Science and Mathematics Education Centre

A STUDY OF THE EFFECTIVENESS OF COMPUTER LABORATORY CLASSES AS LEARNING ENVIRONMENTS

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This thesis is presented as part of the requirements for the award of the Degree of Doctor of Philosophy of Curtin University of Technology

July 1998

ABSTRACT

This study focuses on the computer laboratory class as a learning environment in university courses. It involved the development and validation of two instruments, the Computer Laboratory Environment Inventory (CLEI) and the Attitude towards Computing and Computing Courses Questionnaire (ACCC). The CLEI has five scales for measuring students' perceptions of aspects of their laboratory environment. These are Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy and Laboratory Availability. The ACCC has four scales, Anxiety, Enjoyment, Usefulness of Computers and Usefulness of the Course. The instruments were administered at three universities, one in Australia, one in England and and one in the United States. The classes surveyed included those in which the development of software was the focus of study, such as Information Systems and Computer Science, and others in which the computer was used as a tool. With the exception of Laboratory Availability, all the environment variables were found to correlate significantly with all attitudinal variables. The only environment variable with significant association with achievement was Student Cohesiveness. However, the results showed that there were significant associations between the attitudinal variables, Anxiety, Enjoyment and Usefulness of the Course and achievement. Regression analysis supported the findings that the environment variables made a significant contribution to the attitudinal variables, and these in turn made a significant contribution to achievement. Further analysis using structural equation modelling suggests that computer laboratory environment affects achievement indirectly by directly affecting students' attitudes towards computers but even more so their attitude towards the course.

The significance of this study is that it is one of the first that has investigated the effectiveness of computer laboratory classes in a university setting in which the computer is central to the discipline being studied. The results demonstrate the importance of the laboratory environment in those courses in which the computer plays a major role. The CLEI will prove useful in the design and implementation of the laboratory component of a course and in the formative evaluation of such a course.

ACKNOWLEDGMENTS

I wish to acknowledge the following people, each of who made a contribution to this study and to the completion of the thesis.

First and foremost, I would like to thank my supervisor, Darrell Fisher, for his guidance and inspiration. He is an outstanding supervisor.

I would also like to thank Barry Fraser, Director of the Science and Mathematics Education Centre for introducing me to this area of research.

My appreciation goes to the following staff in the School of Information Systems at Curtin University for allowing me to survey their classes: Gregg Boalch, Heinz Dreher, Noelene Kitis, Paul Lucas, Donald McIntyre, Alan Parkinson, Richard Potger, Alex Rusli and Charles Zhao.

My appreciation also goes to Steven Dunne of the University of Teesside and George Marcoulides of California State University at Fullerton who arranged for me to conduct surveys at their respective universities.

My thanks go to all the students who participated in this study.

Finally, I wish to thank my wife, Ammie, for believing in me and for her love, understanding and support throughout this study.

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CHAPTER 1

INTRODUCTION

The study described in this thesis concentrates on university computer laboratories and their effectiveness as learning environments. Most university computing courses within Australia have a practical focus, aimed at enabling students to solve problems which are pertinent to real-world applications. Computer laboratory classes are provided so that students have the opportunity of gaining these practical skills and they account for between one third and one half of the scheduled time in computing courses. This implies that there is a considerable investment of staff time in providing suitable learning experiences. In addition, there are the physical resources required to furnish the necessary computing facilities. Given the fact that computers are being used in an increasing number of courses, it is desirable to conduct research into the psychosocial aspects of computer laboratory environments, and the associations between students' perceptions of their environment and student outcomes.

1.1 Background to the Study

Computers have been used in higher education for over thirty years as a subject of study in their own right and as a tool in other disciplines. Initially the computer systems were batch in nature. In this kind of computing environment the input medium was either punched cards or paper tape, and students prepared their programs and applications off-line. Programs were submitted for processing and results would be returned up to 24 hours later. Computer laboratory classes in today's sense did not exist. In the 1970s, the multi-access computer was introduced into many universities, and access to it was via the dumb terminal. This resulted in a change in the approach to teaching computing. Students could gain immediate access to the system, and did not have to wait for their results, they could get them online. Since that time, computer laboratory classes have become an integral part of most computing courses in many countries. Furthermore, being able to access computer systems at any time led to the development of applications which are specific to education. These include many Computer Assisted Learning systems, systems for on-line assessment, and more recently, Internet applications for course delivery. All of these require access to computers, and this is normally provided through laboratories.

Over the same period of time, the study of learning environments has developed as a thriving field of research (Fraser & Tobin, 1998; Fraser, 1994; Fraser & Walberg, 1991). This applies particularly to the conceptualisation, assessment and investigation of participants' perceptions of aspects of classroom environments. The development of the *Learning Environment Inventory* (Anderson & Walberg, 1968) was followed by many investigations, using it and other instruments, into the qualities of the learning environment from the student's point of view. In recent times, there have been research studies into science laboratory environments (McRobbie & Fraser, 1993), inquiry-based classroom environments (Maor & Fraser, 1993), constructivist classroom environments (Taylor, Fraser, & Fisher, 1997), computer-assisted instruction classroom environments (Teh & Fraser, 1995), and distance education environments (Jegede, Fraser, & Fisher, 1998).

This study extends research in this field by modifying the *Science Laboratory Environment Inventory* for use in computer laboratory classes at the post-secondary level. The new instrument, called the *Computer Laboratory Environment Inventory*, was used to assess students' perceptions of the learning environment of their computer laboratory classes.

Previous studies have shown that student outcomes are associated with students' perceptions of the learning environment (Anderson & Walberg, 1974; Haladyna & Shaughnessy, 1982). These outcomes include both cognitive achievement and attitude. In the context of computer laboratory classes, there are a number of aspects that may be taken into account with respect to attitude. These are attitude towards computers, towards computing as a subject of study and to the course itself. Attitude towards computers applies not only to students but, with the increase in the use of computers within society as a whole, it also applies to the whole community. As with learning environments, there has been a considerable amount of research carried out into attitude towards computers since the 1960s, leading to the development of instruments with a variety of different scales designed to measure attitude. For the purpose of this study, it was decided to restrict the attitudinal student outcomes to attitude towards computers and attitude towards the usefulness of the course. An instrument called the *Attitude towards Computers and Computing Course Questionnaire* was developed. Three of its scales are based on those of the *Computer Attitude Scale* (Loyd & Loyd, 1985) and these are Anxiety, Enjoyment or Liking, and Perceived Usefulness of Computers. A fourth scale measures the perceived usefulness of the course.

It has been reported that computer attitudes, especially anxiety, is associated with achievement (Marcoulides, 1988). In reported studies, achievement has been measured in different ways, for example, by performance in assignments (Marcoulides, 1988) or by performance in practical tests (Ayersman & Reed, 1996). Different courses which involve a computer laboratory class as an integral part have different methods by which the course is assessed. It is a decision that is made by the staff member running the course. At Curtin University, where the main study was done, most computing courses involve a number of components of assessment, which may include a final examination, assignments, and laboratory exercises. Each of these may contribute to the final overall grade, although the final examination usually contributes in excess of 50%. Given the fact that all components are likely to be affected in some way by the environment, the student's final grade was included as an outcome measure.

In previous studies into learning environments, there have been a number that have investigated determinants of perceived classroom environments. Of all student variables, the one which has received most attention is gender. Differences have been reported for gender, particularly for science classrooms (Fraser, Giddings, & McRobbie, 1995) and computer classrooms (Levine & Donitsa-Schmidt, 1995). Gender and gender-related issues also figure prominently in the studies on attitudes towards computers, as does age, and prior experience (Loyd & Gressard, 1984b; Dyck & Smither, 1994). This study described in this thesis includes an investigation into a number of student variables that could be determinants of perceived environment or student outcome.

Scheduled computer laboratory classes are the norm in many countries, including Australia and the United Kingdom, but are not in the United States (Denk, Martin, & Sarangarm, 1994). It follows that those students in the United States who are currently taking courses in which they have scheduled laboratory classes are less likely to have experienced them in previous courses than their counterparts in Australia and the United Kingdom. One student variable that is dealt with in detail is country of study to see if there are differences in environment and attitude that is attributable to the student's location.

The purpose of this study was to investigate the relationships between the students' perceptions of their computer laboratory class and their achievement and attitudes. To do this it was necessary to develop an instrument suitable for measuring students' perceptions of the psychosocial environment of a computer laboratory class, and an instrument for assessing their attitudes towards computers and their course. The rationale for this research is given in the next section and this is followed by the research questions which underlie the study.

1.2 Rationale for the Study

Research studies on learning environments in a variety of classroom settings have indicated that there are associations between students' perceptions of their classroom environment and attitudinal and cognitive outcomes. These associations are found consistently even in those studies where other variables have been controlled (Fraser, 1994; Fraser, Walberg, Welch, & Hattie, 1987; Haertel, Walberg, & Haertel, 1981), and provide a rationale for the use of instruments in the study of classroom environments.

Laboratory classes have traditionally been used in science courses to provide students with practical experience of science, and have been found to improve both attitude to science and achievement in science knowledge (Freedman, 1997). Since the advent of on-line access to computer systems in the 1970s, university computing courses have provided computing laboratories for students to use. In many courses, laboratory classes form an integral part of the teaching and learning pattern. The spread of the use of computers from the traditional disciplines of computer science and information systems to areas such as business, education, and the arts will increase the demand for computer laboratories to be provided. Computing laboratories are expensive to equip and maintain, and as the technology itself is changing rapidly, most computing hardware becomes obsolete in about three years, and some software even sooner. Expenditure on computer laboratories is often questioned by academic administrators, who ask whether they are necessary or effective, and whether the same learning experience may be provided in other ways. Laboratory classes are also expensive in terms of teaching resources and in some cases the provision of computer laboratory classes within a course often depends on the instructor. Professional computer bodies have proposed curricula for Computer Science (ACM/IEEE-CS, 1991) and Information Systems (Cougar, et al., 1995), and in both the authors claim that computer laboratory classes provide a valuable learning experience. Despite these claims, there is little empirical evidence to support them.

This study investigates the effectiveness of computer laboratory classes by examining associations between the environment and student outcomes in those courses where the computer or its applications are the subject of study.

1.3 Research Questions

In terms of effectiveness of computer laboratory classes, the most important question to students, educators and administrators is whether or not they influence students' attitudes and achievement. Previous research indicating evidence of associations between student perceptions of their learning environment in a science laboratory setting and student outcomes provides the rationale for Research Question #1:

What associations exist between students' perceptions of their computer laboratory classroom environment and their attitudinal and cognitive outcomes in a university setting?

Prior research into attitudes towards computers and achievement showed that there is an association between some attitude measures and achievement. This research formed the focus of Research Question #2:

What associations exist between students' achievement and their attitude towards both computers and their course?

Differences have been found in students' perceptions of their learning environments based upon a number of other variables, some of which are student specific such as gender, whereas others are classroom specific such as size of class. In the context of computer laboratories, there is a third type of variable, based upon the type of computer system used. This provided another focus for this study, and is addressed in Research Question #3:

Are there differences in students' perceptions of their computer laboratory classroom environment based upon student variables, course variables and computer variables?

The results of previous research which described differences in attitudes towards computers based upon a number of variables, both exogenous and endogenous, formed the basis of Research Question #4:

Are there differences in students' attitudinal and achievement outcomes based upon student variables, course variables and computer variables?

Computer laboratory class experiences may be provided in a number of different ways, and this may vary from course to course, and from university to university. For example, in the United States, it is the norm not to schedule laboratory classes (Denk, Martin, & Sarangarm, 1994), whereas in Australia and the United Kingdom the reverse is true. This provides the rationale for Research Question #5:

> Are there differences in students' perceptions of their computer laboratory classroom environment and attitudinal outcomes based upon location of their place of study?

The next section of this chapter gives reasons why it was necessary to modify existing instruments for use in this study.

1.4 Instruments Used in this Study

Before being able to provide some answers to the research questions posed in the previous section, it was necessary to investigate existing instruments that could possibly be used for this purpose. The Science Laboratory Environment Inventory (SLEI) (McRobbie & Fraser, 1993) was specifically designed for science laboratory classrooms, and as is mentioned in Chapter 5, it contains some scales that may be relevant to the computer laboratory classroom, but not all of its scales are. Two other instruments based on the SLEI had been developed to measure computer classroom environment, the *Computer Classroom Environment Inventory* (CCEI) (Maor & Fraser, 1993) and the *Geography Classroom Environment Inventory* (GCEI) (Teh & Fraser, 1993). Both of these instruments were designed for specific purposes (see Chapter 5) and could not be used to measure the environment of a general computer laboratory classroom. Therefore, one of the major tasks of this research was to develop and validate a suitable instrument for this purpose.

Four out of the five research questions in Section 1.3 involve student attitudinal outcomes. In order to be able to do this, it was necessary to decide on which attitudinal outcomes to measure and then to find or develop an instrument to do so. As with the computer classroom environment, no completely suitable instrument was found, so another major task was to develop and validate such an instrument.

The final section of this chapter provides an overview of the thesis.

1.5 Overview of the Thesis

The present chapter has described the purpose of the study and given some background information to set the study into context. Chapter 2 contains a review of the literature regarding learning environments, with particular attention being paid to laboratory classes and the associations between classroom environment and student outcomes. Research that has been carried out into the use of computer laboratories is also reviewed in Chapter 2, and here the emphasis is on those studies that investigated the psychosocial environments of computer laboratories or their effectiveness. In Chapter 3 the literature regarding attitude towards computers is reviewed, with the focus being on those studies that investigate the relationships between attitude and cognitive outcomes.

The methodology employed in the study is described in Chapter 4. Details of the courses surveyed are given together with information on how computer laboratory classes are organised. Data collection methods are described, as is the way in which achievement was measured for the Australian sample. Chapter 5 describes how an instrument for measuring the computer laboratory environment, the *Computer Laboratory Environment Inventory*, was developed and gives information regarding its reliability, discriminant validity and predictive validity. The development of an instrument for measuring students' attitudes towards computers and computing courses, the *Attitudes towards Computers and Computing Courses Questionnaire*, is described in Chapter 6, and a discussion of its reliability and discriminant validity is included.

Chapters 7 and 8 deal with the Australian study. In Chapter 7, associations between students' perceptions of their computer laboratory classroom environment and both their attitude and achievement are discussed, along with the associations between their attitude and achievement. A two-level model is proposed and tested. Chapter 8 gives the results of using both laboratory environment and student outcomes as criterion variables with student variables, course-related variables and computer-related variables as independent variables.

Chapter 9 gives a comparison of the studies carried out in Australia, the United Kingdom and the United States from the perspective of instrument reliability and discriminant validity, and also describes differences in the students' perceptions and attitudinal outcomes that may be attributable to their country of study.

Conclusions from this study are drawn in Chapter 10 in which the major findings are discussed with reference to the research questions posed in this chapter. Implications of the findings are discussed, as are the limitations of the research, and suggestions for future research in this area are proposed.

CHAPTER 2

LEARNING ENVIRONMENTS AND COMPUTER LABORATORIES

2.1 Introduction

This chapter places the study into context by providing a review of the literature relating to learning environments and computer laboratories. The first section of the review examines previous research on learning environments with section 2.2.1 distinguishing between school-level environments and classroom environments. Section 2.2.2 gives an overview of classroom environments as an area of study and gives particular emphasis to the development of instruments for measuring those environments. As the present study is within the university setting, instruments for assessing the university classroom climate are reviewed in section 2.2.3. Studies of the associations between classroom environment and student outcomes, both in terms of achievement and attitude, are discussed in section 2.2.4, and section 2.2.5 covers investigations in which the environment is the dependent variable, examining the role various student variables play in explaining the variance in perceived environment. As this thesis deals with computer laboratories as learning environments, section 2.2.6 considers research that has been done on the environment of science laboratories, which have some similarities with computer laboratories.

The second part of this chapter overviews the use of computer laboratories in computing courses. Section 2.3.1 gives some background to the development of computing courses within universities, and section 2.3.2 discusses the role of computer laboratories. Some studies of computer laboratories are described in section 2.3.3, and these include those that use instruments to measure aspects of the classroom environment as well as others that investigate the effectiveness of laboratories.

2.2 Learning Environments

Educational environments have been a subject of academic research for many years. The research arose from many questions which were of concern to teachers, educational researchers, curriculum developers and policy makers in education. These questions cover issues such as the effect of a classroom's environment on student learning and attitudes, the effect of a school's environment on teacher job satisfaction and effectiveness, the effect of a new teaching method or curriculum on the classroom's environment, and the determinants of classroom and school environment (Fraser, 1994). Such issues have been at the centre of the research effort into educational environments for the past 30 years.

2.2.1 *School-level environments*

It is important to distinguish between school-level environments and classroom environments. School environments are considered to be more global than classroom ones, and involve psychosocial aspects of the school as a whole (Anderson, 1982; Fraser & Rentoul, 1982; Genn, 1984). Research into school environments is based upon viewing the school as a formal organisation (Thomas, 1976), and owes a great deal of its theory and methodology to work on organisational climate in business contexts (Anderson, 1982). The interpersonal relationships involved in a school environment differ from those in a classroom. In the former, they are between teachers, heads of department and principals, whereas in the latter, they are between teacher and students, and among students. Also, school climate is usually measured in terms of staff perceptions, whereas classroom climate is measured in terms of both student and teacher perceptions. One of the first objective measures of an educational environment was the *College Characteristics Index* (CCI) (Pace & Stern, 1958; Stern, 1970), a school-level instrument, and it was used to assess the environment of five colleges in the United States.

There is an alternative view of learning environments, which includes both school-level and classroom environments (Cavanagh, Dellar, & Ellett, 1998). It is based on the concept that a school should be viewed as a community rather than as a formal organisation (Sergiovanni, 1993). The assumption underlying this view is that behaviour and learning are consequences of context or social environment, what sociologists term culture. As stated by Fullan (1993), the moral purpose of education 'is to make a difference in the lives of students regardless of background, and to help produce citizens who can live and work productively in increasingly dynamic societies'. The term school effectiveness is used to describe the extent to which schools address this purpose, and it is contributed to at both the school and classroom level. Research into school effectiveness has shown that beliefs, attitudes, and values of teachers influence student learning outcomes (Sammons, Thomas, & Mortimore, 1995).

2.2.2 *Classroom environments*

Classroom environment research concerns psychosocial aspects of a single classroom. Although the concept of a classroom environment is a subtle one, teachers have always been aware of it in an informal manner. Different classes have different characteristics arising from the ways in which individuals interact with each other, with the teacher, and with their environment. The research in this area has succeeded in conceptualising learning environments. Much of the early work in this area used direct observation which would involve a trained external observer who categorised classroom events, communications and interactions (Dunkin & Biddle, 1974). Using pre-defined categories of behaviour, such as teacher praise, or student "on-task" behaviour, for systematic classroom observation increases the inter-observer reliability and therefore the validity of the findings (Erickson, 1986). Rosenshine and Furst (1973) make a distinction between 'low-inference measures' and 'high-inference measures'. Low-inference measures would include specific items recorded during classroom observation, such as the number of questions asked, whereas high-inference measure require an observer, either independent or a member of the classroom milieu, to make an inference about the teacher's behaviour, such as degree of teacher friendliness. These inferences require judgement on the part of the observer. Compared with low inference measures, high inference measures are involved more with the psychological significance of a classroom event for students and teachers. High inference measures using student and teacher perceptions as the indicators of the quality of the classroom environment are seen to have the following advantages over direct observation (Henderson, 1995):

- Students observe more of a teacher's typical behaviour than would an outside observer.
- Students are more familiar with teacher's idiosyncrasies, which may be interpreted differently by an observer.
- Students are in a better position to judge certain aspects of a teacher's behaviour, such as clarity of expression.
- Students may observe aspects of a teacher's behaviour that the observer does not.
- The presence of an observer could change the classroom climate.
- The use of trained observers is more expensive, time-consuming, and the findings more difficult to analyse than the use of questionnaires.

The use of objective measures for classroom environments was given an impetus by two independent programmes which started at about the same time in the late 1960s. As part of the evaluation of the Harvard Physics Project (Anderson, Walberg, & Welch, 1968), the Learning Environment Inventory (LEI) was developed (Anderson & Walberg, 1968; Walberg & Anderson, 1968). The final version of this instrument consists of 15 scales, or climate dimensions, and each scale contains 7 items (Anderson, 1971), with respondents being asked to express their degree of agreement or disagreement on a 4 point scale from Strongly Agree, Agree, Disagree and Strongly Disagree. The climate dimensions of the LEI were chosen to include those concepts identified as good predictors of learning, those considered relevant to psychosocial theory, those similar to ones found to be useful in educational research and those judged relevant to the social psychology of the classroom (Fraser, 1991). Those dimensions are Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Dimension, Disorganisation and Democracy.

Working in a separate field, Moos developed a number of social climate scales, including those for use in correctional institutions (Moos, 1968) and psychiatric hospitals (Moos & Houts, 1968). He classified the characteristics of psychosocial environments into one of three categories which he called dimensions (Moos, 1974). The relational dimensions measure the nature and intensity of personal relationships within the environment and the extent to which people are involved with and supportive of each other. The personal growth or goal orientation dimensions are indicative of the underlying goals of the particular settings. The system maintenance and system change dimensions involve the degree of structure, clarity of expectations and openness to change. Moos has developed a number of scales which include the *Classroom Environment Scale* (Trickett & Moos, 1973) for measuring the environment of a classroom, the *Family Environment Scale* for measuring the environment at home, and the *Work Environment Scale* which measures the environment at work (Moos, 1991). The final version of the Classroom Environment Scale (CES) (Moos & Trickett, 1987) contains nine scales with 10 items of a True-False response format on each scale. The scales are Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organisation, Rule Clarity, Teacher Control.

Both the LEI and the CES have general applicability but were designed for use in secondary schools. A number of other instruments for assessing different contextual learning environments have been developed since that time. The *Individualised Classroom Environment Questionnaire* (ICEQ) was developed for open or individualised classrooms (Rentoul & Fraser, 1979), *My Class Inventory* (MCI), a simplified version of the LEI for primary schools settings (Fisher & Fraser, 1981), the *College and University Classroom Environment Inventory* (CUCEI) for post-secondary institutions (Fraser & Treagust, 1986), the *Science Laboratory Environment Inventory* (SLEI) for science laboratories in secondary and higher education (Fraser, McRobbie, & Giddings, 1993), and the *Distance and Open Learning Environment Scale* (Jegede, Fraser, & Fisher, 1998) for university distance education settings. There are many others.

These instruments may be used to assess the actual classroom environment as measured by the scales, but also may be used to determine the ideal classroom environment from both the teacher and student's viewpoint (Moos, 1980). The two versions of the instrument are called the 'actual' form and the 'preferred' form (Fraser, 1991). The actual form deals with perceptions of the classroom environment as it is, the preferred form as the respondents would like it to be. Using the preferred form the students or teacher describe their ideal classroom environment, and this form of the questionnaire deals with goals and values orientations (Fraser, 1994).

Another consideration when dealing with classroom environments is whether it is the individual student's perceptions of their personal involvement within the class or whether it is the individual's perception of the class as a whole. This leads to other forms of the instruments, the personal form and the class form (Fraser, Fisher & McRobbie, 1996). Students and teachers often perceive the same classroom environment differently (Fisher & Fraser, 1983). To enable these differences to be measured, many instruments have one version for students and a slightly modified one for teachers (Fraser & Treagust, 1986).

Taking the view of the school as a community to the classroom level has led to a constructivist approach to teaching which emphasises the importance of the classroom social environment on the acquisition and development of knowledge (Cole, 1991). The most well-known aspect of constructivism is the concept of *learning as a construction of knowledge*, which contrasts with the traditional view as *teaching as transmission of knowledge* (von Glasersfeld, 1990). In order to assist researchers in assessing the degree to which a particular classroom is consistent with a constructivist approach, the *Constructivist Learning Environment Survey* (CLES) was developed (Taylor, Fraser, & Fisher, 1997). This instrument contains five scales, Personal Relevance, Shared Control, Critical Voice, Student Negotiation, Uncertainty. It was field tested with a sample of 1626 students in 120 grade 9-12 science classes in the Dallas Public School District. All scales were found to have acceptable reliability, discriminant validity and predictive validity using both individual and class as the unit of analysis.

2.2.3 *Classroom instruments in higher education*

There have been a number of classroom environment instruments designed specifically for use in higher education whereas others have been adapted for use in such settings. The College and University Classroom Environment Inventory (CUCEI) (Fraser & Treagust, 1986) was designed for small classes, either seminars or tutorials of up to 30 students. The final form has seven scales, each with seven items. The items are responded to on a four-point Likert scale with the alternatives of Strongly Agree, Agree, Disagree, and Strongly Disagree. The scales are Personalization, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation and Individualization. As with other instruments there are actual and preferred versions, as well as versions for both students and instructors. It was field tested by administering it to 372 students in 34 classes and to 20 instructors, and gave acceptable reliabilities and mean correlations with other scales for the student sample on both the actual and preferred forms. For the instructors, the reliability coefficients were smaller, but acceptable, on both forms of the instrument. The mean correlations were also smaller. Both of these results could be due to the small sample size for instructors. A variant of the CUCEI, called the *College and University Lecture Classroom Environment Inventory* (CULCEI) was developed to measure the environment of larger classes or lectures (Schuh, 1996). It has the same scales as the CUCEI but the wording of some of the items has been changed. Jegede, Fraser and Fisher (1998) have developed an instrument, called the Distance and Open Learning Environment Scale (DOLES) for university distance education settings particularly in science. It has five core scales, Student Cohesiveness, Teacher Support, Personal Involvement and Flexibility, Task Orientation and Material Environment, and Home Environment. It also has two optional scales which may be used when appropriate; these are Communications Technology Resources and Study Centre Environment. The final version of DOLES has 52 items in seven scales, with the number of items per scales varying from 6 to 12. It was tested with 660 distance education students in two universities. The resulting factor analysis confirmed the a priori structure, and the scales were found to have acceptable reliabilities and discriminant validity. The *Teaching and Learning Environment Questionnaire* (TLEQ) (Chauvin & Bowdish, 1998) was designed as a shortened form of *Student Assessment of Teaching and Learning* (SATL) instrument (Loup, Ellett, Culross, & Evans, 1993). The SATL was developed to extend an observation-based system called *System for Teaching and Learning Assessment and Review* (STAR) (Ellett, Loup, & Chauvin, 1991). The SATL contains 65 items and was considered too long for application in the specific setting of a medical school. The TLEQ contains 18 questions with responses on a five point Likert scale from Definitely No to Definitely Yes. It was administered to 345 medical students and factor analysis indicated two factors, accounting for 62% of the variance. One factor consisting of 15 items, covers the contextual elements and the other factor of three elements learner involvement. The authors suggest that this instrument would be particularly useful for determining aspects of the classroom learning environment of university professional schools.

2.2.4 *Studies involving classroom instruments*

There have been a number of studies involving these classroom instruments. Fraser (1994) gives a table of 54 studies into associations between classroom environment and various student outcomes, cognitive, affective and behavioural.

The study of classroom environments has demonstrated that perceived classroom environment may be predictive of student learning and other outcomes. Using the LEI in three separate studies the learning environment was shown to account for considerably more variance in learning outcomes than the Intelligence Quotient, which was widely used at that time as a predictor of achievement. Anderson and Walberg (1968) found that the scales of the LEI accounted for between 33% and 46% of the variance in cognitive outcomes, whereas IQ accounted for 0%-7%; Walberg (1971) found that between 18%-30% of cognitive outcomes were predicted by the LEI and between 13%-16% by IQ; in another study (Anderson & Walberg, 1972), the figures were 43%-46% for the LEI and 7%-12% for IQ. In terms of student achievement, the findings that environment is associated with student outcomes has been supported by later studies (Walberg & Haertel, 1980; Fraser & Fisher, 1982). In a meta-analysis of psychosocial learning environments, Haertel, Walberg, and Haertel (1981) analysed 734 correlations from 12 studies encompassing 823 classes representing 17,805 students in four countries. Their results demonstrated that learning outcomes are positively associated with Cohesiveness, Satisfaction, Task Difficulty, Formality, Goal Direction, Democracy and the Material Environment and negatively associated with Friction, Cliqueness, Apathy and Disorganisation. Further studies have reinforced these results (Fraser, 1986; Fraser, Walberg, Welch, & Hattie, 1987). It is clear that a student's perception of classroom environment plays an important role in learning, and Walberg (1971) suggests environment has the same relationship to instruction as ability has to achievement. This is in the sense that both student's ability and the classroom environment are more general and lasting than the specific and temporary achievement and instruction.

The use of actual and preferred forms allows person-environment fit studies of whether students perform better when their actual learning environment is close to the one that they prefer. In a study using the actual and preferred forms of the ICEQ, Fraser and Fisher (1983) showed that student achievement may be enhanced if the actual perceived environment was modified to fit the students' preferred environment. In another study, both the actual and preferred forms of the CES were administered to secondary school science students in Australia (Fraser & Fisher, 1986). In the light of the students' perceptions of the actual and their preferred environments, the teacher introduced an intervention in an attempt to modify the environment. Re-administration of the actual form of the instrument after two months showed that the students perceived their environment differently. This study demonstrated the potential usefulness of classroom environment instruments as a means of providing guidelines to improving classroom climate.

Most of the research into classroom environments has been carried out by science educators, so that many studies have investigated the associations between learning environment and both attitudes towards science and scientific attitudes. An instrument that has been widely used in attitudinal research in science is the Test of Science-Related Attitudes (TOSRA) (Fraser, 1978). It is based upon a classification of science attitudes due to Klopfer (1971), in which there are six categories: attitude to science and scientists, attitude towards inquiry, adoption of scientific attitudes, enjoyment of science learning experiences, interest in science, and interest in a career in science. In a meta-analysis of 49 studies, Haladyna and Shaughnessy (1982) found that perceived environment variables are highly related with student attitudes, as are some teacher variables. Further, Talton and Simpson (1987) showed that 56-61% of the variance in attitudes could be predicted by the learning environment. In a number of studies involving the LEI, some of its scales have been found to be associated with student attitudes. These include Goal Direction, Satisfaction, Speed and Friction (Hofstein, Gluzman, Ben-Zvi, & Samuel, 1979) and Friction and Favouritism (Lawrenz, 1976).

2.2.5 *Studies using environment as the criterion variable*

The studies mentioned so far have dealt with classroom environments as independent variables. As environment is such an important factor in education it is desirable to investigate the factors that affect it. Fraser (1986) lists 47 studies involving environment as a dependent variable and in a later review lists 56 studies, again with environment as the criterion variable, involving only science classes (Fraser, 1994). The independent variables in these studies have included curriculum evaluation

(Welch & Walberg, 1972), innovation (Maor & Fraser, 1992), differences between student and teacher perceptions (Wubbels, Brekelsmans, & Hooymayers, 1991), differences between actual and preferred environments (Fisher & Fraser, 1983; Fraser & Treagust, 1986), type of school (Hofstein, Gluzman, Ben-Zvi, & Samuel, 1980; Trickett, Trickett, Castro, & Schaffner, 1982), class size (Anderson & Walberg, 1972), gender of both students and teacher (Owens & Straton, 1980; Byrne, Hattie & Fraser, 1986; Lawrenz, 1987), and cultural background (Waldrip & Fisher, 1996).

2.2.6 *Studies of laboratory environments*

One specific classroom environment that has received attention over recent years is the science laboratory, and Science Laboratory Environment Inventory (SLEI) was developed to be used in this classroom setting (Fraser, McRobbie & Giddings, 1993). The final version of this instrument consists of five scales, all with seven items, which are responded to on a five point Likert scale from Almost Never, Seldom, Sometimes, Often and Very Often. The scales are Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment; a description of the scales is given in Chapter 5 of this thesis. There are actual and preferred forms, as well as personal and class forms of the SLEI. It has been field tested in six countries (Australia, USA, Canada, United Kingdom, Israel, and Nigeria) and these studies involved 3727 students in 198 classes in 40 schools. Factor analysis supported the structure of the instrument, and all five scales showed reasonable reliability, discriminant validity and predictive validity, when both the student and the class were used as the unit of analysis.

The SLEI has been used in a number of different studies. In the first investigation of the associations between environment and student outcomes in a laboratory setting, McRobbie and Fraser (1993) used the SLEI with a sample of 1594 senior high school students. The student outcomes were assessed on four attitude measures and two measures of enquiry skills. They found that the environment variables accounted for between 17% and 45% of the variance in student outcomes when the class mean was used as the unit of analysis. Wong and Fraser (1995) carried out a study with high school chemistry students in Singapore. Not only did this study demonstrate further the cross-cultural validating of the SLEI, but it was also found that all the environment scales, except Open-Endedness, were positively associated with student attitudinal outcomes. Another study investigated the associations between laboratory environment and both attitudes towards science, practical skills and cognitive achievement with a sample of 489 students from 28 biology classes in Tasmania (Henderson, 1995). The results indicated that the associations between perceptions of the learning environment were stronger with the attitudinal outcomes than with achievement or practical skills.

At the secondary level, the laboratory has tended to be a setting unique to science teaching. At the university level, laboratories have been used in engineering teaching, languages and computing. With the increase in the use of computers in secondary education, there is a corresponding increase in computing laboratories as learning environments. Among other things, laboratories are intended to reinforce concepts covered in other types of classes and give students the opportunity to practice skills they have learned. In order to do this, laboratories must be suitably equipped and usually require specialised non-teaching staff to maintain them. There is frequent questioning by educational administrators as to whether the expense of maintaining and staffing laboratories is justified (Hofstein & Lunnetta, 1982). This applies as much to computing laboratories as to science laboratories. It raises the question as to whether concepts can be reinforced without the use of laboratories (Pickering, 1980). In the case of computing laboratories, there is the added problem of the rapid obsolescence of both hardware and software. At the university level, there is an expectation by students and potential employees that they will gain experience on the latest systems.

A computer laboratory class is an example of a classroom environment, albeit one which has its own special characteristics. The increased use of computers in classrooms has led to studies to evaluate the effectiveness of computer assisted learning (Maor & Fraser, 1993; Teh & Fraser, 1993). The next section discusses the role of computer laboratories in university courses and some of the investigations that have been carried out into their effectiveness.

2.3 Computer Laboratories

2.3.1 *Background*

The first electronic computer was developed in the 1940s, and up to the mid 1950s, the use of computers was restricted to scientific and engineering applications. Commercial applications of computers started in a small way in the late 1950s and expanded rapidly over the next 20 years. However, up to 1980, computer usage was not as widespread as it is today. At that time, organisations used a central computer and had a specialist Data Processing or Information Systems Department. These departments were usually the only part of the organisation with access to computers. This situation changed with the advent of the microcomputer in the 1980s, and later the local area network. Following their introduction, the use of computers spread to all levels of organisations and today it would be unusual to find a desk in any organisation without a workstation on it.

This evolution in the use of computers is mirrored in the provision of computer education and training. Initially, computer manufacturers ran specialist intensive courses in programming and operating systems over three to five days; this practice continues and indeed has been extended to cover many aspects of the computing and communications industries. The first tertiary computing courses started in the 1960s. They had titles such as Computer Science, Computer Studies or Electronic Data Processing and were intended for the computing specialist, who would start their careers as programmers or systems analysts. Computer Science has established itself firmly as a discipline in most universities and in such courses the emphasis is on the study of computer systems themselves. The other terms mentioned have, in general, been replaced by Business Computing or Information Systems, which is now emerging as a discipline in its own right. Courses under these titles concentrate on the application of computers to business problems. In addition, many universities offer programs in Software Engineering and Computer Engineering. All the courses mentioned involve the study of programming as the means by which computer-based systems are developed.

The introduction of the microcomputer in the early 1980s led to the wider use of computers throughout tertiary education in courses such as business, education and engineering. Here the computer is often used as a tool to assist in learning, as a means of delivering educational material and for on-line assessment. More recently, the availability of multimedia has extended the use of computers to graphic design and architecture, and the Internet has made the workstation an invaluable educational and research tool. This has led to the inclusion of some form of computer education in most disciplines at the university level.

2.3.2 *The role of laboratories*

The one aspect that most computing courses, both specialist and non-specialist, have in common is the use of computer laboratories. This aspect is understandable given that using a computer, particularly for programming, is perceived as a skill which cannot be learned by simply reading a book and needs practice in order for it to be acquired (Azemi, 1995). This skill must be mastered before any progress can be made, and laboratory classes provide an opportunity for students to gain proficiency.

Computer laboratory classes have some similarities with science laboratories in terms of objectives but there are also marked differences. Boud, Dunn, and Hegarty-Hazel (1986) give a list of 22 aims for science laboratory classes, but not all of these are pertinent to computer laboratory classes. The following, modified as appropriate, were deemed to be relevant:

1. to teach basic practical skills;
2. to familiarise students with the computing environment;
3. to reinforce material taught in the lecture;
4. to teach students the principles of using computers;
5. to provide closer contact between staff and students;
6. to stimulate and maintain interest in the subject;
7. to teach theoretical material not included in lectures;
8. to foster critical awareness e.g. avoiding systematic errors;
9. to develop skills in problem solving;
10. to simulate conditions in an information systems development environment;
11. to stimulate independent thinking;
12. to develop skills in communicating technical concepts and solutions;
13. to provide motivation to acquire specific knowledge;
14. to bridge the gap between theory and practice.

Other authors take a different view and classify the laboratory class according to what experience is to be provided. One such classification is into reinforcement, comparison, improvement and discovery laboratories (Naps, 1990); others include deductive or verification, technical skill, and problem solving laboratories (Collette & Chiappetta, 1995).

In the United States, the joint Association of Computing Machinery – Institute of Electrical and Electronic Engineers (ACM-IEEE) Curriculum Task Force recommended that introductory computer science courses should be supported by extensive laboratory work (Denning et al, 1989; ACM/IEEE-CS, 1991) More recently the ACM SIGCSE (Special Interest Group on Computer Science Education) Working Group on Computing Laboratories published guidelines for the use of laboratories in computer science education (Knox et al, 1996). Their report was predicated on a number of assumptions, one of which was that laboratory experiences are relevant in most computer science courses across all levels from literacy and language courses for non-specialists to graduate level theory courses. It discusses a number of aspects in detail, and these are the scope of laboratories, the relationship between lecture and laboratory, pedagogy, an Internet repository, institutional support and the use of technology.

Whatever the computer laboratory class experience to be provided, there are a number of ways in which it can be done. In a collaborative effort, the Association of Computing Machinery (ACM), the Association for Information Systems (AIS), the Data Processing Manufacturer's Association (DPMA), and the International Conference on Information Systems (ICIS) developed guidelines for an undergraduate Information Systems Curriculum (Couger, et al., 1995). In the report, they identified three types of laboratories, the structured laboratory, the open laboratory and the specialised laboratory. The structured laboratory is a closed or formal laboratory (Prey, 1996; Lin, Wu, & Chiou, 1996). It is scheduled in the same way as lectures and tutorials with specific exercises being set for students. Such laboratories are generally staffed by a lecturer or higher grade academic who is available to help guide the students. On the other hand, open or public laboratories are provided so that students may complete exercises and assignments outside scheduled laboratory classes. Students are allowed to come and go as they please with technical assistance, if any, being provided by laboratory demonstrators who are often senior students. For these an instructor assigns a problem and students work on it in their own time usually individually but sometimes in groups. Finally, there is the specialised laboratory, which is provided to support up-to-date programmes with state of the art technology. Examples of specialised laboratories are systems development laboratories, providing access to CASE (Computer Assisted Software Engineering) tools, data communication laboratories with hands-on access to network management tools, and decision conferencing laboratories with access to group support systems software (Cougar, et al., 1995). Most computing classes run in Australian and British universities provide formal scheduled laboratory classes, with different levels of prescription with respect to the work to be done. However, in the United States, it seems that the open laboratory is the norm (Prey, 1996). One study showed that only about a third of the university courses surveyed used formal laboratory classes (Denk, Martin, & Sarangarm, 1994).

The relationship between lecture and laboratory can vary considerably in terms of how the laboratory component is organised within the curriculum, the content level, the type of activity, the type of interaction, and the objectives of the laboratory. The laboratory component may be independent of the lecture, a situation which is desirable in some literacy courses where students are required to gain knowledge about computers and also skills in using them. The lecture and laboratory may be connected across semesters, with the theory course first followed by the practical laboratory course, or both may be integrated so a course consists of both theory and practical components in the same semester.

The content level of a laboratory may vary from purely mechanical knowledge of a computer system, such as which key to strike to perform a certain task, to developing a computer based solution to a problem. Laboratories may also be used for exploration and the illumination of difficult concepts. However, it must be recognised that proper development of laboratory materials requires a commitment on the part of both the staff member and the university.

The activity type describes what the student is doing in the laboratory. This could be using a computer-based learning (CBL) system for a tutorial and/or on-line assessment, developing a software system from scratch, modifying existing software, analysing data, exploring a system to find out how it works, or using the Internet as a research tool. Each activity type will have different laboratory needs.

The interaction type is indicative of how the class members work together: students could work on their own, or in groups, and in addition, the staff member may be involved with students either individually or in groups. Closed laboratories allow for greater interaction between staff and students and amongst the students themselves.

The objectives give the competency levels expected to be achieved by students on completion of a laboratory class. They are based on Bloom's taxonomy (Bloom, 1956) modified by Dale (1996), and may be described as recognition, generation and projection levels. For a recognition level class, the objectives would be for students to be able to describe a new concept and to gain new skills; for a generation level class, the expectation would be that students could work with a concept and use existing skills in a modified setting; finally, for a projection level class, students would be expected to master the concept and apply skills in a new setting.

There are a number of ways in which a computer laboratory may be staffed, and these will affect the way in which the teacher interacts with the students. For closed laboratories, it is usual for these to be staffed by the lecturer who is responsible, with an alternative being a graduate teaching assistant. In either case, the teacher would be able to give a high level of interaction, answering questions on advanced concepts, as well as on technical details. One advantage of closed laboratories is that they tend to encourage both active learning (Huss, 1995; McConnell, 1996) and cooperative learning (Prey, 1996). Specialised laboratories are normally closed and only available when a member of staff is present.

The level of assistance provided in open laboratories varies from none to the provision of technical help supplied by non-academic staff. Many universities use undergraduate student assistants in this role to help students with basic questions. Often, because of staffing problems, this is the only help that students get, particularly in open laboratories. This can lead to senior students passing on bad practice to their junior colleagues and generating a philosophy of 'getting it to work at all costs' (Newby, 1994). One reason for providing technical help in laboratories is the need for rapid feedback (Pitt, 1993). A student can spend hours looking at a program which will not compile and which produces an unhelpful error message, when all that is needed is a semi-colon to be removed.

Within the laboratory environment, it is possible for students to work alone, or in groups. The former has advantages when it comes to assessing a student's performance, but has been criticised as not providing students with the realistic experience of team work (Grant & Smith, 1992). This applies especially to specialist courses, where upon getting their first job they will be expected to work cooperatively.

Institutional support is necessary for the success of computer laboratory classes. The provision of computer laboratory facilities does not just involve a room full of workstations. There must be an infrastructure of technical support for both hardware and software, together with a help desk available to both staff and students.

The uses of technology in computer laboratory classes may be classified by the activities they support and the concepts they reinforce. They include learning to use the technology, using the technology as a tool, using the technology to develop new systems, and using technology to support group work. In each of these cases, different demands will be put on the laboratory class.

There are a number of issues which arise from using computer laboratories as an integral part of teaching and learning. These cover technology both hardware and software, physical environment, organisation, assignment difficulty, technical support, and staff training. Problems can arise when any of these aspects are not addressed (Pitt, 1993). The hardware must be capable of running the software satisfactorily and in the case of shared resources such as multi-user systems or networks, able to handle the required number of users. The software must be suitable for the curriculum, and enable some of the requirements of laboratory classes given above to be satisfied, as deemed necessary by the lecturer. At the very least such classes should teach practical skills and reinforce the theoretical aspects covered in lectures and tutorials. Also, the fundamentals of such software must be able to be mastered in a relatively short period of time, for example, half a semester. It has been recognised that some software is extremely complex (Knox et al, 1996). This applies particularly to commercial software, and it often means that the learning curve for its use is too extensive for such software to be included in a single course (Granger & Little, 1996). This difficulty, together with the high cost of commercial software, makes the provision of realistic laboratory assignments problematic. In some cases, this situation is exacerbated by an unrealistic use of software. For example, in a laboratory class where students access a multi-user system, there may be as many as 30 students performing similar tasks using the same software whereas in a practical (commercial) environment there would be only two or three at any one time. In the student environment, this may lead to poor performance with slow response time, giving the impression that the software is inadequate, an attitude that may remain with students after they graduate.

As many university computing courses are preparing students for a career in a commercial or public sector environment, both the hardware and software must have commercial credibility. Of course, this requirement sometimes conflicts with the need for the software to be easy to learn. Organisations would obviously prefer graduates who have been exposed to the systems that they use rather than having to go to the expense of training. However, this is a somewhat contentious point and many surveys indicate that employers are at least interested in general skills as in specific ones (Trauth, Farwell, & Lee, 1993; Richards & Pelley, 1994). As stated earlier, to develop practical computing skills, students will have to complete various computer-based tasks such as laboratory exercises or assignments. Such tasks must be within the average student's capability. If they are too simple, they give the wrong impression regarding the subject. If they are too difficult or time consuming, this can lead to frustration and a negative attitude towards the course, the software or computing in general. In recent years, there have been changes in the style of development software from text-based systems to graphical user interfaces (GUI) and multimedia. Systems developed using GUIs are usually easier for the user, but the development tool itself is more complex and more difficult to learn (Mutchler & Laxer, 1996; Wolz, Weisgarber, Domen, & McAuliffe, 1996).

All these issues must be taken into account by a university teacher when designing and using computer laboratories as part of a course. In addition, a further factor is the provision of computer resources. The technology within this field is changing rapidly with both hardware and software becoming obsolete, in some cases, in as little as three years. Computer laboratories are an expensive resource and there is often a need to justify their provision.

Despite the perceived importance of computer laboratories within computing courses, very little research has been done into their effectiveness. The next section describes some of the studies that have been associated with computer laboratories.

2.3.3 *Studies involving computer laboratories*

One of the first studies that used an instrument for assessing a computer-based classroom was by Maor and Fraser (1993). They developed the Computer Classroom Environment Inventory (CCEI), specifically for an inquiry-based learning approach using a computerised database. It measured the classroom environment on five scales, Investigation, Open-Endedness, Organisation, Material Environment and Satisfaction. In its final version, the instrument had six items in each scale, and the responses were on a five point Likert scale: Never, Seldom, Sometimes, Often and Very Often. Both student and instructor forms of the questionnaire were designed. It was administered to 120 secondary school students and seven teachers at the start and end of the programme of study. For the students as a whole, there were significant increases in Investigation and Open-Endedness, and a small but significant decrease in Organisation. At about the same time, the Geography Classroom Environment Inventory (GCEI) was developed (Teh & Fraser, 1993, 1995). Its purpose was to measure aspects of a computer assisted learning environment which involved the use of the language micro-PROLOG for teaching the topic of decision-making in geography. The instrument has four scales, Gender Equity, Investigation, Innovation and Resource Adequacy. It was administered to 671 secondary school students in 24 classes in Singapore, and after factor analysis, the final version had 8 items per scale. As with the CCEI, the responses are on a 5 point Likert scale: Almost Never, Seldom, Sometimes, Often and Very Often. It was found that all environment variables were strongly correlated with both achievement (as measured by the *Geography Achievement Test*) and attitude (as measured by the *Semantic Differential Inventory*). Regression analysis indicated that 30% of the variance in achievement and 16% of the variance in attitude could be explained by the environment. Khoo and Fraser (1997) used a modified version of the What Is Happening In this Class questionnaire (Fraser, Fisher, & McRobbie, 1996) in a study of classes in professional computer courses in Singapore. The final version of the instrument called the *Computer Classroom Environment Personal Form* (CCEPF) had five scales, Teacher Support, Involvement, Autonomy, Task Orientation and Equity. Each course lasted three days, and taught aspects of Microsoft Office products, as well as Microsoft Windows and Lotus 123. The study involved 250 adults attending numerous courses run by five separate private computer schools. The instrument was shown to have good reliability on all scales and was predictive of class membership. It was found that satisfaction with the course was significantly correlated with all the scales of the CCPEF. Regression analysis showed that 21% of the variance in satisfaction came from four of the five environment variables with Task Orientation and Autonomy making the greatest contributions.

In a study of computer laboratory environments, Zandvliet and Fraser (1998) looked at three aspects of them, the physical environment, the psychosocial environment and the information technology environment. For the physical environment, they developed an instrument called the *Computerised Classroom Ergonomic Inventory*, which has five physical variables measured or noted by the researcher. These are grouped into the domains of workspace, computer, visual, and spatial environments, together with a measure of overall air quality. The psychosocial environment was measured by using five scales of *What Is Happening In this Class* questionnaire (Fraser, Fisher, & McRobbie, 1996). These are Student Cohesiveness, Involvement, Autonomy, Task Orientation, and Cooperation. The questionnaire was administered to 1404 secondary students in 81 classes, and the classrooms were assessed by one of the researchers using the Computerised Classroom Ergonomic Inventory. The results showed there were significant correlations between the workspace environment and both Cooperation and Autonomy, and between the visual environment and both Student Cohesiveness and Task Orientation. Also, there were correlations between all psychosocial environment variables and student satisfaction, with regression analysis showing that 36% of the variance in satisfaction may be accounted for by

Task Orientation and Autonomy, a result similar to that obtained by Khoo and Fraser (1997).

Using a different approach, Duplass (1995) conducted an empirical study to investigate the effect of scheduled laboratory classes on students' ability to complete assignment projects and tutorial exercises. He taught two classes of student teachers for a whole semester. The course was introductory and included use of an application package Microsoft Works. Both classes had the same number of hours of instruction, but one of them had 25% of the time in a scheduled laboratory, where the instructor gave "over the shoulder" advice, whereas in the other class, this time was spent in demonstration of the process. Open laboratories were available to both groups of students. The study showed that those who had the benefit of the scheduled laboratory completed their projects in significantly less time (about 14%) than those who did not, but there was no significant difference in times taken to complete the tutorial exercises. This indicates that computer laboratory classes may have greater influence on students' ability to tackle larger problems.

Denk, Martin, and Sarangarm (1994) classified classroom computer usage into two categories, imbedded in the classroom, and adjunct to the classroom. Imbedded includes closed laboratories, and using computers as a presentation tool. Adjunct includes open laboratories. In a survey of 302 faculty in three universities in the United States into the instructional use of computers in higher education, they found that most faculty had more positive attitudes towards computers as an adjunct to the classroom rather than imbedded in the classroom. They also found that the perceived greatest hindrances to the instructional uses of computers were inadequate funding, lack of available training, and difficulties academic staff have in maintaining up-to-date knowledge of computer technology.

In a study involving writing classes, Levine and Donitsa-Schmidt (1995) developed the *Classroom Environment Questionnaire for Computer-Supported Writing Classes*. This instrument had 21 questions, and factor analysis indicated there were 6 factors. These were Teacher-student relation, Peer relation, Writing processes, Role of the computer, Classroom management, and Student responsibility. By comparing computer-based classes with traditional writing classes, the authors demonstrated that introduction of computers into a classroom changes the learning environment, and that using computers effectively creates a classroom that is more student centred and cooperative. In fact, as has been mentioned, the use of closed laboratories in computing courses is seen as an opportunity to introduce cooperative learning strategies (Prey, 1996).

There have been other studies into aspects of computer laboratories such as availability (Valenstein, Treling, & Aller, 1996) and its adverse impact on outcomes and costs, and also into their use in non-traditional areas like Sociology (Raymondo, 1996), Accounting (Stone, Arunachalam, & Chandler, 1996), Management (Oram, 1996), and Economics (Ray & Grimes, 1992).

2.4 Summary

This chapter reviewed some of the literature relating to previous studies involving learning environments focusing on their use in higher education and in laboratory settings. These studies indicate that aspects of learning environments are associated with student outcomes both in terms of achievement and attitudes. Studies into computer laboratory environments are also reviewed. These environments tend to be specific to using the computer as a tool in such applications as computer assisted learning, or word processing. The only study that measured effectiveness of computer laboratories did so by comparing the time taken for students to complete their assignments or laboratory exercises.

The review of previous studies indicated that there was no instrument suitable for use in a university computer laboratory setting, and so it was necessary to develop and validate such an instrument. The study described in this thesis is unique in that it deals with the development and validation of an instrument to measure the computer laboratory environment specifically for use in both specialist and non-specialist courses in a university setting and with its use to determine associations between perceived environment and student outcomes.

The next chapter reviews the literature on attitudes towards computers, and describes some of the instruments that have been developed to measure such attitudes. Research involving these instruments is also discussed.

CHAPTER 3

ATTITUDE TOWARDS COMPUTERS

3.1 Introduction

Since the introduction of computer systems into the workplace, there has been an interest in their effects upon people who work with them, and whether or not they will be accepted. In other words, what will people's attitudes towards computers be. Following the wider use of computers in the workplace, educational institutions and the community at large, attitudes towards computers has become a fertile field of study. This chapter discusses some of these studies. There are a number of different understandings of the term 'attitude', and section 3.2 gives an overview of some of these definitions, indicating the underlying theoretical framework. Section 3.3 deals specifically with attitude towards computers, and is in two parts. Section 3.3.1 describes some of the instruments that have been developed for measuring computer attitudes, and placing these instruments into the framework provided by social psychology. Section 3.3.2 outlines some of the studies into attitude towards computers focussing mainly, but not exclusively, on educational settings. Some of these investigations involve computer attitudes as dependent variables, and in others as independent variables.

3.2 Measurement of Attitude

The study of attitude as a part of social psychology has been undertaken for over a century. As would be expected over this period of time there have been a number of different definitions of attitudes. These definitions differ in their focus, but underlying them is the need to predict how individuals will be predisposed to behave

towards certain objects, situations, actions, individuals or ideas. A selection of definitions of attitude is given below:
"An attitude is a tendency to act toward or against something in the environment which becomes thereby a positive or negative value" (Bogardus, 1931 cited in Allport, 1935/1971).
"An attitude is a mental disposition of the human individual to act for or against a definite object" (Droba, 1933 cited in Allport, 1935/1971).
"Attitude is the affect for or against a psychological object" (Thurstone, 1931/1971).

Most definitions have in common 'the readiness to act for or against an object' in certain situations, and this is best summarised by Allport's definition:
"An attitude is a mental or neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" (Allport, 1935/1971).

Rosenberg and Hovland (1960) define attitude as:
" a predisposition to respond in a particular way towards a specified class of objects".

As such attitude is not directly observable or measurable. One definition which covers the central ideas of attitude is due to Triandis (1971):
"An attitude is an idea charged with emotion which predisposes a class of actions to a particular class of social situations".

Most researchers view attitude as having three components:

- A cognitive component, based on what an individual believes; these beliefs do not need to be true. An example of a belief is "computers are useful".
- An affective component which is the emotion which the "object" engenders in the individual.
- A behavioural component which is a predisposition to action based on the cognitive and affective components. This component is merely a predisposition to act, and it does not mean that the action will necessarily take place.

The minimum condition required for having an attitude is cognitive. In other words, having a belief about objects or situations is needed before an individual can have an attitude. In addition, it is necessary to have this belief about the objects / situations associated with pleasant or unpleasant events or desirable or undesirable goals. When this happens, the individual's emotions are affected by the object / situation, and it is said to become charged with affect. This in turn leads to a predisposition to behave in a certain way. If the events are pleasant or the goals perceived to be desirable then the individual will have a positive attitude towards the object / situation, and vice versa. Studies have shown that the relationship between attitude and behaviour to be rather weak and individuals do not always act as they say they will (LaPiere, 1934 cited in Triandis, 1971; Kutner, Wilkins, & Yarrow, 1952 cited in Triandis, 1971). It should be noted that attitude is not the only factor that influences behaviour, there are others such as habit and peer pressure (Wicker, 1969/1971). The traditional assumption in attitude research has been that behaviour is caused by attitude. However, there is one school of thought that suggests that the causal relationship is the other way. In extensive laboratory experiments, Breer and Locke (1965) produced results that supported the hypothesis that beliefs, attitudes and values of a group of people are determined by their task experiences.

Ajzen (1988) introduced a fourth component of attitude which he called perceived behavioural control. This is defined as the perceived ease or difficulty of carrying out a particular behaviour, and could be interpreted as a confidence construct aimed at specific behaviours (Kay, 1993). It was developed from the more general concept of locus of control (Rotter, 1966) or perceived self-efficacy (Bandura, 1982). This component explains such factors as peer pressure and social norms as well as self-confidence.

Although attitude cannot be measured directly, it is possible to measure the four components and from those to infer attitude. Of the four components, the cognitive one is the most easily measured, as questions may be posed regarding specific aspects of what individuals believe about the 'object' under investigation. The affective component is more general in nature so, in turn, questions must be more general. It deals with emotional aspects and the way that the attitude affects the way the respondents feel. The behavioural component must be measured using hypothetical questions such as "what would you do if...". The perceived behavioural control component is measured by answering questions relating to an individual's ease or ability to perform a given task or behave in a certain way in a given situation.

3.3 Attitude Towards Computers

3.3.1 *Instruments for measuring attitude*

The introduction of new technology into society is generally accompanied by some resistance and negative feelings towards it (Cancro & Slotnik, 1970). This has been the case with both educational technology (Tobias, 1968) and computers (Huntington, 1981; Jay, 1981). It is often caused by the inability to keep up with technological advances, and leads to what has been termed "computerphobia". Clearly attitude plays a role in this resistance and attitude towards computers has been an area of study since the 1960s.

One of the first of these studies was conducted by Lee (1970). His questionnaire consisted of 20 items covering the cognitive component of attitude. It was administered to 3000 people over the age of 18 in 1963, and factor analysis identified two attitudinal factors, namely, the belief that computers are beneficial tools and the belief that computers are autonomous entities capable of supplanting individuals. Regression analysis showed that 23% of the variance in the second factor was accounted for by two psychosocial variables, intolerance to uncertainties and ambiguities, and alienation. The first of these deals with a requirement of individual to feel certain about their environment, and the second with feeling comfortable about an object or situation. These two variables are closely related to the perceived behavioural control and affective components of attitude respectively. Other researchers have developed attitude towards computers scales using similar bi-dimensional constructs (Zoltan & Chapanis 1982). Rafaeli (1986) developed a scale which was aimed at people working with computers rather than a general scale and factor analysis revealed a two factor structure. A number of empirical applications of these scales has been reported (e.g., Coovert & Goldstein 1980; Kerber 1983). These scales measured attitude on the cognitive dimension.

Loyd and Gressard (1984a) developed the *Computer Attitude Scale* consisting of 30 items. It was administered to 155 school students aged 13 to 18. Factor analysis revealed three subscales: anxiety or fear of computers, confidence in one's ability to use or learn about computers, and a liking for or enjoyment of computers. These subscales accounted for 55% of the total variance and there were strong correlations between all three subscales. Similar results were obtained when the instrument was given to a group of 192 teachers (Gressard & Loyd 1986). The Computer Attitude Scale was extended by the addition of a further ten items to make it a 40-item instrument (Loyd & Loyd, 1985). The new subscale was perceived usefulness of computers in present or future work. This was administered to 114 teachers enrolled in one of six classes involving the use of microcomputers in education. The factor analysis produced a three factor solution in which the items for Anxiety and Confidence loaded on one scale, and Liking and Usefulness on two separate scales. All told, the three factor solution accounted for 48% of the variance. There were strong correlations between Anxiety, Confidence and Liking. The four subscales measure different aspects of attitude, Anxiety and Liking measure an affective component, Confidence measures an aspect of perceived behavioural control and Computer Usefulness measures a cognitive component. Koohang (1989) also extended the original Computer Attitude Scale and added a 12 item perceived usefulness of computers scale. The Computer Attitude Scale was translated in Turkish (Berberoglu & Calikoglu, 1993) in a way that ensured that the meanings of the English and the Turkish versions were the same. It was administered to 282 students in three universities in Turkey. Factor analysis did not produce the same simple structure with four subscales, and the authors suggested that the Computer Attitude Scale operates differently in Turkish culture where it measures a single trait.

Kay (1993) took the approach of developing an instrument on the theoretical basis of the four constructs of attitude given by Ajzen (1988), and this lead to the *Computer Attitude Measure*. It consists of 50 items with 15 covering cognitive attitudes, 10 affective, 18 behavioural and seven perceived behavioural control of the computer. The cognitive attitude consisted of three subscales, one pertaining to beliefs about students, one about personal beliefs and another about general beliefs. The behavioural attitude scale consisted of two subscales, one for behaviour at home, the other for behaviour in class. This made a total of seven subscales in total. It was administered to 647 preservice teachers selected from universities in Canada. A factor analysis followed by an oblique rotation confirmed the structure of the instrument and the seven factors accounted for 60% of the variance. The subscales were correlated but not as strongly as were those for the Computer Attitude Scale.

A number of uni-dimensional scales have been developed. These include those for measuring general attitude covering one or more aspects of attitude (Reece & Gable, 1982; Dambrot, et al., 1985; Nickell & Pinto, 1986) and those for measuring specific aspects, particularly the affective domain (Francis, 1993). In some cases, a multi-dimensional scale has been developed, but the factor analysis indicates factors which are difficult to name (Popovich, Hyde, Zakrajsek, & Blumer, 1987). These are often seen as uni-dimensional scales (Brock & Sulsky, 1994). Of these general scales, the *Bath County Computer Attitude Scale* (Bear, Richards, & Lancaster, 1987) was designed to assess attitudes of school age students towards five areas: general computer use, computer- assisted learning, programming and technical aspects, social issues surrounding computers, and computer history. The scale comprises 26 items and covers mainly cognitive aspects, with some items covering the affective domain. This instrument has been administered in the United States (Bear, Richards, & Lancaster, 1987), in South Africa (Pike, Hofer, & Erlank, 1993), in India (Miller & Varma, 1994), in the United Kingdom (Francis & Evans, 1995), in Israel (Katz, Evans, & Francis, 1995) and in Lebanon (Yaghi, 1997). The questionnaire was in English for all studies except the one in Israel, where it was translated into Hebrew. The studies confirmed the uni-dimensional structure of the scale. A scale developed by Francis (1993) measures only the affective dimension. He administered five existing scales to a sample of 378 first year undergraduate students. These are *Computer Survey Scale* (Stevens, 1982), the *Computer Use Questionnaire* (Griswold, 1983), the Computer Attitude Scale (Gressard & Loyd, 1986), and the *Attitude Towards Computers Measure* (Reece & Gable, 1982). The fifth scale was the Bath County Computer Attitude Scale (Bear, Richards, & Lancaster 1987). Using content analysis and exploratory factor analysis the original 93 questions were reduced to 24 questions which were considered to measure the students' attitudes in the affective domain.

One aspect of the affective component of attitude that has received a great deal of attention is anxiety about computers, both about using them and concern about how they may replace humans in the workforce. In fact, one of the factors of Lee's instrument (Lee, 1970) measured the perception of the computer as an autonomous entity capable of supplanting individuals. Many of the multi-dimensional scales include anxiety as a subscale, but there are a number which cover only anxiety itself. Marcoulides (1989) designed the *Computer Anxiety Scale.* It consists of 20 questions and was used with a sample of 145 undergraduate students. Subsequent factor analysis indicated two factors and confirmatory factor analysis supported this model. The two factors cover a general computer anxiety and a more specific equipment anxiety. These factors were strongly correlated. The Computer Anxiety Scale was translated into Chinese (Marcoulides & Wang, 1990; Marcoulides, 1991) and administered to two samples of students, one from Los Angeles, California, the other from Hunan, People's Republic of China. The translated instrument exhibited the same structure as the English one. The Computer Anxiety Scale has also been used outside an educational setting when administered to 320 law enforcement officers in Southern California (Marcoulides, Mayes, & Wiseman, 1995). This study confirmed its structure. Another specific computer anxiety scale called the *Computer Anxiety Factor* was developed by Kernan and Howard (1990). It consists of 14 items and reflects a potential fear of computers and of being excluded from the "computer revolution" (Szajna, 1994). Bandolos and Benson (1990) modified the Computer Attitude Scale to produce another Computer Anxiety Scale of 23 items. The *Computer Anxiety Index* (Maurer & Simonson, 1984 cited in Gardner, Discenza, & Dukes, 1993) examines attitude towards computer from the points of view of avoidance, negative feelings, caution, and disinterest.

Other scales which measure different specific aspects of attitude include the *Computer Apathy and Anxiety Scale* (Charlton & Birkett, 1995) which has three subscales, for apathy, for anxiety, and for societal overemphasis on computers. Apathy is behavioural in nature, anxiety is affective and societal overemphasis is cognitive so this instrument covers three of the four components of attitude. The *Computer Attitudes Scale* (Richards, Johnson, & Johnson, 1986) also has three subscales, liking for computers, perception of computers as a male domain, and the necessity of computers. Of these the first one is affective in nature and the others are cognitive. The *Blomberg-Lowery Computer Attitude Task* (BELCAT) (Erickson, 1987 cited in Gardner, Discenza, & Dukes, 1993) has five subscales which are anxiety, liking, perceived usefulness of computers, success with computers and perception of computers as a male domain. Chen (1986) modified the questionnaire designed by the Minnesota Educational Computing Consortium (Anderson, Klassen, Krohn, & Smith-Cunnien, 1982 cited in Chen, 1986). This scale contained five subscales, Computer Interest, Gender Equality in Computer Use, Computer Confidence, Computer Anxiety, and Respect through Computers.

As can be seen, there are many instruments for measuring attitude towards computers, and different researchers have taken different approaches. In order to compare scales Woodrow (1991a) and Gardner, Discenza and Dukes (1993) in two separate studies administered more than one scale to a group of students. Woodrow (1991a) administered four instruments to 98 student teachers simultaneously. These scales were the Computer Attitude Scale (Gressard & Loyd, 1986), the Computer Use Questionnaire (Griswold, 1983), the Attitudes Toward Computers Measure (Reece & Gable, 1982), and the Computer Survey Scale (Stevens, 1982). Apart from the Computer Use Questionnaire (CUQ), there were strong correlations between the instruments. This may be explained by the fact that the CUQ sampled attitudes only on the cognitive scale, whereas the other three cover more than one aspect of attitude. The study of Gardner, Discenza and Dukes (1993) administered four instruments to 244 undergraduate students. Two of the instruments were the same as the previous study, the Computer Attitude Scale and Attitudes Toward Computers Measure. The other two were replaced by BELCAT (Erickson, 1987) and the Computer Anxiety Index (Maurer & Simonson, 1984 cited in Gardner, Discenza, & Dukes, 1993). Again the scales showed great similarity, indicating that any of them could be used to measure attitude provided they contained the construct of interest. Table 3.1 contains a summary of some of the scales investigated together with their subscales and domains.

Table 3.1
Computer Attitude Instruments and Scales

Name of Scale	Subscales	Domains
Beliefs about Computers (Lee, 1970)	Beneficial Tool Autonomous Machine	Cognitive Cognitive
Computer Attitude Scale (Loyd & Gressard, 1984a)	Computer Anxiety Computer Confidence Computer Liking	Affective Perceived Control Affective
Computer Attitude Scale (Loyd & Loyd, 1985)	Computer Anxiety Computer Confidence Computer Liking Perceived Usefulness	Affective Perceived Control Affective Cognitive
Computer Attitudes Scale (Richards, Richards, & Johnson, 1986)	Liking for Computers Male Domain Necessity for Computers	Affective Cognitive Affective
Attitude Towards Computer Usage (Popovich, Hyde, Zakrajsek, & Blumer, 1987)	Negative reactions to computers Positive reactions to computers Computers and education Reactions to computer-related equipment	Affective Affective Cognitive Affective
Attitude Towards Computers (Reece & Gable, 1982)	General	Cognitive and Affective
Computer Attitude Measure (Kay, 1993)	Affective Home Behaviour Class Behaviour Student Education Personal Use General Cognitive Perceived Control	Affective Behaviour Behaviour Cognitive Cognitive Cognitive Perceived Control
Bath County Computer Attitude Scale (Bear, Richards, & Lancaster, 1987)	General	Cognitive
Computer Apathy and Anxiety Scale (Charlton & Birkett, 1995)	Computer Apathy Computer Anxiety Societal Overemphasis of Computers	Behavioural Affective Cognitive
Affective Attitude Towards Computers (Francis, 1993)	Affective aspects	Affective
Computer Anxiety Scale (Marcoulides, 1989)	General Anxiety Equipment Anxiety	Affective Affective
Computer Use Questionnaire (Griswold, 1983)	Awareness	Cognitive
BELCAT (Erickson, 1987)	Perceived Usefulness Liking Attitude towards Success Male Domain Anxiety	Cognitive Affective Cognitive Cognitive Affective
Computer Anxiety Index (Maurer & Simonson, 1984)	Anxiety	Affective
Computer Anxiety Factor (Kernan & Howard, 1990)	Anxiety	Affective

3.3.2 *Studies involving attitude towards computers*

There have been many studies involving attitudes towards computers and other variables. The independent variable that has attracted most attention is gender. Interest in this stems from the fact that most courses in computing studies, whether at university or secondary level, historically have been associated with mathematics and the sciences. Combined with the considerable number of studies reporting gender differences in attitude towards and achievement in mathematics and science (Hawkins, 1985; Martin & Hoover, 1987; Parker, Rennie, & Fraser, 1996), it would seem likely that such differences would be observable in computing. Munger and Loyd (1989) conducted a study into attitudes towards computers in relationship to performance in mathematics. The Computer Attitude Scale was administered to a group of high school students, together with a measure of mathematics performance. The only subscale that correlated with mathematics performance was confidence in using computers. It is suggested that one reason why the relationship between mathematics performance and computer attitudes is weak is that the use of computers is being introduced into other parts of the curriculum and no longer just part of mathematics. However, a study by Marcoulides (1988) of 72 university students showed that there was a correlation between computer anxiety and mathematical anxiety, indicating that mathematics could still be a factor in computer anxiety.

Results regarding the effect of gender on attitudes towards computers show some inconsistencies, with some studies indicating a significant effect with others showing little or no effect. Shashaani (1993) carried out a study of 1750 secondary school students using an instrument which measured five category variables, namely interest in computers, stereotyping, concept (perceived usefulness) of computers, computer confidence and perceived parents'/teachers' attitude towards computers. The results indicated that there are gender differences in computer attitudes with male students having greater interest in computers, greater confidence in using them, and more likely to see them as a masculine technology. Females reported fear of using computers and feeling helpless around them, yet showed equal competencies to male students in using them. There was no difference in the perceptions of male and females as to the usefulness of computers. Perhaps, the most interesting result of this study was the strong correlation between students' attitudes towards computers and their perception of the attitudes of their parents. It supports the hypothesis that the differences in attitude reflect gender-role socialisation.

A later study of 202 college students (Shashaani, 1997) showed similar results. Males were found to have greater enjoyment in using computers and greater confidence. There was agreement between males and females on gender equality on the use of computers, indicating little stereotyping amongst the students, and on the perceived usefulness of computers. There were significant correlations between the parents' perceived behaviour towards computers and male and female attitudes. For males, the father's view was positively correlated with enjoyment and confidence, and for females, both parents' views were negatively correlated with enjoyment and confidence. These results are supported by a study in the United Kingdom of 144 first year undergraduate students (Colley, Gale, & Harris, 1994). This study employed the Computer Attitude Scale and the *Bem Sex Role Inventory* (Bem, 1974). Males were found to have lower anxiety, higher confidence and greater liking than females. However, when the effects of experience and gender stereotyping were removed, there were no significant gender differences on these measures.

A number of other studies support findings that there is little stereotyping amongst the students themselves. Francis (1994) surveyed 378 first year undergraduate students using the Computer Attitude Scale (CAS) together with two questions related to stereotyping. He found there was no significant differences between the sexes on any of the subscales of the CAS or with respect to stereotyping. Adopting a different approach based on sixteen personality attributes (Siann, Durndell, MacLeod, & Glissov, 1988), Colley, Hill, Hill, and Jones (1995) asked 150 students to rate a male and a female fictitious target figure on these attributes. The results suggested there was little evidence of negative stereotyping of females with respect to computers by fellow students.

There are other studies that have found that gender affects computer attitudes (Temple & Lips, 1989), whereas others find no significant differences (Loyd & Gressard, 1984b; Pope-Davis & Twing, 1991; Busch, 1995). In a study of secondary school students, Woodrow (1994) found that there were minimal gender differences in perception of gender equity in computer classes at grade eight level but the differences were very marked at grade eleven. However, Morse and Daiute (1992) (as cited in Wiburg, 1994-95) questioned the use of quantitative approaches, and using a qualitative methodology found there were no differences in computer anxiety or interest in computers attributable to gender.

One factor that seems to influence computer attitudes is prior computer experience. Chen (1986) in a study of 1138 high school students found that those with more experience with computers had lower anxiety about, greater interest in, and greater confidence about using computers, and this supports the findings of Loyd and Gressard (1984b). A later study by Colley, Gale, and Harris (1994) demonstrates the importance of experience in determining how males and females perceive computers, although Joiner, Messer, Littleton, and Light (1996) found that gender differences persisted even after the effect of experience was taken into account.

The one specific aspect of computer attitude that has received a great deal of attention is computer anxiety. There are studies which indicate that anxiety is reduced by increased exposure to computers (Gilroy & Desai, 1986; Dyck & Smither, 1994), but Rosen, Sears, and Weil (1987) found that there was no change in anxiety levels when students used computers for one to five hours a week. Even computer ownership did not seem to be associated with reduced computer anxiety although it was with increased computer confidence (Motwani & Jang, 1995). Marcoulides (1988) found that computer anxiety is less in students with prior computer experience but it is still present. In the same study he also found that achievement as measured by computer homework assignments was more strongly correlated (negatively) to anxiety than it was to experience. Using multiple regression, it was shown that anxiety as measured on the Computer Anxiety Scale accounts for 53% of the variance in achievement. In a study that was both qualitative and quantitative, Gos (1996) used the Computer Anxiety Index with a group of undergraduate education majors. He concluded that prior computer experience itself does not result in reducing computer anxiety, it is the quality of the prior computer experience that matters. An unpleasant experience with computers can actually increase computer anxiety. Also, the study indicated that in many cases, computer anxiety is actually programming anxiety, caused in many cases by students being given unrealistic programming tasks in introductory courses (Gos, 1996).

It has been found that one of the most effective ways of reducing computer anxiety is to introduce the computer as a tool adapted for a wide range of purposes, such as word processing (Hawkins, 1985). Reed and Liu (1994) examined the effect of programming in BASIC and HyperCard on problem solving and computer anxiety. They found that BASIC programming increased problem solving skills more than HyperCard programming, but a later study (Liu, 1997) showed that problem solving skills increased with more time spent on HyperCard programming. In both studies, the computer anxiety of the students was reduced significantly suggesting a relationship between problem solving and anxiety. Ayersman and Reed (1996) also examined the relationship between programming and anxiety, and found that programming instruction reduced computer anxiety significantly. Another study which looked at anxiety among novice computer users investigated the association of cognitive appraisal, locus of control and level of prior experience with anxiety (Crable, Brodzinski, Scherer, & Jones, 1994). The study involved 425 students undertaking an introductory computer course and it was found that cognitive appraisal had the strongest relationship with anxiety. This suggests that those individuals who assess the computer course as a challenge had exhibited less anxiety than those who viewed the course as threatening. Level of prior experience was also found to have a significant association with anxiety.

One educational aspect that computer experience has been shown to affect is commitment to learning (Levine & Donitsa-Schmidt, 1997). In this study of 309 secondary school students, the researchers considered computer confidence as separate from computer attitudes and demonstrated that a causal model exists such that computer use affects both confidence and attitudes, which in turn affect commitment to learning about computers. The interesting result from this is that the effect of confidence on commitment to learning is negative, indicating that the greater the student's confidence about computers the less the student's desire to learn.

The results of the effect of age on computer attitudes is mixed, with many studies reporting no differences associated with age (Gilroy & Desai, 1986; Massoud, 1991; Woodrow, 1991b). These results could have been because the age differences in the samples were not significant. However, Dyck and Smither (1994) in a study of 219 young subjects (mean age 21.6) and 203 older subjects (mean age 67.7) found that there were significant differences with the older group having less anxiety about computers and greater enjoyment of them. It is suggested that this finding could be associated with the type of computer experience the two groups had and the context in which that experience occurred.

Studies have been carried out into the relationship between a student's individual learning style and computer anxiety (Ayersman & Reed, 1996; Ayersman, 1996). The results indicated that students with certain learning styles tend to exhibit a significantly greater reduction in computer anxiety after a course of study than others. The Convergers were less anxious after the course than either the Divergers or the Assimilators, although there was no significant difference in their anxiety levels before the course.

The way in which a course involving computers is organised has been investigated to see if the course structure affects attitudes. Bohlin and Hunt (1995) conducted a study of 381 students in a course using the subscales of the Computer Attitude Scale as pre-test and post-test measures. Sixteen sections of the course were surveyed. Each section was classified as long (more than 11 weeks) or short (less than 11 weeks), and as meeting infrequently (once a week) or frequently (two to four times a week). All sections met for a total of approximately 60 hours. It was found that students enrolled in long courses had a greater reduction in anxiety and a greater increase in confidence, perception of usefulness and liking for computers than those enrolled in shorter courses. Also, those students in courses that met more frequently had significantly greater improvements in the four attitude measures. Ayersman and Reed (1996) found that only eight hours of class was sufficient to reduce anxiety significantly, but that the reduction was greater if the classes were spread over four weeks rather than being in one day. In a study in which two courses were used, one of 15 hours over 5 weeks, and one of 45 hours over 15 weeks, both groups of students showed a significant decrease in anxiety, but the reduction was not significantly different for the two groups (Ayersman, 1996).

A study into the acceptance of microcomputer technology (Igbaria, Schiffman, & Wieckowski, 1994) used perceived usefulness of computers, perceived fun, anxiety and satisfaction as the dependent variables. A total of 519 managers in 54 companies in the United States were surveyed, using an instrument developed by the authors. They found that perceived usefulness is more influential than fun in determining acceptance of microcomputer technology, but that fun had a greater effect on satisfaction. Computer anxiety affected fun more than usefulness. This study reinforced the importance of computer anxiety in inhibiting computer use.

3.4 Summary

This chapter reviewed the literature pertaining to attitudes towards computers, and many of the studies regarding such attitudes. The focus of the review was the development of instruments and their use in an educational setting, particularly higher education. One observation that is made is that most of the instruments dealt with cognitive and affective aspects, rather than behavioural aspects of attitude.

The aspect of attitude that received the most attention has been anxiety, an emotion that is frequently induced in unfamiliar settings or contexts. For many people using a computer system is a novel activity, and as such can induce anxiety. Some studies discussed in this chapter have shown computer anxiety is negatively associated with achievement. The investigations into the relationship between prior experience and anxiety produced mixed results with some indicating that experience reduces anxiety, whereas others suggest that it depends on the type of experience.

A large number of studies examined the associations between gender and computer attitudes. Many of them showed that attitude was gender-related, but others did not. There were also others that indicated some gender stereotyping about computer use within the community. Other factors that were investigated as possible predictors of computer attitude were course structure, course content, and learning style.

However, one aspect that has not been addressed is the laboratory environment. This study is unique in that it investigates the associations between the psychosocial environment of a computer laboratory and both computer attitudes and achievement.

The next chapter describes the development of an instrument to measure psychosocial aspects of a university computer laboratory environment.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This study involved the development and validation of two instruments, the Computer Laboratory Environment Inventory (CLEI) and the Attitude towards Computing and Computing Courses (ACCC). The former was used to measure students' perceptions of their computer laboratory classes and the latter their attitudes towards computers and their course. The development of the CLEI is described in Chapter 5 and the development of the ACCC in Chapter 6.

This chapter contains a description of the methodology used in the study. A pilot study was employed to develop the two instruments and this is described in Section 4.2. The main study involved the application of the two instruments at Curtin University of Technology in Australia and was followed by further studies in two universities, one in the United Kingdom and the other in the United States. The reason for selecting universities in these three countries is that each uses a different method or combination of methods for providing students with computer laboratory class experience. Sections 4.3, 4.4 and 4.5 outline the courses in the Australian, UK and US studies respectively, and include a description of how laboratory classes are organised together with a description of the samples. The next section reports how the data including those for student achievement were obtained, and this is followed by a section describing how the data were entered in the computer system. The statistical methods used for data analysis are given in section 4.8.

4.2 Pilot Study

In the development of the two instruments, a pilot study was carried out on a group of students from the Curtin Business School in Perth, Western Australia. For convenience of administration, the two instruments were combined into a single questionnaire with questions 1-35 covering the CLEI and questions 36-63 covering the ACCC. Some demographic data covering age, gender, mode of study and course were also collected. Appendix A contains a copy of the original questionnaire.

4.2.1 *Data collection*

Staff from the School of Information Systems at Curtin University who were in charge of units involving a laboratory component were approached and three agreed to participate in the pilot study. The questionnaire was administered during the eleventh week of a fifteen week semester. The researcher attended five laboratory classes, with sufficient copies of the questionnaire and explained the purpose of the research. The students were advised that their participation was voluntary and were assured of the confidentiality of their responses. The completed questionnaires were collected and have remained in the possession of the researcher since that time.

4.2.2 *The sample*

A total of 54 students in three courses participated in the pilot survey. One of the courses was an introductory one for undergraduate Business students, the other two were specialist programming units. In this sample there were 29 females, 21 males and 4 who did not give their gender; 43 students studied full-time and 11 part-time; 29 were under 20 years of age.

4.2.3 *Data entry*

The questionnaires were hand coded by the researcher, checked for errors and the data were entered into SPSS for Windows Release 6.0. Both instruments use a five-point Likert response format. The possible CLEI responses were Almost Never, Seldom, Sometimes, Often and Almost Always. The ACCC responses were Strongly Disagree, Disagree, Not Sure, Agree and Strongly Agree. Both were coded on a five point numeric ordinal scale. Separate columns were allocated for gender, course, mode, and age. Gender was coded as 1 for female, 2 for male; course was coded 1,2, or 3 for the three courses; mode was coded as 1 for part-time, 2 for full-time and age was coded on an ordinal scale for the ranges less than 21, 21 to 25 inclusive, 26 to 30 inclusive, 31 to 35 inclusive, and over 35.

4.2.4 *Data analysis*

The data were prepared for analysis by recoding the reverse-scored items of the questionnaires into separate variables. This enabled the original data to be retained. The questions requiring recoding were numbers 3, 4, 5, 6, 8, 15, 23, 25, 26, 27 and 33 for the CLEI, and 36, 37, 38, 41, 48, 51, 52 and 63 for the ACCC. SPSS was used to calculate alpha reliability and mean correlation coefficients for each of the scales and a factor analysis was performed on each of the two instruments.

4.2.5 *Interviews with staff and students*

Following the pilot study, the findings were discussed with three staff members and five students. The staff members were interviewed individually and the students in a group.

4.3 Australian Study

The Australian study was carried out within the School of Information Systems at Curtin University, using a revised version of the CLEI and the original version of the ACCC. The questionnaire used for this purpose is shown in Appendix B.

4.3.1 *Courses and programmes*

The School of Information Systems is one of the constituent Schools of the Curtin Business School and is responsible for the teaching of computing courses within that School. The undergraduate programmes are majors (or specialisms) of the Bachelor of Commerce, and cover most business areas including Accounting, Economics, Management, Marketing and Information Systems. The computing courses are intended for both specialist and non-specialist students. The specialist courses are part of majors such as Information Systems and Information Technology. They involve the development of information systems through programming, database design, communications and networks. The non-specialist ones are of both an awareness nature and the use of software such as spreadsheets programs. Postgraduate programmes include Master of Commerce degrees, which also have a number of specialisms and a Graduate Diploma in Business Computing, which has been designed for non-computing graduates to change their careers. As with the undergraduate programmes, they include both specialist and non-specialist courses.

Most courses which involve a laboratory component have a teaching pattern consisting of a lecture, a tutorial and a laboratory class. For these courses, there is normally only one lecture which is all students attend. For very large units, in excess of 300 students, there will be two or more lectures, but the student attends only one of them. Tutorials and laboratory classes have up to 20 students. There is a single course controller who usually delivers the lecture and organises the complete course, deciding on tutorial content, setting assignments, laboratory exercises and the final examination.

4.3.2 *Availability of laboratory classes*

Laboratory classes are scheduled as part of a course, usually for two hours per week for each student. These are closed laboratory classes, with a class size of 15 to 20 students and supervised by a tutor who is a member of the academic staff. For introductory courses, the staff member is assisted by a laboratory demonstrator. The laboratories are available outside class times provided that another class is not scheduled in them. No assistance is provided within the laboratory setting outside scheduled classes, and access to the laboratories is unregulated during these times.

4.3.3 *Data collection*

All staff from the School of Information Systems at Curtin University who were in charge of units involving a laboratory component were approached. Nine agreed to participate and each was provided with sufficient copies of the revised questionnaire. A covering letter was attached to the questionnaire and this explained the purpose of the research. The students were advised that their participation was voluntary and were assured of the confidentiality of their responses. The survey was carried out in the eleventh week of the semester. To obtain information about each student's achievement, the student's number was requested. These were the most sensitive data requested, and giving the number was made optional even for those who completed the rest of the survey. The completed questionnaires were collected by the staff member, sent to the researcher and have remained in his possession ever since. Data relating to means and standard deviations of grades in the courses were obtained from statistics produced by the University's Examinations Section.

A student's achievement on the course was measured by the overall grade awarded by the lecturer. This grade is a percentage and is contributed to by examinations, assignments and laboratory exercises. It was used as the most convenient and least invasive method of measuring student achievement. Given that any other form of objective measure would have to have been administered towards the end of semester, the researcher felt that this would unfairly interfere with the students' preparation for the final examination. Using individual components of assessment to measure achievement leads to a problem of consistency as assignments and laboratory exercises are marked by tutors, and there could be as many as 10 tutors involved in a course. It is recognised that using overall grade for measuring achievement also has a consistency problem, but it will be smaller than using individual components of assessment. The grade for each student as a mark out of 100 was obtained by the researcher from the University's student record system.

4.3.4 *The sample*

The questionnaires were administered to 208 students in 10 courses from 29 different programmes. They covered both postgraduate and undergraduate courses. The total number of students enrolled in these courses was 777, although only 450 were provided with questionnaires giving a response rate of 46%. Of the 208 who responded, 142 provided their student number allowing their grade to be determined, a response rate of 68%.

4.4 United Kingdom Study

The United Kingdom study took place in the School of Computing and Mathematics at the University of Teesside.

4.4.1 *Courses and programmes*

The School of Computing and Mathematics offers a wide variety of programmes at both the undergraduate and postgraduate level, and most of them include courses which have an integral laboratory component. The undergraduate programmes include both Bachelor of Science degrees and Higher National Diplomas, a two year sub-degree programme. The specialisations at the Bachelor of Science level are Computer Science, Software Engineering, Business Computing, Information Technology, Information Sciences, International Business / Information Technology, Visualisation, and Information Society. At the Master's level, the School offers programmes in Computer Aided Graphical Technology Applications, Information Technology, Medical Informatics, and Multimedia Applications. Overall, courses are organised in a manner similar to Curtin University with a single large lecture, plus smaller tutorials and laboratory classes.

4.4.2 *Availability of laboratory classes*

As with the Australian courses, laboratory classes are scheduled and they are supervised by a member of the academic staff but without assistance from laboratory demonstrators. Class size is no more than 20 students. Access to laboratories outside scheduled classes is controlled with a limit placed on the length of time any student can spend on a computer at one time. In addition to general laboratories, there are also a number of specialist laboratories to which access is restricted to students on a particular course.

4.4.3 *Data collection*

Staff in charge of a number of courses were approached and eight agreed to participate. A covering letter specifically for the UK study was produced, and this is shown in Appendix C. The questions to elicit demographic information was modified to meet local terminology, and the UK questionnaire is also shown in Appendix C. Sufficient copies of the questionnaire were prepared for each class. The survey was carried out in the latter half of the UK semester. The researcher attended each class, explained to the students the purpose of the research and assured them of confidentiality. The completed questionnaires were collected and have remained in the researcher's possession ever since.

4.4.4 *The sample*

The sample consisted of 107 students from 8 courses in 5 programmes at sub-degree, undergraduate and postgraduate levels. The sample was selected by choosing those staff who would allow their students to participate, so it is best described as a sample of convenience (Rudestam & Newton, 1992, p. 64).

4.5 United States Study

The United States study was carried out within the Department of Management Science and Information Systems, California State University, Fullerton.

4.5.1 *Courses and programmes*

The Department of Management Science and Information Systems is part of the School of Business Administration and Economics, which offers programmes at the undergraduate and postgraduate levels. At the undergraduate level, there is a Bachelor of Arts in Business Administration with concentrations in Accounting, Business Economics, Finance, Management, Management Information Systems, Management Science, and Marketing. In addition, there is a Bachelor of Arts in Economics, and one in International Business with concentrations in a number of languages. There are minors in Business Administration, Economics and Management Information Systems. At the postgraduate level, there are a number of Masters programmes including a Master of Business Administration with various concentrations and a Master of Science in Management Science. In a manner similar to the School of Information Systems at Curtin University, the Department of Management Science and Information Systems is responsible for the teaching of computing courses, both specialist and non-specialist, on these programmes.

Courses are organised differently from either the Australian or United Kingdom universities that were surveyed. A professor runs a course with up to 45 students in it and is solely responsible for the content, structure and assessment of that group of students. There are similar courses run by other professors. Decisions regarding laboratory use is made by the professor, who may attend laboratory classes when this is deemed necessary.

4.5.2 *Availability of laboratory classes*

Both open and closed laboratories are available. Some courses do have scheduled laboratory classes, with the number of students in the class being as many as 40. These classes are run by the faculty member usually without assistance. The closed laboratories are not available outside scheduled hours. The main provision of laboratory experience is through open laboratories. These are never scheduled for classes and access to them is controlled with the time any student can spend on a computer at one time being limited.

4.5.3 *Data collection*

A professor within the Department of Management Science / Information Systems agreed to allow students in his classes to participate in the study. After discussions, question 58 of the original questionnaire was changed, as were the questions relating to demographic information. The reason for changing question 58 was that the term 'tertiary' to describe post-secondary education is not in common use within the United States; it was replaced by 'university'. In the questions relating to demographic information, country of birth was replaced by ethnic background, and no request was made for student number or method of fee payment as these were considered to be too sensitive. The covering letter was also changed. The modified questionnaire and letter are shown in Appendix D. Sufficient copies of both the letter and questionnaire were provided for the classes. They were distributed to the students in a class during the final two weeks of a semester. After completion, they were collected and returned to the researcher. They have been in the researcher's possession since that time.

4.5.4 *The sample*

The sample consisted of 72 undergraduate students in one course. All were undergraduate students from the Bachelor of Arts (Business Administration) degree program but from 13 different concentrations (specialisms). As with the United Kingdom study, this sample is best described as a sample of convenience.

4.6 Data Entry

The questionnaires were hand coded by the researcher, checked for errors and the data were entered into SPSS for Windows Release 6.0. Both instruments use a five-point Likert scale and these were coded on a five point numeric ordinal scale. Separate columns were allocated for gender, mode, age, course, programme, country of study, country of birth, method of fee payment and final grade. For the US study, country of birth was replaced by ethnic group. All of these variables except final grade were given ordinal codes and these are specified in Appendix E. Final grade was only available for the Australian study.

4.7 Data Analysis

The data were prepared for analysis by recoding the reverse-scored items of the questionnaires into separate variables. This enabled the original data to be retained. The questions requiring recoding were numbers 3, 4, 5, 6, 8, 15, 23, 26, 27, 30 and 33 for the CLEI, and 36, 37, 38, 41, 48, 51, 52 and 63 for the ACCC. Missing values were replaced by the mean of the available responses. This was done on a group basis, taking country of study as the criterion of group membership. This technique is conservative in that it will change the mean very little, but will reduce the group variance (Tabachnick & Fidell, 1996, p. 63). The grade was converted into a standardised z-score on a course basis using the means and standard deviations of the grades of all students on a particular course.

SPSS was used for most of the data analysis. Firstly, factor analysis was performed on the two instruments separately. Alpha reliability and mean correlation coefficients were calculated for each of the scales in all three studies. Correlation and regression analyses were performed. Finally, AMOS 3.6 (AMOS, 1996) was used for structural equation modelling of the Australian study.

4.8 Summary

This chapter has described the situation regarding the pilot study, and three subsequent major studies in Australia, the United Kingdom, and the United States. Outlines are given of the programmes and courses being undertaken by the students who participated in this study, together with the way in which the courses are organised and the role of computer laboratories.

The next chapter describes the development and validation of the Computer Laboratory Environment Inventory, including the role of the pilot study and the interviews with staff and students.

CHAPTER 5

THE COMPUTER LABORATORY ENVIRONMENT INVENTORY

5.1 Introduction

This chapter describes the development of the Computer Laboratory Environment Inventory (CLEI), an instrument for measuring aspects of a computer laboratory classroom environment. Section 5.2 describes the rationale and philosophy underlying the CLEI and how the original scales were determined. Section 5.3 gives the analysis of the pilot study of 54 Information Systems students. In light of the pilot study results, the instrument was refined and this is described in section 5.4. Finally, section 5.5 provides the reliability and validity statistics for the Australian sample of 208 students.

5.2 Development of the Original Instrument

The instrument for assessing computer laboratory environment is based on the actual version of the personal form of the Science Laboratory Environment Inventory designed by Fraser, Giddings, and McRobbie (1991). The SLEI has five scales Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment, using seven items per scale. It was designed with the following five criteria in mind:

1. Consistency with the literature on laboratory teaching
2. Consistency with instruments for non-laboratory settings
3. Coverage of Moos' general categories (Moos, 1974)
4. Salience to teachers and students
5. Economy

(Fraser, McRobbie, & Giddings, 1993)

Table 5.1 shows descriptive information for each of the scales, together with the classification according to Moos' dimensions.

Table 5.1
Descriptive Information for the Scales of the Science Laboratory Environment Inventory

Scale Name	Description	Moos' Category
Student Cohesiveness	Extent to which students know, help, and are supportive of each other	Relationship
Open-Endedness	Extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation	Personal Development
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	Personal Development
Rule Clarity	Extent to which behaviour in the laboratory is guided by formal rules	System Maintenance
Material Environment	Extent to which the laboratory equipment and materials are adequate	System Maintenance

Source: Fraser, McRobbie, & Giddings (1993)

The SLEI was field tested and subjected to item and factor analysis. The field testing was performed on a cross-national basis by administration to secondary students in Australia, USA, Canada, England, Israel, and Nigeria. It involved 3227 students in 198 classes in 40 schools. The Cronbach alpha coefficient which measures the internal consistency of each scale varied from 0.70 to 0.83; the mean correlation with other scales varied from 0.07 to 0.37 indicating that there is little overlap in what the scales are measuring. In addition, it was shown that the instrument was able to differentiate between the perceptions of students in different classrooms.

Given the reliability and validity of the SLEI, it was decided to use it as the basis of the Computer Laboratory Environment Inventory (CLEI). However, although there are similarities between science and computer laboratories, there are also fundamental differences. From the scales of the SLEI, Student Cohesiveness, Integration, Open-Endedness and Material Environment were retained but Rule Clarity was removed. The reasoning behind this decision was that the nature of a computer laboratory class is such that rules tend to be restricted to "No food or drink in this laboratory", or deal with the legal and appropriate use of software, whereas in a science laboratory, the primary purpose of rules is for student safety (Collette & Chiappetta, 1995).

Two other instruments were also examined for suitable scales. These were the Geography Classroom Environment Inventory (GCEI) (Teh & Fraser, 1995) and the Computer Classroom Environment Inventory (CCEI) (Maor & Fraser, 1993). The GCEI was devised for computer-assisted learning classrooms and has four scales, Gender Equity, Investigation, Innovation and Resource Adequacy. The CCEI was designed for inquiry-based classrooms and has five scales, Investigation, Open-Endedness, Organisation, Material Environment and Satisfaction. Tables 5.2 and 5.3 give descriptions of each of the scales of GCEI and CCEI respectively. Investigation was rejected as being too specific to inquiry-based classrooms, and Innovation was seen as being more relevant to CAL classes than to general computer laboratory classes. Satisfaction is really an affective outcome of the class rather than an environment variable. Although Gender Equity is an important factor with respect to all aspects of teaching, it was rejected as a possible scale. However, it was intended to include gender as a variable so that gender-based analysis could be conducted. Organisation was also rejected on the grounds of economy of the questionnaire and the belief that some of the organisational aspects would overlap with Integration. The two remaining scales were Resource Adequacy from GCEI and Material Environment from CCEI. Both seem to cover a similar perception, which is the extent to which the computer hardware and software are adequate. This is an important aspect of a computer laboratory class environment, and a necessary scale of the CLEI. An examination of the questionnaire of the GCEI shows that the Resource Adequacy scale covers the physical environment of the laboratory as well.

The researcher sees adequacy of the technology and the physical environment as separate scales.

Table 5.2
Descriptive Information for the Scales of the Geography Classroom Environment Inventory

Scale Name	Description
Gender Equity	Extent to which boys and girls are treated equally by the teacher
Investigation	Extent to which the skills and processes of inquiry are used in problem-solving and investigation
Innovation	Extent to which the teacher plans new and varying activities and techniques, and encourages students to think creatively
Resource Adequacy	Extent to which the computer hardware and software are adequate

Source: Teh & Fraser (1995)

Table 5.3
Descriptive Information for the Scales of the Computer Classroom Environment Inventory

Scale Name	Description
Investigation	Extent to which the student is encouraged to engage in enquiry learning
Open-Endedness	Extent to which the computer activities emphasise an open-ended, divergent approach to inquiry
Organisation	Extent to which classroom activities are planned and well organised
Material Environment	Extent to which the computer hardware and software are adequate and user friendly
Satisfaction	Extent to which the student is interested in using the computer and in conducting investigations

Source: Maor & Fraser (1993)

One of the new scales for the CLEI was called Technology Adequacy and it measures the suitability of the technology for the task required. This would be ascertained by answers to questions such as, "is the software suitable for the specified tasks?" and "is the hardware powerful enough to handle the number of users?". The Material Environment was retained in the original version of the CLEI, and measured the suitability and availability of the computer laboratory itself. Table 5.4 shows descriptive information for the original version of the CLEI and Appendix A shows the actual questionnaire.

Table 5.4
Descriptive Information for the Scales of the Original Version of the Computer Laboratory Environment Inventory

Scale Name	Description	Moos' Category
Student Cohesiveness	Extent to which students know, help, and are supportive of each other	Relationship
Open-Endedness	Extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation	Personal Development
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	Personal Development
Technology Adequacy	Extent to which the hardware and software is adequate for the tasks required	System Maintenance
Material Environment	Extent to which the laboratory is suitable and available for use	System Maintenance

5.3 Pilot Study

The original CLEI questionnaire was administered in a pilot study to a group of 54 students from the Curtin Business School. The Attitude towards Computers and Computing Courses Questionnaire (see Chapter 6) was also administered but minimal demographic data were collected. Table 5.5 shows some statistical information from this study regarding reliability and discriminant validity. The Cronbach alpha coefficient varies from 0.51 to 0.93, showing that the internal consistency for at least three of the scales is reasonable. The mean correlation with the other scales varies from 0.13 to 0.25 showing that there is little overlap in what the scales are measuring.

Table 5.5
Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the CLEI in the Pilot Study

Scale	Alpha Reliability	Mean Correlation
Student Cohesiveness	0.81	0.13
Open-Endedness	0.51	0.15
Integration	0.93	0.19
Technology Adequacy	0.72	0.25
Material Environment	0.55	0.23

The alpha reliability for Open-Endedness seems low at 0.51, but this is consistent with some of the values obtained in the cross-national study of Fraser, McRobbie, and Giddings (1993). In that study, this coefficient varied from 0.78 for England to 0.49 for Nigeria. It was on these grounds that the Open-Endeness scale was retained. The coefficient for Material Environment also seems low.

Using SPSS for Windows, a principle components analysis was carried out in order to examine further the internal structure of the questionnaire. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for factor analysis was 0.54 which is classed as *miserable* but acceptable (Norusis, 1990). The scree plot (Cattell, 1966) is shown in Figure 5.1 and this indicates five factors. A principal factor analysis was performed to extract five factors. This was followed by a varimax rotation to generate orthogonal factors.

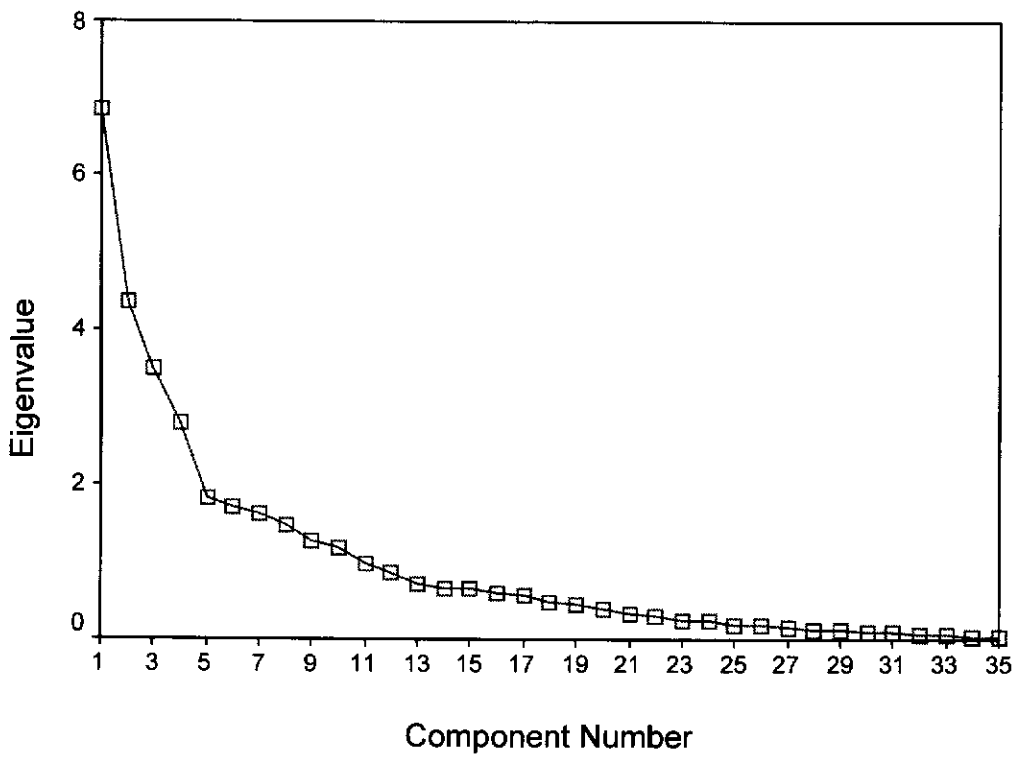

Figure 5.1. Scree plot for pilot study of the CLEI

Table 5.6 shows the factor loadings obtained for the 54 students. The reported loadings are those that are greater than or equal to the accepted 0.30 for analyses involving the individual as the unit of analysis (Kline, 1994).

A number of observations can be made about these results.

- All the a priori items for Integration have loadings of at least 0.30
- Six out of seven a priori items for the scales Student Cohesiveness, Open-Endedness and Technology Adequacy have loadings of at least 0.30
- Material Environment has three out of seven a priori items with loadings of at least 0.30
- Items 15, 27 and 25 do not load onto any of the five scales
- The percentage of variance explained by these factors is 48.8

Table 5.6
Factor Loadings for Original Version of CLEI after Varimax Rotation

Item Number	Student Cohesiveness	Open-Endedness	Integration	Technology Adequacy	Material Environment
1	0.68				
6	0.61			0.35	
11	0.83				
16	0.88				
21	0.71				
26	0.58		0.36		
31				0.38	
2		0.37			
7	0.37	0.41			
12		0.48			
17		0.47	0.49		
22		0.60			
27					
32		0.35		0.57	
3			0.74		
8			0.90		
13			0.82		
18			0.80		
23			0.79		
28			0.86		
33			0.74		
4			0.30		
9				0.54	
14				0.61	
19			0.33	0.45	
24		0.35		0.54	0.37
29				0.79	
34		0.38		0.68	
5		0.55			0.41
10					0.78
15					
20					0.64
25					
30				0.36	
35		0.42		0.41	
% Variance	10.7	6.5	16.3	10.2	5.1
Eigenvalue	4.35	2.79	6.84	3.49	1.83

5.4 Refining the Instrument

The results of the factor analysis suggest that the scales of the instrument need some refinement. The Integration scale is satisfactory as it stands. Technology Adequacy needs an item to replace item 4. Both the Student Cohesiveness and Open-Endedness scales item were taken directly from the SLEI and have undergone thorough field testing. In the light of this it was decided to leave these scales unchanged. The scale requiring greatest change is Material Environment as only three of the a priori items load onto it and two of them do not load onto any of the scales. This suggests that the items from the Material Environment scale are actually measuring at least two distinct aspects of the laboratory environment. A re-examination of the questions supports this, as items 10 and 20 concern availability, items 15, 25, 30 and 35 concern the physical environment, and item 5 both.

Discussions took place with both staff and students involved in the courses. From these discussions, it became clear that the physical environment of a computer laboratory is of much less importance than other factors, in particular the availability of the laboratories for student use. This is understandable at the university level, where students are required to complete laboratory-based assignments and exercises outside the normal scheduled classes. As mentioned earlier, two items cover this in the Material Environment scale, but it was decided to replace Material Environment with a new scale called Laboratory Availability. This scale measures the extent to which the laboratory and computers are available for use. Table 5.7 gives descriptive information on the revised version of the CLEI, Appendix F gives the items in each scale and Appendix B contains the actual questionnaire.

Table 5.7
Descriptive Information for the Scales of the Revised Version of the Computer Laboratory Environment Inventory

Scale Name	Description	Moos' Category
Student Cohesiveness	Extent to which students know, help, and are supportive of each other	Relationship
Open-Endedness	Extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation	Personal Development
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	Personal Development
Technology Adequacy	Extent to which the hardware and software is adequate for the tasks required	System Maintenance
Laboratory Availability	Extent to which the laboratory and computers are available for use	System Maintenance

The revised CLEI was administered to 208 students taking courses within the Curtin Business School. All courses involved a laboratory component. The sample was representative with respect to gender, age, mode of study, and level of study (undergraduate / postgraduate). The classes surveyed included those in which the development of software was the focus of study, such as Information Systems, and others in which the computer was used as a tool for word processing, spreadsheets and access to the Internet. The computer systems used were standalone PCs, networked computers, or a multi-access system.

Again, in order to examine the internal structure further, a principal components analysis was carried out on the 35 items. The KMO measure of sampling adequacy was 0.78 which is classed as *middling* (Norusis, 1990). The scree plot is shown in Figure 5.2 and indicates either five or nine factors. For simplicity and because it conformed to the proposed structure, the five factor structure was investigated. A principal factor analysis was performed to extract five factors and this was followed by a varimax rotation. The factor loadings for the five scales of the CLEI are shown in Table 5.8

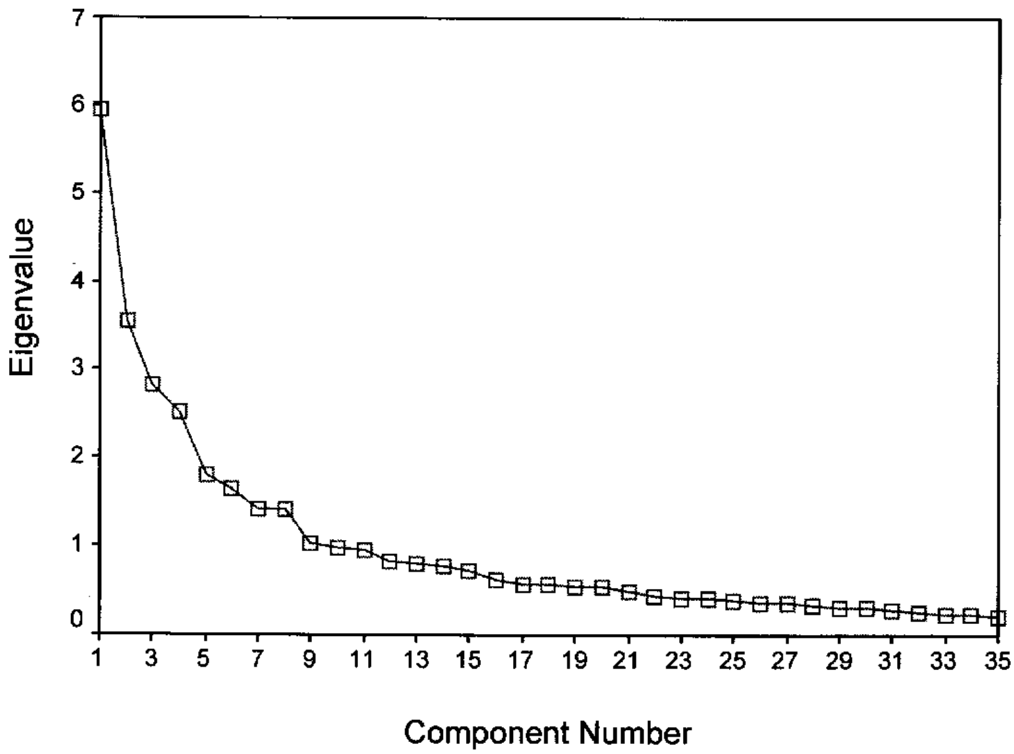

Figure 5.2. Scree plot for CLEI with the Australian sample

The following observations may be made from the factor analysis of the revised version of the CLEI.

- All the a priori items for Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability had loadings of at least 0.30 on the appropriate scale
- Six out of seven a priori items for Student Cohesiveness had loadings of at least 0.30
- The only items that loaded onto scales in addition to their a priori scales were items 2 and 35.
- Item 6 does not load on any factor with a weighting greater than 0.3
- The percentage of variance explained by these factors is 39.4

Table 5.8
Factor Loadings for Revised Version of CLEI after Varimax Rotation

Item Number	Student Cohesiveness	Open-Endedness	Integration	Technology Adequacy	Laboratory Availability
1	0.60				
6					
11	0.56				
16	0.66				
21	0.63				
26	0.30				
31	0.31				
2	0.31	0.33			
7		0.46			
12		0.50			
17		0.41			
22		0.39			
27		0.30			
32		0.59			
3			0.72		
8			0.78		
13			0.75		
18			0.68		
23			0.73		
28			0.68		
33			0.80		
4				0.32	
9				0.59	
14				0.69	
19				0.62	
24				0.55	
29				0.73	
34				0.79	
5					0.57
10					0.65
15					0.72
20					0.48
25					0.56
30					0.57
35				0.34	0.59
% Variance	5.8	4.7	11.7	9.1	8.0
Eigenvalue	2.52	1.81	5.94	3.56	2.84

Item 6 does not load onto any of the scales. Its a priori scale is Student Cohesiveness, one of the original scales of the SLEI, so it was decided to leave it unchanged. Item 2 loads on both Open-Endedness, its a priori scale, and Student Cohesiveness.

However, as Open-Endedness is one of the original scales of the SLEI, it was left unchanged. Item 35 loads onto both Technology Adequacy and Laboratory Availability, but with a higher weighting on the latter, its a priori scale, than the former. It is accepted that there is going to be some overlap in what these two scales measure, and so it was decided to leave the scales as they had been formulated with the items as given in Appendix F. The percentages of the total variance extracted by the five factors is reasonable and is similar to that obtained for the SLEI when the individual is used as the unit of measure (Fraser McRobbie, & Giddings, 1993). Taking into account the issues regarding items 2, 6 and 35, the factor analysis confirms the structure of the CLEI.

5.5 Reliability, Discriminant Validity and Predictive Validity

Table 5.9 reports some statistical information about the revised CLEI when used with the sample of 208 students. The Cronbach alpha reliability coefficients presented in the table show that for the seven item scales the alpha reliability figures ranged from 0.60 to 0.89. According to Nunnally (1967), a reliability coefficient of 0.60 or greater is acceptable, so the values of each scale indicate that they are satisfactory in terms of their internal consistency. The mean correlation of a scale with the other scales of the questionnaire is accepted as a measure of discriminant validity and is the extent to which the scales are unique in what they are measuring. Table 5.9 indicates that the mean correlations of the scales of the CLEI ranged from 0.08 to 0.22, indicating that there is little overlap in what they measure.

Table 5.9
Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the Revised CLEI

Scale	Alpha Reliability	Mean Correlation
Student Cohesiveness	0.66	0.13
Open-Endedness	0.60	0.08
Integration	0.89	0.15
Technology Adequacy	0.81	0.18
Availability	0.81	0.22

A desirable characteristic of a classroom environment instrument is its ability to discriminate between different classes, with class membership being the grouping factor. For this research, data regarding class membership were not collected so this analysis could not be performed. However, for the courses within the Curtin Business School that require a laboratory component the course itself is a natural unit for differentiation. Irrespective of the number of students enrolled in a course, there is only one lecturer in charge of that course. Students attend a lecture, a tutorial and a formal laboratory class. For courses with a small enrolment, the lecturer runs all classes, but for other courses, they are supported by tutors and in some cases, laboratory demonstrators. The course content for both lecture and tutorial is decided upon by the lecturer, and they set all laboratory exercises, assignments, and examinations. They also make decisions on the hardware and software to be used, within the constraint of availability and resources. From the point of view of the CLEI, all the scales would seem to be affected more by the course than by the individual class. The only scale where class membership is a possible major influence is Student Cohesiveness, and even for this there will be factors attributable to the course itself. In the study, students from ten different courses were surveyed and each of these had its own characteristics, covering relationship between laboratory and non-laboratory classes, type of computer system, level of course, students' prior familiarity with the computer environment and expectation of staff regarding student's ability to work independently. Table 5.10 shows the characteristics for each of the courses involved in the study.

The characteristics for each course have been obtained from knowledge of course objectives, course design, computer system used, and from the lecturer in charge. From the table it can be seen that none of the courses has exactly the same set of characteristics. These characteristics contribute to the computer laboratory environment, some directly such as Integration, others by a more indirect means. For example, there are only two laboratories that allow access to the multi-access computer, so this may affect perceptions of Laboratory Availability. Based on these different characteristics and the way courses are organised, it was decided to use course as the unit of discrimination.

Table 5.10
Characteristics of Courses Surveyed

Course	Close Integration	Computer Type	Level	Familiarity	Expectation
Information Systems 100	No	Standalone	General Introductory	Low	Low
Personal Computing 211	Yes	Standalone	General Intermediate	Medium	High
Program Design 102	Yes	Multi-access	Specialist Introductory	Low	Low
Systems Implementation 202	Yes	Multi-access	Specialist Intermediate	High	High
Database Systems 202	No	Multi-access	Specialist Intermediate	High	High
Transaction Processing Systems 302	Yes	Multi-access	Specialist Advanced	High	High
Distributed Systems 302	Yes	Network	Specialist Advanced	Medium	High
Business Microcomputing 311	Yes	Standalone	General Advanced	High	High
Distributed Systems 502	Yes	Network	Specialist Intermediate	Low	Medium
Systems Implementation 502	Yes	Multi-access	Specialist Intermediate	Low	Medium

A one-way ANOVA was performed on each of the scales using Course as the grouping factor, and the results are presented in Table 5.11.

The results show that each scale differentiated significantly ($p < .01$) between courses. The eta^2 statistic measures the amount of the variance that can be attributed to the course, and it varies from 0.12 for Technology Adequacy to 0.34 for Integration. This indicates that the CLEI is able to differentiate between students on the basis of the course being taken.

Table 5.11
Results of ANOVA on Scales of CLEI using Course as Factor

Variable	F Value	eta^2
Student Cohesiveness	3.83^{***}	.16
Open-Endedness	5.08^{***}	.20
Integration	10.48^{***}	.34
Technology Adequacy	2.91^{**}	.12
Laboratory Availability	4.16^{***}	.17

$^{**}p < .01$, $^{***}p < .001$

5.6 Summary

This chapter has described the development of an instrument for measuring various aspects of a computer laboratory environment. A pilot study was used to investigate the reliability and factorial validity of an instrument which was closely based on the Science Laboratory Environment Inventory. This study showed that the instrument had a number of overlapping scales and could be improved by being modified. This was done following interviews with staff and students. Factor analysis of the data obtained in the Australian study using the revised instrument, called the Computer Laboratory Environment Inventory, demonstrated that it has the structure ascribed to it during the development of the questionnaire. The individual scales were shown to have satisfactory reliability, discriminant validity, and ability to differentiate between courses. This meant that the instrument was able to be used with confidence in the investigations into associations between computer laboratory classroom environments and student outcomes described in later chapters of this thesis.

The next chapter describes the development and validation of the second instrument used in this study, the Attitude towards Computers and Computing Courses Questionnaire.

CHAPTER 6

THE ATTITUDE TOWARDS COMPUTERS AND COMPUTING COURSES QUESTIONNAIRE

6.1 Introduction

This chapter describes the development of an instrument for measuring four aspects of a student's attitude towards computers and computing courses. The instrument is called the Attitude towards Computers and Computing Courses Questionnaire (ACCC). Section 6.2 gives the background and philosophy underlying its design. Section 6.3 gives results, including a factor analysis, when it was administered to a pilot group of 54 Information Systems students. Following the pilot study, the instrument was administered to 208 students from the Curtin Business School. Section 6.4 describes the results obtained from a factor analysis of these data. Finally, section 6.5 discusses the reliability and discriminant validity of each of the scales.

6.2 Development of the Instrument

The instrument for measuring the attitude towards computers and computing courses is based on a number of other instruments. As was described in Chapter 3 of this thesis there are many instruments for measuring computer attitude and these contain a number of different scales. The instrument used as the basis for the Attitude towards Computers and Computing Courses Questionnaire (ACCC) was the Computer Attitude Scale (Loyd & Loyd, 1985). This contains four scales which are Anxiety, Confidence, Enjoyment or Liking for, and Perceived Usefulness of Computers. All scales except Confidence were used in the ACCC. Confidence was rejected on two grounds. Firstly, a need for economy in the questionnaire and secondly, confidence is highly correlated with anxiety (Loyd & Loyd, 1985; Gressard & Loyd, 1986). Indeed, in one study (Levine & Donitsa-Schmidt, 1997) confidence is treated as a separate variable from attitude, but it both influences and is influenced by attitude. Other instruments were also examined and they contained a number of other scales. These included Apathy (Charlton & Birkett, 1995), Equipment Anxiety (Marcoulides, 1989), Impact of Computers on Society (Raub, 1981 cited in Gardner, Discenza & Dukes, 1993), and Computers as a Male Domain (Erickson, 1987). The decision was made to restrict the number of scales for measuring aspects of attitude towards computers to three. This was done on the grounds of economy. The three chosen were anxiety, enjoyment and perceived usefulness of computers. Anxiety was chosen as it has been included in almost all instruments for measuring computer attitude, and the use of technology would appear to be associated with anxiety (Rosen, Sears, & Weil, 1987). Both enjoyment and perceived usefulness of computers were included as these are known to be associated with motivation (Levine & Donitsa-Schmidt, 1997). Finally, because a major aspect of the study described in this thesis was the effectiveness of computer laboratories as learning environments, a fourth scale was added to measure the perceived usefulness of the course. Each scale consists of seven items with each item being measured on a Likert scale from 1 (strongly disagree) to 5 (strongly agree), with some of the items being negatively scored. A copy of the instrument is given in Appendix B.

Table 6.1
Descriptive Information for the Scales of the Attitude Towards Computers And Computing Courses Questionnaire

Scale Name	Description	Domain
Anxiety	Extent to which the student feels nervous or uncomfortable using a computer	Affective
Enjoyment	Extent to which the student enjoys using a computer	Affective
Usefulness of Computers	Extent to which the student believes computers are useful	Cognitive
Usefulness of Course	Extent to which the student found the course useful	Cognitive

This instrument consists of two affective attitudinal scales, Anxiety and Enjoyment and two cognitive attitudinal scales, Usefulness of Computers and Usefulness of the Course. Descriptions of them together with the domain they cover are given in Table 6.1. Appendix G gives the items in each of the four scales.

6.3 The Pilot Study

The ACCC questionnaire was administered in a pilot study to a group of 54 students from the Curtin Business School along with the original version of the CLEI (see Chapter 5). Table 6.2 shows some statistical information from this study. The Cronbach alpha coefficient varies from 0.74 to 0.91, showing that the internal consistency for all the scales is reasonable (Nunnally, 1967). The mean correlation with the other scales varies from 0.23 to 0.52 showing that there is some overlap in what the scales are measuring. However the mean correlations are considerably less than the reliability coefficients indicating that the scales do measure distinct aspects of attitude.

Table 6.2
Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the ACCC in the Pilot Study

Scale	Alpha Reliability	Mean Correlation
Anxiety	0.85	0.37
Enjoyment	0.91	0.52
Usefulness of Computers	0.74	0.46
Usefulness of Course	0.74	0.23

In order to examine the internal structure further, a factor analysis was carried out on all items. Using SPSS for Windows, a principal components analysis was performed to determine the number of factors. The KMO measure of sampling adequacy was 0.69 which is classed as *mediocre* (Norusis, 1990). The scree plot (Cattell, 1966) is shown in Figure 6.1 and indicates four factors. A principal factor analysis was carried out to extract four factors and this was followed by a varimax rotation. Table 6.3 shows the factor loadings for these factors obtained for the sample of 54 students.

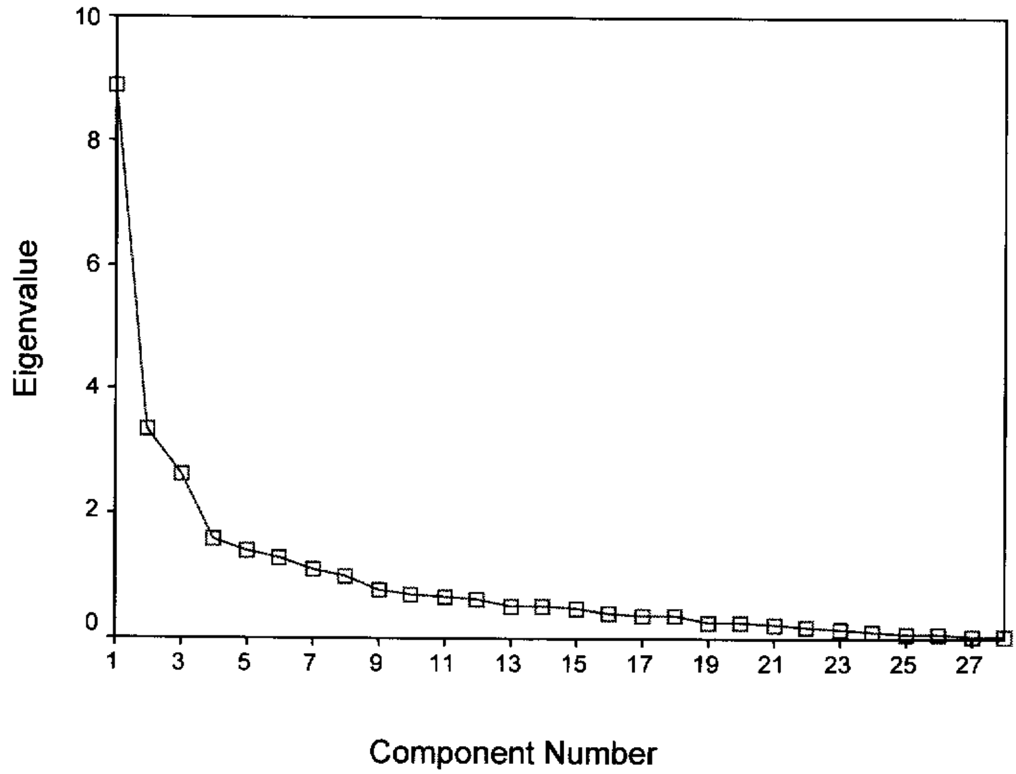

Figure 6.1. Scree plot for pilot study of the ACCC

The reported loadings are those that are greater than or equal to the accepted 0.30 for analyses involving the individual as the unit of analysis (Kline, 1994).

A number of observations may be made about these results.

- All the a priori items of the Usefulness of Course scale load onto Factor 3;
- Six out of seven a priori items for the Anxiety scale load onto Factor 2;
- All a priori items from both the Enjoyment and Usefulness of Computers scale except for item 38 load onto Factor 1;
- The percentage of variance explained by these factors is 52.4.

Table 6.3
Factor Loadings on Four Factors of the ACCC for the Pilot Study after Varimax Rotation

Item Number	Factor 1	Factor 2	Factor 3	Factor 4
36			0.59	
40	0.37		0.68	
44			0.77	0.34
48			0.32	
52		0.33	0.58	
56			0.36	0.64
60			0.47	0.34
37	0.52			
41	0.54	0.63		
45		0.71		
49		0.79		
53		0.75		
57		0.83		
61		0.76		
38				
42	0.56			0.48
46	0.39			
50	0.55	0.38		
54	0.54			
58	0.57			
62	0.69			
39	0.77			
43	0.73	0.32		
47	0.77			
51	0.60			
55	0.77			
59	0.67			
63	0.67			
% Variance	23.4	14.7	9.1	5.2
Eigenvalue	8.91	3.34	2.63	1.60

As it was believed that these factors were correlated, the analysis was repeated with a direct oblimin rotation with $\delta=0$. The results are shown in Table H1 in Appendix H. The oblique rotation produced four factors similar those produced by the varimax rotation. The maximum correlation coefficient is between Factors 1 and 2 and is only 0.23, which is considered to be too low to investigate other values of δ (Tabachnick & Fidell, 1996, p. 674). There is little difference in the factors obtained using orthogonal axes and those using oblique axes. It was decided to leave the ACCC unchanged as two out of the four a priori scales were identified by the factor analysis and the other two a priori scales loaded onto a single factor.

6.4 Factor Analysis of the Australian Study

The ACCC was administered to 208 Curtin Business School students. As before, a principle components analysis was performed. The KMO measure for this sample was 0.92 which is classified as *marvelous* (Norusis, 1990). The scree plot is shown in Figure 6.2, and suggests four or five components. As the instrument had been designed to have four factors, a principle factor analysis was then performed on all items to extract four factors and this was followed by a varimax rotation. The results are shown in Table 6.4.

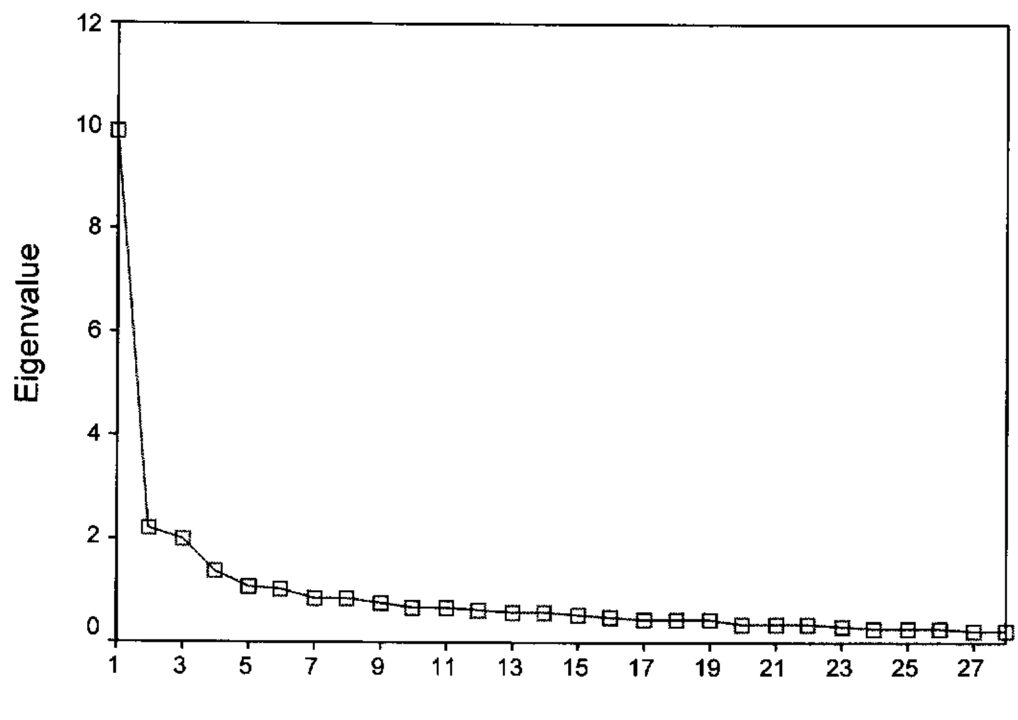

Figure 6.2. Scree plot for the ACCC with the Australian sample

Table 6.4
Factor Loadings on Four Factors of the ACCC for the Australian Sample after Varimax Rotation

Item Number	Factor 1	Factor 2	Factor 3	Factor 4
36			0.67	
40			0.64	
44			0.46	
48				
52			0.62	
56			0.47	0.44
60	0.35		0.58	
37	0.54	0.30		
41	0.70			
45	0.83			
49	0.68			
53	0.80			
57	0.86			
61	0.57			
38		0.50		
42		0.55		
46		0.31		
50		0.67		
54		0.69		
58		0.59		
62		0.64		
39	0.39	0.37		0.36
43	0.60	0.39		0.39
47	0.41	0.47		0.49
51	0.46	0.36		
55	0.41	0.53		0.43
59	0.48	0.47		0.37
63	0.41	0.45		0.31
% Variance	33.7	6.1	5.3	2.8
Eigenvalue	9.90	2.21	2.00	1.36

From these results it may be seen that

- All a priori items from both the Anxiety and Usefulness of Computers scales load onto Factor 1;
- All a priori items from both the Enjoyment and Usefulness of Computers scale load onto Factor 2;
- Six out of seven a priori items of the Usefulness of Course scale load onto Factor 3;

- Six out of seven a priori items of the Usefulness of Computers scale load onto Factor 4;
- The percentage of variance explained by these factors is 47.9.

These factors have more in common than those produced from the factor analysis of the pilot study. The fact that there is such an overlap in the factors would suggest that an oblique rotation could reveal a structure in which the factors are correlated. Direct oblimin rotation was used with $\delta=0$. The results from this are shown in Table H2 in Appendix H. The correlations between the factors produced are given in Table 6.5.

Table 6.5
Correlation Coefficients between the Factors Obtained from Principal Factors Analysis using Direct Oblimin Rotation with $\delta = 0$ for the Australian Study

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.00			
Factor 2	-0.50	1.00		
Factor 3	-0.43	0.40	1.00	
Factor 4	0.25	-0.13	0.14	1.00

The relatively high correlations between factors 1, 2 and 3 suggest that an oblique rotation could produce a simple structure.

Various values of δ were used and the rotation which seemed to produce the simplest structure used $\delta = -2.5$. The results for this are shown in Table 6.6. The first column under each factor gives the pattern matrix, and this consists of the weights on each item to produce the factor score. The second column consists of the factor loadings. It can be seen from these results that:

- Factor 1 contains all the a priori items from the Anxiety scale
- Factor 2 contains all the a priori items from the Usefulness of Computers scale
- Factor 3 contains six out of seven a priori items from the Usefulness of Course scale
- Factor 4 contains six out of seven of the a priori items from the Enjoyment scale
- There is overlap between Factors 1 and 4, and between Factors 3 and 4.

- The loadings show that the scales are correlated with items loading on more than one scale, something to be expected from oblique rotations; Table 6.7 shows the correlations between the factors obtained.
- Item 48 is not part of the pattern of Factor 3 and does not load on factor 3; it has a weight of 0.32 in the pattern of factor 4 but does not load on factor 4.
- Item 51 is not part of the pattern of Factor 4 but does load on factor 4 with a loading of 0.39.
- Item 46 loads on Factor 2 with a correlation of 0.32.

Table 6.6
Pattern Matrix and Factor Loadings on Four Factors of the ACCC for the Australian Study using Direct Oblimin Rotation with $\delta = -2.5$

Item Number	Factor 1		Factor 2		Factor 3		Factor 4	
	Pattern	Loading	Pattern	Loading	Pattern	Loading	Pattern	Loading
36					0.70	0.68		
40					0.65	0.69		0.33
44				0.32	0.43	0.52		0.43
48							0.32	
52					0.66	0.65		
56					0.43	0.54	0.45	0.54
60		0.41			0.56	0.65		0.42
37	0.49	0.59		0.40				
41	0.65	0.76		0.41		0.42		0.35
45	0.86	0.84						
49	0.67	0.72		0.33		0.32		
53	0.77	0.84		0.40		0.33		0.31
57	0.86	0.88				0.38		
61	0.53	0.62		0.40		0.34		
38		0.39	0.43	0.56		0.34		
42		0.39	0.46	0.61		0.32		0.41
46			0.31	0.32				
50			0.65	0.69				0.34
54		0.32	0.67	0.74				0.32
58			0.61	0.62		0.31		
62		0.30	0.59	0.68		0.31		0.40
39		0.46		0.46		0.39	0.38	0.54
43	0.50	0.66		0.51			0.42	0.59
47		0.49		0.55		0.32	0.52	0.68
51	0.35	0.54		0.46		0.45		0.39
55		0.50	0.35	0.61		0.36	0.46	0.64
59	0.35	0.56		0.69		0.38	0.39	0.58
63		0.50		0.54		0.40	0.32	0.51

Table 6.7
Correlation Coefficients between the Factors Obtained from Principal Factors Analysis using Direct Oblimin Rotation with $\delta = -2.5$ for the Australian Study

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.00			
Factor 2	-0.35	1.00		
Factor 3	-0.30	0.30	1.00	
Factor 4	-0.33	0.23	0.24	1.00

The above results indicate that it would be reasonable to use the scales as originally proposed with item 48 removed from Usefulness of Course, item 46 from Usefulness of Computers and item 51 from Enjoyment. This means that Factor 1 measures Anxiety, Factor 2 Usefulness of Computers, Factor 3 Usefulness of Course and Factor 4 Enjoyment. This would suggest a simple structure of with four scales, Anxiety, Enjoyment, Usefulness of Computers and Usefulness of Course. Anxiety consists of seven items, and the other three scales six each. The items for each scale and how they are scored are given in Table 6.8.

Table 6.8
Items in the Scales of the Final Version of the ACCC

Scale	Items
Usefulness of Course	36(-), 40, 44, 52(-),56,60
Anxiety	37(-),41(-),45,49,53,57,61
Usefulness of Computers	38(-), 42, 50, 54, 58, 62
Enjoyment	39,43,47, 55,59,63(-)

6.5 Reliability and Discriminant Validity

Using these scales, Cronbach alpha reliability and the mean correlations were calculated for the Australian sample. The results are shown in Table 6.9.

These show higher reliabilities than those obtained in the pilot study for all scales except Enjoyment, but even that still has reliability of 0.90. The alpha reliability coefficients indicate that all four scales are internally consistent. The mean correlations between the scales were also higher but less than the reliability coefficients. These high mean correlations are to be expected since the scales are known to be correlated. However as has been demonstrated by the factor analysis, the scales do measure distinct aspects of a student's attitude towards computers and computing courses.

Table 6.9
Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the Final Version of the ACCC

Scale	Alpha Reliability	Mean Correlation
Anxiety	0.90	0.55
Enjoyment	0.90	0.63
Usefulness of Computers	0.83	0.56
Usefulness of Course	0.80	0.49

6.6 Summary

This chapter has described the development of the ACCC using separate factor analyses on data obtained from the pilot study and the main Australian study. The analysis of the pilot study supported a structure of four factors and this was confirmed by analysis of the data from the main study. In the main study the four factors accounted for 47.9% of the variance. As was expected, given the relatively high mean correlations between the scales, a simple structure was obtained using oblique axes. In the light of the analysis three of the scales, Enjoyment, Usefulness of Computers and Usefulness of Course from the original ACCC were modified by each having one item deleted. This resulted in higher reliability coefficients. These results meant that the revised version of the ACCC could be used with confidence in the rest of this study.

The next chapter deals with the use of these instruments in determining associations between the scales of the CLEI, the scales of the ACCC and student achievement which is measured by grade in the course.

CHAPTER 7

ASSOCIATIONS BETWEEN COMPUTER LABORATORY ENVIRONMENT AND STUDENT OUTCOMES

7.1 Introduction

Studies in learning environments have shown that the environment is associated with student outcomes, both achievement and attitudes (Fraser, 1986, 1994). This chapter describes the results obtained when the CLEI and ACCC were used with the sample of students at Curtin University in Australia. Observed variables were constructed to represent the environment variables, Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability, and the attitudinal variables Anxiety, Enjoyment, Usefulness of the Course, and Usefulness of Computers. This was done by summing the responses to individual items in each scale. This led to each environment variable having a range from 7 to 35, Anxiety having a range 7 to 35, and the other attitudinal variables 6 to 30.

Section 7.2 gives simple correlation coefficients between the environment variables and the attitudinal variables. Section 7.3 gives the results of regression analysis in which the attitudinal scales are treated as dependent variables with the environment scales as the independent variables. In section 7.4 , simple correlations between the achievement measured by z-score and both environment and attitudinal variables are presented. It also gives the results of regression analysis with the z-score as the dependent variable and the environment and attitudinal variables as the independent variables. Finally, section 7.5 investigates possible models of the relationships between environment, attitude and achievement using structural equation modelling

7.2 Correlations between Environment and Attitudinal Variables

Simple correlations were calculated between all the scales of the CLEI and all the scales of the ACCC. Table 7.1 shows the correlations between the scales of the CLEI and the ACCC for the Australian study involving 208 Business students. This shows 17 out of a possible 20 correlations are significant. With the exception of Laboratory Availability, all environment variables correlate significantly with the attitudinal variables, negatively in the case of Anxiety. In addition, Laboratory Availability correlates with Usefulness of the Course.

Table 7.1
Correlations between the Scales of the CLEI and the ACCC for the Australian Study

	Anxiety	Enjoyment	Usefulness of computers	Usefulness of course
Student Cohesiveness	-0.18^{**}	0.22^{**}	0.17^{*}	0.26^{***}
Open-Endedness	-0.25^{***}	0.25^{***}	0.14^{*}	0.38^{***}
Integration	-0.17^{**}	0.22^{**}	0.20^{**}	0.38^{***}
Technology Adequacy	-0.26^{***}	0.26^{***}	0.26^{***}	0.26^{***}
Laboratory Availability	-0.04	0.03	0.04	0.14^{*}

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

7.2.1 *Discussion*

The only non-significant associations involve Laboratory Availability, indicating that this is not a factor in influencing attitude except in perceived usefulness of the course. There are strong correlations between four environment variables and Anxiety (negatively), Enjoyment and Usefulness of Course. Usefulness of Computers is strongly correlated with Integration and Technology Adequacy and weakly with Student Cohesiveness and Open-Endedness.

Important observations from these results are the associations between the attitudinal variables and all environment variables except Laboratory Availability. This could imply that a laboratory class which is integrated with non-laboratory classes, where the approach is open-ended, where the students are a more cohesive group, and where the technology provided is suitable for the task at hand, will lead to a reduction in anxiety about computers, an increase in enjoyment of computers and a perception that the course is more useful. From another viewpoint, it can be seen that there are associations between course integration, technology adequacy, open-endedness and all attitudinal variables. This highlights both the importance of course design, particularly the relationship between laboratory classes and non-laboratory classes, the open-endedness of laboratory exercises, and the need to provide hardware and software that is adequate for the exercises assigned to students. This latter point also means that the lecturer running the course must take hardware and software availability into account when designing laboratory work. The availability of laboratories would seem to be important only from students' perceptions of the usefulness of the course.

This section has demonstrated significant correlations between environment and attitudinal variables using Pearson's correlation coefficients. The next section investigates these relationships further using the more conservative multivariate regression analysis.

7.3 Regression Analysis of Attitudinal and Environment Variables

A multivariate regression analysis was carried out on the combined data using the environment variables as independent variables and each of the attitudinal variables in turn as the dependent variable. Prior to the analysis, the data were checked for outliers. Outliers are cases which stand out from other cases within the sample. In univariate analysis would be a case which has an extreme value. A multivariate outliers is a case with an unusual combination of scores on two or more variables (Tabachnick & Fidell, 1996, p.66). Outliers are known to affect regression analysis. To identify outliers, regression analysis was run on the data, and requests were made for cases that lay more than three standard deviations outside the mean. After removing outliers, regression analysis was carried out again, and this process was continued until no further outliers were found. Table 7.2 shows the cases for each of the attitudinal variables that have been identified as outliers. Given the small numbers of them, it was decided to delete these cases from the sample when carrying out regression analysis.

Table 7.2
Outliers for Attitudinal Variables

Variables	Outliers
Anxiety	117
Enjoyment	74,75
Usefulness of Computers	74,75,168,177, 189
Usefulness of Course	150

7.3.1 *Regression analysis on Anxiety*

A standard regression was carried out with Anxiety as the dependent variable and Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability as independent variables. The data consisted of the whole sample with one outlier deleted. Table 7.3 shows the results from this analysis and the columns consist of the simple correlation coefficient (r), the unstandardised regression coefficient (B), the standardised regression coefficient (β), and the semi-partial correlation (sr^2). The table also shows the multiple correlation (R), R^2, adjusted R^2, and the F value. R^2 measures the contribution that all the independent variables contribute to the variance, and sr^2 is the unique contribution that each independent variable makes separately to the variance.

R for regression was significantly different from zero, $F(5,201) = 8.46$, ($p < .001$). Four out the five independent variables contributed significantly to the prediction of Anxiety with Open-Endedness and Technology Adequacy contributing most. Laboratory Availability did not contribute at all. Altogether, 17.4% of the variance in Anxiety was predicted by knowing the learning environment variables.

Table 7.3
Standard Multiple Regression of Environment Variables on Anxiety

Variable	r	B	β	sr^2
Student Cohesiveness	-0.18^{**}	-0.22^{*}	-0.16	0.024
Open-Endedness	-0.25^{***}	-0.33^{***}	-0.22	0.047
Integration	-0.17^{**}	-0.13^{*}	-0.14	0.018
Technology Adequacy	-0.26^{***}	-0.27^{***}	-0.25	0.050
Laboratory Availability	-0.04	0.12	0.12	0.012
$R = 0.42$ $R^2 = 0.174$ Adjusted $R^2 = 0.153$		$F(5,201) = 8.46^{***}$		

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

7.3.2 *Regression analysis on Enjoyment*

Table 7.4 displays the results for a standard multiple regression of the environment variables on Enjoyment for the combined sample with four outliers deleted. The multiple regression R was significantly different from zero, F(5,201) = 8.46, ($p <$ .001). Three out the five independent variables contributed significantly to the prediction of Enjoyment, this time with Open-Endedness and Student Cohesiveness contributing most. This time neither Laboratory Availability nor Technology Adequacy contributed significantly. Altogether, 14.4% of the variance in Enjoyment was predicted by knowing the learning environment variables.

Table 7.4
Standard Multiple Regression of Environment Variables on Enjoyment

Variable	r	B	β	sr^2
Student Cohesiveness	0.22^{**}	0.21^{*}	0.17	0.027
Open-Endedness	0.25^{***}	0.32^{***}	0.25	0.061
Integration	0.22^{**}	0.14^{*}	0.16	0.027
Technology Adequacy	0.26^{***}	0.12	0.12	0.011
Laboratory Availability	0.03	-0.10	-0.12	0.011
$R = 0.38$ $R^2 = 0.144$ Adjusted $R^2 = 0.123$		$F(5,200) = 6.75^{***}$		

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

7.3.3 *Regression analysis on Usefulness of Computers*

Table 7.5 displays the results for a standard multiple regression of the environment variables on Usefulness of Computers for the combined sample with six outliers deleted. The multiple regression R was significantly different from zero, F(5,197) = 3.02, ($p < .05$). Student Cohesiveness and Open-Endedness contributed significantly to the prediction of Usefulness of Computers. Only 7.1% of the variance in Usefulness of Computers was predicted by knowing the learning environment variables.

Table 7.5

Standard Multiple Regression of Environment Variables on Usefulness of Computers

Variable	r	B	β	sr^2
Student Cohesiveness	0.17^*	0.12^*	0.15	0.019
Open-Endedness	0.14^*	0.16^*	0.18	0.030
Integration	0.20^{**}	0.06	0.10	0.010
Technology Adequacy	0.26^{***}	0.03	0.06	0.002
Laboratory Availability	0.04	-0.06	-0.10	0.008
$R = 0.27$ $R^2 = 0.071$ Adjusted $R^2 = 0.048$		$F(5,197) = 3.02^*$		

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

7.3.4 *Regression analysis on Usefulness of Course*

Table 7.6 displays the results for a standard multiple regression of the environment variables on Enjoyment for the combined sample with two outliers deleted. The multiple regression R was significantly different from zero, F(5,201) = 23.15, ($p < .001$). Four of out the five independent variables contributed significantly to the prediction of Usefulness of Course with Open-Endedness, Integration and Student Cohesiveness contributing most. Laboratory Availability did not contribute at all. Altogether, 36.5% of the variance in Usefulness of Course was predicted by knowing the learning environment variables.

Table 7.6
Standard Multiple Regression of Environment Variables on Usefulness of Course

Variable	r	B	β	sr^2
Student Cohesiveness	0.26^{***}	0.18^{**}	0.17	0.027
Open-Endedness	0.38^{***}	0.44^{***}	0.38	0.140
Integration	0.38^{***}	0.27^{***}	0.37	0.123
Technology Adequacy	0.26^{***}	0.11^{*}	0.13	0.013
Laboratory Availability	0.14^{*}	-0.01	-0.02	0.000
$R = 0.61$				
$R^2 = 0.365$				
Adjusted $R^2 = 0.350$		$F(5,201) = 23.15^{***}$		

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

7.3.5 *Discussion*

The regression analysis in general supported the findings of the simple correlation analysis, although there were some differences. Laboratory Availability was not a significant predictor for any of the attitudinal variables. This seems to be at variance with the information obtained by discussions with staff and students mentioned in Chapter 5. It could be that this sample of students has sufficient access to computers, either because they own one or the laboratory opening hours are adequate for their needs.

Technology Adequacy correlates significantly with all the attitudinal variables, but the regression analysis indicates that it contributes significantly to only two of them, Anxiety and Usefulness of the Course.

Usefulness of the Course is the attitudinal variable whose variance is most explained by the environment variables. The most significant contributions comes from Open-Endedness (with a unique contribution of 14%) and Integration (with 12.3%) with minor contributions from Student Cohesiveness and Technology Adequacy. This would imply that courses whose laboratory classes are more open-ended and more integrated with the non-laboratory classes are perceived to be more useful.

The environment variables explained 17.4% of the variance of Anxiety with Technology Adequacy accounting for 5% and Open-Endedness for 4.7%. There were minor but significant contributions from Student Cohesiveness and Integration. These results suggest that the suitability of the hardware and the software for the tasks that the students are required is important in reducing their anxiety about using computers. They also appear to imply that reduced anxiety is associated with a more open-ended approach to laboratory classes.

For Enjoyment, 14.4% of its variance is explained by the environment variables, with the main contribution coming from Open-Endedness (6.1%) and minor contributions from Student Cohesiveness and Integration.

The environment variable whose variance is least explained by the environment variables is Usefulness of Computers. Only 7.1% is explained with significant contributions from only Open-Endedness (3%) and Student Cohesiveness (1.9%). It would seem that students' perceptions of the usefulness of computers are dependent on other influences and their computer laboratory environment does little to change this perception.

Looking at the contribution that the environment variables make to the attitudinal variables, it can be seen that Open-Endedness makes a significant contribution to all of them, implying that a laboratory class which encourages a divergent approach reduces anxiety, increases enjoyment, perception of the course's usefulness and perception of the usefulness of computers. Except for Anxiety, Technology Adequacy has a minimal effect on the attitudinal variables. This runs counter to much anecdotal evidence, but for this sample could be explained by the fact that the hardware and software are suitable and so the students do not consider it to be an issue. A similar observation could be made about Laboratory Availability.

7.4 Correlation and Regression for Achievement

7.4.1 *The sample*

Achievement was measured as the grade obtained in the course, as a mark out of 100. Depending on the way the course had been organised, this grade consisted of contributions from one or more of the following components, examination, assignments and laboratory exercises. Not all courses involved all three components, although most had a final examination and at least one assignment which required the use of a computer. Using means and standard deviations obtained for each course, the grade was converted into a z-score. Of the 208 students, 142 provided their student number allowing their grades to be determined.

7.4.2 *Regression on the environment variables*

A simple correlation and standard multiple regression were carried out on the z-score with both environment and attitudinal variables. Table 7.7 gives the correlation, the unstandardised regression coefficient, the standardised regression coefficient and the square of the semipartial correlation for z-score with the environment variables. The only significant simple correlation is with Student Cohesiveness. The multiple correlation coefficient R is not significantly different from zero, $F(5,136) = 1.62$.

Table 7.7
Correlation Coefficients and Standard Multiple Regression of Environment Variables on Achievement

Variable	r	B	β	sr^2
Student Cohesiveness	0.18^*	0.04^*	0.19	0.034
Open-Endedness	0.07	0.01	0.04	0.002
Integration	0.05	0.00	0.01	0.000
Technology Adequacy	0.13	0.02	0.14	0.016
Laboratory Availability	0.08	0.00	-0.02	0.000
$R = 0.24$				
$R^2 = 0.056$				
Adjusted $R^2 = 0.021$			$F(5,136) = 1.62$	

$^*p < .05$

7.4.3 *Regression on the attitudinal variables*

Table 7.8 gives the results of a standard multiple regression of the attitudinal variables on achievement. The multiple correlation coefficient R is significantly different from zero, $F(4,137) = 5.44$, ($p < .001$).

Table 7.8
Correlation Coefficients and Standard Multiple Regression of Attitudinal Variables on Achievement

Variable	r	B	□	sr^2
Anxiety	-0.20*	-0.01	-0.04	0.009
Enjoyment	0.25**	0.05*	0.26	0.032
Usefulness of Computers	0.01	-0.05*	-0.22	0.033
Usefulness of Course	0.29**	0.05*	0.24	0.043

$R = 0.37$
$R^2 = 0.137$
Adjusted $R^2 = 0.112$ F(4,137) = 5.44***

*$p < .05$, **$p < .01$, ***$p < .001$

The simple correlations indicate that Anxiety, Enjoyment and Usefulness of Course are associated with achievement, and Usefulness of Computers is not. However, the regression coefficients demonstrate that Enjoyment, Usefulness of Course and Usefulness of Computers contribute significantly to the prediction of achievement. Anxiety does not. It can be seen that the standardised regression coefficient (β) for Usefulness of Computers is significantly different from zero, and is substantially larger than the absolute value of the simple correlation between Usefulness of Computers and achievement measured by the z-score. This indicates that Usefulness of Computers could be a suppressor variable (Tabachnick & Fidell, 1996, p. 165). A suppressor variable is one which contributes to increasing the multiple R^2 by virtue of its correlation with other independent variables. Further analysis was carried out by conducting standard multiple regressions on achievement with the independent variables, individually and in all combinations. The results of these analyses are shown in Appendix I. From these it can be seen that as a single variable, Usefulness of Computers makes no contribution to predicting achievement. When it is included with any other variables or set of variables, it increases the multiple R^2, in most cases significantly. This confirms that Usefulness of Computers is a suppressor variable, and it increases the variance accounted for by both Enjoyment and Usefulness of the Course by suppressing variance due to their perception on how useful computers are or will be. To summarise, three out of the four attitudinal variables contribute significantly to the prediction of achievement, with Usefulness of Computers being a suppressor variable. Anxiety did not contribute to the prediction. In all, 13.7% of variability in achievement is accounted for by the attitudinal variables.

7.4.4 *Discussion*

The results for the environment variables show that only Student Cohesiveness is associated significantly with achievement ($p < .05$). The lack of association of the other variables is possibly explained by the way in which achievement is measured. It is the composite grade obtained summing a number of components, and in most cases, it is dominated by a formal examination, which contributes at least 50%. Influence of computer laboratory environment on formal examinations will be indirect so may not be measurable. The component that is influenced most by laboratory environments is laboratory exercises, but these usually contribute least, if at all, to the final grade. The other major component is a set of assignments, which are practical in nature. In many cases, students work together on assignments, even where they are intended to be individual pieces of work. This could explain the association between student cohesiveness and achievement.

The standard multiple regression of environment variables on achievement produced a multiple regression R which was not significant, and so achievement cannot be predicted from these variables.

For the attitudinal variables, Anxiety, Enjoyment and Usefulness of Course are correlated significantly with achievement. This would imply that achievement in terms of grade is higher for those students with lower anxiety about computers, enjoy using them more, and who perceive the course to be more useful. Perceived usefulness of computers was found not to be associated with achievement. The association between lack of anxiety and achievement supports previous findings (Marcoulides, 1988).

The regression analysis resulted in a multiple R that was significant ($p < .001$), with the variables Enjoyment, Usefulness of Course and Usefulness of Computers being significant predictors of achievement. Anxiety was not a significant predictor. Perceived usefulness of computers is a suppressor variable which increases the contribution of both enjoyment and perceived usefulness of the course. All the attitudinal variables are significantly correlated (see Table 7.9), and the suppressor variable removes effects from the total variability caused by perceived usefulness of computers, thereby increasing the significance of both enjoyment and perceived usefulness of the course. These results demonstrate that both enjoyment and perceived usefulness of the course contribute to achievement.

Table 7.9
Correlations between the Scales of the ACCC for the Australian Study

	Anxiety	Enjoyment	Usefulness of Computers	Usefulness of Course
Anxiety	1.00	-0.70***	-0.50***	-0.47***
Enjoyment	-0.70***	1.00	0.68***	0.51***
Usefulness of Computers	-0.50***	0.68***	1.00	0.42***
Usefulness of Course	-0.47***	0.51***	0.42***	1.00

*** $p < .001$

7.5 Structural Equation Modelling of Environment-Outcome Relationships

7.5.1 *Use of structural equation modelling*

Structural equation modelling (SEM) provides a highly flexible method for investigating relationships between observed and latent (or unobserved) variables using one, two or higher level models. By providing an explicit model of measurement error, this technique allows for the examination of relationships among factors that are free from such error and so involve only the common variance (Ullman, 1996, p. 712). It resolves multicollinearity problems and is the only analysis that allows complete and simultaneous tests of all relationships in complex multidimensional models.

The results obtained in Sections 7.3 and 7.4 suggest a two level model with environment affecting attitude and attitude affecting achievement. SEM is an appropriate method for investigating such a model.

7.5.2 *Proposed model*

As SEM is a confirmatory technique, the first step is to specify the model to be tested. The associations to be tested are between the computer laboratory environment variables, as measured by the scales of the CLEI and student outcomes, as measured by the scales of the ACCC and student grade. The first model proposed is shown in Figure 7.1. There are two latent variables, Environment and Attitude. The latent variable Environment affects the responses to the questions relating to the scales of the CLEI and the variable Attitude the responses to the questions relating to the scales of the ACCC. Further it is hypothesised that there is a causal relationship between Environment and Attitude and between Attitude and achievement, as measured by z-score. Two models are investigated. The one in Figure 7.1 allows the error terms of the scales of the ACCC to covary, and in the model in Figure 7.2, there is no correlation between the scales. The environment variables, the attitudinal variables and achievement are observed endogenous variables, each one has an error variable associated with it. Attitude is a latent endogenous variable so has a disturbance variable associated with it. Environment is a latent exogenous variable so has no disturbance term.

7.5.3 *Analysis of the model*

For this part of the study the Australian sample was used as it was the only one that contained achievement data. The data were run with Amos 3.6 (AMOS, 1996), and the model in Figure 7.1 converged in 10 iterations. A summary of the results is shown in Tables 7.10 and 7.11. The full results are shown in Table J1 of Appendix J.

From these it can be seen that the regression coefficient of Availability on Environment is not significant. Also, the only covariance that is significant is the one between the error terms of Enjoyment and Usefulness of Computers.

Table 7.10
Regression Coefficients for Original Model of Environment-Attitude-Achievement

Relationship	B	β
Attitude ← Environment	2.49	0.96**
Student Cohesiveness ← Environment	0.88	0.32**
Open-Endedness ← Environment	1.00	0.41#
Integration ← Environment	0.93	0.25**
Technology Adequacy ← Environment	0.83	0.25**
Laboratory Availability ← Environment	0.67	0.17
Anxiety ← Attitude	-0.77	-0.57**
Enjoyment ← Attitude	0.72	0.64**
Usefulness of Computers ← Attitude	0.28	0.32**
Usefulness of Course ← Attitude	1.00	0.94#
Achievement ← Attitude	0.07	0.34**

used for identification, ** $p < .01$

Table 7.11
Covariances and Correlation Coefficients between Error Terms for the Original Model of Environment-Attitude-Achievement

Error Term Relationship	Covariance	Correlation
Anxiety ↔ Enjoyment	-3.84	-0.31
Anxiety ↔ Usefulness of Computers	-2.08	-0.18
Anxiety ↔ Usefulness of Course	2.44	0.48
Enjoyment ↔ Usefulness of Computers	4.59	0.50**
Enjoyment ↔ Usefulness of Course	-2.58	-0.66
Usefulness of Computers ↔ Usefulness of Course	0.34	0.09

used for identification, ** $p < .01$

There are many indices for measuring how well a model fits the data (Marcoulides & Herschberger, 1997, pp. 243-249 ; Schumaker & Lomax, 1996, chap. 7), and the ones given in Table 7.12 on page 106 are the χ^2 degrees of freedom ratio (χ^2/ df), the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI), the Root Mean Square Residual (RMR), the Root Mean Square of the Error of the Approximation (RMSEA), and the Expected Value of the Cross Validation Index

(EVCI). The ratio χ^2/ df is a frequently used measure, and a value of less than 2 is considered to show a very good fit. The GFI measures the relative amount of variance and covariance in the data accounted for by the proposed model. Values in excess of 0.90 are considered to indicate a good fit. The AGFI makes allowance for the complexity of the model and again a figure above 0.90 is considered a good fit. The RMR measures the amount of remaining variance not explained by the model and a figure of 0.05 indicates a good fit. The RMSEA is a measure of the discrepancy of the fitted model per degree of freedom, and a value of 0.05 shows a close fit with a value of 0.08 representing reasonable errors (Jöreskog, 1993). The ECVI is a measure of the discrepancy between the fitted covariance matrix in the analysed sample and the expected covariance matrix obtained that would be obtained in another sample of the same size (Browne & Cudeck, 1993). The smaller the value of the ECVI, the better the fit.

As can be seen from Table 7.12, for this model, the Goodness of Fit Index (GFI) is 0.933, χ^2 is 57.29, χ^2/(degrees of freedom) is 1.975, the RMR 0.116, the RMSEA is 0.083 and the ECVI is 0.775, with a 90% confidence interval of (0.649, 0.956). The value of the RMR is well outside the acceptable limits but the other indices would indicate that the model is a reasonable fit.

Table 7.12 also shows the fit indices for the model (Model 7.2) with no correlation between the attitudinal variables, and demonstrates that the model with covarying error terms for the attitudinal variables is a better fit on all indices except RMR.

Model 7.1 was refined by removing the least significant covariances at each stage and Figure 7.3 shows the model that was obtained. In this model, the only covariances are between the error terms of Anxiety and Enjoyment and between the error terms of Enjoyment and Usefulness of Computers. Table 7.12 gives the values of the fit indices for this and the two previous models.

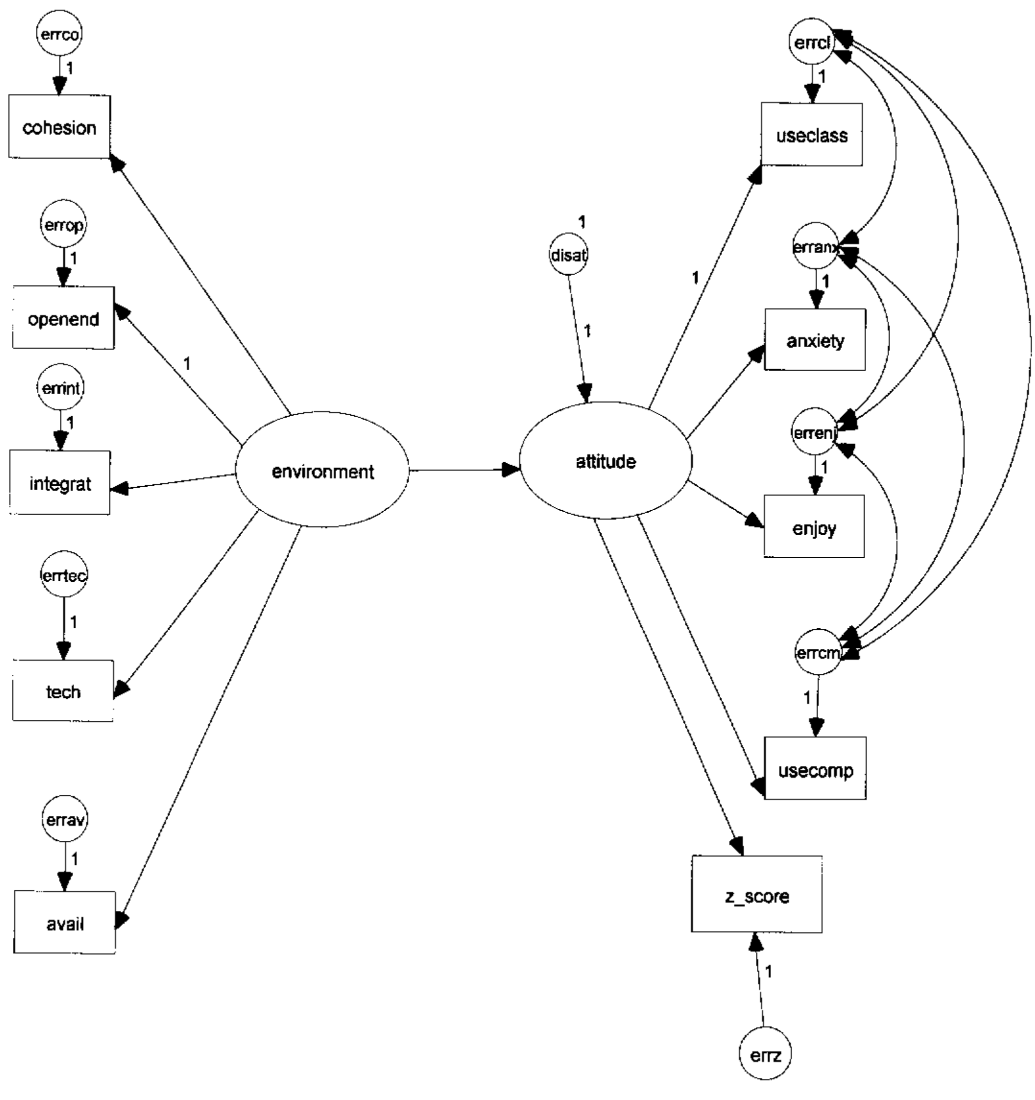

Figure 7.1. Original proposed model for Environment-Attitude-Achievement

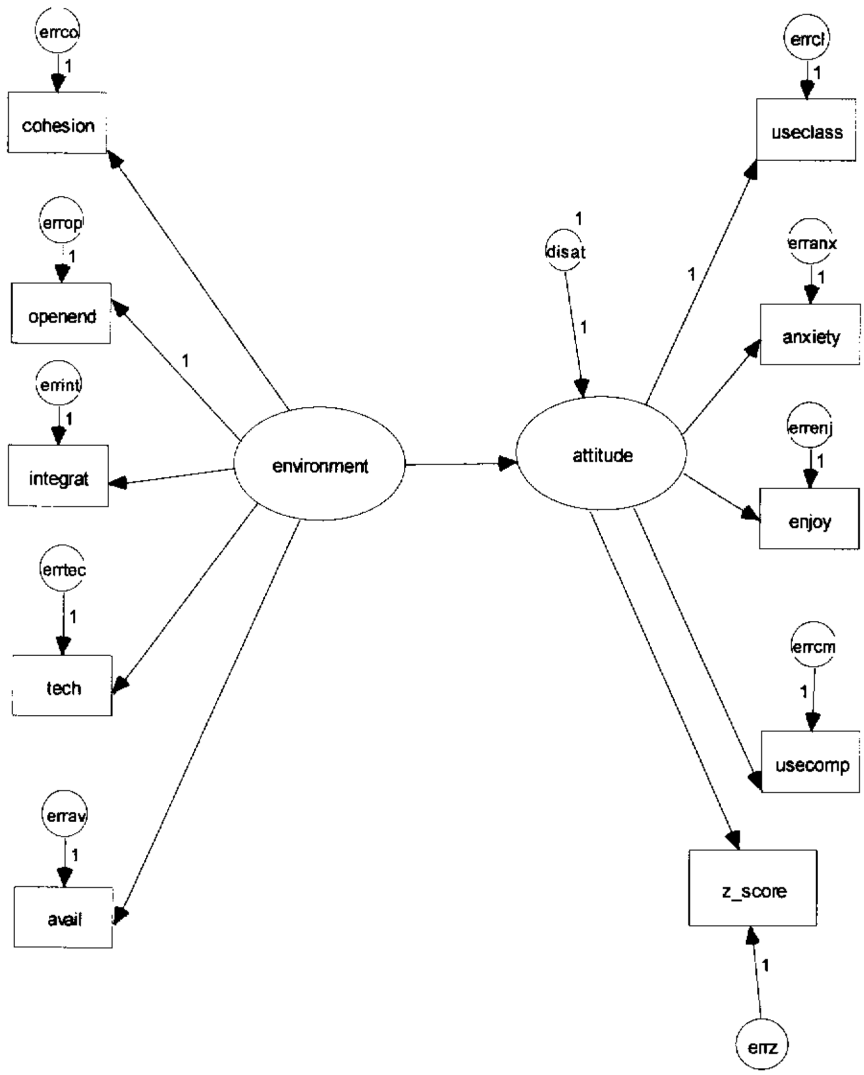

Figure 7.2. Model with no correlation between variables

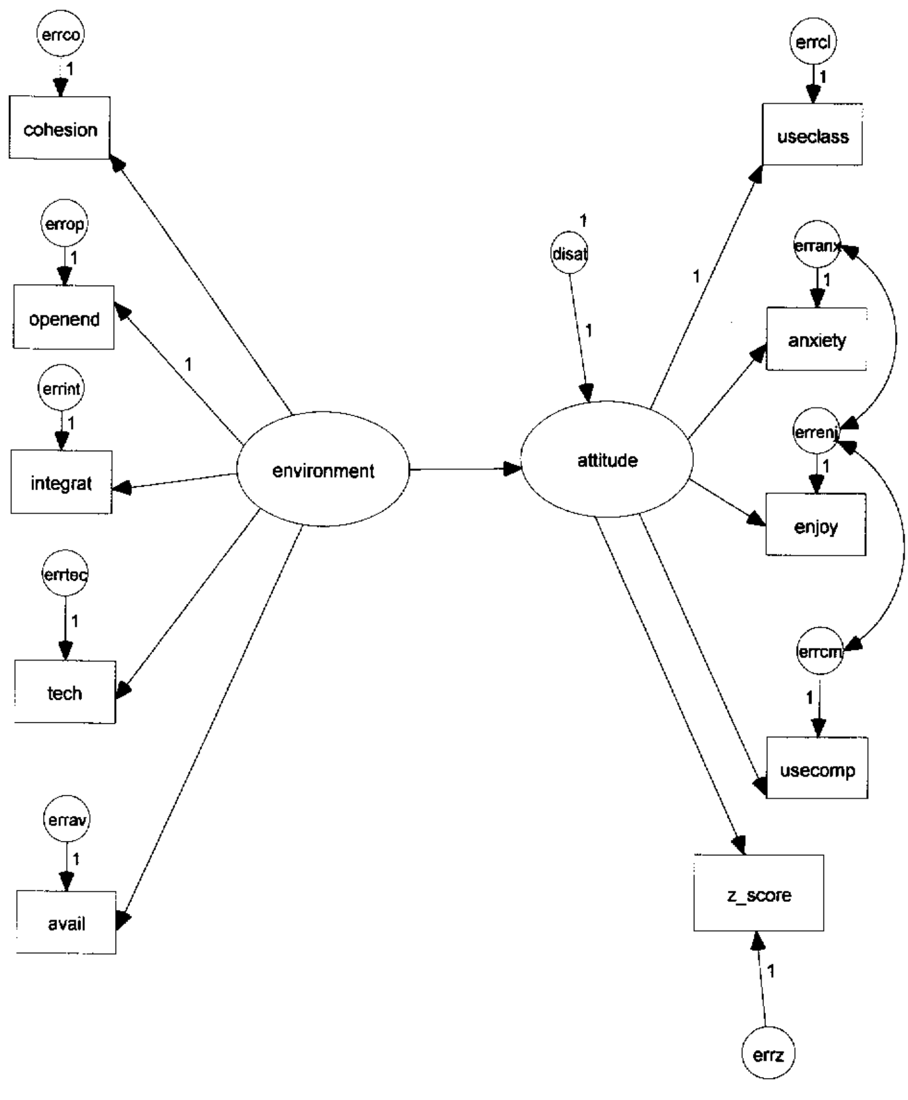

Figure 7.3. Proposed model of Environment-Attitude-Achievement with covariances between error terms of Usefulness of Computers and Enjoyment and of Enjoyment and Anxiety

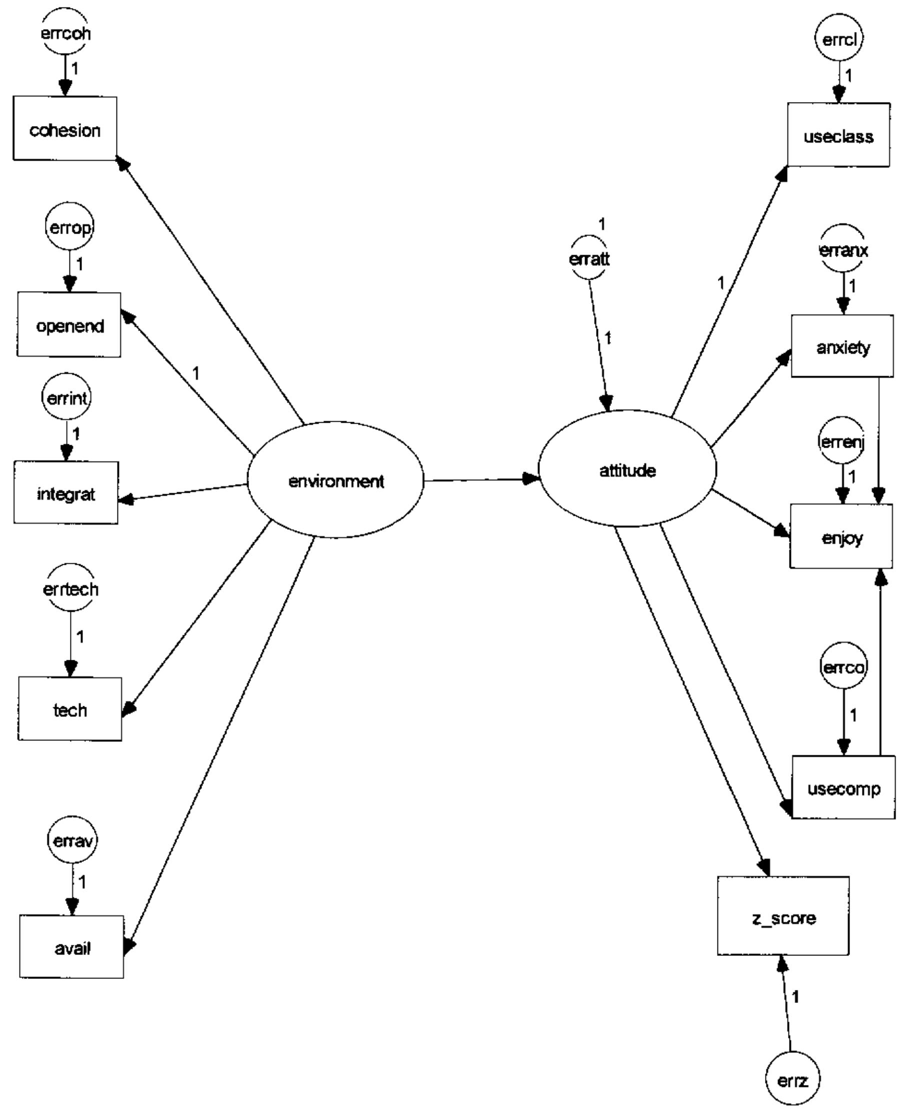

Figure 7.4. Proposed model of Environment-Attitude-Achievement with direct relationships Usefulness of Computers → Enjoyment and Anxiety → Enjoyment

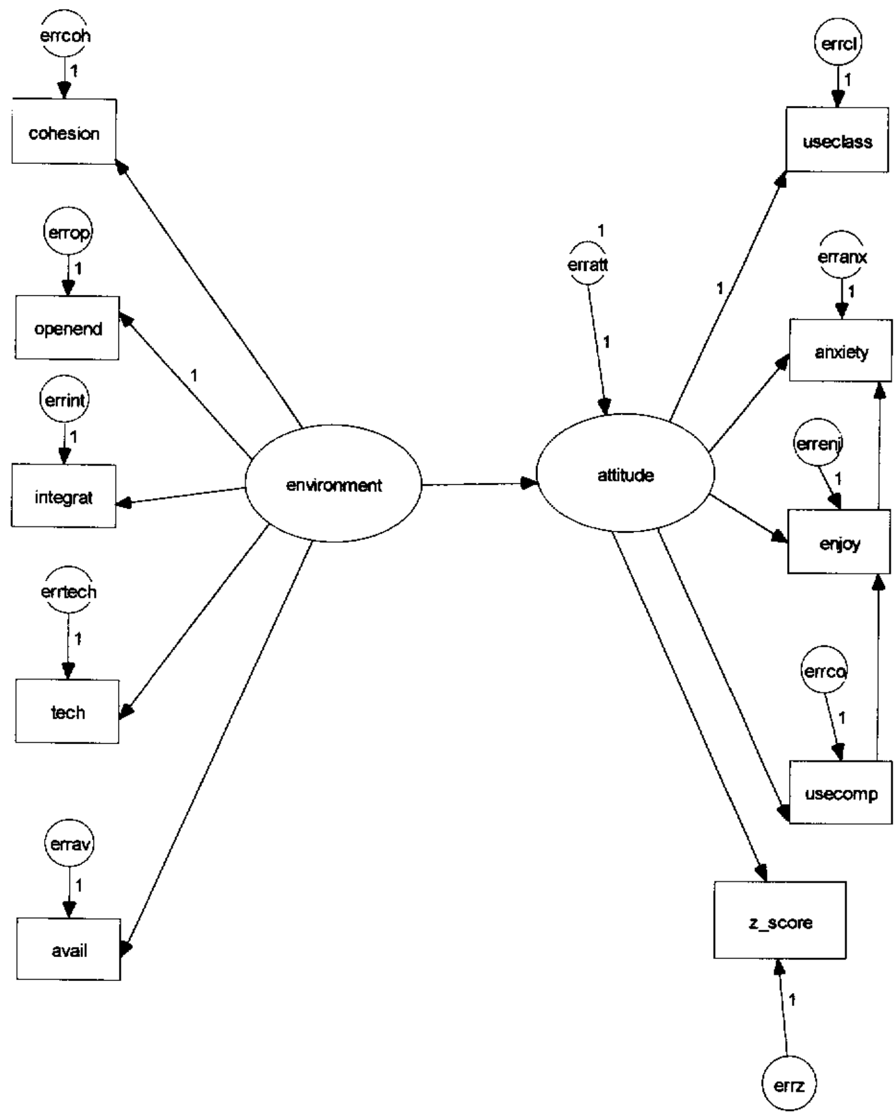

Figure 7.5. Proposed model of Environment-Attitude-Achievement with direct relationships Usefulness of Computers → Enjoyment and Enjoyment → Anxiety

Table 7.12
Comparisons of Models for Environment-Attitude-Achievement

Model	χ^2	df	χ^2/df	GFI	AGFI	RMR	RMSEA	ECVI
7.1	57.29	29	1.975	0.933	0.873	0.116	0.083	0.775
7.2	91.91	35	2.626	0.889	0.826	0.117	0.107	0.936
7.3	64.27	33	1.948	0.924	0.873	0.115	0.082	0.768
7.4	64.27	33	1.948	0.924	0.873	0.115	0.082	0.768
7.5	60.76	33	1.841	0.929	0.881	0.115	0.077	0.743

7.5.4 *A further refinement of the model*

The model in Figure 7.3 shows covariances between the error terms of Anxiety and Enjoyment and between the error terms of Enjoyment and Usefulness of Computers. This model is statistically indistinguishable to one in which there are directed relationships between Anxiety and Enjoyment and between Enjoyment and Usefulness of Computers (Marcoulides & Herschberger, 1997, p.261). There are four possible combinations of these directed relationships:

- Anxiety → Enjoyment and Enjoyment → Usefulness of Computers;
- Enjoyment → Anxiety and Enjoyment → Usefulness of Computers;
- Anxiety → Enjoyment and Usefulness of Computers → Enjoyment;
- Usefulness of Computers → Enjoyment and Enjoyment → Anxiety.

The complete results for these are given in Tables J4 to J7 of Appendix J. From these it may be seen that the first two combinations lead to models in which the direct relationship between Attitude and Usefulness of Computers is no longer significant. The models for the last two combinations are shown in Figures 7.4 and 7.5 respectively. Table 7.12 gives the values of the fit indices for both of these models. With the exception of RMR all the indices indicate that both models are acceptable.

7.5.5 *Discussion*

From the results it can be seen that all models considered fit the data better than the model 7.2 which has no relationships between the scales of the ACCC. This result is to be expected from the factor analysis of the scales of the ACCC given in Chapter 6. Of the other models, model 7.1 has the highest value of the GFI, but its values for the other indices are worse than those for the other three models. Models 7.3 and 7.4 have identical values for the fit indices chosen, and indicate that either one is a reasonable fit to the data. However, of the two the preferred model would be 7.4 as this involves direct relationships between variables rather than covariances between error terms (Marcoulides & Herschbeger, 1997, p. 261). Of all the models, the best overall fit is model 7.5 and both unstandardised and standardised regression weights for this model are given in Table 7.13. It may be seen that the regression coefficients are significant (p<.01) for all postulated relationships.

For this model the standardised regression coefficient for the effect of perceived usefulness of computers on enjoyment is 0.44 and for the effect of enjoyment on anxiety is –0.43. From this it would appear that students' perceptions of how useful computers are to them or will be in the future influences their enjoyment. If using computers allows them to do things more quickly then they enjoy using them. Also enjoying using computers would seem to reduce computer anxiety.

Further, the model shows that the standardised regression coefficient for the effect of environment on attitude is 0.95, and for attitude on achievement is 0.35, so the indirect effect of environment on achievement has a regression weight of 0.33. This finding supports the hypothesis that the environment affects achievement indirectly through its effect on attitude.

Table 7.13
Regression Coefficients for Model 7.5 for Environment-Attitude-Achievement

Relationship	B	β
Attitude ← Environment	2.19	0.95^{**}
Student Cohesiveness ← Environment	0.94	0.34^{**}
Open-Endedness ← Environment	1.00	$0.42^{\#}$
Integration ← Environment	1.01	0.28^{**}
Technology Adequacy ← Environment	1.02	0.31^{**}
Laboratory Availability ← Environment	0.93	0.24^{**}
Anxiety ← Attitude	-0.38	-0.25^{**}
Enjoyment ← Attitude	0.44	0.36^{**}
Usefulness of Computers ← Attitude	0.35	0.36^{**}
Usefulness of Course ← Attitude	1.00	$0.86^{\#}$
Achievement ← Attitude	0.08	0.35^{**}
Enjoyment ← Usefulness of Computers	0.56	0.44^{**}
Anxiety ← Enjoyment	-0.52	-0.43^{**}

$^{\#}$ used for identification, $^{**}p < .01$

7.6 Summary

This chapter examined the possible relationships between the environment variables and attitudinal variables using both simple correlation and standard multiple regression. Further, it investigated the associations between achievement as measured by the final grade and both environment and attitudinal variables. It was found that there were significant associations between the environment and attitudinal variables, and between attitudinal variables and achievement but only one weakly significant association between environment and achievement. Structural equation modelling supported a proposed model in which the effect of environment on achievement is indirect. In this model, environment affects attitude, which in turn affects achievement.

The next chapter looks at factors that could influence students' perceptions of their computer laboratory environment, their attitude towards computers and computing courses, and their achievement.

CHAPTER 8

FACTORS INFLUENCING PERCEPTIONS OF COMPUTER LABORATORY ENVIRONMENT, ATTITUDES AND ACHIEVEMENT

8.1 Introduction

There are a number of factors apart from environment that may affect student outcomes, and these factors may affect environment itself (Fraser, 1986, 1991, 1994). Some of these, particularly gender and age, have been used in studies of learning environment (Lawrenz, 1987; Linn & Hyde, 1989) and attitude towards computers (Comber, Colley, Hargreaves, & Dorn, 1997; Pope-Davis & Twing, 1991). In this study, demographic information was collected from the participants and these provide a set of such factors which are given in Table 8.1 together with possible values. This chapter investigates the effect of these factors on students' perception of their computer laboratory environment and on their outcomes, both in terms of attitude and achievement. Each of these factors has been classified as Personal, Course-related or Computer-related, and this is also shown in Table 8.1. Most of the factors are self explanatory, but others need explanation.

In Australia, tuition fees are subsidised for local students using a scheme called the Higher Education Charge Scheme (HECS). Under this students pay around 25% of full fees and this is recouped from the student via the taxation system after the student has started to earn. Most overseas students pay full fees, but there are some who are subsidised by their own or in some cases the Australian government. In the study, students were classed as subsidised if they received government aid from any quarter, and self-funded otherwise. The students in the Australian study came from 28 different countries, mainly from European backgrounds (e.g. Australia, United Kingdom) or from South East and East Asia (e.g. Singapore, Malaysia, Hong Kong).

Using country of origin, students were classified as coming from cultural backgrounds which were either European, Asian, or Other.

Programmes have been classified in three categories, specialist Information Systems / Computer Science, general Information Systems / Computer Science and other disciplines. For the specialists approximately 65% of their programme are computing subjects, for the generalists about 35% and the students from other disciplines take the occasional computing course. The level of a course is in one of six categories as shown. Although this is not a hard and fast rule, in general, students in the specialist programmes take the specialist courses, the generalists the generalist courses and the student from other disciplines, the generalist courses. Lecturers in different courses have different expectations of students and these have been classified as low, medium and high.

Finally, one factor that has been investigated in relationship to its effect on attitude towards computers is prior experience (Dyck & Smither, 1994; Chen, 1996). It is suggested that prior experience per se does not reduce anxiety (Marcoulides, 1988), so it was decided to classify experience as prior familiarity with the particular computer system being used in the course.

The frequencies and percentages of these variables in the Australian sample are shown in Table 8.2, and with the exception of Other in Cultural Background, and General Advanced in Level of Course, all categories are reasonably represented.

A one-way analysis of variance was carried out on all environment and outcome variables and the results are discussed in the next two sections. Section 8.2 of this chapter deals with computer laboratory environments, and Section 8.3 with attitudinal variables and achievement.

Table 8.1
Factors that may affect Environment and Outcome

Factor	Possible Values	Classification
Age	<20 20-25 25-30 30-35 >35	Personal
Gender	Female Male	Personal
Mode of Study	Part-time Full-time	Personal
Method of fee payment	Subsidised Self-funded	Personal
Cultural Background	European Asian Other	Personal
Course	See Table 5.10	Course
Programme Type	Specialist IS/CS General IS/CS Other discipline	Course
Year of Programme	1st Year Undergraduate 2nd Year Undergraduate 3rd Year Undergraduate Postgraduate	Course
Level of Course	Specialist Introductory Specialist Intermediate Specialist Advanced General Introductory General Intermediate General Advanced	Course
Expectation of Lecturer	Low Medium High	Course
Type of Computer System	Stand-alone Workstation Multi-access centralised computer Networked Computers	Computer
Prior familiarity with particular computer system	Low Medium High	Computer

Table 8.2

Frequencies of the Variables in the Australian Sample

Factors	Value	Frequency	Percentage
Age	<20	28	13.5
	20-25	106	51.0
	25-30	31	14.9
	30-35	17	8.2
	>35	10	4.8
	Missing	16	7.7
Gender	Female	72	34.6
	Male	121	58.2
	Missing	15	7.2
Mode of Study	Part-time	31	14.9
	Full-time	161	77.4
	Missing	16	7.7
Method of fee payment	Subsidised	112	53.8
	Self-funded	75	36.1
	Missing	21	10.1
Cultural Background	European	81	38.9
	Asian	98	47.1
	Other	5	2.4
	Missing	24	11.5
Programme Type	Specialist IS/CS	92	44.2
	General IS/CS	50	24.0
	Other discipline	39	18.8
	Missing	27	13.0
Year of Programme	1st Year Undergraduate	50	24.3
	2nd Year Undergraduate	103	49.5
	3rd Year Undergraduate	21	10.1
	Postgraduate	32	15.4
	Missing	2	1.0
Level of Course	Specialist Introductory	22	10.6
	Specialist Intermediate	86	41.3
	Specialist Advanced	17	8.2
	General Introductory	28	13.5
	General Intermediate	49	23.6
	General Advanced	4	1.9
	Missing	2	1.0
Expectation of Lecturer	Low	50	24.0
	Medium	32	15.4
	High	124	59.6
	Missing	2	1.0
Type of Computer System	Stand-alone Workstation	81	38.9
	Multi-access centralised computer	91	43.8
	Networked Computers	34	16.3
	Missing	2	1.0
Prior familiarity with particular computer system	Low	82	39.4
	Medium	56	26.9
	High	68	32.7
	Missing	2	1.0

8.2 Computer Laboratory Environment

8.2.1 *Personal factors*

Table 8.3 shows a summary of the results from an ANOVA using each of the personal factors.

Table 8.3

Results of ANOVA of Environment Variables using Personal Factors

Factor			Student Cohesion	Open-Endedness	Integration	Technology Adequacy	Laboratory Availability
Age	<20	Mean	22.9	24.7	22.6	24.3	19.6
	20-25		22.6	23.4	24.8	23.8	19.0
	25-30		22.5	22.8	26.9	25.0	20.2
	30-35		21.9	23.2	26.9	25.9	20.7
	>35		22.5	24.2	23.2	26.6	21.2
		F	0.15	1.28	3.23*	1.62	0.56
		eta^2	0.00	0.03	0.06	0.03	0.02
		N	192	192	192	192	192
Age	Under 25	Mean	22.6	23.7	24.3	23.9	19.2
	Over 25		22.4	23.2	26.3	25.6	20.5
		F	0.20	0.86	5.19*	5.28*	2.51
		eta^2	0.00	0.00	0.03	0.03	0.01
		N	192	192	192	192	192
Gender	Female	Mean	22.2	22.6	25.2	24.7	19.4
	Male		22.7	24.1	24.8	24.2	19.7
		F	0.60	8.60**	0.35	0.52	0.09
		eta^2	0.00	0.04	0.00	0.00	0.00
		N	193	193	193	193	193
Mode	Part-time	Mean	22.6	22.0	25.0	26.9	21.3
	Full-time		22.6	23.8	25.1	24.1	19.4
		F	0.00	7.13**	0.01	10.26**	3.40
		eta^2	0.00	0.04	0.00	0.05	0.02
		N	192	192	192	192	192
Fees	Subsidised	Mean	22.9	23.9	24.6	24.9	20.5
	Self-funded		22.2	23.1	25.8	24.1	18.7
		F	1.46	2.44	2.12	1.22	4.96*
		eta^2	0.01	0.01	0.01	0.01	0.03
		N	187	187	187	187	187
Background	Asian	Mean	22.5	23.0	25.9	24.0	19.0
	European		23.0	24.3	23.9	25.2	20.2
	Other		20.2	25.0	27.8	27.8	24.0
		F	1.38	3.95*	3.82*	3.22*	2.77
		eta^2	0.01	0.04	0.04	0.03	0.03
		N	184	184	184	184	184

$^{*}p < 0.05$, $^{**}p < 0.01$

It can be seen that there is a significant difference in the means in Integration when age and cultural backgrounds are factors, Open-Endedness when gender, mode of study and cultural background are factors, Technology Adequacy when mode of study and cultural background are factors, and Laboratory Availability when method of fee payment is a factor. Students in the age range 25-35 perceived the laboratory and non-laboratory classes to be more integrated. If the sample is classified by age as under and over 25, it is found that there are significant differences in the means for both Integration and Technology Adequacy, with the older students perceiving higher integration and higher suitability of the hardware and software. Males perceived the class to be more open-ended than females. Full-time students perceived the class to be more open-ended than part-timers. However, part-time students thought that the technology was more adequate than did the full-time ones. Students from an Asian background perceived their laboratory classes to be less open-ended, more integrated with non-laboratory classes and the technology less adequate than their classmates from a European background. Finally, students who paid full fees themselves considered that the laboratories were less available for use than those for whom fees were subsidised.

8.2.2 *Course-related factors*

Table 8.4 shows the results of an ANOVA of the environment variables with the course-related factors. The ANOVA indicates significant differences in the means for Student Cohesiveness, Open-Endedness and Integration with all course-related factors. There were also significant differences in Laboratory Availability with all factors except the type of programme. However, the only factors which produced significant differences in Technology Adequacy were the course itself, the type of programme and the level of the course.

Students following a specialist Information Systems programme perceive greater Student Cohesiveness, Open-Endedness and Integration but less Technology Adequacy. Second year students seem to be less cohesive, postgraduates perceive less open-endedness, first and third year students perceive less integration with non-laboratory classes, and second and third year students score Laboratory Availability lower than first years and postgraduates. Cohesiveness is less for students on courses at the general intermediate level, and open-endedness is less for the specialist intermediate courses. Both general advanced and introductory level students perceived their laboratory classes to be less integrated with other classes in the course. Students on all the specialist courses felt that the technology was less adequate for their requirements compared with those on general courses. Laboratory availability was seen as being less by students on the general advanced and intermediate courses. For courses where the lecturer's expectation was high, both student cohesiveness and laboratory availability were less than for those where the expectation was low or medium. Courses where the lecturer's expectation was medium were perceived to be less open-ended, and where the expectation was low, the laboratory class was less integrated with the rest of the course.

Table 8.4
Results of ANOVA of Environment Variables using Course-related Factors

Factor			Student Cohesion	Open-Endedness	Integration	Technology Adequacy	Laboratory Availability
Program	Special	Mean	23.4	22.7	26.1	23.9	20.3
	General		21.2	25.3	24.9	25.0	18.8
	Other		21.4	24.6	23.1	26.1	18.8
		F	7.24^{**}	11.61^{**}	4.52^{*}	3.37^{*}	1.83
		eta^2	0.08	0.12	0.05	0.04	0.02
		N	180	180	180	180	180
Year	UG1	Mean	23.5	24.4	22.6	24.8	20.5
	UG2		21.6	23.9	26.0	24.2	18.2
	UG3		24.2	24.1	23.2	23.2	18.6
	PG		23.3	20.5	26.0	25.2	22.5
		F	5.02^{**}	10.49^{***}	6.23^{***}	0.99	6.42^{***}
		eta^2	0.07	0.13	0.08	0.01	0.09
		N	206	206	206	206	206
Level	SI	Mean	23.8	23.7	27.0	23.8	22.4
	SM		22.9	21.9	26.3	23.7	20.2
	SA		24.6	23.6	23.9	22.8	19.7
	GI		23.3	24.9	19.1	25.6	19.1
	GM		20.5	25.0	25.5	25.8	17.4
	GA		22.5	26.0	20.0	25.1	14.3
		F	5.10^{***}	7.40^{***}	11.66^{***}	2.31^{*}	4.10^{**}
		eta^2	0.11	0.16	0.23	0.05	0.09
		N	206	206	206	206	206
Expectation	Low	Mean	23.5	24.4	22.6	24.8	20.5
	Med		23.3	20.5	26.0	25.2	22.5
	High		22.1	23.9	25.5	24.1	18.3
		F	3.21^{*}	15.78^{***}	6.56^{**}	1.07	9.62^{***}
		eta^2	0.03	0.13	0.06	0.01	0.09
		N	206	206	206	206	206

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

8.2.3 *Computer-related factors*

Table 8.5 shows the results of an ANOVA of the environment variables with the computer-related factors. There were significant differences in the means for all environment variables with type of computer and all except Integration with prior familiarity with the specific computer system. Students using standalone workstations found student cohesiveness to be less, open-endedness to be greater, integration to be less, the technology more adequate, but the laboratories less available than those using a centralised computer or a network. In addition, there was a significant difference in open-endedness between those using a network and those using a centralised computer system. Students with a high familiarity thought the technology was less adequate than those with less familiarity, and those with low familiarity considered the laboratories to be more available. Student cohesiveness was less and open-endedness seen as greater for students with medium familiarity.

Table 8.5
Results of ANOVA of Environment Variables using Computer-related Factors

Factor			Student Cohesion	Open-Endedness	Integration	Technology Adequacy	Laboratory Availability
System	PC	Mean	21.6	25.0	23.0	25.7	17.8
	Central		23.2	23.1	26.3	23.3	20.3
	Network		23.6	21.0	25.5	24.5	21.1
		F	5.56^{**}	20.09^{***}	8.89^{***}	6.38^{**}	6.76^{**}
		eta^2	0.05	0.17	0.08	0.06	0.06
		N	206	206	206	206	206
Familiarity	Low	Mean	23.4	22.9	23.9	25.0	21.3
	Med		21.3	24.9	25.6	25.3	17.6
	High		22.7	23.1	25.5	23.0	18.8
		F	5.52^{**}	6.28^{**}	2.33	5.05^{**}	9.02^{***}
		eta^2	0.05	0.06	0.02	0.05	0.08
		N	206	206	206	206	206

$^{**}p < 0.01$, $^{***}p < 0.001$

8.2.4 *Discussion*

The results demonstrate that personal factors have little impact on students' perceptions of their computer laboratory environment, but the few perceived significant differences deserve comment. Open-endedness was less for female students than for male students, less for part-time students than for full-time ones, and less for students from an Asian background than for those from a European background. These results indicate a reluctance on the part of certain students to experiment with computer systems. For females this could be associated with anxiety which was also shown to be higher for females than for males. Female students would seem to want to get the required work done, and not investigate the system further. Part-time students often do not have the time to take a divergent approach to learning, and so perceive a learning environment that is rather more restrictive. With Asian students, differences in their perceptions of open-endeness and integration seem likely to be associated with their cultural and prior educational background. Teaching in schools within South East and East Asia tends to involve the transmission of knowledge from teacher to student with little emphasis on divergent thinking (Aldridge, Fraser, & Huang, 1998). Differences in perceptions in learning environment in students from diverse cultural backgrounds have been observed in other studies (Waldrip & Fisher, 1996; Rickards & Fisher, 1997), and one study indicated that students from an Asian cultural background prefer their teachers to be stricter (Fisher, Rickards, Goh, & Wong, 1997). Coming from this background it seems that Asian students, in general, are likely just to complete the laboratory work and assignments that are set using the methods indicated by the lecturer, and go no further.

Integration was also seen to be greater by older students, but it is the researcher's view that this is due to the type of course taken by older students as courses later in the programme tend to be more integrated than the earlier ones. The reason for this is that the computing courses in the later years of a programme deal with more specific topics and often uses specific software. The laboratory component provides a means by which the lecture material is reinforced.

Part-time students considered the technology to be more adequate for the tasks required than full-time students. Many part-time students work in the computing industry and are more realistic about the suitability of technology, and are less susceptible to marketing pressures.

Laboratory availability was significantly lower for students paying their own fees. These students possibly see that having paid a considerable amount of money for their courses, they expect laboratories to be more available than they seem to be.

The course-related factors seem to have a greater effect on perceptions of laboratory environment. Student cohesiveness is higher for specialist classes and this is demonstrated by the significant differences with type of programme and level of course. To some extent this could be explained by the fact that specialist programmes are more prescriptive as far as computing units are concerned than non-specialist programmes. This means that students on specialist programmes tend to study the same courses and hence have a greater opportunity to get to know each other. In those courses in which there was a higher lecturer expectation, student cohesiveness was lower. One interpretation of this would be that such courses encourage competition and so students would tend to work on their own.

Open-endedness was less for both specialist programmes and courses. Again, this has much to do with the nature of the courses in which students have insufficient time to take a divergent approach to learning. Postgraduate courses are perceived as being less open-ended than undergraduate ones. These courses are intended for people who wish to change their careers and so are relatively intensive with the necessity of providing skills in a short period of time. Such courses do not encourage open-endedness.

Integration of the laboratory classes with non-laboratory classes was seen as being different across years of programmes. It is also lower for general introductory courses than for others. For these courses the lectures and laboratories are run independently, so this result is as would be expected.

Students on specialist programmes and courses perceived the hardware and software to be less adequate than other students. This is not surprising since these students would be expected to have a lot of experience of computer systems and know what the capabilities are. There is always a tendency to want the system you are using to do more.

The availability of laboratories was seen as higher by postgraduate students, and this is explained by the fact that there is a computer laboratory reserved for the sole use of postgraduate students. Laboratory availability was considered to be low by students in courses where the lecturer expectation was high, a result explained by such courses involving a lot of laboratory work.

Computer-related factors produced significant differences in the environment variables in all cases except one. Student cohesiveness is perceived as less in those classes that use standalone workstations. This result could be explained by the fact that students tend to work more independently with such computing facilities. Where networks and centralised computers are used, response time is almost invariably slower allowing time for more social activities. Students using individual workstations perceive greater open-endedness and less integration. Both of these could be due to workstations being used primarily for general introductory courses which give greater scope for divergence in learning, but have been designed to be less integrated.

The type of computer system gives differences in Technology Adequacy with a centralised system being less adequate than a network and the network in turn being less than a standalone workstation. This is a result that is consistent with observations that response time is likely to be longer on a system that is shared (Rusli, 1993). Also if a centralised computer fails then it affects large numbers whereas if a workstation fails it affects one person. It is also seen that where students have a high prior familiarity with a computer system, they perceive the technology to be less adequate. This could be a case of familiarity breeding contempt or they need to perform more complex tasks.

The perceived availability of laboratories is seen as less by students requiring individual workstations, which could be caused by greater numbers on courses that use them and this in turn leads to greater demand. Lower laboratory availability is also seen by students who have a high prior familiarity.

8.3 Attitude and Achievement

8.3.1 *Personal factors*

Table 8.6 shows the results of an ANOVA of outcome variables with personal factors. The only significant differences found for personal factors were in Anxiety for both gender, method of fee payment and background. Females were found to have higher anxiety about computers than their male counterparts. Subsidised students were found to have lower anxiety than those who funded themselves or were funded by their families. Students from a European background also had lower anxiety than those from an Asian background.

Table 8.6
Results of ANOVA of Outcome Variables using Personal Factors

Factor			Anxiety	Enjoyment	Usefulness of Course	Usefulness of Computers	Achievement
Age	<20	Mean	13.9	25.0	22.8	26.8	0.66
	20-25		14.1	24.6	22.2	26.2	0.40
	25-30		15.2	24.9	22.3	26.7	0.30
	30-35		13.4	26.3	24.5	27.0	0.76
	>35		13.6	24.9	22.2	25.9	0.93
		F	0.44	0.70	1.38	0.34	2.32
		eta^2	0.01	0.01	0.03	0.01	0.06
		N	192	192	192	192	140
Age	Under 25	Mean	14.1	24.7	23.3	26.4	0.44
	Over 25		14.4	25.5	22.9	26.7	0.56
		F	0.16	1.42	1.00	0.25	0.77
		eta^2	0.00	0.01	0.01	0.00	0.00
		N	192	192	192	192	140
Gender	Female	Mean	15.8	24.2	22.3	26.7	0.64
	Male		13.2	25.3	22.6	26.4	0.41
		F	11.68^{**}	3.17	0.47	0.33	3.11
		eta^2	0.06	0.02	0.00	0.00	0.02
		N	193	193	193	193	141
Mode	Part-time	Mean	13.7	25.1	22.2	26.5	0.54
	Full-time		14.1	25.0	22.7	26.6	0.48
		F	0.14	0.00	0.65	0.06	0.15
		eta^2	0.00	0.00	0.00	0.00	0.00
		N	192	192	192	192	142
Fees	Subsidised	Mean	13.3	25.0	22.6	26.7	0.56
	Self-funded		15.2	25.0	22.6	26.6	0.34
		F	7.00^{**}	0.03	0.00	0.06	3.13
		eta^2	0.04	0.00	0.00	0.00	0.02
		N	187	187	187	187	138
Background	Asian	Mean	14.1	24.3	22.1	25.9	0.27
	European		11.3	24.4	21.7	26.5	0.39
	Other		8.3	22.1	14.7	24.0	-0.19
		F	7.42^{**}	0.09	0.09	1.81	1.02
		eta^2	0.08	0.00	0.00	0.02	0.02
		N	184	184	184	184	137

$^{**}p < 0.01$

8.3.2 *Course-related factors*

The results of an ANOVA of outcome variables using course-related factors are shown in Table 8.7. The only significant differences found were for Anxiety and Enjoyment in the case of type of programme. Students for whom computing is an integral part of the course, whether specialist or generalist, had lower anxiety and a higher enjoyment of computers than those from other disciplines.

Table 8.7
Results of ANOVA of Outcome Variables using Course-related Factors

Factor			Anxiety	Enjoyment	Usefulness of Course	Usefulness of Computers	Achievement
Program	Special	Mean	13.7	25.2	22.1	26.5	0.49
	General		12.8	26.1	23.5	27.3	0.48
	Other		15.7	23.7	23.0	26.4	0.49
		F	3.88*	4.12*	2.71	1.22	0.00
		eta^2	0.04	0.04	0.03	0.01	0.00
		N	180	180	180	180	136
Year	UG1	Mean	14.9	24.7	22.5	26.6	0.55
	UG2		13.6	25.1	22.7	26.7	0.41
	UG3		13.5	25.6	22.7	25.8	0.82
	PG		14.9	24.5	22.0	26.4	0.49
		F	1.09	0.44	0.30	0.57	1.38
		eta^2	0.02	0.01	0.00	0.01	0.03
		N	206	206	206	206	142
Level	SI	Mean	15.0	25.2	21.3	26.6	0.35
	SM		13.5	25.2	22.1	26.8	0.41
	SA		13.6	24.8	22.1	24.9	0.79
	GI		14.8	24.3	23.4	26.6	0.72
	GM		14.6	24.6	23.2	26.3	0.47
	GA		13.3	28.8	25.3	29.3	1.10
		F	0.59	1.01	1.82	1.70	1.31
		eta^2	0.01	0.03	0.04	0.04	0.05
		N	206	206	206	206	142
Expectation	Low	Mean	14.9	24.7	22.5	26.6	0.55
	Med		14.9	24.5	22.0	26.4	0.49
	High		13.6	25.2	22.7	26.5	0.47
		F	1.63	0.58	0.46	0.08	0.13
		eta^2	0.02	0.01	0.00	0.00	0.00
		N	206	206	206	206	142

$^{*}p < 0.05$, $^{**}p < 0.01$

8.3.3 *Computer-related factors*

Table 8.8 gives the results of an ANOVA of the outcome variables using computer-related factors. Significant differences were found for perceived usefulness of the course with the factor computer type. Students who used standalone workstations perceived their course to be more useful than those who used a centralised computer system. There were differences between networked computers and both standalone systems and centralised systems but these were not significant. The only other significant difference was for anxiety where the factor was familiarity with the computer system. Those with higher prior familiarity with the specific computer system used in the course had a lower anxiety than those who had not.

Table 8.8
Results of ANOVA of Outcome Variables using Computer-related Factors

Factor			Anxiety	Enjoyment	Usefulness of Course	Usefulness of Computers	Achievement
System	PC	Mean	14.6	24.7	23.3	26.5	0.58
	Central		13.5	25.3	21.8	26.6	0.41
	Network		14.5	24.7	22.5	26.4	0.56
		F	1.02	0.61	3.94*	0.07	0.88
		eta^2	0.01	0.01	0.04	0.00	0.01
		N	206	206	206	206	142
Familiarity	Low	Mean	14.9	24.6	22.3	26.5	0.52
	Med		14.6	24.5	23.3	26.1	0.50
	High		12.7	25.8	22.2	26.9	0.46
		F	3.70*	1.98	1.90	0.91	0.89
		eta^2	0.04	0.02	0.02	0.01	0.00
		N	206	206	206	206	142

*$p < 0.05$

8.3.4 *Discussion*

Of the personal factors, only gender, method of fee payment and ethnic background give significant differences. For gender, there is a difference in anxiety with females having greater anxiety. This results are consistent with those produced by other studies (Fariña, Arce, Sobral, & Carames, 1991; Newby & Fisher, 1997). However, there are no significant differences in perceived usefulness of computers or usefulness of the class associated with gender. The association between Open-Endedness and Anxiety suggest that computer anxiety in females might be reduced by encouraging a more divergent approach to problem solving. On the other hand, it could be that the perception of lower open-endedness amongst female students is caused by their anxiety which leads to a reluctance or fear to experiment.

Students who pay full fees also have greater anxiety about computers than subsidised students, but this could be part of a general anxiety about performing well on the course. In many cases these students are funded by their families, pay a considerable amount in fees and subsequently are under enormous pressure to perform. A similar difference in anxiety levels is shown for cultural background with students from an Asian background exhibiting greater anxiety than those from a European background. This conflicts with a previous Australian study in which there were no significant differences in attitudes due to country of origin (Lau, Ang, & Winley, 1995). However it should be noted that the overwhelming majority of Asian students pay full fees, whilst the majority of those from a European background are subsidised, so the higher anxiety value could be the result of method of fee payment rather than cultural background.

The course-related factors seem to have little effect on student outcomes. One significant factor is the type of programme with anxiety and enjoyment. Students from non-computing disciplines are more anxious about computers and enjoy them less, a result to be expected.

Of the computer-related factors, significant differences occur in perceived usefulness of the class depending on the type of computer system used. Courses which involve the use of a centralised computer are deemed to be less useful. For courses where the students use a central computer, they access it through a terminal. The computer's operating system schedules the various programs to be run. If two or more students make a request to perform a processor-intensive task or one that requires a great deal of disk input-output at the same time, then this often has a detrimental effect on the computer's apparent performance. This manifests itself with slow response time. Another problem with using a centralised computer for teaching is that if it fails then no one can access it at all, a problem that is less likely to occur with networked computers or standalone workstations. These potential problems probably explain why courses which use a centralised computer are deemed less useful by students.

8.4 Summary

This chapter examined personal factors, course-related and computer-related factors to see if there were any significant differences in environment variables and student outcomes associated with these factors. For the environment variables, most of the significant differences occurred with the course-related and computer-related factors. Gender is an important factor with Open-Endedness of the environment variables producing a significant difference. The outcome variables were less affected by these factors than the environment variables with one notable exception. Anxiety was significantly higher for females than for males, for students who pay their own fees, and for students from an Asian background.

The next chapter examines the effect of country of study on perceptions of computer laboratory environment and on attitude.

CHAPTER 9

COMPARATIVE STUDIES IN THE UNITED KINGDOM AND THE UNITED STATES OF AMERICA

9.1 Introduction

Universities in different countries organise their courses differently and this could affect perceptions of computer laboratory environments and student outcomes. Previous chapters have dealt with the study carried out at Curtin University in Australia, but studies were also carried out at the University of Teesside in the United Kingdom and California State University Fullerton in the United States. For these three universities there are fundamental differences in programme structure, in course organisation, in tuition pattern and in the provision of laboratory class experience. These differences are described in Chapter 4. In summary, a Curtin University course has a single course controller who is responsible for all aspects of the course. He or she is assisted by a number of tutors and laboratory demonstrators. Laboratories are scheduled and at other times the laboratories are unsupervised. The University of Teesside course organisation is similar to that at Curtin but the programme structure is different in that it is year based. At California State University at Fullerton, individual courses are the sole responsibility of the professor who runs it. Laboratory classes are not generally scheduled, and where they are the class size is greater than in the other two universities which were surveyed. The main method of providing students with laboratory experience is through open laboratories. Given these differences, it would be expected that differences in both environment and attitudinal variables would be observed.

This chapter describes the UK and the US studies and compares the results with the Australian study. The comparison is restricted to the environment variables and the attitudinal variables as the grade was unavailable for both the UK and the US studies. Section 9.2 gives the reliabilities and mean correlation coefficients for all three studies and the studies combined. Section 9.3 describes the results for the United Kingdom, section 9.4 the results for the United States study, and section 9.5 the results obtained by combining all three studies. Section 9.6 gives the results of an analysis of variance using country of study as the grouping factor. Section 9.7 discusses the comparative results.

9.2 Reliability and Discriminant Validity

9.2.1 *The Computer Laboratory Environment Inventory*

Table 9.1 gives the Cronbach alpha reliability coefficients and the mean correlation coefficients for the scales of the CLEI for all three samples and for the combined sample.

Table 9.1
Internal Consistency and Discriminant Validity of CLEI Scales for the Australian, United Kingdom, United States and Combined Samples

	Australia		United Kingdom		United States		Combined	
Scale	Alpha	Disc	Alpha	Disc	Alpha	Disc	Alpha	Disc
Student Cohesiveness	0.66	0.13	0.82	0.11	0.73	0.30	0.75	0.21
Open-Endedness	0.60	0.08	0.61	0.13	0.43	0.17	0.66	0.14
Integration	0.89	0.15	0.83	0.13	0.86	0.38	0.88	0.22
Technology Adequacy	0.81	0.18	0.67	0.18	0.83	0.34	0.79	0.21
Laboratory Availability	0.81	0.22	0.83	0.20	0.79	0.39	0.83	0.28
Sample Size	208		107		72		387	

The results show that, with the exception of Open-Endedness for the United States sample, the reliability coefficients for all scales with all samples exceed 0.60 and so the scales are satisfactory from that point of view (Nunnally, 1967). The mean correlations with other scales are relatively small except for the United States, where four of them are greater than 0.30. Even in these cases, the mean correlations are considerably less than the reliability coefficients, indicating that the scales measure distinct but somewhat overlapping aspects of the computer laboratory environment. Another explanation in this case is the relatively small sample size. Similar results have been reported for the first three scales when used as part of the Science Laboratory Environment Inventory, with Open-Endedness giving alpha reliabilities as low as 0.47 (Fraser, McRobbie, & Giddings, 1993).

9.2.2 *The Attitude towards Computers and Computing Courses Questionnaire*

The reliability coefficients and mean correlation coefficients for the scales of the ACCC for each sample and the combined sample are shown in Table 9.2. Each sample gives very similar values for both coefficients on every scale. The mean correlation coefficient tends to be relatively large, but the scales are known to be correlated. This confirms that the instrument generally has satisfactory reliability and sufficient discriminant validity for use in all three countries.

Table 9.2
Internal Consistency and Discriminant Validity of ACCC Scales for the Australian, United Kingdom, United States and Combined Samples

	Australia		United Kingdom		United States		Combined	
Scale	Alpha	Disc	Alpha	Disc	Alpha	Disc	Alpha	Disc
Anxiety	0.90	0.55	0.84	0.46	0.89	0.58	0.90	0.54
Enjoyment	0.90	0.63	0.82	0.50	0.90	0.53	0.89	0.58
Usefulness of Computers	0.83	0.56	0.72	0.35	0.83	0.50	0.79	0.47
Usefulness of Course	0.80	0.49	0.77	0.32	0.79	0.42	0.77	0.43
Sample Size	208		107		72		387	

9.3 United Kingdom Study

The United Kingdom sample consisted of 107 students, mainly from Computer Science related courses. Simple correlation analysis was carried out on the variables from both the CLEI and the ACCC, along with a standard linear regression on each of the attitudinal variables using the environment variables as the independent variables. Table 9.3 shows the results of these analyses giving the correlation coefficients (r) and standardised regression coefficients (β). It also shows the multiple correlation coefficient R^2.

With the UK sample, there were only four significant correlations. Usefulness of Course correlates with Student Cohesiveness, Open-Endedness, and Integration, and Anxiety correlates negatively with Integration. The regression analysis supports three of these correlations involving Usefulness of the Course, but not the one between Anxiety and Integration. The multiple correlation coefficient for Usefulness of Course is significant and indicates that the environment variables explain 39% to the variance in this variable, with Student Cohesiveness, Open-Endedness and Integration all making significant contributions.

Table 9.3
Associations between the CLEI Scales and the ACCC Scales for UK Sample

	Strength of Environment-Outcome Association							
Scale	Anxiety		Enjoyment		Usefulness of Computers		Usefulness of Course	
	r	β	r	β	r	β	r	β
Student Cohesiveness	-0.06	-0.04	0.12	0.12	0.00	-0.05	0.48^{***}	0.50^{***}
Open-Endedness	-0.06	-0.02	0.04	-0.07	-0.14	-0.13	0.34^{***}	0.30^{**}
Integration	-0.22^{*}	-0.19	0.18	0.20	0.16	0.23^{*}	0.36^{***}	0.40^{***}
Technology Adequacy	-0.11	-0.05	0.03	0.02	0.13	0.13	0.14	0.09
Laboratory Availability	-0.12	0.06	-0.06	-0.09	-0.07	-0.15	0.06	-0.06
Multiple R^2	0.01		0.01		0.05		0.39^{***}	

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$ N=107

9.4 United States Study

Table 9.4 presents the simple correlations and standardised regression coefficients for the scales of the CLEI and the ACCC for the United States study of 74 students from one course.

In this case, there are 12 significant correlations. Of the attitudinal variables, only Usefulness of the Course correlates with all the environment variables, and of those only Technology Adequacy correlates significantly with all attitudinal variables. Integration correlates with all attitudinal variables except Anxiety and Laboratory Availability with all except Usefulness of Computers. The regression analysis shows that two of the multiple correlation coefficients are significant. For Enjoyment, 18% of the variance is explained by the environment variables with only Open-Endedness making a significant contribution. For Usefulness of Course, both Open-Endedness and Integration make significant contributions with 25% of the variance being explained by the environment variables.

Table 9.4
Associations between the CLEI Scales and the ACCC Scales for US Sample

Scale	Strength of Environment-Outcome Association							
	Anxiety		Enjoyment		Usefulness of Computers		Usefulness of Course	
	r	β	r	β	r	β	r	β
Student Cohesiveness	-0.04	-0.06	0.12	0.11	0.18	0.07	0.34^{**}	0.16
Open-Endedness	-0.15	-0.17	0.22	0.24^{*}	0.21	0.14	0.35^{**}	0.25^{*}
Integration	-0.16	0.05	0.33^{**}	0.21	0.25^{*}	0.12	0.45^{***}	0.26^{*}
Technology Adequacy	-0.29^{*}	-0.21	0.26^{*}	0.06	0.30^{**}	0.23	0.29^{*}	0.06
Laboratory Availability	-0.29^{*}	0.11	0.35^{**}	0.10	0.17	-0.06	0.34^{**}	0.08
Multiple R^2	0.06		0.18^{**}		0.07		0.25^{***}	

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$ N=72

9.5 Combined Results

Table 9.5 shows the simple correlation coefficients, standardised regression coefficients and multiple correlation coefficients for environment and attitudinal variables when the data from all three studies are combined. These results of the simple correlations show 18 significant correlations out of a possible 20.

Table 9.5
Associations between the CLEI Scales and the ACCC Scales for the Combined Study

Scale	Strength of Environment-Outcome Association							
	Anxiety		Enjoyment		Usefulness of Computers		Usefulness of Course	
	r	*β*	*r*	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	-0.18***	-0.10*	0.19***	0.12*	0.10*	0.05	0.37***	0.22***
Open-Endedness	-0.26***	-0.21***	0.20***	0.16**	0.03	0.01	0.38***	0.30***
Integration	-0.23***	-0.14**	0.25***	0.17**	0.20***	0.12*	0.42***	0.32***
Technology Adequacy	-0.25***	-0.19***	0.23***	0.12*	0.25***	0.14*	0.25***	0.13*
Laboratory Availability	-0.17**	0.01	0.10*	-0.08	0.06	-0.09	0.23***	-0.01
Multiple R^2	0.15***		0.09***		0.03*		0.36***	

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$ N=387

There are strong correlations between all the environment variables and both Anxiety (negatively) and Usefulness of Course. Enjoyment is correlated strongly with all environment variables except Laboratory Availability with which it is still correlated significantly. Usefulness of Computers is correlated with Integration, Technology Adequacy and Student Cohesiveness. The multiple correlation coefficients for all four attitudinal variables are significant when these variables are regressed on the environment variables. The environment variables' contribution to Anxiety is 15%, with Open-Endedness and Technology Adequacy making the major contributions. For Enjoyment, 9% of the variance is explained by the environment with Open-

Endedness and Integration making the most significant contribution. Only 3% of the variance of Usefulness of Computers is explained by the environment variables. For Usefulness of the Course, 36% of its variance is explained by Student Cohesiveness, Open-Endedness, Integration and Technology Adequacy. It should be noted that Laboratory Availability makes no significant contribution to the prediction of any attitudinal variables.

9.6 Analysis of Variance

9.6.1 *Combined samples*

An analysis of variance was carried out on the environment variables using Country of Study as the grouping variable. The results of this are shown in Table 9.6.

These show that there are significant differences in the means for all the variables. Scheffé's test was applied to the pairwise differences of the means and Table 9.7 gives these results. All the scales of the CLEI show significant differences in the means for the samples from the three countries, with all except Technology Adequacy significant at $p<0.001$ level.

Table 9.6

Results of Analysis of Variance of the Environment Variables using Country of Study

		Mean		eta^2
Scale	Australia	United Kingdom	United States	
Student Cohesiveness	22.6	25.2	21.7	0.09^{***}
Open-Endedness	23.5	26.1	21.2	0.20^{***}
Integration	24.8	27.7	25.1	0.06^{***}
Technology Adequacy	24.3	25.3	24.8	0.02^{*}
Laboratory Availability	19.4	23.6	22.1	0.12^{***}

$^{*}p<0.05$, $^{***}p<0.001$

Table 9.7
Results of Scheffé's Test for Pairwise Differences of the Means of the Environment Variables

Scale	Country 1	Country 2	Difference
Student Cohesiveness	Australia	United Kingdom	-2.67^{***}
	Australia	United States	0.83
	United Kingdom	United States	3.50^{***}
Open-Endedness	Australia	United Kingdom	-2.69^{***}
	Australia	United States	2.34^{***}
	United Kingdom	United States	5.03^{***}
Integration	Australia	United Kingdom	-2.94^{***}
	Australia	United States	-0.28
	United Kingdom	United States	2.67^{**}
Technology Adequacy	Australia	United Kingdom	-0.95
	Australia	United States	-1.31
	United Kingdom	United States	-0.37
Laboratory Availability	Australia	United Kingdom	-4.16^{***}
	Australia	United States	-2.69^{***}
	United Kingdom	United States	1.47

$^{**}p<0.01$, $^{***}p<0.001$

The Scheffé test gives greater detail. For both Student Cohesiveness and Integration, the mean of the United Kingdom sample differs significantly from those of both the Australian and United States samples. The mean of Open-Endedness differs significantly for all three samples. For Laboratory Availability, the mean of the Australian sample differs from both the United Kingdom and United States samples. Finally, there are no significant differences in the means for Technology Adequacy for any of the samples, contrary to the result given by the ANOVA.

Table 9.8 gives the results of a one-way analysis of variance performed on the attitudinal variables using Country of Study as the grouping variable, and Table 9.9 the post hoc results from Scheffé's test. All the scales of the ACCC except Enjoyment have significantly different means across the three samples.

Table 9.8
Results of Analysis of Variance of the Attitudinal Variables using Country of Study

Scale	Mean			eta^2
	Australia	United Kingdom	United States	
Anxiety	14.2	11.2	14.0	0.07^{***}
Enjoyment	28.7	29.9	29.1	0.01
Usefulness of Computers	30.3	30.6	32.0	0.03^{**}
Usefulness of Course	25.3	27.8	26.4	0.06^{***}

$^{**}p<0.01$, $^{***}p<0.001$

The Scheffé test shows that the United Kingdom sample has a significantly lower mean score for Anxiety than either the Australian and the United States samples. The mean for Usefulness of Computers is significantly less for the Australian sample than for the United States sample. For Usefulness of the Course, the mean for the Australian sample is less than that for the United Kingdom sample.

Table 9.9
Results of Scheffé's Test for Pairwise Differences of the Means of the Attitudinal Variables

Scale	Country 1	Country 2	Difference
Anxiety	Australia	United Kingdom	2.96^{***}
	Australia	United States	0.20
	United Kingdom	United States	-2.76^{***}
Enjoyment	Australia	United Kingdom	-0.80
	Australia	United States	-0.30
	United Kingdom	United States	0.49
Usefulness of Computers	Australia	United Kingdom	-0.26
	Australia	United States	-1.21^{*}
	United Kingdom	United States	-0.95
Usefulness of Course	Australia	United Kingdom	-1.73^{***}
	Australia	United States	-0.81
	United Kingdom	United States	0.92

$^{*}p<0.05$, $^{***}p<0.001$

9.6.2 *Sample of computing specialists*

Because the results for the UK sample appear on the surface to be substantially different from both the Australian and US samples, a further ANOVA was carried out. This time the sample consisted of those Australian students who were Information Systems specialists together with the complete UK sample, who were all Computer Science specialists. The grouping variable was Country of Study. The results for the environment variables are given in Table 9.10. These show that the means of all these variables for the Australian sample are significantly lower than those for the UK sample, with the differences for Open-Endedness and Laboratory Availability being most significant. Table 9.11 gives the results for the attitudinal variables for the same samples. These show that only the means for Anxiety and Usefulness of the Course are significantly different with the Australian sample having a higher mean for Anxiety and a lower one for Usefulness of Course.

Table 9.10
Results of Analysis of Variance of the Environment Variables for the Specialist Sample using Country of Study

Scale	Mean		eta^2
	Australia (N=92)	United Kingdom (N=107)	
Student Cohesiveness	23.4	25.2	0.05^{**}
Open-Endedness	22.9	26.1	0.21^{***}
Integration	25.9	27.7	0.04^{**}
Technology Adequacy	23.7	25.3	0.03^{**}
Laboratory Availability	20.2	23.6	0.11^{***}

$^{**}p<0.01$, $^{***}p<0.001$

Table 9.11
Results of Analysis of Variance of the Attitudinal Variables for the Specialist Sample using Country of Study

Scale	Mean		eta^2
	Australia (N=92)	United Kingdom (N=107)	
Anxiety	13.7	11.2	0.09^{***}
Enjoyment	25.2	25.7	0.00
Usefulness of Course	22.1	24.1	0.08^{***}
Usefulness of Computers	26.5	26.7	0.00

$^{***}p<0.001$

9.7 Discussion

There would appear to be some inconsistencies in the results from the three studies.

In the Australian study, which is given in Table 9.12, the only non-significant associations involve Laboratory Availability, indicating that this is not a factor in influencing attitude except in perceived usefulness of the course.

The United Kingdom study indicates that of all the attitudinal variables, the only one associated strongly with any of the environment variables is Usefulness of Course, and it is not significantly correlated with either Technology Adequacy or Laboratory Availability. This could be interpreted as meaning that for this group of students, the technology that they are currently using and its availability are neutral as far as affecting attitude both affective and cognitive. It could be that as specialists in the discipline, they have already formed their attitudes towards computers, and specific technology will not change those attitudes. The study in the United States shows results which are closer to the Australian ones. Again, there are significant associations between all environment variables and perceived Usefulness of Course, suggesting the importance of computer laboratory environment to how useful students see courses to be. The adequacy of the technology and its availability seems to have greater impact on attitude than with the United Kingdom sample.

Table 9.12
Associations between the CLEI Scales and the ACCC Scales for the Australian Sample

Scale	Strength of Environment-Outcome Association							
	Anxiety		Enjoyment		Usefulness of Computers		Usefulness of Course	
	r	β	r	β	r	β	r	β
Student Cohesiveness	-0.18^{**}	-0.16^{*}	0.22^{**}	0.17^{*}	0.17^{*}	0.15^{*}	0.26^{***}	0.17^{**}
Open-Endedness	-0.25^{***}	-0.22^{***}	0.25^{***}	0.25^{***}	0.14^{*}	0.18^{*}	0.38^{***}	0.38^{***}
Integration	-0.17^{**}	-0.14^{*}	0.22^{**}	0.16^{*}	0.20^{**}	0.10	0.38^{***}	0.37^{***}
Technology Adequacy	-0.26^{***}	-0.25^{***}	0.26^{***}	0.12	0.26^{***}	0.06	0.26^{***}	0.13^{*}
Laboratory Availability	-0.04	0.12	0.03	-0.12	0.04	-0.10	0.14^{*}	-0.02
Multiple R^2	0.15^{***}		0.12^{***}		0.05^{*}		0.35^{***}	

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$ N=208

The most important observations from these results are the associations between both anxiety and perceived usefulness of the course and all environment variables. This could imply that a laboratory class which is integrated with non-laboratory classes, where the approach is open-ended, where the students are a more cohesive group, where the technology provided is suitable for the task at hand, and where laboratories are freely available, will lead to a reduction in anxiety about computers and a perception that the course is more useful. From another viewpoint, it can be seen that there are associations between both course integration and technology adequacy and all attitudinal variables. This highlights both the importance of course design, particularly the relationship between laboratory classes and non-laboratory classes, and the need to provide hardware and software that is adequate for the exercises assigned to students. This latter point also means that the lecturer running the course must take hardware and software availability into account when designing laboratory work.

The results from the ANOVA support the findings from correlation and regression analyses in terms of similarity between the Australian and United States samples. The mean of the United Kingdom sample was significantly different from both the Australian and United States samples for three out of the five environment variables, namely Student Cohesiveness, Open-Endedness, and Integration. For all three scales, the mean score of the UK sample was greater than those for the other two countries. The content and structure of the programmes surveyed at the University of Teesside may explain this. Firstly, the students in this sample are all specialists in Computer Science or a related discipline, and computers are central to the courses being undertaken to a much greater extent than even Information Systems specialists. Laboratory classes will tend to be more integrated with the lectures than in non-specialist courses, in which the computer is used as a tool. In addition, Computer Science students as specialists will need to and be encouraged to explore the computer system's capabilities by themselves, leading to a higher score for Open-Endedness. The second factor is the programme structure and the culture within UK universities. Although academic programmes in most UK universities consist of a number of distinct courses or modules, progression to the next semester is determined by the student's overall performance on a set of modules. There is a tendency to allow students to continue their programme even if they have not achieved a pass grade in one subject. In such cases, a pass grade is conceded and the student is permitted to continue without the need to take the module again. This leads to the situation where students remain in cohorts, and so there is a greater likelihood of higher student cohesiveness. The fact that there is no significant difference in the means of student cohesiveness for the Australian and United States samples could be explained by their similar programme structures. In both countries, students must repeat a course if they fail it and this tends to break up cohorts.

For Open-Endedness, the mean for the UK sample was significantly greater than that for the Australian sample which in turn was greater than that for the US sample. One possible explanation for this is the level of assessment in typical courses within the three universities. There is much more assessment in terms of mid-semester tests, projects and assignments during a semester in a US university course than there is in an Australian university course where the number of in-semester assignments is usually no more than two. Both of these contrast with the UK where there is little if any in-semester assessment, although students are expected to do assigned work. It would seem that that an emphasis on assessment leaves little time for students to adopt an open-ended, divergent approach to learning.

There is no significant difference in the means for Technology Adequacy across the three samples, indicating that students in all three universities have similar beliefs regarding the suitability of the hardware and software provided. This could be because all three universities provide the same type of facilities, for example Microsoft Windows, Sun Workstations and Unix.

The mean of Laboratory Availability for the Australian students is significantly less than those for both the UK and the US students. One difference that could affect this is the regulation of the laboratories outside scheduled classes. In the Australian study, it was seen that there is no control of access to the laboratories unless it is being used by a class. This often leads to students monopolising computers for many hours preventing others from using them at all. In both the UK and the US, this could not happen because access is regulated. In addition to this, there are a number of other possible reasons, including over scheduling of classes leaving little or no time for unsupervised use of laboratories, insufficient laboratory resources, and the setting of too many assignments that require computing facilities. These factors have not been investigated.

Of the attitudinal variables, Anxiety has a significantly lower mean for the UK sample than either the Australian or US samples. One possible explanation for this is that the UK sample consists of Computing specialists who, in general, have taken more computer-related courses and so their familiarity with computer systems tends to reduce their anxiety. This may be so in this case, but it is unclear from previous studies whether computer anxiety is lessened by prior computer experience or not (Marcoulides, 1988). Both Enjoyment and Usefulness of Computers have high means and the only significant difference ($p<.05$) is between the US and Australian samples. This would seem to reflect similarities in the three societies which all have a great dependence on and experience with information technology. The mean of Usefulness of the Course for the Australian sample is significantly less than that of the UK sample. The mean of US sample is also less than the mean of the UK sample but not significantly. One possible reason is that the UK sample consists of Computer Science students and none of the courses surveyed is introductory. There are other possibilities such as level of exposure to computers in secondary school. Students who have studied computers previously often believe they are covering similar material, especially in introductory courses.

The analysis involving the students from Australia who are Information Systems specialists and those from the UK who are Computer Science specialists shows significant differences in the means of all environment variables, and in anxiety and perceived usefulness of course of the attitudinal variables. This would tend to support the hypothesis that differences in these variables can be attributed to the way courses and programmes are organised in the UK. However, even though Computer Science and Information Systems are both specialist computing programmes, there are considerable differences in the emphases on aspects of the subject, and these could be responsible for the differences observed in the means.

9.8 Summary

This chapter provided the results obtained when the CLEI and the ACCC were administered to students in two universities, one in the United Kingdom, the other in the United States. It also gave results when these two samples were combined with the Australian sample. The reliabilities and mean correlations showed that both instruments exhibited satisfactory internal consistency and discriminant validity across the three samples. Correlation and regression analysis produced substantially different results for all three countries with the United Kingdom results being most at variance with the other two. An ANOVA using country of study as the grouping variable revealed differences in perceptions of computer laboratory environment and in the attitudinal variables. Differences in the results could be caused by the nature of the courses, their content or the course structure and deserves further investigation.

The final chapter of this thesis provides a review of the study. The major findings are discussed with reference to the research questions posed in Chapter 1, as are the implications of these findings for teachers involved in designing courses which involve the use of a computer either as a tool or as a subject of study. The limitations of the study are reviewed and suggestions for future research are outlined.

CHAPTER 10

CONCLUSIONS

10.1 Introduction

During the past thirty years, a great deal of attention has been paid to two areas of study which inform this thesis. Firstly, there have been many research studies into classroom environments, and this has led to the development and use of instruments to assess the qualities of these environments from the perspective of the student (Fraser & Walberg, 1991; Fraser, 1994). One specific classroom setting that has received a lot of interest is the science classroom (McRobbie & Fraser, 1993), and more recently the computer classroom (Maor & Fraser, 1993; Teh & Fraser, 1995). The second area is the introduction of university courses which involve computers and their applications as a subject of study. For over 25 years computer laboratory classes have been an integral part of courses within computer science and business computing programmes.

In recent years there have been a number of studies involving computer classrooms, but the focus has tended to be in computer-assisted learning settings (Maor & Fraser, 1993) or professional short courses (Khoo & Fraser, 1997). Studies that address student outcomes emphasise student variables, particularly gender, age and experience (Pope-Davis & Twing, 1991) or investigate associations between different student outcomes such as anxiety and achievement (Marcoulides, 1988) or attitude and commitment to learning (Levine & Donitsa-Schmidt, 1997). This study is unique for two reasons. Firstly, it involved the development of an instrument for measuring students' perceptions of a computer laboratory classroom environment, where the laboratory classes were part of a course in which computer applications were the focus of the study. Secondly, the instrument was used to determine associations between computer laboratory environment and student outcomes, both in terms of attitude and achievement.

10.2 Review of the Study

The thesis has presented the results of investigations into the associations between students' perceptions of the psychosocial environment of a computer laboratory class and student outcomes. The studies were carried out in three universities in three countries. In each course that was surveyed the computer was used either to develop systems, as it would be in programming courses for example, or as a tool in applications like statistics. None of the courses involved computer-based learning. As there was no instrument which was suitable for measuring the environment of a computer laboratory class in this setting, an existing instrument designed for science laboratories was modified. The introduction of new technology into any part of society has been demonstrated to cause a reaction, either for or against, although some individuals manage to remain indifferent. Because of this, three of the measured student outcomes concerned their attitude towards computers, with a fourth one being concerned with perceptions of usefulness of the course. This led to the development of an instrument, based on an existing one, for measuring attitudinal outcomes in this context. Given that this was the first time that these instruments were used it was important to ensure that they were satisfactory from the points of view of reliability and discriminant validity.

Chapter 2 contained a review of some of the literature relating to previous research on learning environments, focussing on those which took place in university settings, laboratory settings or involved the use of computers. It also contained a review of research into the use of computer laboratory classrooms, and their role within the teaching of computing. Chapter 3 reviewed past research into attitudes towards computers with particular emphasis on how attitudes are associated with student variables and student outcomes.

The methodology employed in the study was given in Chapter 4. The types of the courses run by the different university departments were described, together with the way in which courses were organised, and laboratories integrated into them. For the Australian study, the ways in which assessment is carried out were also described. The methods of statistical analysis used in the study were also given along with the way in which the raw data were entered into the system. The use of standardised z-scores was described. These enabled comparisons of achievement on different courses to be made.

In Chapter 5, the development of an instrument for measuring aspects of a computer laboratory environment, the Computer Laboratory Environment Inventory, was described. It contains five scales, Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy and Laboratory Availability. Factor analysis supported the a priori structure. The Cronbach alpha coefficients, accepted as a measure of the internal consistency of the scales, were found to vary between 0.60 for Open-Endedness to 0.89 for Integration, indicating that the reliabilities of the scales were reasonable in the worst case to very good. The mean correlations with the other scales, which is used as a measure of the extent to which the scales overlap varied from 0.08 for Open-Endedness to 0.22 for Laboratory Availability. This indicated that the scales measure different aspects of the computer laboratory environment. The results from an ANOVA showed that each scale differentiated significantly ($p < .01$) between courses. The eta^2 statistic measures the amount of the variance that can be attributed to the course, and it varied from 0.12 for Technology Adequacy to 0.34 for Integration. This indicated that the CLEI is able to differentiate between students on the basis of course being taken. The reliability, mean correlation and predictive validity for each scale demonstrated that the CLEI is a suitable instrument for measuring specific aspects of a computer laboratory classroom environment.

The development of the instrument for measuring students' attitudinal outcomes, the Attitude towards Computers and Computing Courses Questionnaire, was described in Chapter 6. This instrument has four scales, Anxiety, Enjoyment, (perceived) Usefulness of Computers, and (perceived) Usefulness of the Course. These scales were found to be correlated. A factor analysis with oblique rotation was carried out and suggested that the a priori structure could be supported if one item was removed from each of the scales Enjoyment, Usefulness of Computers, and Usefulness of the

Course. Having done this, it was found that the Cronbach alpha coefficients varied from 0.80 for Usefulness of Course to 0.90 for both Anxiety and Enjoyment, showing very good internal consistency on each scale. The mean correlations with other scales varied from 0.49 for Usefulness of Course to 0.63 for Enjoyment. These indicated that the scales overlap, but this was to be expected given that the factor analysis required oblique axes to obtain a simple structure. The results of this analysis showed that the ACCC is a reliable instrument for measuring student attitudinal outcomes.

Associations between perceptions of aspects of a computer laboratory classroom environment and student outcomes for the Australian sample were dealt with in Chapter 7. The results show that most environment variables were associated significantly with attitudinal variables, but less so with achievement. However, achievement is shown to be associated with attitudinal variables. A two level model suggests that environment influences achievement through attitude. A full discussion of these results is given in the next section.

Chapter 8 dealt with factors that may be predictive of students' perceptions of their computer laboratory environment. It also discussed factors other than learning environment that may be predictive of student outcomes. The variables considered were personal, course-related and computer-related. A number of significant differences in environment variables were found for the independent variables, but there were very few differences in the student outcome measures. A full discussion of the results is given in the next section.

In Chapter 9, the results from studies in three universities were compared. All scales of the CLEI for the United Kingdom study and all scales, except Open-Endedness, for the United States show satisfactory reliability. When the samples are combined all scales exhibit satisfactory reliability. The mean correlations for all samples are acceptable, and indicate that the five scales measure relatively distinct aspects of a computer laboratory environment. For the ACCC, the scales exhibit satisfactory reliability for all samples, and also similar mean correlations. The results from the three samples support the usefulness of both instruments, one for measuring students' perceptions of aspects of a computer laboratory classroom environment and the other students' attitudes towards computers and computing courses. The comparison also showed that there are differences in the ways that the students in the three countries perceived their laboratory environment. There are also differences in the student attitudinal outcomes. These differences could be due to the country of study or could be due to the nature of the course. A further investigation between specialist Computer Science students in the United Kingdom and specialist Information Systems students in Australia was carried out. The results from this showed significant differences suggesting that country of study could make a difference. However, there are other possible causes.

10.3 Major Findings of the Study

The first research question posed for this study was:

> What associations exist between students' perceptions of their computer laboratory classroom environment and their attitudinal and cognitive outcomes in a university setting?

The results for the Australian study which are given in Chapter 7 show anxiety, enjoyment, perceived usefulness of computers and perceived usefulness of the course are all correlated significantly with all environment variables except Laboratory Availability. The regression analysis in general supported these associations. The most significant relationships were found for perceived usefulness of the course, with 36.5% of its variance being accounted for by environment variables. Courses were perceived to be more useful where the approach was more open-ended, where laboratory classes were more integrated with non-laboratory classes, where there was greater cohesion and where the technology was seen to be adequate. Classes perceived to have these attributes were also associated with students exhibiting less computer anxiety. The results from the United Kingdom and United States studies give somewhat different results, but one consistent relationship was between perceived usefulness of the course and environment variables, particularly Integration, Open-Endedness and Student Cohesiveness. For the UK study, environment variables explained 39% of the variance in the perceived usefulness of the course, and in the US study 25%.

In the Australian study, of the environment variables only Student Cohesiveness was significantly correlated to achievement, and then only weakly. The results from regression analysis showed that environment was not a direct predictor of achievement. Previous research suggests that achievement may be associated with some attitudinal variables and this leads to a consideration of the second research question which was:

> What associations exist between students' achievement and their attitude towards both computers and their course?

Achievement was found to be correlated with anxiety, enjoyment and perceived usefulness of the course. Regression analysis showed that perceived usefulness of the course and enjoyment but not anxiety were predictive of achievement. Perceived usefulness of computers was also a significant predictor, but it is a suppressor variable, which increases the overall variance explained by the attitudinal variables through its correlation with enjoyment. Of the variance in achievement 13.7% was explained by the attitudinal variables.

The observation that there is a significant relationship between environment and attitude and one between attitude and achievement suggested a two level model. Structural equation modelling supported this, and the standardised regression coefficient between environment and attitude is 0.95 and between attitude and achievement is 0.35, indicating a regression coefficient between environment and achievement of 0.33. It would seem that computer laboratory classroom environment does influence achievement but it does so indirectly through attitude. The relationship between environment and achievement appears to be weak but this could be due to the way in which achievement is measured. As was described in Section 4.3.3 the overall grade is made up of a number of different assessable components not all of which are affected by computer laboratory environment to the same degree.

The third research question of this study was:

> Are there differences in students' perceptions of their computer laboratory classroom environment based upon student variables, course variables and computer variables?

Chapter 8 identifies certain variables that may affect students' perceptions of their computer laboratory environment, and classifies them according to whether they are personal to the student such as gender and age, whether they are course related such as type of course, or whether they are computer related such as type of computer system. There were very few significant differences in the environment variables that were due to student variables. The only gender related difference was in open-endedness, and female students perceived the computer laboratory class to be less open-ended than did male students. This is contrary to some other studies that have found gender related differences in a number of aspects of laboratory classroom environment (Henderson, 1995). Small but significant differences were found in both integration and technology adequacy associated with age. Students under the age of 25 perceived that the laboratory and non-laboratory classes were less integrated and that the technology was less adequate. Also part-time students found the laboratory classes to be more open-ended and the technology more adequate than full-time students. There were significant differences in the means of open-endedness, integration and technology adequacy associated with cultural background, with students from an Asian background perceiving less open-endedness, greater course integration and less technology adequacy.

There were significant differences in most environment variables due to course-related factors. These factors were type of programme, year of study, level of course, and expectation of lecturer. There were significant differences in the means of Student Cohesiveness, Open-Endedness, and Integration for all these variables. The mean of Laboratory Availability differed for all course-related variables except type of programme. In those courses where the lecturers' expectations were high, the students perceived that the availability of the laboratories was much less than those in other courses. For Technology Adequacy, the differences in the means were only significant for type of programme and level of course.

Two computer-related variables were used. These were type of computer system, either standalone workstation, networked computers or multi-access, and prior familiarity with the specific computer system being used. For type of computer system, there were significant differences in the means for all the environment variables, and for prior familiarity, there were significant differences for all except Integration.

From this it may be seen that although there are some student variables for which there are differences in students' perceptions of their computer laboratory environment, both course variables and computer variables are more important.

The fourth research question proposed was:

> Are there differences in students' attitudinal and achievement outcomes based upon student variables, course variables and computer variables?

There was a gender related difference in the means for anxiety with females exhibiting higher anxiety than males. The other difference related to student variables was a higher anxiety in students who pay full fees and in students from an Asian background. Of the course variables, there was a higher anxiety and lower enjoyment for students on non-computing programmes. There was lower anxiety in those students who had high prior familiarity with the computer system being used within the programme. Overall, there were very few differences in attitudinal variables due to student, course and computer variables. There were no differences in achievement due to these variables.

The final research question proposed in this thesis was:

> Are there differences in students' perceptions of their computer laboratory classroom environment and attitudinal outcomes based upon location of their place of study?

In Chapter 9, results of an ANOVA show that there are significant differences in the means of all environment variables using country of study as the grouping variable. The Scheffé's test indicates the details of these differences, and these show that there are differences between countries for all environment variables except Technology Adequacy. Open-Endedness had differences for all three countries, the United Kingdom exhibited greater Student Cohesiveness and Integration than both Australia and the United States, and the Laboratory Availability was significantly less in Australia than the other two countries. For the attitudinal variables, the results indicate that the United Kingdom sample was less anxious about computers than students in both Australia and the United States. In addition, Australian students perceived their course to be less useful than those in the United Kingdom, and perceived computers to be less useful than the students in the United States did.

10.4 Implications of the Study

This study reports the development and use of an instrument for measuring the psychosocial environment of a computer laboratory classroom. It was used in a university setting in courses which involve using the computer as an integral part of the course, not as a means of delivering educational material. These courses all used scheduled laboratory classes which were staffed. A second instrument was developed based on existing instruments to measure students' attitudes towards computers and computing courses.

The relationships between environment variables and the attitudinal variables have implications for staff who run courses which contain a laboratory component. The results show that computer laboratory classes which are more cohesive, the approach is more open-ended, the laboratory and non-laboratory classes more integrated and the technology is seen to be adequate are associated with lower computer anxiety, greater enjoyment, and more positive perceptions of the usefulness of computers and the course. Each of these environment variables can be influenced by the course controller or programme administrator. Firstly, student cohesiveness is a function of class size and the number of times the students are in class together. If the teaching pattern consists of one large lecture, and then smaller classes such as tutorials and laboratories, then student cohesiveness may be improved by making sure that the same group of students goes to the same tutorial and laboratory sessions, enabling them to get better acquainted. This is something that can be achieved by appropriate timetabling. The other three variables concern the way in which the course material, including lectures, tutorial and laboratory exercises, and assignments, is structured. To improve integration of non-laboratory and laboratory classes, it is important that some part of the laboratory class is spent reinforcing concepts dealt with in lectures and tutorials. On the other hand, open-endedness would be increased by providing exercises that encourage more divergent and exploratory approaches. This would suggest that the course controller should set graduated laboratory exercises based on the competency levels proposed by Dale (1996). The need for adequate technology means that teachers must ensure that the exercises and assignments must be able to be completed in a reasonable time using the hardware and software provided. If the technology is not suitable for the course content, then this has implications for the university. Either the course content is changed or suitable computing equipment must be supplied to satisfy the needs of the course. One observation is that laboratory availability does not seem to be associated with any of the attitude towards computers variables, but it is correlated with perceived usefulness of the course. This could be interpreted as students requiring time out of scheduled classes when they can work on their assignments and laboratory exercises. A number of universities have proposed that students should be required to buy their own machines, but this study has shown that computer laboratory classes may have an influence on attitudes, particularly on perceived usefulness of the course. So even if it is desirable for students to own a computer, laboratory classes will still be necessary on pedagogical grounds.

Achievement was not directly associated with the environment variables, except for student cohesiveness, and that relationship was weak. However, achievement was associated with the attitudinal variables. A two level model indicates that environment influences achievement by influencing attitude. In addition the model suggests that enjoying using computers reduces computer anxiety. These findings reinforce the importance of providing a positive computer laboratory classroom environment.

Most differences in students' perceptions of their computer laboratory environment were found for course and computer related variables, there were very few due to personal student variables. This would suggest that course structure and content, types of assignments and lecturer variables affect the laboratory environment. The differences due to computer related variables indicate the importance of the computer system and prior familiarity with it. This would imply that except in those cases where it is necessary to give students experience of a multi-access system, the standalone or networked workstations should be used for courses. In addition, when networks are used, then to minimise network traffic, required software should where possible be provided on the workstation. Students with higher prior familiarity with the computer system being used for the course showed lower anxiety. This would imply that using the same computer system, or at least the same interface, across a number of courses could reduce anxiety. Many software suppliers already provide a consistent interface (e.g. Microsoft Office™) and this approach will help in increasing familiarity. Although this may be desirable in non-specialist courses, students in specialist programmes should be exposed to a number of different computing environments.

Although gender related differences have been reported for science laboratory classroom environments, with females perceiving a more positive environment on five scales (Henderson, 1995), the only scale of the CLEI that showed a difference was Open-Endedness. Females perceived the environment to be less open-ended than males did. This could be due to female students wanting to complete laboratory exercises and assignments, and perhaps being more focussed on this than their male counterparts who may be more inclined to explore these systems. Female students were also found to be more anxious about computers than males were. This is consistent with a number of other studies (Shashaani, 1993; Reinen & Plomp, 1997). Encouraging female students to adopt a more divergent approach in computer laboratories may help to reduce their anxiety, but there may be other factors that are responsible for it, thus requiring further investigation.

Cultural background would seem to play a role in how students perceive their computer classroom environment, especially with respect to open-endedness and integration. Students from an Asian background appear to see in their laboratory environment what they are accustomed to, which are less open-ended and more integrated courses. However, it should be noted that these students also exhibit higher anxiety. If educators want students from such backgrounds to adopt a more divergent approach to learning, then perhaps it needs to done in a gradual manner with the laboratory component of introductory courses being more structured than laboratories in later courses. Again, this is an area that needs further investigation.

10.5 Limitations of the Study

The most serious limitation to this study is the sample of students. They were those from courses in which the course controller agreed to participate. The Australian sample was drawn from computing courses that were run by the School of Information Systems, which is part of a Business School. The United Kingdom sample was drawn from courses run by the School of Computing and Mathematics. Although there were a number of different courses represented in the sample, they were mainly Computer Science in nature. This made comparisons between students from these samples problematic as it was unclear whether the effects were due to country of study or the nature of the course. The sample from the United States consisted of students from a single course run by the Department of Management Science and Information Systems, which is part of a School of Business Administration and Economics. Having only one course represented in the sample makes it difficult to make comparisons and it also makes it difficult to generalise the results.

A second limitation is the measurement of achievement. Firstly, it was only measured for the Australian sample, and the information required to determine achievement was made optional which reduced the number of subjects by 32%. Also, achievement was measured by the final grade obtained in the course. This is composed of a number of different components, such as final examination, assignments, and laboratory exercises. In addition, these components have different weights in different courses. Even though z-scores were used to enable grade comparisons to be made, the assumption underlying using grade measured in this manner is that environment variables and attitudinal variables affect the grade components consistently.

Another limitation is that both environment and student outcomes were measured on only one occasion. For achievement and perceived usefulness of the course, this is valid, but for computer anxiety or perceived usefulness of computers, it might have been preferable to measure changes in the variables due to the computer laboratory environment.

10.6 Recommendations for Further Research

Further work needs to done to confirm the factorial validity of both the Computer Laboratory Environment Inventory and the Attitude to Computers and Computing Courses Questionnaire. This could be done by administering it to specialist computing students and to non-specialist students in a number of countries, both English-speaking and non-English speaking.

The version of the Computer Laboratory Environment Inventory developed for this study measures a student's perceptions of their actual computer laboratory classroom environment from the viewpoint of the student's personal involvement in the class. One area of research would be to develop a preferred form of the CLEI and use it in conjunction with the actual form in a number of studies. This would allow investigations into differences between actual and preferred environments on the basis of student variables such as gender, mode of study, and cultural background. Studies into associations between student outcomes and differences between actual and preferred could also be made. In addition to the personal form of the CLEI, a class form could be used to measure students' perceptions of the classroom milieu. A further option is an instructor's version of both the actual and preferred CLEI. Such instruments would open up a rich field of study. Comparisons between instructor's and students' perceptions of the same classroom environment, both actual and preferred, could be made.

The present study found little evidence of gender related differences in students' perceptions of their classroom environment or in their outcomes, with the notable exception of computer anxiety. However, other studies have shown gender-related differences in perceptions of environment and computer attitudes, so an extended investigation involving gender would be valuable.

Differences in students' perceptions of some aspects of their laboratory environment were found to be due to cultural background, and this warrants further investigation. Also, the three studies were limited to countries which are predominantly English speaking. Although there are differences in the educational culture of Australia, the United Kingdom and the United States, there are marked similarities. Non-English speaking countries tend to have different educational cultures, even where the medium of instruction is English. It would be useful to conduct studies into the associations between perceptions of laboratory environment and student outcomes in non-English speaking countries.

One aspect that has been viewed as a limitation in the present study is the measurement of achievement. Future studies could investigate how different components of achievement, formal examination, practical assignments and successful completion of laboratory exercises are associated with the perceived laboratory environment.

Differences in the environment variables were found to be associated with course-related variables. Further investigations could be carried out to determine to what extent course structure, organisation, and assessment method influence students' perceptions of computer laboratory environment.

10.7 Summary

In this research, two instruments were developed, the Computer Laboratory Environment Inventory and the Attitude towards Computers and Computing Questionnaire. The ACCC is based on a number of existing instruments with one original scale to gauge students' perceptions of the usefulness of the course. This instrument is a useful addition to those that measure computer attitude. Although the CLEI is based on an existing instrument, it is used in a completely novel setting, the computer laboratory classroom. The development of the CLEI is one of the most significant outcomes from this research. This instrument has been shown to have factorial validity. Its scales have been shown to have acceptable reliability and discriminant validity in three separate studies in Australia, the United Kingdom and the United States. This instrument is now available to researchers and lecturers, and should prove useful in the design and implementation of the laboratory component of a course and in the formative evaluation of such a course.

The other important result is the finding that computer laboratory environment influences attitude which in turn affect achievement. The effect of environment on attitude is direct, whereas its effect on achievement is indirect but relatively strong, considering the limitations on how achievement was measured. All attitudinal variables are associated with more than one aspect of laboratory environment, but it is perceived usefulness of the course that is associated most strongly. This would imply that a positive laboratory environment is likely to lead to more positive views of students towards the course, and in turn to improved academic performance. No longer should computer laboratories be seen as an expensive overhead by educational administrators, and computer laboratory classes as a component of a course requiring little preparation. Computer laboratory classes have been shown to be an important part of university computing courses, and should be planned with as much care as would be given to lectures. Although the open laboratory with access to laboratories outside normal scheduled classes is desirable, it is the planned closed laboratory class that provides a more satisfying educational experience. The results from the study described in this thesis should convince educators and educational administrators of the value of and necessity for computer laboratory classes.

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APPENDIX A

Original Questionnaire for the Computer Laboratory Environment and the Attitude towards Computers and Computing Questionnaire

		Almost Never	Seldom	Sometimes	Often	Almost Always
1	I get on well with students in this laboratory class.	1	2	3	4	5
2	There is opportunity for me to pursue my own computing interests in this laboratory class.	1	2	3	4	5
3	What I do in the lecture is unrelated to my laboratory work.	1	2	3	4	5
4	The computer software is difficult to use.	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the computer.	1	2	3	4	5
6	I have little chance to get to know other students in this laboratory class.	1	2	3	4	5
7	In this laboratory class, I am required to design my own solutions to a given problem.	1	2	3	4	5
8	The laboratory work is unrelated to the topics that I am studying in my lecture.	1	2	3	4	5
9	The computer software runs without any problems	1	2	3	4	5
10	The laboratory room is readily available.	1	2	3	4	5
11	Members of this laboratory class help me.	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions than I do for the same problem.	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5
14	The computers are powerful enough to cope with the demands	1	2	3	4	5
15	I am concerned about the appearance of the laboratory.	1	2	3	4	5
16	I get to know students in this laboratory class well.	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigations of my own.	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5
19	The computer software available enables students to make good use of the computer	1	2	3	4	5
20	I can access to the laboratory outside my normal classes	1	2	3	4	5
21	I am able to depend on other students for help during laboratory classes.	1	2	3	4	5
22	In my laboratory sessions, I solve different problems than some of the other students.	1	2	3	4	5
23	The topics covered in lectures are quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5
24	There are enough computers / terminals for students to use	1	2	3	4	5
25	I find that the laboratory is hot and stuffy.	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1	2	3	4	5
27	In my laboratory sessions, the instructor decides the best way for me to solve a given problem.	1	2	3	4	5
28	What I do in laboratory sessions helps me to understand the theory covered in lectures.	1	2	3	4	5
29	The computers are suitable for running the software I am required to use	1	2	3	4	5
30	The laboratory is an attractive place for me to work in.	1	2	3	4	5
31	I work cooperatively in laboratory sessions.	1	2	3	4	5
32	I decide the best way to proceed when developing a solution to a problem given in the laboratory class	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5
34	The computers are in good working condition	1	2	3	4	5
35	My laboratory has enough room for individual or group work.	1	2	3	4	5

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
36 I do not think I will ever use what I learned in this class	1	2	3	4	5
37 I feel comfortable when a conversation turns to computers	1	2	3	4	5
38 Studying about computers is a waste of time	1	2	3	4	5
39 It is fun to find out how computer systems work	1	2	3	4	5
40 This class provided me with skills I expect to use in the future	1	2	3	4	5
41 I feel at ease when I am around computers	1	2	3	4	5
42 My future career will require a knowledge of computers	1	2	3	4	5
43 I enjoy using a computer	1	2	3	4	5
44 This class has increased my technical skills	1	2	3	4	5
45 Working with a computer makes me very nervous.	1	2	3	4	5
46 I cannot imagine getting a job that does not involve using computers	1	2	3	4	5
47 I think working with computers would be enjoyable and stimulating	1	2	3	4	5
48 I gained few useful skills from this class	1	2	3	4	5
49 I get a sinking feeling when I think about trying to use a computer	1	2	3	4	5
50 Computers are an important factor in the success of a business.	1	2	3	4	5
51 The challenge of solving problems using a computer does not appeal to me	1	2	3	4	5
52 The skills gained in this class are too specific to be generally useful in the future	1	2	3	4	5
53 Computers make me feel uncomfortable.	1	2	3	4	5
54 The use of computers will increase in the future	1	2	3	4	5
55 I would like to work with computers.	1	2	3	4	5
56 This class helped develop my problem-solving skills	1	2	3	4	5
57 Computers make me feel uneasy and confused.	1	2	3	4	5
58 All tertiary students need a course about using computers	1	2	3	4	5
59 I enjoy learning on a computer	1	2	3	4	5
60 As a result of this class I feel confident about tackling unfamiliar problems involving computers	1	2	3	4	5
61 I feel aggressive and hostile towards computers	1	2	3	4	5
62 Knowledge of the use of computers will help me get a job	1	2	3	4	5
63 Learning about computers is boring	1	2	3	4	5

STUDENT NUMBER ____________________

UNIT ____________________

COURSE ____________________ **MAJOR (if applicable)** ____________________

MODE OF STUDY ☐ **Part-time** ☐ **Full-time**

GENDER ☐ **Female** ☐ **Male**

AGE ☐ **<20** ☐ **20-24** ☐ **25-29** ☐ **30-35** ☐ **>35**

FEES PAYMENT ☐ **HECS** ☐ **Extension** ☐ **AusAid** ☐ **Self funded**

COUNTRY OF BIRTH ____________________

APPENDIX B

Revised Questionnaire for the Computer Laboratory Environment and the Attitude towards Computers and Computing Questionnaire used for the Australian Study

CURTIN UNIVERSITY OF TECHNOLOGY

SCHOOL OF INFORMATION SYSTEMS

COMPUTER LABORATORY SURVEY

The attached questionnaire is being used to investigate the effectiveness of computer laboratories. It is hoped that this will allow us to provide more appropriate laboratory environments within the Curtin Business School.

- Your participation in this survey is voluntary.
- I have requested your student number so that I can use it to correlate your responses to these questions with the grade you obtain in this unit. Your student number will be used for no other purpose. However if you wish your responses to remain anonymous, do not give your student number.
- The data collected will remain confidential and I will be the only person who will see it.
- I realise that this is a very busy time of semester for you, but this is the most appropriate time to carry out this survey.
- The questionnaire should take about 10 minutes to complete and will provide us with information which could be used to improve the way that laboratory classes are run.
- If you have been completed this questionnaire for another unit this semester, there is no need for you to complete it again; if you have completed it in a previous semester I would request you to do so again as it has been modified.

Your participation in this survey is greatly appreciated

Michael Newby
Senior Lecturer
School of Information Systems

		Almost Never	Seldom	Sometimes	Often	Almost Always
1	I get on well with students in this laboratory class.	1	2	3	4	5
2	There is opportunity for me to pursue my own computing interests in this laboratory class.	1	2	3	4	5
3	What I do in the lecture is unrelated to my laboratory work.	1	2	3	4	5
4	The computer software is difficult to use.	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the computer.	1	2	3	4	5
6	I have little chance to get to know other students in this laboratory class.	1	2	3	4	5
7	In this laboratory class, I am required to design my own solutions to a given problem.	1	2	3	4	5
8	The laboratory work is unrelated to the topics that I am studying in my lecture.	1	2	3	4	5
9	The computer software runs without any problems	1	2	3	4	5
10	The laboratory room is readily available.	1	2	3	4	5
11	Members of this laboratory class help me.	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions than I do for the same problem.	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5
14	The computers are powerful enough to cope with the demands	1	2	3	4	5
15	Outside my normal laboratory classes, I have to wait if I want to use a terminal or a computer.	1	2	3	4	5
16	I get to know students in this laboratory class well.	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigations of my own.	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5
19	The computer software available enables students to make good use of the computer	1	2	3	4	5
20	I can gain access to the laboratory outside my normal classes	1	2	3	4	5
21	I am able to depend on other students for help during laboratory classes.	1	2	3	4	5
22	In my laboratory sessions, I solve different problems than some of the other students.	1	2	3	4	5
23	The topics covered in lectures are quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5
24	The computers are in good working condition	1	2	3	4	5
25	There is enough free laboratory time during the week for me to complete all my laboratory work comfortably.	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1	2	3	4	5
27	In my laboratory sessions, the instructor decides the best way for me to solve a given problem.	1	2	3	4	5
28	What I do in laboratory sessions helps me to understand the theory covered in lectures.	1	2	3	4	5
29	The computers are suitable for running the software I am required to use	1	2	3	4	5
30	It is difficult for me to find a terminal / computer free when I want to use one.	1	2	3	4	5
31	I work cooperatively in laboratory sessions.	1	2	3	4	5
32	I decide the best way to proceed when developing a solution to a problem given in the laboratory class	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5
34	When I make a mistake, the computer software behaves satisfactorily (i.e. the computer does not 'hang').	1	2	3	4	5
35	There are enough computers / terminals for students to use	1	2	3	4	5

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
36 I do not think I will ever use what I learned in this class	1	2	3	4	5
37 I feel comfortable when a conversation turns to computers	1	2	3	4	5
38 Studying about computers is a waste of time	1	2	3	4	5
39 It is fun to find out how computer systems work	1	2	3	4	5
40 This class provided me with skills I expect to use in the future	1	2	3	4	5
41 I feel at ease when I am around computers	1	2	3	4	5
42 My future career will require a knowledge of computers	1	2	3	4	5
43 I enjoy using a computer	1	2	3	4	5
44 This class has increased my technical skills	1	2	3	4	5
45 Working with a computer makes me very nervous.	1	2	3	4	5
46 I cannot imagine getting a job that does not involve using computers	1	2	3	4	5
47 I think working with computers would be enjoyable and stimulating	1	2	3	4	5
48 I gained few useful skills from this class	1	2	3	4	5
49 I get a sinking feeling when I think about trying to use a computer	1	2	3	4	5
50 Computers are an important factor in the success of a business.	1	2	3	4	5
51 The challenge of solving problems using a computer does not appeal to me	1	2	3	4	5
52 The skills gained in this class are too specific to be generally useful in the future	1	2	3	4	5
53 Computers make me feel uncomfortable.	1	2	3	4	5
54 The use of computers will increase in the future	1	2	3	4	5
55 I would like to work with computers.	1	2	3	4	5
56 This class helped develop my problem-solving skills	1	2	3	4	5
57 Computers make me feel uneasy and confused.	1	2	3	4	5
58 All tertiary students need a course about using computers	1	2	3	4	5
59 I enjoy learning on a computer	1	2	3	4	5
60 As a result of this class I feel confident about tackling unfamiliar problems involving computers	1	2	3	4	5
61 I feel aggressive and hostile towards computers	1	2	3	4	5
62 Knowledge of the use of computers will help me get a job	1	2	3	4	5
63 Learning about computers is boring	1	2	3	4	5

STUDENT NUMBER ______________________________

UNIT __________________

COURSE ________________ **MAJOR (if applicable)** ____________

MODE OF STUDY ☐ **Part-time** ☐ **Full-time**

GENDER ☐ **Female** ☐ **Male**

AGE ☐ **<20** ☐ **20-24** ☐ **25-29** ☐ **30-35** ☐ **>35**

FEES PAYMENT ☐ **HECS** ☐ **Extension** ☐ **AusAid** ☐ **Self funded**

COUNTRY OF BIRTH ______________________________

APPENDIX C

Letter and Questionnaire for the Computer Laboratory Environment and the Attitude towards Computers and Computing Questionnaire used for the United Kingdom Study

SCHOOL OF INFORMATION SYSTEMS

CURTIN UNIVERSITY OF TECHNOLOGY
PERTH, WESTERN AUSTRALIA

COMPUTER LABORATORY SURVEY

I am a Senior Lecturer in the School of Information Systems at Curtin University, Perth, Western Australia and am currently researching the effectiveness of computer laboratory classes. The attached questionnaire is being used to investigate this effectiveness. I have surveyed students in Western Australia and would like to extend the research to the United Kingdom. I am seeking your assistance in doing so and would ask you to note the following points:

- Your participation in this survey is voluntary.

- I have requested your student number so that I can use it to correlate your responses to these questions with the grade you obtain in this unit. Your student number will be used for no other purpose. However if you wish your responses to remain anonymous, do not give your student number.

- The data collected will remain confidential and I will be the only person who will see it.

- The questionnaire should take about 10 minutes to complete and will provide us with information which could be used to improve the way that laboratory classes are run.

Your participation in this survey is greatly appreciated

Michael Newby
Senior Lecturer
School of Information Systems

		Almost Never	Seldom	Sometimes	Often	Almost Always
1	I get on well with students in this laboratory class.	1	2	3	4	5
2	There is opportunity for me to pursue my own computing interests in this laboratory class.	1	2	3	4	5
3	What I do in the lecture is unrelated to my laboratory work.	1	2	3	4	5
4	The computer software is difficult to use.	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the computer.	1	2	3	4	5
6	I have little chance to get to know other students in this laboratory class.	1	2	3	4	5
7	In this laboratory class, I am required to design my own solutions to a given problem.	1	2	3	4	5
8	The laboratory work is unrelated to the topics that I am studying in my lecture.	1	2	3	4	5
9	The computer software runs without any problems	1	2	3	4	5
10	The laboratory room is readily available.	1	2	3	4	5
11	Members of this laboratory class help me.	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions than I do for the same problem.	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5
14	The computers are powerful enough to cope with the demands	1	2	3	4	5
15	Outside my normal laboratory classes, I have to wait if I want to use a terminal or a computer.	1	2	3	4	5
16	I get to know students in this laboratory class well.	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigations of my own.	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5
19	The computer software available enables students to make good use of the computer	1	2	3	4	5
20	I can gain access to the laboratory outside my normal classes	1	2	3	4	5
21	I am able to depend on other students for help during laboratory classes.	1	2	3	4	5
22	In my laboratory sessions, I solve different problems than some of the other students.	1	2	3	4	5
23	The topics covered in lectures are quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5
24	There are enough computers / terminals for students to use	1	2	3	4	5
25	There is enough free laboratory time during the week for me to complete all my laboratory work comfortably.	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1	2	3	4	5
27	In my laboratory sessions, the instructor decides the best way for me to solve a given problem.	1	2	3	4	5
28	What I do in laboratory sessions helps me to understand the theory covered in lectures.	1	2	3	4	5
29	The computers are suitable for running the software I am required to use	1	2	3	4	5
30	It is difficult for me to find a terminal / computer free when I want to use one.	1	2	3	4	5
31	I work cooperatively in laboratory sessions.	1	2	3	4	5
32	I decide the best way to proceed when developing a solution to a problem given in the laboratory class	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5
34	The computers are in good working condition	1	2	3	4	5
35	When I make a mistake, the computer software behaves satisfactorily (i.e. the computer does not 'hang').	1	2	3	4	5

		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
36	I do not think I will ever use what I learned in this class	1	2	3	4	5
37	I feel comfortable when a conversation turns to computers	1	2	3	4	5
38	Studying about computers is a waste of time	1	2	3	4	5
39	It is fun to find out how computer systems work	1	2	3	4	5
40	This class provided me with skills I expect to use in the future	1	2	3	4	5
41	I feel at ease when I am around computers	1	2	3	4	5
42	My future career will require a knowledge of computers	1	2	3	4	5
43	I enjoy using a computer	1	2	3	4	5
44	This class has increased my technical skills	1	2	3	4	5
45	Working with a computer makes me very nervous.	1	2	3	4	5
46	I cannot imagine getting a job that does not involve using computers	1	2	3	4	5
47	I think working with computers would be enjoyable and stimulating	1	2	3	4	5
48	I gained few useful skills from this class	1	2	3	4	5
49	I get a sinking feeling when I think about trying to use a computer	1	2	3	4	5
50	Computers are an important factor in the success of a business.	1	2	3	4	5
51	The challenge of solving problems using a computer does not appeal to me	1	2	3	4	5
52	The skills gained in this class are too specific to be generally useful in the future	1	2	3	4	5
53	Computers make me feel uncomfortable.	1	2	3	4	5
54	The use of computers will increase in the future	1	2	3	4	5
55	I would like to work with computers.	1	2	3	4	5
56	This class helped develop my problem-solving skills	1	2	3	4	5
57	Computers make me feel uneasy and confused.	1	2	3	4	5
58	All university students need a course about using computers	1	2	3	4	5
59	I enjoy learning on a computer	1	2	3	4	5
60	As a result of this class I feel confident about tackling unfamiliar problems involving computers	1	2	3	4	5
61	I feel aggressive and hostile towards computers	1	2	3	4	5
62	Knowledge of the use of computers will help me get a job	1	2	3	4	5
63	Learning about computers is boring	1	2	3	4	5

STUDENT NUMBER ______________________________

MODULE ____________________

COURSE ____________________ **ROUTE (if applicable)** ____________

MODE OF STUDY ☐ **Part-time** ☐ **Full-time**

GENDER ☐ **Female** ☐ **Male**

AGE ☐ **<20** ☐ **20-24** ☐ **25-29** ☐ **30-35** ☐ **>35**

FEES PAYMENT ☐ **Local Authority** ☐ **Full fee** ☐ **Repeat Class** ☐ **Other**

COUNTRY OF BIRTH ______________________________

APPENDIX D

Letter and Questionnaire for the Computer Laboratory Environment and the Attitude towards Computers and Computing Questionnaire used for the United States Study

COMPUTER LABORATORY SURVEY

The attached questionnaire is being used to investigate the effectiveness of computer laboratories.

- Your participation in this survey is voluntary.
- The data collected will remain confidential.
- The questionnaire should take about 10 minutes to complete.

Michael Newby
Senior Lecturer
School of Information Systems
Curtin University
Perth
Western Australia

George Marcoulides
Professor
Department of Management Science
California State University, Fullerton
Fullerton
California

Demographic Information

COURSE____

MAJOR____

MODE OF STUDY (please check) ☐ **Part-time** ☐ **Full-time**

GENDER (please check) ☐ **Female** ☐ **Male**

AGE (please check) ☐ **<20** ☐ **20-24** ☐ **25-29** ☐ **30-35** ☐ **>35**

ETHNIC-RACIAL BACKGROUND (please check)

American Indian or Alaskan native ☐
Black, non-Hispanic, African American ☐
Mexican-American, Mexican, Chicano ☐
Other Latino, Hispanic ☐
Asian ☐
Pacific Islander ☐
White, non-Hispanic ☐
Other (please specify) ____________________

		Almost Never	Seldom	Sometimes	Often	Almost Always
1	I get on well with students in this laboratory class.	1	2	3	4	5
2	There is opportunity for me to pursue my own computing interests in this laboratory class.	1	2	3	4	5
3	What I do in the lecture is unrelated to my laboratory work.	1	2	3	4	5
4	The computer software is difficult to use.	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the computer.	1	2	3	4	5
6	I have little chance to get to know other students in this laboratory class.	1	2	3	4	5
7	In this laboratory class, I am required to design my own solutions to a given problem.	1	2	3	4	5
8	The laboratory work is unrelated to the topics that I am studying in my lecture.	1	2	3	4	5
9	The computer software runs without any problems	1	2	3	4	5
10	The laboratory room is readily available.	1	2	3	4	5
11	Members of this laboratory class help me.	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions than I do for the same problem.	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5
14	The computers are powerful enough to cope with the demands	1	2	3	4	5
15	Outside my normal laboratory classes, I have to wait if I want to use a terminal or a computer.	1	2	3	4	5
16	I get to know students in this laboratory class well.	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigations of my own.	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5
19	The computer software available enables students to make good use of the computer	1	2	3	4	5
20	I can gain access to the laboratory outside my normal classes	1	2	3	4	5
21	I am able to depend on other students for help during laboratory classes.	1	2	3	4	5
22	In my laboratory sessions, I solve different problems than some of the other students.	1	2	3	4	5
23	The topics covered in lectures are quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5
24	There are enough computers / terminals for students to use	1	2	3	4	5
25	There is enough free laboratory time during the week for me to complete all my laboratory work comfortably.	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1	2	3	4	5
27	In my laboratory sessions, the instructor decides the best way for me to solve a given problem.	1	2	3	4	5
28	What I do in laboratory sessions helps me to understand the theory covered in lectures.	1	2	3	4	5
29	The computers are suitable for running the software I am required to use	1	2	3	4	5
30	It is difficult for me to find a terminal / computer free when I want to use one.	1	2	3	4	5
31	I work cooperatively in laboratory sessions.	1	2	3	4	5
32	I decide the best way to proceed when developing a solution to a problem given in the laboratory class	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5
34	The computers are in good working condition	1	2	3	4	5
35	When I make a mistake, the computer software behaves satisfactorily (i.e. the computer does not 'hang').	1	2	3	4	5

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
36 I do not think I will ever use what I learned in this class	1	2	3	4	5
37 I feel comfortable when a conversation turns to computers	1	2	3	4	5
38 Studying about computers is a waste of time	1	2	3	4	5
39 It is fun to find out how computer systems work	1	2	3	4	5
40 This class provided me with skills I expect to use in the future	1	2	3	4	5
41 I feel at ease when I am around computers	1	2	3	4	5
42 My future career will require a knowledge of computers	1	2	3	4	5
43 I enjoy using a computer	1	2	3	4	5
44 This class has increased my technical skills	1	2	3	4	5
45 Working with a computer makes me very nervous.	1	2	3	4	5
46 I cannot imagine getting a job that does not involve using computers	1	2	3	4	5
47 I think working with computers would be enjoyable and stimulating	1	2	3	4	5
48 I gained few useful skills from this class	1	2	3	4	5
49 I get a sinking feeling when I think about trying to use a computer	1	2	3	4	5
50 Computers are an important factor in the success of a business.	1	2	3	4	5
51 The challenge of solving problems using a computer does not appeal to me	1	2	3	4	5
52 The skills gained in this class are too specific to be generally useful in the future	1	2	3	4	5
53 Computers make me feel uncomfortable.	1	2	3	4	5
54 The use of computers will increase in the future	1	2	3	4	5
55 I would like to work with computers.	1	2	3	4	5
56 This class helped develop my problem-solving skills	1	2	3	4	5
57 Computers make me feel uneasy and confused.	1	2	3	4	5
58 All college students need a course about using computers	1	2	3	4	5
59 I enjoy learning on a computer	1	2	3	4	5
60 As a result of this class I feel confident about tackling unfamiliar problems involving computers	1	2	3	4	5
61 I feel aggressive and hostile towards computers	1	2	3	4	5
62 Knowledge of the use of computers will help me get a job	1	2	3	4	5
63 Learning about computers is boring	1	2	3	4	5

Thank you for your cooperation

APPENDIX E

Coding for Student and Course Variables

Variable	Code	Meaning
Age	1	< 20
	2	20-24 inclusive
	3	25-29 inclusive
	4	30-35 inclusive
	5	> 35
Gender	1	Female
	2	Male
Mode of Study	1	Part-time
	2	Full-time
Country of Birth	1	Australia
	2	Singapore
	3	Malaysia
	4	Thailand
	5	Vietnam
	6	Indonesia
	7	Korea
	8	Japan
	9	Iran
	10	Maldives
	11	Taiwan
	12	United Kingdom
	13	Sudan
	14	China
	15	Hong Kong
	16	Germany
	17	Ireland
	18	Sri Lanka
	19	India
	20	Tanzania
	21	Mongolia
	22	Poland
	23	Brazil
	24	New Zealand
	25	South Africa
	26	Uzbekistan
	27	Macau
	28	Brunei
	29	Cyprus
	30	Romania
	31	France
	32	Greece
	33	Botswana
	34	Bahrain
	35	Pakistan

Variable	Code	Meaning
Ethnic Group (US)	51	American Indian
	52	African American
	53	Mexican American
	54	Hispanic
	55	Asian
	56	Pacific Islander
	57	Caucasian
	58	Middle Eastern
	59	Indian
Method of Fee Payment	1	Local state subsidised
	2	Self-funded: not for credit
	3	Overseas subsidised
	4	Self-funded
Country of Study	1	Australia
	2	United Kingdom
	3	United States
Course	1	Information Systems 100
	2	Personal Computing 211
	3	Program Design 102
	4	Systems Implementation 202
	5	Database Systems 202
	6	Transaction Processing Systems 302
	7	Distributed Systems 302
	8	Business Microcomputing 311
	9	Distributed Systems 502
	10	Systems Implementation 502
	21	Production Animation
	22	Multimedia Authoring
	23	Distributed Computing
	24	Multimedia Technology
	25	Graphical Programming
	26	Creative Animation Techniques
	27	Formal Methods
	28	Data Structures
	41	Quantitative Business Analysis: Probability & Statistics

Variable	Code	Meaning
Programmes / Majors	1	BComm (Information Systems)
	2	BComm (Information Technology)
	3	BComm (International Business & Information Systems)
	4	BComm (Marketing & Information Systems)
	5	BComm (HRM & Information Systems)
	6	BComm (Accounting & Information Systems)
	7	BComm (Management & Information Systems)
	10	Graduate Diploma in Business Computing
	11	Postgraduate Diploma in Information Systems
	12	MComm (Information Systems)
	20	BComm (General)
	21	BComm (Property Studies)
	22	BComm (Marketing)
	23	BComm (Accounting)
	24	BComm (Management & Marketing)
	25	BComm (International Business)
	26	BComm (Marketing & Public Relations)
	27	BComm (Human Resource Management)
	28	BComm (Economics & Finance)
	29	BComm (Finance)
	40	BA (Social Science) / BComm
	50	BSc (Multi-disciplinary)
	51	BEd
	52	BSc (Health Sciences)
	53	BSc (Medical Science)
	54	BA (Mass Communication)
	55	BSc (Health Information Management)
	56	BApplSc (Information & Library Studies)
	57	BSc (Chemical Engineering)
	101	MSc (CAGTA)
	102	BSc (Information Society
	103	BSc (Computer Science)
	104	BSc (Visualisation)
	105	HND (Computing)
	201	BA (Bus Admin – Marketing)
	202	BA (Bus Admin – Finance)
	203	BA (Bus Admin – MIS)
	204	BA (Bus Admin – Management)
	205	BA (Bus Admin – International Business)
	206	BA (Bus Admin – Economics)
	207	BA (Bus Admin – Accounting & MIS)
	208	BA (Bus Admin – Accounting & Finance)
	209	BA (Bus Administration)
	210	BA (Bus Admin – Management Science)
	211	BA (Bus Admin – Management & Marketing)
	212	BA (Bus Admin – Operations Management)

APPENDIX F

Scale Allocation for Items in the Computer Laboratory Environment Inventory

Student Cohesiveness

1. I get on well with students in this laboratory class.
6. I have little chance to get to know other students in this laboratory class.
11. Members of this laboratory class help me.
16. I get to know students in this laboratory class well.
21. I am able to depend on other students for help during laboratory classes.
26. It takes me a long time to get to know everybody by his/her first name in this laboratory class.
31. I work cooperatively in laboratory sessions.

Open-Endedness

2. There is opportunity for me to pursue my own computing interests in this laboratory class.
7. In this laboratory class, I am required to design my own solutions to a given problem.
12. In my laboratory sessions, other students produce different solutions than I do for the same problem.
17. I am encouraged to go beyond the regular laboratory exercise and do some investigations of my own.
22. In my laboratory sessions, I solve different problems than some of the other students.
27. In my laboratory sessions, the instructor decides the best way for me to solve a given problem.
32. I decide the best way to proceed when developing a solution to a problem given in the laboratory class.

Integration

3. What I do in the lecture is unrelated to my laboratory work.
8. The laboratory work is unrelated to the topics that I am studying in my lecture.
13. My lecture material is integrated with laboratory activities.
18. I use the theory from my lecture sessions during laboratory activities.
23. The topics covered in lectures are quite different from topics with which I deal in laboratory sessions.
28. What I do in laboratory sessions helps me to understand the theory covered in lectures.
33. My laboratory work and lecture material are unrelated.

Technology Adequacy

4. The computer software is difficult to use.
9. The computer software runs without any problems.
14. The computers are powerful enough to cope with the demands.
19. The computer software available enables students to make good use of the computer.
24. The computers are in good working condition
29. The computers are suitable for running the software I am required to use
34. When I make a mistake, the computer software behaves satisfactorily (i.e. the computer does not 'hang').

Laboratory Availability

5. I find that the laboratory is crowded when I am using the computer.
10. The laboratory room is readily available.
15. Outside my normal laboratory classes, I have to wait if I want to use a terminal or a computer.
20. I can gain access to the laboratory outside my normal classes
25. There is enough free laboratory time during the week for me to complete all my laboratory work comfortably.
30. It is difficult for me to find a terminal / computer free when I want to use one.
35. There are enough computers / terminals for students to use

(Underlined numbers indicate those items where the scoring is reversed)

APPENDIX G

Scale Allocation for Items in the Attitude towards Computers and Computing Courses Questionnaire

Anxiety

37. I feel comfortable when a conversation turns to computers.
41. I feel at ease when I am around computers.
45. Working with a computer makes me very nervous.
49. I get a sinking feeling when I think about trying to use a computer.
53. Computers make me feel uncomfortable.
57. Computers make me feel uneasy and confused.
61 I feel aggressive and hostile towards computers.

Enjoyment

39. It is fun to find out how computer systems work.
43. I enjoy using a computer.
47. I think working with computers would be enjoyable and stimulating.
51. The challenge of solving problems using a computer does not appeal to me.
55. I would like to work with computers.
59. I enjoy learning on a computer.
63. Learning about computers is boring.

Usefulness of Computers

38. Studying about computers is a waste of time.
42. My future career will require a knowledge of computers.
46. I cannot imagine getting a job that does not involve using computers.
50. Computers are an important factor in the success of a business.
54. The use of computers will increase in the future.
58. All tertiary students need a course about using computers.
62. Knowledge of the use of computers will help me get a job.

Usefulness of Course

36. I do not think I will ever use what I learned in this class.
40. This class provided me with skills I expect to use in the future.
44. This class has increased my technical skills.
48. I gained few useful skills from this class.
52. The skills gained in this class are too specific to be generally useful in the future.
56. This class helped develop my problem-solving skills.
60. As a result of this class I feel confident about tackling unfamiliar problems involving computers.

(Underlined numbers indicate those items where the scoring is reversed)

APPENDIX H

Pattern Matrix and Factor Loadings on Four Factors of the ACCC using Direct Oblimin Rotation with $\delta=0$

Table H1

Pattern Matrix and Factor Loadings on Four Factors of the ACCC for the Pilot Study using Direct Oblimin Rotation with δ=0

Item Number	Factor 1		Factor 2		Factor 3		Factor 4	
	Pattern	Loading	Pattern	Loading	Pattern	Loading	Pattern	Loading
36					0.71	0.71		
40		0.41			0.64	0.69		
44	0.33	0.42			0.74	0.80		
48	0.40				0.56	0.48		
52			0.37	0.40	0.64	0.52		
56	0.41	0.38			0.41	0.48	0.45	0.41
60		0.31			0.47	0.54	0.43	0.41
37	0.45	0.50					0.38	0.44
41	0.54	0.64	0.59	0.70				
45			0.77	0.76				
49			0.81	0.84				
53		0.33	0.78	0.82				
57			0.83	0.83				
61			0.81	0.81				
38							0.70	0.69
42	0.39	0.44					0.60	0.65
46		0.38				0.33	0.38	0.41
50	0.46	0.60	0.34			0.31		
54	0.54	0.61				0.30		
58	0.64	0.61						
62	0.69	0.71						
39	0.84	0.85						
43	0.72	0.77		0.41				
47	0.82	0.83		0.32				
51	0.60	0.69		0.47		0.39		
55	0.73	0.74						0.40
59	0.72	0.77				0.32		
63	0.71	0.76		0.36				

Table H2

Pattern Matrix and Factor Loadings on Four Factors of the ACCC for the Australian Study using Direct Oblimin Rotation with δ=0

Item Number	Factor 1		Factor 2		Factor 3		Factor 4	
	Pattern	Loading	Pattern	Loading	Pattern	Loading	Pattern	Loading
36					0.79	0.75		
40				0.33	0.75	0.77		
44		0.35			0.55	0.62		0.35
48							0.61	0.57
52					0.71	0.68	0.43	0.31
56				0.33	0.56	0.64	0.41	0.50
60				0.48	0.64	0.72		0.31
37		0.42	0.60	0.65				
41		0.42	0.74	0.82		0.42		
45			0.94	0.85				
49		0.32	0.78	0.76		0.30		
53		0.40	0.85	0.86		0.32		
57			0.93	0.87		0.36		
61		0.42	0.61	0.67		0.31		
38	0.50	0.61		0.45		0.34		
42	0.54	0.66		0.46		0.33		
46	0.49	0.44						
50	0.76	0.76						
54	0.74	0.76		0.38				
58	0.73	0.70				0.31		
62	0.68	0.74		0.37		0.32		
39		0.50	0.33	0.55		0.43	0.33	0.44
43		0.53	0.60	0.74		0.32	0.32	0.44
47	0.35	0.60	0.35	0.59		0.37	0.42	0.54
51		0.49	0.43	0.62		0.47		
55	0.42	0.65	0.33	0.60		0.40	0.35	0.48
59	0.32	0.60	0.42	0.65		0.41	0.31	0.44
63	0.35	0.59	0.34	0.58		0.43		0.36

APPENDIX I

Standard Multiple Regressions of Attitudinal Variables on Achievement for the Australian Study

Table I1

Standard multiple regressions of attitudinal variables on achievement taken one at a time

Variables	B	β	sr^2
Anxiety	-0.03*	-.20	0.042
Multiple $R^2 = 0.042$			
Enjoyment	0.05**	-.20	0.063
Multiple $R^2 = 0.063$			
Usefulness of Computers	0.00	0.01	0.000
Multiple $R^2 = 0.000$			
Usefulness of Course	0.06**	0.29	0.083
Multiple $R^2 = 0.083$			

Table I2

Standard multiple regressions of attitudinal variables on achievement taken two at a time

Variables	B	β	sr^2
Anxiety	-0.03*	-0.22	0.045
Usefulness of Computers	-0.01	-0.06	0.003
Multiple $R^2 = 0.045$			
Enjoyment	0.07***	0.36	0.088
Usefulness of Computers	-0.05*	-0.20	0.026
Multiple $R^2 = 0.088$			
Usefulness of Course	0.06**	0.32	0.091
Usefulness of Computers	-0.02	-0.09	0.008
Multiple $R^2 = 0.091$			
Anxiety	-0.01	0.09	0.006
Enjoyment	0.04*	0.20	0.027
Multiple $R^2 = 0.068$			
Anxiety	-0.02	-0.11	0.009
Usefulness of Course	0.05*	0.25	0.051
Multiple $R^2 = 0.092$			
Enjoyment	0.03	0.16	0.020
Usefulness of Course	0.04*	0.22	0.040
Multiple $R^2 = 0.102$			

Table I3

Standard multiple regressions of attitudinal variables on achievement taken one at a time

Variables	B	β	sr^2
Anxiety	-0.01	-0.09	0.006
Enjoyment	0.06^{**}	0.31	0.049
Usefulness of Computers	-0.05^{*}	-0.20	0.026
Multiple $R^2 = 0.094$			
Anxiety	-0.02	-0.13	0.014
Usefulness of Course	0.05^{**}	0.27	0.060
Usefulness of Computers	-0.03	-0.12	0.013
Multiple $R^2 = 0.105$			
Enjoyment	0.05^{**}	0.27	0.046
Usefulness of Course	0.05^{**}	0.24	0.048
Usefulness of Computers	-0.05^{*}	-0.23	0.034
Multiple $R^2 = 0.136$			
Anxiety	-0.01	0.04	0.001
Enjoyment	0.02	0.13	0.012
Usefulness of Course	0.04	0.21	0.035
Multiple $R^2 = 0.104$			

Table I4

Standard multiple regressions of attitudinal variables on achievement taken one at a time

Variables	B	β	sr^2
Anxiety	-0.01	-0.04	0.009
Enjoyment	0.05^*	0.26	0.032
Usefulness of Course	0.05^*	0.24	0.043
Usefulness of Computers	-0.05^*	-0.22	0.033
Multiple $R^2 = 0.137$			

APPENDIX J

Results of Structural Equation Modelling of Environment-Attitude-Achievement

Table J1

Results for Structural Equation Modelling of Original Proposed Model

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                                                    Thu Jun 11 15:30:55 1998




                          Amos
                      Version 3.6 (w32)

                    by James L. Arbuckle





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            * Model71: Thursday, June 11, 1998   03:30 PM  *
            *----------------------------------------------*
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                    Serial number 55501773
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Appendix J contains seven tables.
Table J1. Results for structural equation modelling of original proposed model.
Table J2. Results for structural equation model with no covariance.
Table J3. Results for structural equation model of model with covariances between the error terms of usefulness of computers and enjoyment and of enjoyment and anxiety.
Table J4. Results for structural equation model of model with direct relationships anxiety – enjoyment and enjoyment – usefulness of computers.
Table J5. Results for structural equation model of model with direct relationships enjoyment – anxiety and enjoyment – usefulness of computers.
Table J6. Results for structural equation model of model with direct relationships anxiety – enjoyment and usefulness of computers – enjoyment.
Table J7. Results for structural equation model of model with direct relationships usefulness of computers – enjoyment and enjoyment – anxiety.