.	1	2	3	4	5
50.	During group work, students do their share of the work.	1	2	3	4	5

SA		Almost Never	Seldom	Some- times	Often	Almost Always
51.	I look forward to this class.	1	2	3	4	5
52.	The lessons in this class are fun.	1	2	3	4	5
53.	I dislike this class.	1	2	3	4	5
54.	This class bores me.	1	2	3	4	5
55.	This is one of the most interesting school subjects.	1	2	3	4	5
56.	I enjoy the lessons in this class.	1	2	3	4	5
57.	The lessons in this class are a waste of time.	1	2	3	4	5
58.	The lessons make me interested in this subject.	1	2	3	4	5

**Thank you for completing this questionnaire about your classroom.  
You may now hand in the completed form to your teacher.**

## **Appendix B**

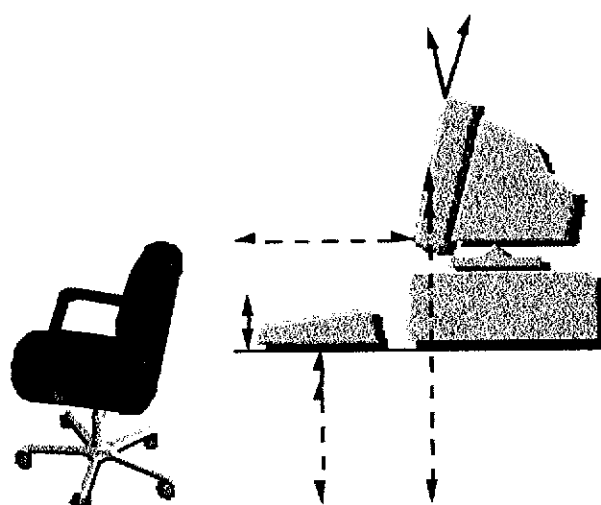

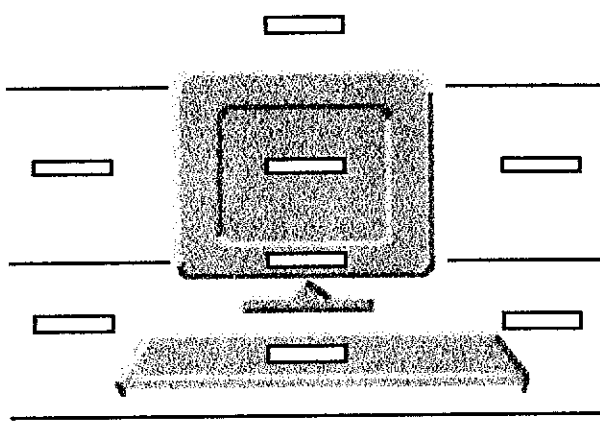

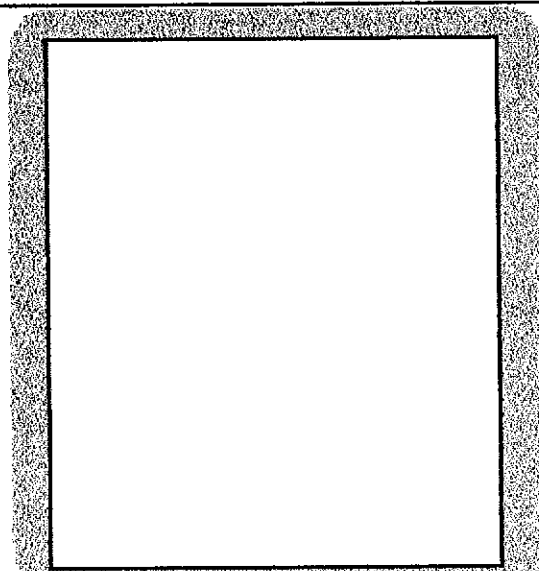
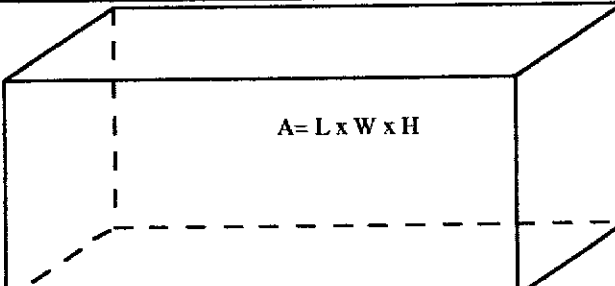
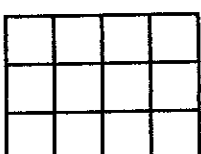
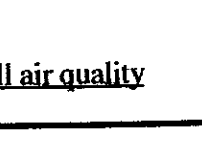

Ergonomic Worksheet and Inventory

*(CCEW and CCEI)*

# Computerised Classroom Ergonomic Worksheet

This worksheet is designed to be used in conjunction with the attached ergonomic inventory (CCEI). Actual measures for physical factors included in the inventory will be recorded on the diagrams below. For measures where marked variation exists (i.e. due to different furniture, equipment or lighting arrangements) each variation will be recorded on a separate worksheet.

Measurements recorded on the worksheets are converted to compliance scores for the items on the CCEI. The maximum score for each item in the inventory is one - indicating 100% compliance with the given standard. Where several variations (and worksheets exist) weighted averages will be calculated incorporating measurements as recorded on all the worksheets (refer to notes for CCEI).

 <p> <u>Workspace / computer environments</u></p>	 <p> <u>Visual environment</u></p>
 <p><input type="checkbox"/> <u>Spatial environment</u></p>	 <p><math>A = L \times W \times H</math></p> <p><math>Q = V \times A</math></p> <p>V (duct) = </p> <p>A (duct) = </p> <p> <u>Overall air quality</u></p>





Location:

Class size:

No. of computers:

# Computerised Classroom Ergonomic Inventory

For each statement below, the observer will tick each condition noted to be true with actual measures recorded on the attached worksheets (see reverse). Where multiple criteria exist, all must be true for the statement to be scored true. The maximum score for each domain total below is five.

	<p style="text-align: center;"><u>Workspace environment</u></p> <ul style="list-style-type: none"> <li>• Adequate workspace exists for the placement of notebooks and other resources</li> <li>• Screen depth (front of screen to table edge) located within the range of 500-750 mm</li> <li>• Chair has adjustable height and back support and is set on moveable (rolling) castors</li> <li>• Keyboard height (floor to home row) is adjustable within a min. range of 700-850 mm</li> <li>• Screen height (screen centre above floor) is adjustable within a range of 900-1150 mm</li> </ul> <p style="text-align: right;">Total score:</p>	Tick if true: (scores)
	<p style="text-align: center;"><u>Computer environment</u></p> <ul style="list-style-type: none"> <li>• Inclination of the viewing monitor is adjustable (within 88° - 105° from the horizontal)</li> <li>• Keyboard height (home row to desk level) is adjustable within a range of 100-260 mm</li> <li>• Operating system utilizes a graphical interface with icons rather than teletype inputs</li> <li>• System uses a colour display monitor with adjustable brightness and contrast controls</li> <li>• Computer software uses a reverse display (dark text on a light or neutral background)</li> </ul> <p style="text-align: right;">Total score:</p>	
	<p style="text-align: center;"><u>Visual environment</u></p> <ul style="list-style-type: none"> <li>• Glare controlled through the use of screens, indirect lighting or equipment positioning</li> <li>• Good light quality with natural or indirect lighting sources (full spectrum preferred)</li> <li>• Excessive contrast of work surfaces are controlled through the use of neutral finishes</li> <li>• Illumination levels (measured on the horizontal plane) fall in the range of 500-750 lux</li> <li>• Luminance of surrounding surfaces is maintained within 10-100% of illumination</li> </ul> <p style="text-align: right;">Total score:</p>	
<input type="checkbox"/>	<p style="text-align: center;"><u>Spatial environment</u></p> <ul style="list-style-type: none"> <li>• Adequate space exists for easy movement among workstations, resources and exits</li> <li>• The number of students in the classroom does not normally exceed thirty students</li> <li>• Resource areas are of sufficient size to display or store necessary learning materials</li> <li>• Overall finishing of room walls, flooring etc. is in light coloured or neutral tones</li> <li>• The aisle width between desks or benches falls within the desired range of 152-183 cms</li> </ul> <p style="text-align: right;">Total score:</p>	
	<p style="text-align: center;"><u>Air quality</u></p> <ul style="list-style-type: none"> <li>• The classroom is climate controlled with localized temperature and humidity controls</li> <li>• Room objects are maintained at temperatures within 2-3 degrees of air temperature.</li> <li>• Draughts at the levels of head and knees have been controlled (do not exceed 2 m/s)</li> <li>• Air volume in the room meets the min. volume standard (5 cubic metres per person)</li> <li>• Air flow rates (measured at duct) conform to a minimum of 30 cubic metres/person/hr</li> </ul> <p style="text-align: right;">Total score:</p>	

Location:

Class size:

No. of computers:

**Notes for inventory and worksheets:**

*This inventory is designed for use in conjunction with the attached ergonomic worksheet (CCEW). Depending on classroom variations, one or more worksheets may be required for observations taken in a given classroom (i.e. due to different equipment or lighting arrangements). The maximum score for each item in the completed inventory is one - denoting 100% compliance with a given standard.*

Where several worksheets have been necessary, weighted averages will be used to complete the inventory. In this calculation, the total score for an inventory item would match the percentage of the given variations that conform to that standard. For example, if a room has ten computers, three of which conform to the standard, the item score is 0.3 - indicating 30% compliance with the standard.



## **Appendix C**

### **Classroom Observation Sheet**

*(Used for Classroom Task Analysis)*

Individual	Moving about the class	Entering data into a computer	Browsing on screen	Reading printed material	Interacting with others	Lecturing / Listening	Off task behaviours
Teacher							
Student 1							
Student 2							