Science and Mathematics Education Centre

The Development, Validation and Application of an Electronics Laboratory Environment Inventory in Indonesia

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This thesis is presented for the Degree of
Doctor of Science Education
of
Curtin University of Technology

September 2004

DECLARATION PAGE

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature, ____________________

Date, September 9th, 2004

DEDICATION

This thesis is dedicated to my family. They have been the force behind me to complete my work.

ABSTRACT

This study investigates and describes the development of an instrument named the Electronics Laboratory Environment Inventory (ELEI), which is used to measure students' perceptions of the electronics laboratory class as a learning environment. The sample consisted of 353 of 708 Computer Engineering active students from eight classes in Bina Nusantara University, Jakarta, Indonesia. Bina Nusantara University which has the largest number of computer engineering students in Indonesia. Students' learning outcomes were measured using z-scores in electronics subjects and students' attitudes in laboratory classes were measured by using the Attitude Towards Electronics Questionnaire (ATEQ).

Directed by the research questions, numerous statistical analyses were performed. These included item analysis, inter-item correlation analysis, one-way analysis of variance for establishing reliability and validity of the laboratory class environment instruments in the present study; descriptive statistics for investigating the nature of the learning environment in electronics subjects; simple and multiple correlation analyses for investigating associations between laboratory class environment and students' outcomes.

In all cases, electronics laboratory classes have played a major role. The scales measured Student Cohesiveness, Open-endedness, Integration, Technology Adequacy, and Laboratory Availability. The results showed that all five scales have a reasonable alpha reliability with low mean correlations.

The study discovered that, generally, students perceived their electronics class learning environments as favourable. It was found that students' perceptions of electronics laboratory class environment were associated with students' learning outcomes. The results of this study make important and unique contributions to students' learning outcomes, suggesting that the instruments are useful for assessing laboratory class environment in the other studies.

ACKNOWLEDGEMENTS

A thesis is never a single-handed endeavour and I would like to convey my sincerest thanks and appreciation to a number of people for their support and their contribution towards the completion of this thesis:

Professor Darrell Fisher for being my wonderful supervisor. I am most grateful for his guidance, encouragement, patience and understanding.

Professor David D. Treagust, my co-supervisor, for his support, guidance and help with this thesis.

Academic and administrative staff of Curtin University of Technology, for support, help and provision of essential resources.

The Bina Nusantara University Foundation which has supported fully my studies at the Curtin University of Technology in Perth, Western Australia.

My colleagues for their support and encouragement in finishing my thesis: Dr. Widia Soerjaningsih, Drs. Rufinus Lahur, Dr. Gerard Polla, Once Kurniawan, S.Kom, MM, and Drs. Wikaria Gazali.

My colleague, Endang Ernawati, M.Lib, who helped me as my editor and mentor with her continuous support.

My Computer Engineering colleagues, Ir. Harjanto Prabowo, MM, Dr. Iman Herdiwiyana Kartawijaya, and Jurike Moniaga, S.Kom who gave permission to conduct the research in the Computer Science Faculty and Computer Engineering Department.

My Hardware Technical Managing Unit colleagues, Steffanus Wiedjaja, S.Kom; Sofyan, S.Kom; Ronald; and all the assistants who helped me with data collection and data entry for questionnaires with online version.

My colleagues, Meyliana, S.Kom, MM and Doddy, S.Kom, MM who supplied data from the database of students' academic records.

My colleague, Dr. Bachtiar Abbas, MSc, who helped me to understand how to run the SPSS statistical analysis program and how to analyse and interpret the statistical data.

My colleague, Anna, DR, who helped with valuable and relevant books and guidance with this thesis.

My staff members, Debby Tanamal, M.Train.Dev; Rachma Sartika; Putri Rahayu; and Nina Mailiza, S.Si; who supported the Learning Resource Center activity while I was busy in completing this research.

The lecturers and students of Computer Engineering Department in the odd semester 2003/2004 at Bina Nusantara University, whose warm welcome and cooperation made this research possible.

I would like to thank to my wife, Sianiwaty, for her encouragement to tackle the Doctoral program and for looking after our family when I was preoccupied, to my children, Michael, Nathasia and Laurencia, to my brother-in-law, Hendy, for their understanding, encouragement and moral support, so that I could keep focused and finish my doctoral study.

My other colleagues whom I can not name individually. I do not know what I would have done without you and your encouragement and moral support.

I hope that this research can be helpful and fruitful to all of us.

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CHAPTER 1

RATIONALE FOR THE STUDY

1.1 INTRODUCTION

The study described in thesis focused on Indonesian university electronics laboratories and their effectiveness as learning environments. Most university electronics courses within Indonesia have a practical aim, directed at enabling student to solve problems which are applicable to real-world applications that use electronics systems. Electronics laboratory classes are provided in Indonesian universities so that students have the opportunity of gaining these practical skills. These laboratory classes account for between one third and one half of the time scheduled for electronics courses.

Bowles (1970) stated that within schools input factors can be divided into internal input and external input. Internal inputs include such aspects as the teachers, principals, equipment and facilities. Whereas external inputs are parental expectations, the time parents spend helping their children to study, and the social welfare of the parents. Windham and Chapman (1990) later commented that input factors such as students, teachers, the school, instructional material, and equipment and facilities are characteristics that influence the output of teaching. In this regard, the electronics laboratory has a big role in providing equipment and facilities so that students can have practical experiences with an electronics system.

Similarly, Walberg (1984) analysed national and international data banks and identified nine factors which correlate with achievement and attitudes of students. These productivity factors were ability, age, motivation, amount and quality of instruction, home and classroom environment, peer influence, and effects of mass media. The factors can be categorised into three broad headings namely, student aptitude, instruction, and environment. The present study was undertaken to examine the nature and impact of two factors of learning productivity, namely, the laboratory learning environment and students' aptitude towards electronics, on the cognitive and affective outcomes of Computer Engineering students at Bina Nusantara University. This university is an information technology-based institution of higher learning in Indonesia.

This chapter describes the background to this study (Section 1.2), significance (Section 1.3), purpose of study (Section 1.4), and overview of methodology (Section 1.5). Also presented in this chapter is an overview of the organisation of the chapters in the remainder of the thesis (Section 1.6).

1.2 BACKGROUND OF THE STUDY

This section provides background information relevant to this study, including a brief introduction to the field of Learning Success Factor (Section 1.2.1), an overview of the present challenges faced by the education system in Indonesia (Section 1.2.2), information concerning Bina Nusantara University and its Computer Engineering Department (Section 1.2.3), and information about the Hardware Technical Managing Unit where the present study took place (Section 1.2.4).

1.2.1 Background to the Field of Learning Environment

Hartshorne and May (1928) and Newcomb (1929) (in Walker, 2003a, p. 3) suggested that the environment can alter normal student behaviour. It was verified by Hartshorne and May that personality traits were poorly correlated to the tendency of students to participate in dishonest behaviour, such as cheating in exams, given the opportunity in different situations. It was further noted by Newcomb that students' talkativeness during the lunch break was a highly persistent trait; however, the same trait did not carry over to other situations, for example when students were in the library. Furthermore, Moos (1979) noted that early studies demonstrated that researchers should consider the environment in which a behaviour takes place in order to predict individual student actions because students' values change according to the expectations of the setting.

The concept that a distinct classroom environment occurs began as early as the 1930s with the work of Kurt Lewin and Henry Murray. Lewin defined classic human behaviour as the foundation of learning environments research and is represented by B = f(P,E) (Walker, 2003b, p. 1), where B is behaviour, f is function, P is person, and E is person's environment. Every scientific psychology study must take into account whole situations, such as the state of both person and environment as noted by Lewin. Determinants of B are explained by composite measures of P and E (Stern, 1974). According to Stern (1974), the conceptualisation of human behaviour with new strategies in psychological research is Lewin's purpose where functional relationships and states of interaction are emphasized over those of correlation of disjointed responses derived from isolated stimuli – the prevailing psychological trend of the time. Murray (1938) developed his needs-press theory. He introduced the term *alpha press* to depict the environment as viewed by an observer and the term *beta press* to depict the environment as perceived by milieu inhabitants or persons functioning within certain situation.

The development of questionnaires was a major stage in research on the effects of learning environments. The *Learning Environment Inventory* (LEI) (Fraser, Anderson & Walberg, 1982) and the *Classroom Environment Scale* (CES) (Moos & Trickett, 1974) were developed in the USA in the late 1960s. The Harvard Project Physics evaluation was one of the starting points in the development of the field of learning environment research which has continued for the last 30 years (Walberg & Anderson, 1968). Since then, numerous studies have demonstrated that students' perceptions of their educational environments can be measured with survey instruments and the results serve as valid predictors of learning (Anderson & Walberg, 1974; Fraser, 1997, 1998a, 1998b), turning evaluation away from individual student achievement and toward the effectiveness of the environment of the learning organization (Walberg, 1974).

With the study of educational environments, students and teachers describe their environment based upon their perceptions. Students, with long hours as learners produce their individual and distinctive frames of reference and have a big interest in what is going on around them in their environments. Their perceptions of school experiences and reactions are significant given that environments, like people, take on distinctive personalities (Fraser, 1998b; Insel & Moos, 1974; Kiritz & Moos, 1974). There is a demonstrated association between students' perceptions, psychosocial characteristics of their classrooms, their learning achievement, and their point of view (Fraser, 1998b). Teachers also can utilize learning environments research to learn of the differences between their perceptions and their students' perceptions. They can then make some changes in the actual classroom environment based upon the students' preferences.

Fraser (2002) noted that there is a shift in activities and studies of learning environments from the Western countries, where the questionnaires originated, into Asian Countries. The main activities of Asian researchers in the last ten years has involved the adaptation of some developed Western questionnaires and their cross-validation for use in several Asian Countries, sometimes involving translation into another language. Fraser (2002) mentioned that although there have been some research activities in the Asian region they have been less active in the development of new instruments. This study set out to develop and validate a new electronics laboratory environment inventory and a students' attitude toward electronics questionnaire for use in Asian countries.

1.2.2 Challenges Facing the Education System in Indonesia

In the next decade, education systems will face major issues concerning globalisation, because competition will continue to increase, both in intensity and in scope. Indonesia's recent economic crisis has rendered many industries inoperative, causing many workers to lose their jobs. Facing this global competition, and to survive the 'Crisis of Economy', Indonesian education institutions will have to contend with the challenge of preparing qualified human resources.

Currently, in Indonesia, there are over 1,300 private universities and colleges with about 1.5 million students, and 75 public universities with around 0.5 million students. Among these, there are close to 150 private higher-learning institutions offering undergraduate program in computing. Some are very large with more than 15,000 students and some very small with only hundreds of students (Directorate General of Higher Education, 2000).

Not all of the universities have enough funds to upgrade their facilities to catch up with the advancement in science. They also have limitations on the number of classrooms and laboratory facilities that they can provide. The impact of these limitations is that the average number of students in one class is greater than 70. As a consequence of this, laboratory scheduling is also a major problem for the universities. Eventually, it leads to student dissatisfaction about their laboratory classes.

My 13 years of experience in the education sector, including three years as Head of the Hardware Technical Managing Unit, has given me insights into some of the problems experienced by the Computer Engineering students. It would appear that many of the major problems experienced by students at the tertiary level in Indonesia are associated with not knowing what they plan to do in the future and therefore they do not know why they must learn electronics system.

1.2.3 Bina Nusantara University and Computer Engineering Department

Since 1981, Bina Nusantara University (BiNus) has been in operation and it has demonstrated particular strengths in information technology. Now, it has around 26,000 students. Because BiNus also is concerned about the quality of its education system, it uses ISO-9001 (Lundquist, 1997) as a standard. It has five faculties, namely, the Faculty of Computer Science, Faculty of Economics, Faculty of Engineering, Faculty of Mathematics and Science, and Faculty of Literature.

Computer Engineering is a field of Computer System Science in the Faculty of Computer Studies at Bina Nusantara University and was established in 1987 and accredited in 1996.

The vision of the Computer Engineering study program corresponds to the vision of Bina Nusantara University, which is: to be recognized as the leading private educational institution in the development and application of science and technology in Indonesia, especially as related to, or supported by, Information Technology. Furthermore, the mission of the Computer Engineering Program is: to offer study programs that support the development and application of information technology in various scientific disciplines, to preserve the relationship and the relevance of academic activities in line with the development of the socio-economic and industrial fields in Indonesia, and to anticipate the future impact of globalization on the lives of the people in Indonesia and to work together with various parties, both national and international, to maintain quality in science and technology application to always be advanced and appropriate to needs.

It is expected that the Computer Engineering graduates will be able to understand computer systems, apply information technology especially in term of Computer System Engineering, and become creative, innovative and skilled because of the effective and efficient learning process supported by a conducive learning environment.

With the byword "To build the state's future through Information and Technology", Computer Engineering as a part of the Faculty of Computer Studies in Bina Nusantara University attempts to improve its graduates' qualifications and technology advancement especially information technology including both hardware and software. To make it relevant, the subject composition is set upon international standards with expert lecturers and extra facilities to yield bright and globally-recognized graduates. This subject major was set up in response to the large demand of engineers to create computer hardware systems and to develop software applications of computer systems.

The curriculum is supported by learning conditions and an environment based on information technology, the development of Computer System Science with the specialization on communication network system and computer system processing and applications.

The specialization of Communication Network Systems is designed to provide ability in designing and processing data communication network, while the specialization of computer system processing and application provides ability in designing hardware application system.

Today, there is a large demand for Computer Engineering professionals due to the vast application of computer automation control and the development of computer system technology, both hardware and software. As a result, competent and ready-to-work professionals are needed to administer the technology. Among the career prospects for Computer Engineering graduates are: System Engineer, Network Designer, Computer Specialist, R&D Engineer, and Computer Engineering Lecturer.

The present study was undertaken in the Computer Engineering Department of Bina Nusantara University with 353 of 708 active students. This department has similar problems to other institutions in Indonesia which all developed under the control and supervision provided by the rules and regulations of the Government.

1.2.4 Hardware Laboratory Technical Service Unit

Since 1987 Bina Nusantara University (BiNus) has opened its Computer Engineering department and established the Hardware Technical Managing Unit or Unit Pelayanan Teknis Perangkat Keras/ UPT PK or the electronics laboratory. All laboratory-work subjects are conducted in the electronics laboratory. Laboratory work helps students to understand the theory covered in lectures and to finish their final projects required for their undergraduate degree.

From the first semester the Computer Engineering students have laboratory classes which consist of integrated electronics laboratory, electric circuit theory laboratory, discrete electronics laboratory, digital system laboratory, advanced control system laboratory, microprocessor application laboratory, digital signal processing laboratory, and robotics/ mechatronics laboratory. The laboratory operates for six days a week and requires seven shifts per day (7:20 – 9:00, 9:20 – 11:00, 11:20 – 13:00, 13:20 – 15:00, 15:20 – 17:00, 17:20 – 19:00, and 19:20 – 21:00).

The problem faced with laboratory classes is the limited number of equipment or modules so that the number of students who can be accommodated in the laboratory at any one time is also limited. Moreover, HIMTEK (the Computer Engineering Student Association) use the laboratory classroom for giving regular assistance to weak students who have particular learning difficulties.

Figure 1.1. **Students in one of the laboratory rooms.**

The laboratory has a room that students can access for designing and testing their electronics system for their final projects (shown in Figure 1.1).

1.3 SIGNIFICANCE

A main purpose of the present study was to investigate the existing electronics laboratory learning environment of the student at the tertiary level in Indonesia. The study was intended to provide useful practical information for guiding the improvement of tertiary electronics related education in Indonesia.

To date, only a few studies of learning success have been undertaken in Indonesia and none have been at the tertiary level. The study, therefore, has the potential to create a clearer picture of the classroom contexts that are needed at the tertiary level for students to attain good academic performance and positive attitudes. In addition, the study could assist lecturers at the university level to determine how to handle a big class size. Such a study could provide information that lecturers can use to modify their module planning accordingly.

The present study also is likely to provide valuable information to the university in which the data gathered that can be used to develop strategies for improving classroom practices, management and administration policies for electronics-related courses.

The results of the study could also provide guidance to other universities in Indonesia regarding achieving better student outcomes in computer-based education. The study also examined whether relationships exists between student cognitive and affective outcomes, student aptitude, and student motivation to select their chosen subject all of which is valuable information for tertiary educators in Indonesia.

1.4 OBJECTIVES OF THE STUDY

The objectives of this study were to:

- develop and validate an actual and preferred form of the Electronics Laboratory Environment Inventory (ELEI);
- develop and validate the Attitude Towards Electronics Questionnaire (ATEQ);

- investigate if there are any associations between students' perceptions of their electronics laboratory environment and their achievement in electronics courses;
- investigate if there are any associations between students' perceptions of their electronics laboratory environment and their attitudes to the electronics courses; and
- provide recommendations for improving tertiary classroom environments in Indonesia.

These objectives led to the development of the following research questions which were the focus of this study:

1. Is the Electronics Laboratory Environment Inventory (ELEI) a valid and reliable questionnaire for use in actual and preferred versions in tertiary electronics laboratories in an Indonesian University?
2. What are students' perceptions of the Electronics Laboratory environment in an Indonesian University?
3. Is the Attitude Towards Electronics Questionnaire (ATEQ) a valid and reliable questionnaire for use in computer engineering students in an Indonesian University?
4. What are students' attitudes towards their Electronics Laboratory Classes in an Indonesian University?
5. Are there associations between the student outcomes of (a) attitude in electronics laboratory classes and (b) achievement on the laboratory subjects and students perceptions of the laboratory classroom environment?
6. To what extent does laboratory environment influence student outcomes (attitudes and achievement)?

1.5 OVERVIEW OF METHODOLOGY

ELEI

The *Science Laboratory Environment Inventory* (SLEI) (Fraser, Giddings & McRobbie, 1991) and the *Computer Laboratory Environment Inventory* (CLEI) (Newby Fisher, 1997) were studied and modified into the Electronics Laboratory Environment Inventory (ELEI). Afterward, the ELEI was validated and used. Student perceptions of their laboratory learning environment were measured using the five-scale, 34-item Electronics Laboratory Environment Inventory (ELEI).

Student Attitudes

The Attitude Towards Electronics Questionnaire (ATEQ) was used to investigate student attitude and to find any associations between student attitudes and their perceptions of their electronics laboratory environment. Student attitudes were measured using the four-scale, 28-item Attitude Towards Electronics Questionnaire. Data were analysed using the individual and class as the unit of analysis to investigate the reliabilities of the four scales. Correlation and regression analyses were performed to investigate association between learning environment scales and students attitudes.

Qualitative Data

Volunteers were sought for the qualitative component of this study to take part in an interview regarding their perceptions of the laboratory environment. Three students were selected from the volunteers and interviewed. Two laboratory staff were also interviewed. In addition to the interviews, the researcher carried out observations in the laboratory.

Data Source

The sample consisted of 353 of 708 Computer Engineering active students. The data were collected using the electronics form at the laboratory intranet web address at http://lab.binus.ac.id/pk/kuis.asp or a paper-based version. Students completed both forms of the instruments, the actual and preferred in Indonesian version.

1.6 ORGANISATION OF THE THESIS

This thesis is composed of seven chapters. Chapter 1 has discussed the rationale for the present study. It provides a brief background to the study, including information about the field of learning environment, an overview of the challenges facing the Indonesian education systems, and a sketch of Bina Nusantara University and Computer Engineering Department where the study took place. This chapter also discusses the purposes of the present study, gives an outline of the research questions, and provides an overview of the organisation of this thesis.

Chapter 2 reviews the literature related to the definition of quality, educational productivity factors, and research on laboratory learning environment, highlighting past research developments and findings. Also reviewed in this chapter is literature focusing on terms, existing assessment instruments and education-related areas.

Chapter 3 discusses the methodology and provides insights into procedural aspects of the present study. This includes the research design used in the different phases of study, and the choice of the sample of this study. Also discussed in this chapter are the development and field testing of the instruments used, the administration of the questionnaires and data collection, and the statistical procedures employed in the data analyses.

Chapter 4 presents the results used to validate the Electronics Laboratory Environment Inventory (ELEI) and the Attitude Towards Electronics Questionnaire (ATEQ).

Chapter 5 reports the data analyses and findings for the applications of the ELEI used with current Computer Engineering students and the alumni. The results provided in this chapter include associations between students' perceptions of their electronics laboratory environment and their achievement in electronics courses.

Chapter 6 reports the data analyses and findings for the application of the ATEQ with current Computer Engineering students and the alumni. Results presented in this chapter also include associations between students' perceptions of their their attitudes towards electronics and their achievement in electronics courses.

Chapter 7 concludes the thesis with an overview of the present study. Also, it discusses the findings from the study in terms of the validation of each assessment instrument, the associations between the students' perception and students' learning outcomes. Furthermore, this chapter discusses the constraints and limitations of the present study, the distinctiveness and contributions of the study, and suggestions for future research in laboratory class environment in Indonesia.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter places the study into context by providing a review of the literature concerning learning environments and electronics laboratories. The chapter falls into five separate parts. First, there is an overview of some key instruments that have been developed as a result of research over the last 40 years. Section 2.2 provides a discussion on learning environments. Section 2.3 is devoted to student attitudes. Section 2.4 provides information about the electronics laboratory. Finally, section 2.5 summarises this literature review.

2.2 LEARNING ENVIRONMENTS

This section reviews literature related to research in the field of learning environments and it is divided into six parts:

- Background issues (Section 2.2.1)
- Historical background to the field of Learning Environment (Section 2.2.2)
- Use of perceptual measures (Section 2.2.3)
- Choice of unit of analysis (Section 2.2.4)
- Instruments used to measure learning environments (Section 2.2.5)
- Associations between learning environments and student outcomes (Section 2.2.6)

2.2.1 Background Issues

For many years educational environments have been a focus of academic research. According to Fraser (1984) there are some questions about 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 a classroom's environment, and the determinants of classroom and school environments. Over the past 40 years those issues have been the focus of the research effort into educational environments (Fraser, 1994, 1998a). The research into learning environments has involved many questions which are of interest to teachers, educational researchers, curriculum developers and policy makers in education. During this period, several approaches have been used in conducting research in the field of learning environments. The exploratory nature of the present study lends itself to the use of questionnaire data that are analysed to investigate associations between the learning environment and student outcomes. A striking feature of this field is the availability of a variety of economical, valid and widely-applicable questionnaires that have been developed and used for assessing students' perceptions of classroom environment (Fraser, 1998b).

2.2.2 Historical Background to the Field of Learning Environment

Despite the fact that the educational environment is a somewhat subtle concept, remarkable progress has been made in conceptualising, assessing and researching its determinants and effects. The research over the last four decades has recognised that students' and teachers' perceptions are important parameters of the social and psychological aspects of the learning environments of school classrooms (Fraser, 1986, 1991, 1994, 1998a; Fraser & Fisher, 1994; MacAuley, 1990). Fraser (1994) supports the importance of this form of research as follows:

> Classroom or school environments in terms of the shared perceptions of the students and teachers in that environment, has the dual advantage of characterising the setting through the eyes of the actual participants and capturing data that the observer could miss or consider unimportant. Students have a good

> advantage point to make judgements about classrooms because they have encountered many different learning environments and have enough time in a class to form accurate impressions. (p. 494).

The groundwork of the study of classroom environments was laid independently by Rudolf Moos and Herbert Walberg. There are many useful instruments developed based upon the work of these two researchers to measure the perceptions of students and teachers in a variety of environment settings (Anderson & Walberg, 1974; Walberg & Haertel, 1980; Chavez, 1984; Fraser, 1994, 1998a; MacAuley, 1990; von Saldern, 1992; Walberg, 1976) and in other monographs (Fisher, 1992, 1993; Fisher & Fraser, 1983a, 1983b; Fraser, 1981a). The following sections are devoted to an overview of the theoretical underpinnings of learning environments and the selected instruments that have been developed and thus appreciated as important contributions to measuring the perceptions of students and teachers of their classroom learning environment.

2.2.3 Use of Perceptual Measures

The literature on research on classroom environment reveals that generally three main methods have been used. These are the use of trained observers to record systematically observations of classroom events and practices, the use of case studies and the assessment of perceptions of students and teachers. Although the dominant past approach has been the use of perceptions of students and teachers in evaluating the importance of classroom environment, it is acknowledged that there are merits in combining the use of two or more methods within the same study.

Perceptual measures can be justified using five main considerations (Fraser, 1993). First, the use of questionnaires to capture perceptions of students and teachers is more economical than paper-and-pencil measures and that it costs much less than the process of having trained outside observers making classroom observations. Second, data from such measure are based on the perceptions of students over many lessons or a period of time, while classroom observations are limited usually to a small number of lessons. Third, it is believed that perceptual measures bring together the pooled opinions of all students in a class, whereas classroom observation techniques generally involve the perceptions of only one observer. Fourth, student perceptions, being determinants of student behaviour in the real situation, can be more important than observed behaviours. Fifth, it has been found that student perceptions account for considerably more variance in student learning outcomes than directly-observed variables in classrooms. After careful consideration of these five factors, it was decided that student perceptions would be used as the source of classroom environment data for the present study.

2.2.4 Choice of Unit of Analysis

It is apparent also from the current literature that research on learning environments often reports results using two levels or units of statistical analysis. The distinction between levels of analysis can be linked to the needs-press theory of Murray (1938) who used the terms 'alpha press' to describe the environment viewed by an external observer and 'beta press' to describe the perception of the environment by inhabitants or persons functioning within the environment. The distinction was carried further when Pace and Stern (1958) used the two terms 'private beta press' (to denote the idiosyncratic view of the environment held by each individual) and 'consensual beta press' (to depict the shared view that members of a group hold about the environment) to differentiate between the personal view of an individual, and the common view shared by a group in that environment.

Obviously, private and consensual beta press could differ from each other and both also could differ from the independent view of a trained non-participant observer (Fraser, 1994). This is relevant to studies including perceptions of classroom environments and the literature often suggests that statistical analysis should be performed for two levels or units of analysis: the individual student's score and the class mean score, which correspond to the distinction between private and consensual beta press.

2.2.5 Instruments Used to Measure the Classroom Learning Environment

Moos (1979) asserted that the classroom climate or environment is one of the most important influences in a student's personal and academic development. For example, Moos (1976) found in his research that students were satisfied in classrooms that had high student involvement, good student-teacher relationships, innovative teaching methods and clear rules governing behaviour. Supporting Moos' (1979) findings, Walberg (1979) reported that students in competitive environments were found to perform poorly, be less self-assured and to experience more failure.

Important findings emerging from the work performed on social environments have three major categories of dimensions that characterise a variety of social milieus (Moos 1973, 1974). Most classroom environment instruments were designed taking into account Moos' scheme for classifying human environments. The three basic types of dimensions defined by Moos are as follows:

1. Relationship Dimension

It identifies the nature and intensity of personal relationships within the environment and assesses the degree to which people are involved in the respective environment and support as well as help each other.

2. Personal Development

It assesses personal growth and self enhancement.

3. System Maintenance and System Change Dimension

It assesses the extent to which the environment is orderly clear in expectation, maintains control and is responsive to change.

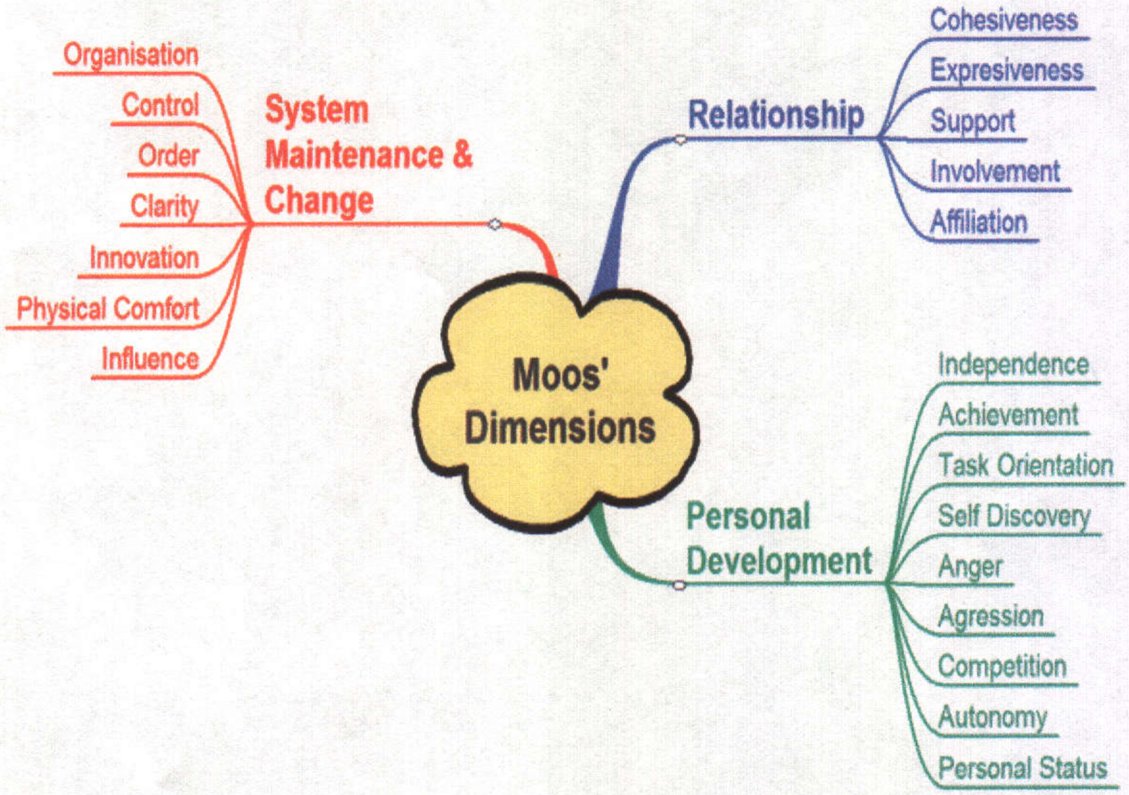

Figure 2.1. Moos' dimensions.

These dimensions resulted from research in numerous social climate settings which included psychiatric hospitals (Moos & Houts, 1968), correctional institutions (Moos, 1968; Wenk & Moos, 1972), schools and university student residences (Gerst & Moos, 1972; Trickett & Moos, 1973). Moos had shown these dimensions to be similar across various environments although unique variations within general categories occurred in specific settings. Table 2.1 illustrates these similarities in differing environments.

Table 2.1
Similarities of Social Climate Dimensions Across Various Environments

Type of Environment	Relationship	Personal Development	System Maintenance & System Change
Correctional Institutions	Involvement, Support, Expressiveness	Autonomy, Practical Orientation, Personal Problem	Order, Organisation, Clarity, Control
University Student Living Groups	Involvement, Emotional Support	Independence, Traditional Social, Orientation, Competition, Academic, Achievement, Intellectuality	Order & Organisation, Student Influence, Innovation
Junior High & High School Classrooms	Involvement, Affiliation, Teacher Support	Task Orientation, Competition	Order & Organisation, Teacher Control, Innovation
Work Milieus	Involvement, Peer Cohesion	Task Orientation, Staff Support	Work Pressure, Control, Innovation, Physical Comfort
Hospitals	Involvement, Support, Spontaneity	Autonomy Practical Orientation, Personal Problem Orientation, Anger & Aggression	Order & Organisations, Clarity, Control

Adapted from Moos (1973)

The pioneering work of Moos and Walberg on perceptions of classroom environments laid the foundation for intensive research resulting in numerous publications over the last four decades (Fraser, 1991, 1994, 1998a, 1998b; Fraser & Fisher, 1994; Wubbels, 1993). Fraser (1991) outlined three common approaches usually employed in research on classroom environment. These were direct observations of events taking place in the classroom by an independent observer, utilising ethnography techniques, and assessing the perceptions of students and teachers using questionnaires. The relative ease of use and the low cost along with the potential for a large sample base has led to the widespread use of questionnaires in learning environment research. Fraser and Walberg (1981) outlined some further advantages on why the measurement of student perceptions is superior to observations in assessing classroom environments:

- perceptual measures are based on student experiences over time whereas observational data are usually restricted to relatively short time spans.

- perceptual measures are based on the combined judgement or feedback from students whereas observational data are obtained primarily by a single observer.

- in most cases student perceptions become more important determinants of student behaviour when compared to those of observed behaviours.

- perceptual measures have been found to account for more variance in student learning outcomes than have interaction variables obtained through observations.

Past research on classroom learning environment has been accompanied by the development and validation of numerous instruments over the last 40 years. The instruments used for assessing various psychosocial dimensions in classrooms and laboratories considered in this section are: the Learning Environment Inventory (LEI) (Fraser, Anderson, & Walberg, 1982; Walberg & Anderson, 1968), the Classroom Environmental Scale (CES) (Fisher & Fraser, 1982, 1983b; Moos & Trickett, 1987), the *Individualised Classroom Environment Questionnaire* (ICEQ) (Rentoul & Fraser, 1979), the *My Class Inventory* (MCI) (Fisher & Fraser, 1981; Fraser, Anderson, & Walberg, 1982), the *College and University Classroom Environment Inventory* (CUCEI) (Fraser & Treagust, 1986), the Science Laboratory Environment Inventory (SLEI) (Fraser, Giddings, & McRobbie, 1991), the Computer Laboratory Environment Inventory (CLEI) (Newby & Fisher, 1997, 1998); the *Constructivist Learning Environment Survey* (CLES) (Taylor, Fraser, & Fisher, 1997); the *What is Happening in this Class?* (WIHIC) (Fraser, Fisher, & McRobbie, 1996) *questionnaire* and the *Questionnaire on Teacher Interaction* (QTI) (Wubbels, Brekelmans, & Hooymayers, 1991). These instruments have been extensively field tested and validated, and all have been developed to be user friendly and can be easily administered and scored either by hand or computer.

Table 2.2 gives an overview of those questionnaires, systematically displaying the names of the scales in each instrument, the level suitable for its use (primary, secondary, higher education), the number of items in each scale and the classification of each scale according to Moos' three broad domains of classroom climate dimensions (Moos, 1979).

Table 2.2
Overview of Scales in Fifteen Classroom Environment Instruments (LEI, CES, ICEQ, MCI, CUCEI, SLEI, CLEI, CLES, WIHIC, QTI, CLEQ, SCCEI, GCEI, CCEI, and CLEI)

Instrument	**Level**	**Item/ Scale**	**Scales Classified According Moos' Scheme**		
			Relationship	**Personal Dev.**	**System Maintenance & Change**
Learning Environment Inventory (LEI)	Secondary	7	Apathy Cliqueness Cohesiveness Favoritism Friction Satisfaction	Competitiveness Difficulty Speed	Democracy Diversity Disorganization Formality Goal Direction Material Environment
Classroom Environment Scale (CES)	Secondary	10	Affiliation Involvement Teacher Support	Competition Task Orientation	Innovation Order and Organization Rule Clarity Teacher Control
Individualized Classroom Environment Questionnaire (ICEQ)	Secondary	10	Participation Personalization	Independence Investigation	Differentiation
My Class Inventory (MCI)	Primary	6-9	Cohesiveness Friction Satisfaction	Competitiveness Difficulty	-
College and University Classroom Environment Inventory (CUCEI)	Higher Education	7	Cohesiveness Involvement Personalization Satisfaction	Task Orientation	Individualization Innovation
Science Laboratory Environment Inventory (SLEI)	Senior Secondary, Higher Education	7	Cohesiveness	Integration Open-endedness	Rule Clarity Material Environment
Computer Laboratory Environment Inventory (CLEI)	Upper Secondary, Higher Education	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment

Instrument	Level	Item/ Scale	Scales Classified According Moos' Scheme		
			Relationship	**Personal Dev.**	**System Maintenance & Change**
Constructivist Learning Environment Survey (CLES)	Secondary	7	Student negotiation	Personal relevance	Critical Voice Shared Control Uncertainty
What Is Happening In This Class Questionnaire (WIHIC)	Secondary	8	Cohesiveness Teacher Support	Cooperation Investigation Task Orientation	Equity
Questionnaire on Teacher Interaction (QTI)	Secondary	8-10	Admonishing Dissatisfied Helpful/ Friendly Leadership Strict Student Responsibility/ Freedom Uncertain Understanding	-	-
Cultural Learning Environment Questionnaire (CLEQ)	Secondary	7	Collaboration Defence Equity	Competition Congruence Modelling	Teacher Authority
Secondary College Classroom Environment, Student Inventory (SCCEI)	Secondary	5	Personalisation Student Cohesion	Task Orientation Individualisation	Formality
Geography Classroom Environment Inventory (GCEI)	Secondary	4	Gender Equity	Investigation	Innovation Resource Adequacy
Computer Classroom Environment Inventory (CCEI)	Secondary	5	Satisfaction	Investigation Open-Endedness	Organisation Material Environment
Chemistry Laboratory Environment Inventory (CLEI)	Secondary	5	Student Cohesiveness	Integration Open-Endedness	Material Environment Rule Clarity

Adapted from Fraser (1998)

These instruments have parallel teacher and student versions. Furthermore, information can be obtained from the perceptions of both the teacher and students of each class concerning the actual and the preferred state of the classroom environment. These four sets of data make it possible to study the different perceptions on different forms and the extent to which this difference or correspondence affects student learning.

This section reports typical validation data for selected classroom environment scales. Table 2.3 provides a summary of a limited amount of statistical information for the 15 instruments (LEI, CES, ICEQ, MCI, CUCEI, SLEI, CLES, WIHIC, QTI, CLEQ, GCEI, CCEI, CLEQ, SCEI, and CLEI) considered previously. Attention is restricted to the student actual form and to the use of the individual student as the unit of analysis. Table 2.3 provides information about each scale's internal consistency reliability (alpha coefficient) and discriminant validity (using the mean correlation of a scale with the other scales in the same instrument as a convenient index), and the ability of a scale to differentiate between the perceptions of students in different classrooms (significance level and eta^2 statistic from ANOVAs). Statistics are based on 1,048 students for the LEI, except for discriminant validity data which are based on 149 class means (Fraser, Anderson, & Walberg, 1982), 1,083 students for the CES (Fisher & Fraser, 1983b), 1,849 students for the ICEQ (Fraser, 1990), 2,305 students for the MCI (Fisher & Fraser, 1981), 372 students for the CUCEI (Fraser & Treagust, 1986), 3,994 high school science and mathematics students for the QTI (Fisher, Fraser, & Rickards 1997), 3,727 senior high school students for the SLEI (Fraser, Giddings, & McRobbie, 1995) and 1,081 high school science students for both the CLES and WIHIC (previously unpublished results).

Table 2.3

Internal Consistency (Alpha reliability), Discriminant Validity (Mean correlation of a scale with other scales), and ANOVA Results for Class Membership Differences (eta^2 statistic and significance level) for Student Actual Form of fifteen Instruments Using Individual as Unit of Analysis

Scale	Alpha Reliability	Mean Correlation with Other Scales	ANOVA Results eta^2	Scale	Alpha Reliability	Mean Correlation with Other Scales	ANOVA Results eta^2
Learning Environment Inventory (LEI)	(N=1,048 students)	(N=149 classes)		**What Is Happening In This Classroom (WIHIC)**	N=1,081 students)		
Cohesiveness	0.69	0.14	–†	Student Cohesiveness	0.81	0.37	0.09*
Diversity	0.54	0.16	–	Teacher Support	0.88	0.43	0.15*
Formality	0.76	0.18	–	Involvement	0.84	0.45	0.10*
Speed	0.70	0.17	–	Investigation	0.88	0.41	0.15*
Material Environment	0.56	0.24	–	Task Orientation	0.88	0.42	0.15*
Friction	0.72	0.36	–	Cooperation	0.89	0.45	0.12*
Goal Direction	0.85	0.37	–	Equity	0.93	0.46	0.13*
Favouritism	0.78	0.32	–				
Difficulty	0.64	0.16	–	**Questionnaire on Teacher Interaction (QTI)**	(N=3,994 students)		
Apathy	0.82	0.39	–				
Democracy	0.67	0.34	–	Leadership	0.82	–‡	0.33*
Cliqueness	0.65	0.33	–	Helping/Friendly	0.88	–	0.35*
Satisfaction	0.79	0.39	–	Understanding	0.85	–	0.32*
Disorganisation	0.82	0.40	–	Student Responsibility/ Freedom	0.66	–	0.26*
Competitiveness	0.78	0.08	–	Uncertain	0.72	–	0.22*
				Dissatisfied	0.80	–	0.23*
Classroom Environment Scale (CES)	(N=1,083 students)			Admonishing	0.76	–	0.31*
				Strict	0.63	–	0.23*
Involvement	0.70	0.40	0.29*				
Affiliation	0.60	0.24	0.21*				

Scale	Alpha Reliability	Mean Correlation with Other Scales	ANOVA Results eta^2	Scale	Alpha Reliability	Mean Correlation with Other Scales	ANOVA Results eta^2
Teacher Support	0.72	0.29	0.34*	**Geography Classroom**	(N=348		
Task Orientation	0.58	0.23	0.25*	**Environment Inventory (GCEI)**	Students)		
Competition	0.51	0.09	0.18*	Gender Equity	0.67	-†	0.38*
Order and Organisation	0.75	0.29	0.43*	Investigation	0.65	-	0.64*
Rule Clarity	0.63	0.29	0.21*	Innovation	0.52	-	0.60*
Teacher Control	0.60	0.16	0.27*	Resource Adequacy	0.68	-	0.53*
Innovation	0.52	0.19	0.26*				
				Computer Classroom Environment	(N=120		
Individualised Classroom	(N=1,849			**Inventory (CCEI)**	Students)		
Environment Questionnaire	students)			Investigation	0.77	0.37	-†
(ICEQ)				Open-Endedness	0.62	0.34	-
Personalisation	0.79	0.28	0.31*	Organisation	0.69	0.47	-
Participation	0.70	0.27	0.21*	Material Environment	0.74	0.39	-
Independence	0.68	0.07	0.30*	Satisfaction	0.91	0.45	-
Investigation	0.71	0.21	0.20*				
Differentiation	0.76	0.10	0.43*	**Cultural Learning Environment**	(N=3,785		
				Questionnaire (CLEQ)	Students)		
My Class Inventory	(N=2,305			Equity	0.74	0.09	0.12*
(MCI)	students)			Collaboration	0.74	0.12	0.08*
Cohesiveness	0.67	0.20	0.21*	Deference	0.69	0.18	0.13*
Friction	0.67	0.26	0.31*	Competition	0.86	0.17	0.09*
Difficulty	0.62	0.14	0.18*	Teacher Authority	0.78	0.08	0.09*
Satisfaction	0.78	0.23	0.30*	Modelling	0.72	0.17	0.13*
Competitiveness	0.71	0.10	0.19*	Congruence	0.83	0.16	0.10*
College and University Classroom	(N=372			**Secondary Colleges Classroom**	(N=1,883		
Environment Inventory (CUCEI)	students)			**Environment Inventory (SCCEI)**	Students)		
Personalisation	0.75	0.46	0.35*	Personalisation	0.80	0.33	0.26*
Involvement	0.70	0.47	0.40*	Informality	0.68	0.11	0.24*

Scale	Alpha Reliability	Mean Correlation with Other Scales	ANOVA Results eta^2	Scale	Alpha Reliability	Mean Correlation with Other Scales	ANOVA Results eta^2
Student Cohesiveness	0.90	0.45	0.47*	Student Cohesiveness	0.85	0.25	0.27*
Satisfaction	0.88	0.45	0.32*	Task Orientation	0.73	0.28	0.28*
Task Orientation	0.75	0.38	0.43*	Individualism	0.73	0.25	0.33*
Innovation	0.81	0.46	0.41*				
Individualisation	0.78	0.34	0.46*	**Chemistry Laboratory**	(N=1,592		
				Environment Inventory (CLEI)	Students)		
Science Laboratory Environment	(N=3,727			Student Cohesiveness	0.68	0.23	0.10*
Inventory (SLEI)	students)			Open-Endedness	0.41	0.03	0.08*
Student Cohesiveness	0.77	0.34	0.21*	Integration	0.69	0.30	0.18*
Open-Endedness	0.70	0.07	0.19*	Rule Clarity	0.63	0.28	0.19*
Integration	0.83	0.37	0.23*	Material Environment	0.72	0.25	0.18*
Rule Clarity	0.75	0.33	0.21*				
Material Environment	0.75	0.37	0.21*	**Computer Laboratory**	(N=80		
				Environment Inventory (CLEI)	Students)		
Constructivist Learning	(N=1,081			Student Cohesiveness	0.75	0.06	-†
Environment Survey (CLES)	students)			Open-Endedness	0.54	0.14	-
Personal Relevance	0.88	0.43	0.16*	Integration	0.94	0.09	-
Uncertainty	0.76	0.44	0.14*	Technology Adequacy	0.73	0.22	-
Critical View	0.85	0.31	0.14*	Material Environment	0.70	0.18	-
Shared Control	0.91	0.41	0.17*				
Student Negotiation	0.89	0.40	0.14*				

*$p < 0.01$

† This statistic is not available.

‡ This statistic is not relevant for the QTI.

Adapted From Fraser (1998c)

The following section briefly describes each of the instruments in turn.

Learning Environment Inventory (LEI)

The Learning Environment Inventory (LEI) was in its infancy in 1960 and was developed in relation to the evaluation and research on Harvard Project Physics (Fraser, Anderson, & Walberg, 1982; Walberg & Anderson, 1968) in secondary classrooms. The final version contains a total of 105 statements (or seven per scale) descriptive of typical school classes. The respondent expresses degree of agreement or disagreement with each statement using the four response choices of Strongly Disagree, Disagree, Agree, and Strongly Agree. The scoring polarity or direction is reversed for several items. A type item in the Cohesiveness scale is: 'All students know each other very well' and in the Speed scale is: 'The pace of the class is rushed'. The LEI was employed in the Hindi language in a large study involving nearly 3,000 tenth grade students in 83 science and 67 social studies classes (Walberg, Singh, & Rasher, 1977). Student perceptions on the LEI accounted for a considerable increment in achievement variance beyond that caused by general ability.

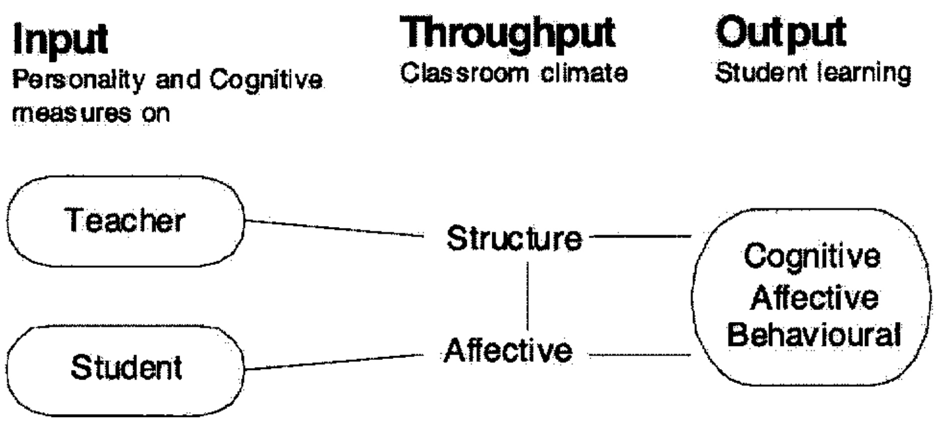

Figure 2.2. Walberg and Anderson's schematic scheme to investigate classroom climate and individual learning (based on Getzels and Thelen's (1960) conceptual scheme of the classroom group as a unique social system).

The theory visualised that social behaviour is the result of the individual's attempt to cope with an environment made of patterns of expectations for the individual's behaviour in a way consistent with the individual's own independent pattern of needs. This can be put in the form of a general mathematical equation, B = f(RP) where B is the observed behaviour, R is a given institutional role defined by the expectations attached to it, and P is the personality of the particular role incumbent defined by his/her need disposition (Getzels & Thelen, 1960).

Walberg (1968) devised an instrument along the general format outlined by Hemphill and Westie (1950). This instrument, the *Classroom Climate Questionnaire* (CCQ), contained 18 scales in total. As a result of earlier studies with this questionnaire, the LEI evolved as an expansion and improvement of the Classroom Climate Questionnaire to the present design with 15 classroom climate scales, with seven items per scale.

Classroom Environment Scale (CES)

The Classroom Environment Scale (CES) was developed by Trickett and Moos at Standford University (Fisher & Fraser, 1983b; Moos, 1979; Moos & Trickett, 1987) and grew out of a comprehensive program of research involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences and work milieus (Moos, 1974). Initially, the CES contained 242 items representing 13 scales. After a number of trials, the final version of the CES contains nine scales with 10 items per each scale, using the response format of True-False. Published materials include a test manual, a questionnaire, and answer sheet and transparent hand scoring key (Moos & Trickett, 1987). Typical item in the Teacher Support scale is: 'The teacher takes a personal interest in the students' and in the Rule Clarity scale is: 'There is a clear set of rules for students to follow'. It has been validated in numerous studies (Fisher & Fraser, 1982). Although the CES was used successfully for a variety of purposes, some researchers and teachers expressed preference for a faster and more economical instrument to administer and score. As a result of this expressed interest, a shorter version of the CES was developed by Fraser and Fisher (1983). The scales in the long and short versions of CES showed satisfactory internal consistency with Cronbach alpha coefficient values ranging from 0.71 to 0.90 and from 0.59 to 0.78 respectively (Fraser & Fisher, 1983). The CES also had adequate discriminant validity values ranging from 0.09 to 0.40. Another desirable characteristic of a questionnaire like the CES is the ability of the instrument to differentiate between the perceptions of students in different classrooms. This involved a one-way ANOVA with class membership as the main effect and using the individual as the unit of analysis. Each CES scale differentiated significantly ($p<0.001$) between classrooms. The eta^2 statistic, which provides an estimate of the amount of variance in the CES scores attributable to class membership, ranged from 18 to 43 percent for different scales (Fraser, 1998b).

Individualized Classroom Environment Questionnaire (ICEQ)

The Individualised Classroom Environment Questionnaire (ICEQ) was developed by Rentoul and Fraser (1979) and has long and short versions. The questionnaire assesses 'individualized' dimensions in the secondary classroom, such as participation and personalization (Fraser, 1990; Rentoul & Fraser, 1979). The final published version of the ICEQ (Fraser, 1990) contains 50 items with 10 items in each scale. Each item is responded to on a five-point scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. The scoring direction is reversed for many of the items. The scales are Personalization, Participation, Independence, Investigation, and Differentiation. Typical item in the Personalisation scale is: 'The teacher considers students' feelings' and in the Differentiation scale is: 'Different students use different books, equipment and materials'. The published version has a progressive copyright arrangement which gives permission to purchasers to make an unlimited number of copies of the questionnaires and responses sheets. This important instrument was one of the first to consider for measuring the learning environment created in the more student-centred classroom. Although useful at the secondary school level, some scales and items were not considered useful at the tertiary level. The validation process of this instrument resulted in Cronbach alpha coefficient values of 0.68 to 0.76 (Fraser, 1991). The short form of the ICEQ consists of 25 items divided equally among the five scales. The alpha reliability values for the short version ranged from 0.63 to 0.85 (Fraser & Fisher, 1983). This short form also showed adequate discriminant validity and the capacity to differentiate between students in different classes. The discriminant validity ranged from 0.07 to 0.28 and the eta^2 statistic ranged from 20% for the Investigation scale to 43 percent for the Differentiation scale (Fraser, 1998b).

My Class Inventory (MCI)

The My Class Inventory (MCI) is a simplified form of the LEI developed primarily for elementary school children in the eight to 12 years age range (Fraser, Anderson, & Walberg, 1982; Fisher & Fraser, 1981; Fraser & Fisher, 1982a, 1982b, 1982c; Fraser & O'Brien, 1985). The MCI has a lowered reading level and a reduction in the number of scales from 15 to five. It was developed in order to minimise weariness among younger children when completing the questionnaire. The MCI contains only five of the LEI's original 15 scales. Students were required to respond to the questionnaire itself, and responses were kept to a simple Yes-No format. The final form of the MCI contains 38 items with six to eight items per scale. Typical item in the Friction scale is: 'Children are always fighting with each other' and in the Satisfaction scale is: 'Children seem to like the class'. Goh, Young and Fraser (1995) have successfully used a three-point response format (Seldom, Sometimes, and Most of the Time) with a modified version of the MCI that includes a Task Orientation Scale. In 2001, the MCI was used with a large sample of mathematics students in Brunei (Majeed, Fraser, & Aldridge, 2001). The final version of the MCI contains five scales and has a total of 38 items. In the validation process of this instruments with a sample size of just over 2,300 students, the Cronbach alpha coefficient values were reported to range from 0.73 to 0.88 (Fraser & Fisher, 1983). The MCI also has a shorter version with 25 items divided equally among the five scales. The shorter version has an internal consistency ranging in Cronbach alpha coefficient values from 0.65 to 0.78 (Fraser, 1991, 1998a, 1998b; Fraser & Fisher, 1983). The MCI also had adequate discriminant validity and the ability to differentiate between classrooms.

College and University Classroom Environment Inventory (CUCEI)

The College and University Classroom Environment Inventory (CUCEI) was developed in 1986 (Fraser, Treagust, & Dennis, 1986; Fraser, Treagust, Williamson,

& Tobin, 1987; Williamson, Tobin, & Fraser, 1986). The instrument was developed parallel to the classroom environment instruments that were used at the secondary and primary school levels. The CUCEI was specifically designed for upper secondary and tertiary levels utilising either seminar or tutorials as the mode of delivery, for small class sizes of about 30 students. The CUCEI was designed to have a relatively small number of scales, each containing a fairly small number of items. There are four versions of the instrument one for the students and another for the instructors, each having the actual and preferred forms. The final form of the CUCEI contains seven scales each having seven items. Each item is responded to on a five-point scales with the alternatives of Strongly Agree, Agree, Disagree, and Strongly Disagree. The polarity is reversed for approximately half of the items. A typical item in the Task Orientation scale is: 'Activities in this class are clearly and carefully planned' and in the Individualisation scale is: 'Teaching approaches allow students to proceed at their own pace'. The instrument was validated in an Australian study (Fraser, Treagust, & Dennis, 1986) resulting in Cronbach alpha coefficient values ranging from 0.72 to 0.92. The instrument was also cross-validated using American and Australian student samples (Fraser, Treagust, & Dennis, 1986). The findings in the study utilizing the CUCEI were replicated in other studies in the USA, in Spanish universities, and in Australia (Fisher & Parkinson, 1998; Marcello, 1988; Winston, Vahala, Nichols, Wintrow, & Rome, 1994; Yarrow, Millwater, & Fraser, 1997). The sensitivity, effectiveness and suitability of the CUCEI for higher education settings is clearly demonstrated in above studies. The discriminant validity for each of the forms of the CUCEI using both the individual and the class as the unit of analysis suggests that each CUCEI scale has adequate discriminant validity for its use in both actual and preferred forms. The discriminant validity figures ranged from 0.34 for the Individualisation scale to 0.47 for the Involvement scale (Fraser, 1991, 1998a; Fraser, Treagust, Williamson, & Tobin, 1987). Furthermore, the instrument was found to be able to differentiate between the perceptions of students in different classrooms. The eta^2 statistic for the CUCEI using a sample size of 372 students in 34 classes ranged from 32% for the Satisfaction scale to 46% for the Individualisation scale (Fraser, 1998a; Fraser, Treagust, Williamson, & Tobin, 1987).

Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) was developed because of the importance laboratory work plays in science education and the instrument was specially designed to assess the environment of science laboratories at the senior secondary or higher education levels (Fraser, Giddings, & McRobbie, 1992, 1993, 1995; Fraser & McRobbie, 1995). The SLEI contains 49 items with seven items in each scale. The final version has seven items in each of the five scales (Student Cohesiveness, Open Endedness, Investigation, Rule Clarity and Material Environment). The SLEI employs a five-point Likert response scale of Almost Never, Seldom, Sometimes, Often and Very Often. Typical item in the Integration scale is: 'I use the theory from my regular science class sessions during laboratory activities' and in the Open-Endedness scale is: 'We know the results that we are supposed to get before we commence a laboratory activities. The Open-Endedness scale was included because of the importance of open-ended laboratory activities often claimed in the literature to be important (Hodson, 1988). The SLEI underscores the importance and uniqueness of the laboratory in science learning. The SLEI was field tested and validated simultaneously with sample of over 5,447 students in 269 classes in six different countries (the USA, Canada, England, Israel, Australia and Nigeria) and cross-validated with 1,594 Australian students in 92 classes (Fraser & McRobbie, 1995), 489 senior high school biology students in Australia (Fisher, Henderson, & Fraser, 1997) and 1,592 grade 10 chemistry students in Singapore (Wong & Fraser, 1995).

Another instrument modified from the SLEI specifically for use in Chemistry classroom was the *Chemistry Laboratory Environment Inventory* (CLEI). The CLEI was developed by Wong and Fraser (1994a, 1994b) and has the same five scales as the SLEI. It was validated with a sample of 1,592 chemistry students in 56 secondary classes in Singapore. The alpha reliability for these scales ranged from 0.41 to 0.72 (Wong & Fraser, 1994a, 1994b). Riah and Fraser (1998) validated CLEI with a sample of 644 grade 10 chemistry students in Brunei Darusallam.

Computer Laboratory Environment Inventory (CLEI)

The Computer Laboratory Environment Inventory (CLEI), an instrument for assessing computer laboratory environment, also was based on the SLEI (Newby & Fisher, 1997, 1998). The instrument had 35 items in five scales, namely, Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. The CLEI was validated with a sample size of 80 students taking higher educational computing courses at both undergraduate and postgraduate levels. The Cronbach alpha reliability for the seven-item scales ranged from 0.54 to 0.94, indicating a satisfactory internal consistency. The discriminant validity ranged from 0.06 to 0.22 indicating that the CLEI measures distinct although somewhat overlapping aspects of the classroom environment. The dimension of Technology Adequacy, which measures the extent to which the hardware and software is adequate for the various tasks required for the laboratory lessons, is a unique characteristic of this instrument.

Constructivist Learning Environment Survey (CLES)

The Constructivist Learning Environment Survey (CLES) was developed with an emphasis on the constructivist learning environment and its theoretical framework is provided by three principles of constructivism: learning as construction of knowledge; knowledge is constructed inter-subjectively; and the learner is an interactive co-constructor of scientific knowledge (Taylor, Dawson, & Fraser, 1995; Taylor, Fraser, & Fisher, 1993, 1997; Taylor, Fraser, & White, 1994). According to the constructivist view, meaningful learning is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process involves active negotiation and consensus building.

The CLES has been developed containing 30 items in five scales: Personal Relevance, Uncertainty of Science, Critical Voice, Shared Control and Student Negotiation (Taylor, Fraser, & Fisher, 1997). The CLES has seven items per scale and uses the response format of Very Often, Often, Sometimes, Seldom and Never.

Typical item in the Personal Relevance scale is: 'I learn how science can be part of my out-of-school life' and in the Student Negotiation scale is: 'It is OK for me to ask teacher "Why do I have to learn this?"'. The new questionnaire is suitable for use in secondary science and mathematics classrooms. The CLES has a reported internal consistency ranging in values from 0.61 to 0.89 (Taylor, Fraser, & Fisher, 1997). The CLES has been validated with 1,083 students from 50 classes in Australia and 1,879 students from 50 classes in Taiwan (Aldridge, Fraser, Taylor, & Chen, 2000; Aldridge & Fraser, 2000).

What Is Happening In This Class (WIHIC) Questionnaire

The What Is Happening In This Class (WIHIC) questionnaire brings thrift to the field of classroom environment by combining modified versions of the most salient scales from a wide range of existing questionnaires with additional scales that accommodate contemporary educational concerns (e.g., equity and constructivism) (Fraser, Fisher, & McRobbie, 1996). The WIHIC has a separate Class form (which assesses a student's perceptions of the class as a whole) and Personal form (which assesses a student's personal perceptions of his or her role in a classroom). The original 90-item nine scale version was refined by both statistical analysis of data from 355 junior high school science students, and extensive interviewing of students about their views of their classroom environment in general, the wording and salience of individual items and their questionnaire responses (Fraser, Fisher, & McRobbie, 1996). Only 54 items in seven scales survived these procedures, although this set of items was expanded to 80 items in eight scales for the field testing of the second version of the WIHIC, which involved junior high school science classes in Australia and Taiwan. The final form of the WIHIC contains seven eight-item scales, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity, has been used successfully in studies in countries including Australia (Dorman, 2001), Australia and Taiwan (Aldridge, Fraser, & Huang, 1999), Australia, Canada and England (Dorman, Adams, & Ferguson, in press), Singapore (Chionh & Fraser, 1998, 2000; Khoo & Fraser, 1997), Brunei (Riah & Fraser, 1998), Canada (Zandvliet & Fraser, 1999), Indonesia

(Margianti & Fraser, 2000; Margianti, Fraser, & Aldridge, 2001; Soerjaningsih, Fraser, & Aldridge, 2001a, 2001b). The validation process of this instrument gave Cronbach alpha coefficient values in the range of 0.81 to 0.89 (Aldridge, Huang, & Fraser, 1998).

Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction (QTI) was developed specially for evaluating teacher-student relationships in secondary classrooms (Wubbels, Brekelmans, & Hooymayers, 1991). The QTI was originally an instrument in the Dutch language developed for use in a teacher education project at the University of Utrecht, Holland. It focuses on the nature and quality of interpersonal relationships between teachers and students (Creton, Hermans, & Wubbels, 1990; Wubbels, Brekelmans, & Hooymayers, 1991; Wubbels & Levy, 1993). Later an English version was used in the USA (Wubbels & Levy, 1991), Australia (Fisher, Henderson, & Fraser, 1995, 1997), Singapore (Goh & Fraser, 1996), Brunei (Riah, Fraser, & Rickards, 1997), Indonesia (Soerjaningsih, Fraser, & Aldridge, 2001a, 2001b). Interpersonal teacher behaviour is mapped using eight scales circumrotating on the two axes of influence (Dominance-Submission) and proximity (Cooperation-Opposition). The eight scales of teacher interaction behaviour (Leadership, Understanding, Helping/Friendly, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing and Strict behaviour) fall naturally within Moos' category of relationships dimensions. Each item has a five-point response scale ranging from Never to Always. Typical item in Student Responsibility scale is: 'She/ he gives us a lot of free times' and in the Admonishing Behaviour scale is: 'She/ he gets angry'.

The Cultural Learning Environment Questionnaire (CLEQ)

Based partially on existing instruments, Fisher and Waldrip (1997) developed a questionnaire to measure culturally sensitive factors of learning environments. The 40-item *Cultural Learning Environment Questionnaire* (CLEQ) assesses students' perceptions of Equity, Collaboration, Risk Involvement, Competition, Teacher

Authority, Modelling, Congruence and Communication. The Cronbach alpha reliability for these scales ranged from 0.69 to 0.86 (Fisher & Waldrip, 1997). Administration of the new questionnaire to 3,031 secondary science students in 135 classes in Australia provided support for the internal consistency reliability and factorial validity of the CLEQ.

Secondary Colleges Classroom Environment Inventory (SCCEI)

An instrument specially designed to study Tasmanian senior secondary colleges and utilising the scales of the CUCEI and the LEI was developed by Kent and Fisher (1997). The *Secondary Colleges Classroom Environment Inventory* (SCCEI), constructed from selected scales of the two existing instruments, contains five scales each having seven items responded to with Strongly Agree, Agree, Disagree and Strongly Disagree. The five scales in the SCCEI are Personalisation, Informality, Student Cohesion, Task Orientation and Individualisation.

Other Instruments

Many studies have derived on scales and items in previous questionnaires to extend modified instruments which better match specific research purposes and research contexts. For a study of the classroom environment of Catholic schools, Dorman, Fraser and McRobbie (1997) elaborated a 66-item instrument which derived on the CES, CUCEI and ICEQ but made significant modifications. The seven scales in this study (Student Application, Interactions, Cooperation, Task Orientation, Order and Organisation, Individualisation and Teacher Control) were validated using a sample of 2,211 grade 9 and 12 students in 104 classes.

Because an inadequate number of classroom environment instruments have a reading level suitable for the primary school level, Sinclair and Fraser (1997) developed a questionnaire based on the MCI and WIHIC for use in teachers' action research aims to improve their primary classroom environments in an urban school district. The instrument has the four scales of Cooperation, Teacher Empathy/ Equity, Task Orientation and Involvement, and it was validated with a sample of 745 students in 43 grade 6-8 classes.

In assessments of computer-assisted learning, Maor and Fraser (1996) and Teh and Fraser (1994a, 1994b, 1995a, 1995b) extracted existing scales in developing specific-purpose instruments. Maor and Fraser developed a five-scale classroom environment instrument (assessing Investigation, Open-Endedness, Organisation, Material Environment and Satisfaction) based on the LEI, ICEQ and SLEI and validated it with a sample of 120 grade 11 students in Australia. Teh and Fraser developed a four-scale instrument to assess Gender Equity, Investigation, Innovation and Resource Adequacy, and validated it among 671 high school geography students in Singapore.

In the first learning environment study worldwide specifically in agricultural science classes, Idiris and Fraser (1997) selected and adapted scales from the CLES and ICEQ in developing a five-scale instrument to assess Negotiation, Autonomy, Student Centeredness, Investigation and Differentiation. This instrument was validated with a sample of 1,175 students in 50 high school agricultural science classes in eight States of Nigeria.

Influenced to a certain extent by the CES, Wong (1993) developed a questionnaire to measure the actual and preferred environment of classes in Hong Kong along the dimensions of Enjoyable, Order, Involvement, Achievement Orientation, Teacher Led, Teacher Involvement, Teacher Support and Collaborativeness.

While most classroom environment instruments concentrate on general psychosocial characteristics, Woods and Fraser (1995) developed a questionnaire to assess student perceptions of specific teacher behaviours. The *Classroom Interaction Patterns Questionnaire* (CIPQ) assesses teaching style with the scales of Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management, and Group Work. Following versions were field tested with a total of 1,470 grade 8-10 students in 62 classes in Western Australia.

Jegede, Fraser, and Fisher (1995) developed the *Distance and Open Learning Environment Scale* (DOLES) for use along with university students studying by distance education. The DOLES has the five core scales of Student Cohesiveness, Teacher Support, Personal Involvement and Flexibility, Task Orientation and Material Environment, and Home Environment, in addition to the two optional scales of Study Centre Environment and Information Technology Resources. Administration of the DOLES to 660 university students presented support for its internal consistency reliability and factor structure.

2.2.6 Associations between Classroom Environment and Student Outcomes

In classroom environment research, associations between classroom learning environment and students' cognitive and affective outcomes have been studied extensively. These studies have shown that students' perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics (Fraser, 1994).

There are nine factors which contribute to the variance in students' cognitive and affective outcomes. These factors are student ability, maturity, motivation, the quality and quantity of instruction, the psychological environment at home, the classroom social group, the peer group outside the classroom and the time involved with the video/ television media in Walberg's theory on educational productivity (Walberg, 1981, 1984, 1991). This model of educational productivity was well tested as part of a national study which demonstrated that student achievement and attitudes were influenced mutually by a number of these factors (Walberg, Fraser, & Welch, 1986). An exciting outcome from these studies was the discovery that classroom and school environments were important influences on student outcomes. These findings support Getzels and Thelen's (1960) theoretical model which describes the class as a social system in which group behaviour can be predicted from personality needs, role expectations and classroom environment.

Research consistently supports the contention that the classroom learning environment accounts for variances in student outcomes. Much of this past research has involved the assessment of science classroom learning environments, from both teacher and student perspectives, and the investigation of associations between learning environment variables and student outcomes. Fraser (1994) tabulated a set of 64 studies which shows that associations between outcome measures and perceptions of classroom environment. These studies have involved a variety of cognitive and affective outcome measures, a variety of classroom environments instruments and a variety of samples (ranging across numerous countries and grade levels).

For example, in a meta-analysis reported by Haertel, Walberg, and Haertel (1981) with a sample of 17,805 students in 823 classes in four nations, student achievement in classes was found to be enhanced with greater Cohesiveness, Satisfaction, Goal Direction, and less Disorganisation and Friction. This meta-analysis revealed consistent and strong associations between post test learning scores and regression-adjusted gains in student cognitive and affective outcomes. Other research studies have consistently supported the existence of associations between classroom environment variables and student outcomes. Fraser, Walberg, Welch, and Hattie (1987) provided further evidence linking educational environments and student outcomes.

Numerous studies of associations between classroom environment and student learning, involving different subject areas, grade levels and countries, tend to support the important link between the two variables. In a study in Australia (Fraser & Fisher, 1982a, 1982b), sizeable associations between student perceptions of classroom environment and student outcomes also lent support to a positive link between classroom environment and students outcomes.

In another study, Anderson, Saltet, and Vervoorn (1980) reported that senior colleges having only year 11 and 12 classes were found to have a distinct culture from that in traditional high schools. In particular there were more favourable perceptions of teacher student relationships as well as student responsibility and freedom. Ramsden (1991) concluded that the Year 12 learning environments are accurate predictors of the quality of learning that students receive. In his study, Ramsden (1991), with a sample of 374 students from both grade 12 and first year of university study, showed that a positive environment is carried over to the first year of higher education through the approaches to learning developed and experienced in Year 12. Regression analysis of the first year approaches on the Grade 12 approaches to learning, school mean ethos, and three variables measuring perceptions of the higher education learning context: good teaching, freedom of learning, and workload clearly showed that students' approaches to learning were functionally related to the environment in which the students found themselves.

Similar findings supporting this link were reported by Henderson, Fisher, and Fraser (1998, 2000) who studied 100 students in seven classes, representing one third of the total population of Environmental Science students in Tasmania. They found that students had more favourable attitudes in classes where they perceived greater cohesion between students, a greater degree of student involvement in classroom activities and a higher level of task orientation. Apart from this, other recent studies using the SLEI, and an instrument specially designed for computer assisted instruction, the CLEI, further supported the associations of students' cognitive and affective outcomes with their perceptions of the classroom environment (Fraser & McRobbie, 1995; Newby & Fisher, 1997, 1998; Teh & Fraser, 1995a, 1995b; Wong & Fraser, 1996).

These findings are in line with those of Moos (1976, 1979) who found in his research that students were satisfied in classrooms that had high student involvement, personal student-teacher relationships, innovative teaching methods and clear rules governing behaviour. Similar findings were also reported by Chang & Fisher (2001a, 2001b) who found that the use of innovative teaching approaches, interactive teaching, in university physics classes increased students' interest, enjoyment, satisfaction and level of involvement. Researchers in general have argued against the effectiveness of didactic ways of teaching and have emphasised the crucial role of engaging the learners in the teaching process (Duit & Treagust, 1998; Linder & Erickson, 1989; McDermott, 1993).

Moos (1976, 1979) also found that students tended to learn more in classrooms that are considered more difficult and competitive. However, in such environments there was a tendency for more absences from the classroom. He also concluded in his study that a structured class may be beneficial to some but in some instances the reverse is true. Walberg (1979) on the other hand reported findings similar to those of Moos (1979) and that students in competitive environments were found to perform disappointingly, be less self-confident and experienced more failure. Similar findings showing that a positive environment is beneficial to learning has been reported by Fraser (1991), Freedman (1997), Germann (1988), and Templeton and Jensen (1993).

The importance of student teacher relationships have been reported in many studies utilising the QTI in Australia, The Netherlands, and Singapore (Fisher, Henderson, & Fraser, 1995; Fraser, 1998a, 1998b; Goh & Fraser, 1996; Goh, Young, & Fraser, 1995; Kent & Fisher, 1997; Fisher, Rickards, & Fraser, 1996, 1997; Wubbels & Brekelmans, 1998). Studies have also indicated that cooperative learning lends to greater student achievement than competitive learning (Johnson & Johnson, 1991; Johnson, Maruyama, Johnson, Nelson, & Skon, 1981).

Moos (1979) also found in his studies that students and teachers were in greater agreement on the characteristics of a preferred classroom, although, teachers placed a greater emphasis on task orientation and rule clarity than did their students. Moos, however, found considerable variations in the qualities perceived by students and teachers. This finding is replicated in numerous studies (Fraser, Giddings, & McRobbie, 1992, 1993; Fraser, Treagust, Williamson, & Tobin 1987; Fraser & Walberg, 1991; Hofstein & Lazarowitz, 1986; Lim, 1997; Raviv, Raviv, & Reisel, 1990; Suarez, Pias, Membiela, & Dupia, 1998; Wong & Fraser, 1994a, 1994b).

Research has also been carried out to gauge the effects of students' age on their perceptions of the classroom environment revealing an interesting trend (Yager & Penick, 1986; Yager & Yager, 1985). As students became older, they became more uncomfortable with science and the subject matter became less interesting to them. However, though there was decline in the attitude towards science by older students, the attitudes toward their teacher were found to be more positive (Hofstein & Welch, 1984).

Although classroom environment instruments originated from Western countries, however, many researchers have adapted and used these instruments in a variety of cultural settings, including Asian countries;

Studies conducted in Asian Countries and Southeast Asian countries, such as India (Walberg, Singh, & Rasher, 1977), Hong Kong (Chan & Watkins, 1994; Wong, 1993), Taiwan (Aldrige & Fraser, 1996, 2000; Aldridge, Fraser, & Huang, 1999; Chen, 1994; Fraser, Taylor, & Chen, 2000; Lin & Crawley, 1987; Huang & Fraser, 1997), Korea (Kim, Fisher, & Fraser, 1999; Kim & Kim, 1995, 1996; Kim & Lee, 1997; Lee & Fraser, 2001, 2002), Indonesia (Fraser, 1985; Fraser, Pearse, & Azmi, 1982; Margianti & Fraser, 2000; Margianti, Fraser, & Aldridge, 200; Paige, 1978, 1979; Schibeci, Rideng, & Fraser, 1987; Soerjaningsih, Fraser, & Aldridge, 2001a, 2001b), Singapore (Chionh & Fraser, 1998, 2000; Chua, Wong, & Cen, 2001; Fraser, 1984, 1998b; Goh, 1994; Goh & Fraser, 1995, 1996; Goh, Young, & Fraser, 1995; Khoo & Fraser, 1997; Quek, Fraser, & Wong, 2001; Teh & Fraser, 1993, 1994a, 1994b, 1995a, 1995b; Wilks, 2000; Wong & Fraser, 1994a, 1994b, 1995, 1996), and Brunei (Ashgar, Fraser, 1995; Khine & Fisher, 2001; Lim, 1997; Majeed, Fraser, & Aldridge, 2001; Riah & Fraser, 1998; Riah, Fraser, & Rickards, 1997) replicated prior research in that the nature of the psychological and social climate of classrooms was found to be an important determinant of student outcomes (Fraser, 2000). These studies indicated that these instruments are reliable and valid for use in different cultures.

Considerable work has been carried out with respect to associations of student outcomes with the classroom environment, though most of this research has been carried out at the primary and secondary levels. Table 2.4 gives an overview of some of the past studies which have looked into this feature of research and have supported the existence of associations between classroom environment variables and student outcomes.

Table 2.4

Overview of Some Similarities of Asociations Between Student Outcomes and Classroom Environment

Study	Outcome Measures	Sample
Studies involving LEI		
Anderson & Walberg (1968) Walberg & Anderson (1968) Anderson (1970)	Selected front: Achievement; understanding of nature of science; science processes; participation in Physics activities; science interest; attitudes	Various samples (maximum of 144 classes) of senior high school Physics students, mainly in USA but some in Canada.
Walberg (1969a, 1969b, 1972)	Examination results	1600 grade 10 and 1 1 students in various subject areas in 64 classes in Montreal, Canada.
Lawrenz (1976)	Science attitudes	238 senior high school science classes in midwest USA.
Fraser (1978b, 1979)	Inquiry skills; attitudes; understanding of nature of science	531 students in 20 grade 7 science classes Melbourne, Australia.
Power & Tisher (1975, 1979)	Achievement; attitudes; satisfaction	315 junior high school students in 20 science classes in Melbourne, Australia.
Hofstein et.al, (1979)	Attitudes	400 grade 11 students in 12 Chemistry classes in Israel.
Haladyna, Olsen, & Shaughnessy (1982) Haladyna, Shaughnessy, & Redsun (1982a, b) Haladyna, Shaughnessy, & Shaughnessy (1983)	Attitudes	5804 science, mathematics and social studies students in 277 grade 4, 7 and 9 classes in Oregon, USA.
Studies involving CES		
Trickett & Moos (1974)	Satisfaction and mood criteria	608 students in 18 classes, USA.
Moos & Moos (1978)	Absences; Grades	19 high school classes in one school, USA.
Moos (1979a)	Indexes of student reactions	241 secondary school classes in various subject areas.
Fisher & Fraser (1983b)	Inquiry skills; attitudes	116 grade 8 and 9 science classes throughout Tasmania, Australia.

Study	Outcome Measures	Sample
Gal Iuzzi et. al. (1980)	Psychological outcomes Self-control	414 grade 5 students in USA.
Humphrey (1984)		750 grade 4 and 5 children in 36 classes, in USA.
Hirata & Sako (1998)	Teacher Control, Sense of Isolation, Order and Discipline, and Affiliation	635 students in Japan.
Keyser & Barling (1981)	Academic self-efficacy beliefs	504 grade 6 children in South Africa.
Studies involving ICEQ		
Rentoul & Fraser (1980)	Inquiry skills; enjoyment	285 junior high school students in 1 science and social science classes in Sydney, Australia.
Wierstra (1984)	Attitudes; achievement	398 15-16 year old students in 9 classes in The Netherlands.
Wierstra et. al. (1987)	Attitudes; achievement	1105 secondary school students in 66 classes involved in Dutch option of Second International Science Study.
Fraser (1981a) Fraser & Butts (1982)	Attitudes	Maximum of 712 students in 30 junior high high school science classes in Sydney, Australia.
Fraser, Nash, & Fisher (1983)	Anxiety	116 grade 8 and 9 science classes throughout Tasmania, Australia.
Fraser & Fisher (1982a)	Inquiry skills; attitudes	116 grade 8 and 9 science classes throughout Tasmania, Australia
Asghar & Fraser (1995)		The lower secondary school level in Brunei Darussalam.
Studies involving MCI		
Fraser & Fisher (1982a, 1982c)	Inquiry Skills; understanding of nature of science; attitudes	2305 grade 7 science students in 100 classes in Tasmania, Australia.
Payne et. al (1974-75) Ellet et. al (1977)	Achievement; school attendance	6151 grade 4 students in 89 schools in Georgia, USA.
Fraser & O'Brien (1985)	Word knowledge; comprehension	758 grade 3 students in 32 classes in Sydney Australia.

Study	Outcome Measures	Sample
Lawrenz (1988)	Energy knowledge; tow energy attitude scales	Approximately 1000 grade 4 and 7 students in 34 classes in Arizona, USA.
Goh, Young, & Fraser (1995)	Task Orientation	1512 primary mathematics students in 39 classes in Singapore.
Majeed, Fraser, & Aldridge (2001)	Cohesiveness, Difficulty, Competitiveness	1565 mathematics students in 81 classes in 15 government secondary schools, Brunei Darussalam.
Studies involving CUCEI		
Fraser & Treagust (1986) Fraser, Treagust, & Dennis (1986) Fraser, Treagust, Williamson, & Tobin (1987)	Satisfaction; locus of control	372 higher education students in 34 classes in various subject areas.
Studies involving SLEI		
Fraser, Giddings, & McRobbie (1995)	Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, Material Environment	5447 students in 269 classes in six countries (USA, Canada, England, Israel, Australia, Nigeria).
Fisher, Henderson, & Fraser (1997) Fraser & McRobbie (1995)		With Australian students.
Wong & Fraser (1995, 1996)		1592 grade 10 chemistry students in 56 classes in 28 schools.
Quek et. al. (2001)		497 gifted and non-gifted chemistry students.
Riah & Fraser (1998)		644 grade 10 chemistry students in Brunei Darussalam.
Kim & Kim (1995, 1996) Kim & Lee (1997) Lee & Fraser (2001, 2002)		In Korea.
Studies involving CLEI		
Newby & Fisher (1997)	Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, Material Environment	387 students taking a higher educational computing courses at undergraduate and postgraduate levels in 31 classes in 5 schools in Australia, England, and United States.

Study	Outcome Measures	Sample
Studies involving CLES		
Taylor, Fraser, & Fisher (1997)	Personal Relevance, Uncertainty, Critical Voice, Shared Control, Student Negotiation	In Austalia.
Wilks (2000)	Political Awareness, Ethic of Care	1046 students in 48 classes in junior colleges in Singapore.
Kim, Fisher, & Fraser (1999)		1083 science students in 24 classes in 12 schools in Korea.
Lee & Fraser (2001)		440 grade 10 and 11 science students in 13 classes in Korea.
Aldridge, Fraser, Taylor, & Chen (2000)		1081 science students in 50 classes in Australia, 1879 science students in 50 classes in Taiwan.
Studies involving WIHIC		
Fraser, Fisher, & McRobbie (1996)	Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, Equity	355 junior high school science students in Australia.
Aldridge & Fraser (2000)		1081 students in 50 clasess in Australia.
Riah & Fraser (1998)		644 grade 10 chemistry students in Brunei Darussalam.
Khine & Fisher (2001)		1188 science students secondary schools in Brunei Darussalam.
Fraser & Chionh (2000)		2310 mathematics and geography students in 75 senior high school classes in Singapore.
Fraser (1998b)		250 adults attending computer courses in 23 classes in four Singapore computing schools.
Aldridge, Fraser, & Huang (1999) Aldridge & Fraser (2000)		1879 junior high school students in 50 classes in Taiwan.
Chua, Wong, & Chen (2001)		1460 students in 50 classes in Taiwan.
Kim et. al. (2000)		543 grade 8 students in 12 school in Korea.

Study	Outcome Measures	Sample
Margianti, Fraser, & Aldridge (2000, 2001)		2498 university students in 50 computer classes in Indonesia.
Soerjaningsih, Fraser, & Aldridge (2001a, 2001b)		422 university students in 12 research methods classes in Indonesia.
Studies involving QTI		
Wubbels & Levy (1993) Wubbels & Brekelmans (1988) Breklermans et al. (1990)	Achievement; attitudes	1105 secondary school students in 66 classes involved in Dutch option of Second international Science Study.
Fisher, Henderson, & Fraser (1995)		In Australia.
Goh & Fraser (1995, 1996)	Achievement; attitudes	1512 primary mathematics students in 39 classes in 13 schools in Singapore.
Quek, Fraser, & Wong (2001)	Achievement; attitudes	497 gifted and non-gifted chemistry students in Singapore.
Fisher, Goh, Wong, & Rickards (1997)	Achievement; attitudes	20 secondary science classes in Singapore.
Scott & Fisher (2001)		3104 primary school students in 136 classes in Brunei Darussalam.
Khine & Fisher (2002)		1188 science students secondary schools in Brunei Darussalam.
Kim, Fisher, & Fraser (2000)		543 grade 8 students in 12 schools in Korea.
Lee & Fraser (2001)		440 grade 10 and 11 science students in Korea.
Soerjaningsih, Fraser, & Aldridge (2001)		422 university students in 12 research methods classes in Indonesia.
Studies involving other instruments		
Kelly (1980)	Achievements	41,657 students in 1735 schools in 14 developed countries in an TEA science study.
Johnson et. al (1981) Johnson et. al (1986) Slavin (1983a, b)	Different studies included; achievement; cross-ethnic relationships; cross-handicap relationships	Various samples involved in studies of cooperative learning strategies in subjects, especially USA.

Study	Outcome Measures	Sample
Talton (1983)	Attitude; achievement	1456 grade 10 biology students in 34 classes in various subject areas.
Perkins (1978)	Basic Skills	3703 grade 4 students in 42 elementary schools in a SE state in USA.
Brookover & Schneider (1975) Brookover et. al. (1978, 1979)	Achievement	8078 grade 4 and 5 students in Michigan, USA
Gardner (1974, 1976)	Attitudes	1014 grade 11 physics students in 58 classes in Melbourne, Australia.
Payne et. al (1974-75)	Achievement	3350 elementary and 3613 secondary students in various subject areas and 1200 teachers in Georgia, USA.
Giddings & Fraser (1990)	Attitudes	4643 senior high school and university students in 225 laboratory classes in Australia, USA, England, and Canada
Studies in developing countries		
Walberg, Singh, & Rasher (1977)	Achievement	3000 grade 10 science and social science students in 150 classes in Rajasthan, India.
Paige (1978, 1979)	Achievement; individual modernity	1621 grade 6 students in 60 schools in East Java, Indonesia.
Holsinger (1972, 1973)	Information learning; individual modernity	2533 grade 3-5 students in 90 classes in Brazil.
Schibeci, Rideng, & Fraser (1987)	Attitudes	250 grade 11 biology students in six classes in Indonesia.
Idiris & Fraser (1997)	Negotiation, Autonomy, Student Centeredness, Investigation and Differentiation	1,175 students in 50 high school agricultural classes in eight States of Nigeria.

Adapted from Fraser (1994) and various sources.

2.3 STUDENTS ATTITUDES

This section reviews the literature on student attitudes and is divided into the definition and evaluation of student attitudes.

2.3.1 Definition of Student Attitudes

The definition of the terms related to the study of students' affective outcomes has caused problems in the past. According to Peterson and Carlson (1979), terminology such 'interests' or 'attitudes' have been used freely and without clarification. Krathwohl, Bloom, and Masia (1964) went some way towards responding to this difficulty when they developed a classification in which affective behaviours were placed along a hierarchical continuum. This clarified some of the terms used to describe affective behaviours.

Klopfer (1976) took this classification one step further and developed a structure for the affective domain specifically related to science education. His structure involves four categories: events in the natural world (awareness and an emotive response to experiences that require no formal study); activities (students' participation in activities related to science, both informal and formal); science (the nature of science as a means of knowing about the world); and inquiry (scientific inquiry processes). The attitude scale used in the present study focuses on Klopfer's (1976) second category which relates to students' attitudes towards their science activities.

2.3.2 Evaluation of Student Attitudes

Students' attitudes towards a subject have been measured using a variety of techniques including interviews, open-ended questions, projective techniques, closed item questionnaires and preference rankings (Laforgia, 1988). In the past, instruments have been designed to elicit the attitudes of students towards science

(Fisher, 1973; Fraser, 1978, 1981b; Mackay, 1971; Wubbels, Creton, & Hoomayers, 1985). Many such instruments have been criticised on conceptual and empirical grounds (Gardner, 1975; Munby, 1980; Schibeci, 1984) and because of their inability to be used in different countries (Schibeci, 1986).

A review of literature reveals numerous scales for assessing science-related attitudes. Of particular interest to this study, is the *Test of Science Related Attitudes* (TOSRA) developed by Fraser (1978, 1981b) to measure students' attitudes towards their science classes. Fraser based the scales of his instrument on Klopfer's (1976) taxonomy of the affective domain related to science education. Modified versions of the TOSRA have been used in previous studies in non-Western countries with a high degree of reliability (Goh, 1994; Goh & Fraser, 1995; Wong & Fraser, 1996).

2.4 ELECTRONICS LABORATORY

This section provides a discussion about the electronics laboratory and is divided into background and the role of laboratories.

2.4.1 Background

There has been tremendous advancement in electronics since static electricity was discovered in 1600 by Gilbert. It took around four hundred years for human can reach planets in the solar system, see the microbacteria with electron microscope, try to hear the outer space sound and find the extraterrestrial with the array of radars in Arizona. The interesting and key point in electronics history and its applications are shown in Appendix F.

The first tertiary electronics courses started in the 1980s which titles, such as Electrics Techniques, Electronics (Small Current Electric Technique), and Computer Engineering. Since 1987, there have been many universities in Indonesia which open their Computer Engineering department. The Computer Engineering is a field of Computer System Science under the Faculty of Computer Studies in Bina Nusantara University that was established in 1987 and was accredited in 1989. The vision of Computer Engineering study program corresponds to the vision of Bina Nusantara University, which is to be recognized as the leading private educational institution in the development and application of science and technology in Indonesia, especially in relation to information technology. The mission of the Computer Engineering Program is to offer study programs that support the development and application of information technology in various scientific disciplines; to preserve the relationship and the relevance of academic activities in line with the development of the socio-economic and industrial fields in Indonesia; to anticipate the future impact of globalization on the lives of the people in Indonesia; to work together with various parties, both national and international, to maintain quality in science and technology application; and to always be advanced and appropriate to needs.

The Computer Engineering graduates will be able to understand computer system and apply information technology especially to Computer System Engineering; and will become creative, innovative, and skilled because of the effective and efficient learning process supported by conducive learning environment.

With the byword, "To build the state's future through Information and Technology", Computer Engineering as a part of the Faculty of Computer Studies in Bina Nusantara University, aims at improving its graduates qualifications with technology advancement especially information technology, both hardware and software. Of relevance is that the subject composition is set upon international standards with expert lecturers and excessive facilities to yield bright and globally-recognized graduates. This major was set up in response to a large demand for engineers to distinguish computer hardware system and to develop it to an application of Computer System control.

The curriculum composition is supported by learning environment based on Information Technology and the development of Computer System Science with the specialization on communication network system, computer system processing and application. The specialization on communication network system will enable students to work in designing and process data communication network, while the specialization of computer system processing and application will enable students to work in designing hardware application system.

Today, there is a large demand for Computer Engineering professionals due to vast application of computer automation control and the development of computer system technology, both hardware and software. As a result, competent and ready-to-work professionals are needed to administer the technology. Career prospects for Computer Engineering graduates are: System Engineer, Network Designer, Computer Specialist, R&D Engineer, and Computer Engineering Lecturer.

2.4.2 The Role of Laboratories

The one element that most electronics courses have in common is the use of electronics laboratories. According to Azemi (1995) this element is reasonable since using an laboratory facilities, such as oscilloscope, multi meters, signal generators, frequency counters, power supply, is professed as a skill which cannot be learned by merely reading a book and needs practice in order for it to be acquired. This skill must be mastered before any development can be made, and laboratory classes provide a chance for students to achieve this expertise.

Electronics laboratory classes have some likeness to science laboratories in terms of aims but there are also marked differences. Boud, Dunn, and Hegarty-Hazel (Newby & Fisher, 1998) made a list of 22 objectives for science laboratory classes, but not all of these are relevant to electronics laboratory classes. The following objectives modified as appropriate, were considered to be those that were related:

- to teach basic practical skills;
- to bridge the gap between theory and practice;
- to reinforce material taught in the lecture;
- to teach theoretical material not included in lectures;
- to familiarise students with electronics environment;
- to teach students the principles of using laboratory facilities;
- to stimulate and maintain interest in the subject;
- to stimulate conditions in electronics system development environment;
- to provide motivation to acquire specific knowledge;
- to develop skills in problem solving.

According to Naps (1990) the classification of the laboratory classes based on experience is divided into reinforcement, comparison, improvement, and discovery laboratories while Collete and Chiappetta (1995) divide laboratories into deductive or verification, technical skill, and problem solving laboratories.

The relationship between lecture and laboratory can vary significantly in terms of how the laboratory element is organised within the curriculum, the content level, the type of activity, the type of interaction, and the aims of the laboratory. The laboratory element may be independent of the lecture, a situation which is desirable in some literacy courses where students are required to gain knowledge about electronics 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 elements in the same semester.

There are some issues concerning the use of electronics laboratories as an integral part of teaching and learning, equipment, physical environment, organisation, assignment difficulty, technical support, and assistant training. According to Pitt (1993) troubles can occur when any of these aspects are not handled properly. The laboratory facilities must be modern, fast enough, and relevant to industry use. The bad impression that the laboratory facilities are inadequate must be avoided as this is an attitude that may remain with students after they graduate.

As mentioned before, to develop practical electronics skills, students will have to complete various tasks such as laboratory exercises or assignments. Such tasks must be within the typical student's capability. If the tasks 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, and electronics in general.

Niedderer & Golberg (1996) investigated learning processes of three college students (prospective elementary school teachers) in the content area of electric circuits. Empirical evidence for learning pathways and knowledge construction is coming from an interpretive analysis of transcripts of six tutorial sessions, in which the students use hands-on experiments and special computer software. Their learning pathways are described by subsequent cognitive states (conceptions) and intermediate processes, starting with a prior conception "everyday current" (well known from previous research) and coming to three new intermediate conceptions "positive and negative current", "microscopic view of current", and "current with electron pressure".

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 electronics 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. Electronics laboratories are an expensive resource and there is often a need to justify their condition.

Despite the perceived importance of electronics laboratories within electronics courses, very little research has been done into students' attitudes or perceptions towards these laboratories.

2.5 SUMMARY

This chapter has presented a review of some of the literature of previous studies involving learning environments concentrating 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 electronics laboratory environments are also reviewed. These environments tend to be specific in using the laboratory facilities as a tool for students find out the relation between theory and the measurement results in the laboratory. The only study that measured effectiveness of electronics laboratories did so by comparing the time taken for students to complete their assignments or laboratory exercises.

The review of previous studies indicates that there is no instrument suitable for use in a university electronics laboratory setting, and so it is 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 electronics laboratory environment specifically for use in electronics courses in a university setting and with its use to determine associations between perceived environment and student outcomes.

The next chapter discusses in detail the methodology in this research along with the modifications that were made to the original CLEI developed by Newby (1997).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

As mentioned in Section 2.2.6, classroom environment instruments originated from Western countries, however, many researchers have adapted and used these instruments in a variety of cultural settings. The studies indicated that these instruments are reliable and valid for use in different cultures. Furthermore, a small number of these learning instruments have been employed successfully in Indonesia (Fraser, 1985; Fraser, Pearse, & Azmi, 1982; Margianti & Fraser, 2000; Margianti, Fraser, & Aldridge, 2001; Paige, 1978, 1979; Schibeci, Rideng, & Fraser, 1987; Soerjaningsih, Fraser, & Aldridge, 2001a, 2001b).

This study focused on the development and validation of two instruments, the Electronics Laboratory Environment Inventory (ELEI) which was used to measure students' perceptions of their electronics laboratory classes and the Attitude Towards Electronics Questionnaire (ATEQ) which was used to assess student attitudes towards electronics and their course. The development of the instruments is described in detail in Chapter 4. The instruments were then validated and applied in an investigation of the nature of the learning environments in electronics classes in Bina Nusantara University's Computer Engineering Department. The study investigated associations between students' cognitive and affective outcomes and their perceptions of electronics laboratory class learning environment.

This chapter includes a description of the methodology used in the study. Section 3.2 presents the research questions. The study consisted of two stages: a pilot study and the main study described in section 3.4 and section 3.4, respectively. Section 3.5 reports how the data were entered in the computer system. The statistical methods used for data analyses are given in section 3.6. Section 3.7 explains research design. Finally, section 3.8 summarises the methodology.

3.2 RESEARCH QUESTIONS

The aim of this study is guided by research questions, such as:

1. Is the Electronics Laboratory Environment Inventory (ELEI) a valid and reliable questionnaire for use in actual and preferred versions in tertiary electronics laboratories in Indonesia?

2. What are students' perceptions of the Electronics Laboratory environment in an Indonesian University?

3. Is the Attitude Towards Electronics Questionnaire (ATEQ) a valid and reliable questionnaire for use in computer engineering students in Indonesia?

4. What are students' attitudes towards their Electronics Laboratory Classes in an Indonesian University?

5. Are there associations between the student outcomes of (a) attitude in electronics laboratory classes and (b) achievement on the laboratory subjects and students perceptions of the laboratory classroom environment?

6. To what extent does laboratory environment influence student outcomes (attitudes and achievement)?

3.3 PILOT STUDY

In the development of the instrument, a pilot study was carried out on a group of alumni and laboratory assistants from the Computer Engineering Department of Bina Nusantara University in Jakarta, Indonesia. For convenience of administration, the two questionnaires were combined into a single survey with questions 1 to 35 covering the ELEI and questions 36 to 63 covering the ATEQ. Some demographic data covering student number, course, batch year, and experience in building electronics systems were also collected. Appendix A contains a copy of the original questionnaire.

3.3.1 Data Collection

Assistants from the Hardware Technical Managing Unit and Electronics Laboratory at Bina Nusantara University who were in charge of units conducting laboratory activities were approached and 18 of them agreed to participate in the pilot study. The questionnaire was administered during the sixth week of a 13 week semester. The researcher attended eight laboratory classes distributing adequate copies of the questionnaires, and described the purpose of the research. The assistants were informed that their participation was voluntary and they were guaranteed confidentiality of their responses. The completed questionnaires were gathered and have remained in the possession of the researcher since that time.

Alumni of Computer Engineering Department are listed at the Hardware Club mailing list at http://groups.yahoo.com/group/hardwareclub. The questionnaire was sent to them during the fifth week of a 13 week semester and six of the alumni responded.

3.3.2 Data Entry

The pilot study questionnaires were hand coded by the researcher, checked for errors and the data were entered into SPSS for Windows Release 11.5. Both instruments used a five point Likert response format. The possible ELEI responses were Almost Never, Seldom, Sometimes, Often and Almost Always and were coded 1, 2, 3, 4 and 5, respectively. The ATEQ responses were Strongly Disagree, Disagree, Not Sure, Agree and Strongly Agree and were coded on a five point numeric ordinal scale similar to the ELEI. Separate columns were allocated for course, batch year, and experience in building electronics system.

Table 3.1 tabulates the course coding and its corresponding course name and Table 3.2 tabulates the batch year coding and number of students of corresponding batch year intake.

Table 3.1
Course Coding

Course Code	Course Name
1	Integrated Electronics
2	Electric Circuit Theory
3	Discrete Electronics
4	Digital System
5	Advanced Control System
6	Microprocessor Application
7	Digital Signal Processing
8	Robotics/ Mechatronics

Table 3.2
Batch Year Coding

Batch Code	Batch Year	Number of students
1	BiNusian 2007	190
2	BiNusian 2006	182
3	BiNusian 2005	196
4	BiNusian 2004†	215
5	1999	218
6	1998	172
7	1997	168

† equal 2000 in old batch year numbering system

Since the year 2000 the batch year numbering has changed from the intake year into the predicted and graduated year. It takes four years for students to get their bachelor degree. With the new batch year numbering system students are taught to be aware of their expectation graduation year in order to remind them that they have limited time.

Table 3.3 tabulates the number of system building experiences coding. Some of electronics courses have a final project at the end of the semester in which the students build an electronics system. Individually, students who have more experience in building an electronics system usually will experience more enjoyment and eagerly follow the theory. They can improve their skills in assembling electronics circuits and in programming their systems as they are required in their final project to complete their degree. Students often build electronics system such as power supply, amplifier, radio, and microprocessor based minimum system.

Table 3.3
Experiences in Building Electronics Systems Coding

Experience Code	Experiences
0	No experience
1	1 system
2	2 systems
3	3 systems
4	$\geq$ 4 systems

3.3.3 Data Analyses

The data for the pilot study and the main study were arranged for analyses by recoding the reverse-scored items of the questionnaires. This facilitated the original data to be retained. The questions involving recoding were numbers 3, 4, 5, 6, 8, 15, 23, 25, 26, 27 and 33 for the ELEI, and 36, 37, 38, 41, 48, 51, 52 and 63 for the ATEQ. The SPSS version 11.5 was used to calculate the alpha reliability and the mean correlation coefficients for each of the scales and this was performed on both instruments. The revisions and improvements of the instruments (ELEI and ATEQ) are described in Section 4.4 and Section 5.4 respectively.

3.4 THE MAIN STUDY

The main study was carried out within the Computer Engineering Department at Bina Nusantara University, using a revised version of the ELEI and the revised version of the ATEQ. The questionnaires used for this purpose are shown in Appendix C for the English version and Appendix D for the Bahasa Indonesia version.

3.4.1 Courses and Programmes

The Computer Engineering Department is one of the departments of the Computer Science Faculty and is responsible for the teaching of electronics courses within that Faculty. There are eight courses, Integrated Electronics, Electric Circuit Theory, Discrete Electronics, Digital System, Advanced Control System, Microprocessor Application, Digital Signal Processing, and Robotics/ Mechatronics which involve a laboratory component and have a teaching pattern consisting of a lecture and a laboratory class. (See Appendix E for more description about the courses.) For these courses, there is normally only one lecture which all students attend. The average number of students in the course class is around 80 while the laboratory classes have up to 12 students. There are seven groups of electronics laboratory classes. There is a lecturer who usually delivers the lecture and assistants who manage the laboratory exercises and the final project assignment in the Hardware Technical Managing Unit.

3.4.2 Availability of Laboratory Classes

Laboratory classes are scheduled as part of a course, usually for 100 minutes per week for each student. These are closed laboratory classes, with a class size of 12 students and supervised by an assistant who is a member of the Hardware Technical Managing Unit. The laboratories are available outside class times provided that another class is not scheduled in the laboratory. No assistance is provided within the laboratory setting outside scheduled classes, and access to the laboratories is not regulated during these times

Table 3.4 shows a summary of the laboratory classroom and equipment usage by student for the period August 2002 to May 2004. The monthly averages for laboratory classroom and use of equipment are 63, 23, 21, five and four for the final year project, laboratory project, hobby, experiment, and lecturer's project, respectively.

Table 3.4
Laboratory Classroom and Equipment Usage Summary

Month	Final Year Project	Laboratory 's Project	Lecturer's Project	Hobby	Experiment
August 2002	8	-	-	-	-
September 2002	11	-	-	2	-
October 2002	37	19	-	2	-
November 2002	142	68	-	15	-
December 2002	54	-	1	-	-
January 2003	111	10	-	3	-
February 2003	66	-	-	7	1
March 2003	54	8	-	30	-
April 2003	65	-	-	26	-
May 2003	65	23	-	21	-
June 2003	120	17	12	18	-
July 2003	124	-	-	-	9
July 2003	124	-	-	-	9
August 2003	18	-	-	13	-
September 2003	29	-	-	14	2
October 2003	37	26	4	31	-
November 2003	20	3	-	8	-
December 2003	40	4	-	29	-
January 2004	58	44	-	49	-
February 2004	25	-	-	27	-
March 2004	37	7	1	53	-
April 2004	56	-	2	32	-
May 2004	110	41	1	10	-
Average	61	23	4	21	5

3.4.3 Data Collection

All assistants from the Hardware Technical Managing Unit who were in charge of units involving a laboratory component were approached. Eighteen of the assistants agreed to participate and each was provided with sufficient copies of the revised questionnaire. A covering letter was shown by overhead projector when the questionnaires were to be used to explain the purpose of the research. The participants were advised that their involvement was voluntary and were assured of the confidentiality of their responses. The survey was carried out in the eleventh week of the semester.

In order to be able to later obtain information about each student's achievement, the student's number was requested. These were the most sensitive data requested, but giving the number was a must for matching their grade. They completed the questionnaires either at the laboratory intranet web address at http://lab.binus.ac.id/pk/kuis.asp or on the paper after they finished their laboratory works. The completed questionnaires were summarised in the relevant programs, 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 Data Support Bureau (Biro Dukungan Data).

The achievement grades were provided at the end of the semester. A student's achievement on the course was measured by the overall grade awarded by the lecturer and from marks recorded in the electronics laboratory. Table 3.5 shows this components of laboratory work which is composed of attendance, laboratory reports and a final project (if any).

Table 3.5
Laboratory Work Components

No	Course	Credits (Theory/ Laboratory)	Attendance	Laboratory Report	Final Project	Notes
1	Integrated Electronics	2/1	10%	60%	30%	Seven experiments + final project
2	Electric Circuit Theory	2/1	10%	90%	-	Six experiments + introduction to instruments
3	Discrete Electronics	4/1	10%	90%	-	Nine experiments
4	Digital System	4/1	10%	60%	30%	Eight experiments + final project
5	Advanced Control System	4/2	10%	90%	-	Six experiments + final project
6	Microprocessor Application	4/1	10%	60%	30%	Seven experiments + final project
7	Digital Signal Processing	2/1	10%	90%	-	Seven experiments
8	Robotics/ Mechatronics	2/2	10%	90%	-	Seven experiments

The final grade is composed of (Laboratory weight * Laboratory works) + (Theory Weight * Theory), where:

- laboratory weight is the percentage of laboratory credits divided by total laboratory and theory credits;
- theory weight is the percentage of theory credits divided by total laboratory and theory credits;
- laboratory works = (10% Attendance + 90% Reports) or (10% Attendance + 60% Reports + 30% Final Project); and
- theory = 20% assignment + 30% mid term exam + 50% final term exam.

For example, Integrated Electronics has 2/1 credits then the laboratory weight is 33.3% and theory weight is 66.7%.

It was used as the most convenient and least invasive method of measuring student achievement. Given that any other form of objective measurement would have to be 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 assistants, and there could be as many as 6 up to 10 reports 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.

3.4.4 The Sample

The questionnaires were administered to 353 of 708 active students from Computer Engineering Department of Bina Nusantara University in eight courses from different semesters. It should be noted that the group of students sampled represented about

50% of the all active students in the Computer Engineering Department. They completed either an electronic form or a paper-based version of the questionnaire at the laboratory intranet web address at http://lab.binus.ac.id/pk/kuis.asp after students finished their laboratory work. Students completed both forms of the instruments, the preferred and the actual.

3.5 DATA ENTRY

The main study questionnaires were hand coded by the researcher, checked for errors and the data were entered into SPSS for Windows Release 11.5. Both instruments use a five point Likert response format. The possible ELEI responses were Almost Never, Seldom, Sometimes, Often and Almost Always. The ATEQ 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 course, batch year, and experience in building electronics system. The coding system for course, batch year and experience were the same as explained in 3.3.2.

3.6 DATA ANALYSES

3.6.1 Questionnaire Recoding

The data were prepared for analyses 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 ELEI, and 36, 37, 38, 41, 48, 51, 52 and 63 for the ATEQ. Missing values were replaced by the mean of the available responses. 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 achievement 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 analyses. Alpha reliability and mean correlation coefficients were calculated for each of the scales in all studies and correlation and regression analyses were performed to determine associations.

3.6.2 Combining Quantitative and Qualitative Methods

Educational researchers claim that there are advantages in moving beyond choosing between quantitative or qualitative methods, to combining quantitative and qualitative methods. In recent years, significant progress has been made towards the desirable goal of combining quantitative and qualitative methods within the same study in research on classroom learning environments (Fraser & Tobin, 1991).

For instance, a team of 13 researchers was engaged in over 500 hours of intensive classroom observation of 22 exemplary teachers and a comparison group of non-exemplary teachers (Fraser & Tobin, 1989). The main data collection methods were based on interpretive research methods and included classroom observation, questioning of students and teachers, and the construction of case studies. But, a distinctive feature was that the qualitative information was complemented by quantitative information acquired from questionnaires assessing student perceptions of classroom psychosocial environment. These instruments provided a picture of life in exemplary teachers' classrooms as seen through the students' eyes. The study suggested that, first, exemplary and non-exemplary teachers could be differentiated in terms of the psychosocial environments of their classrooms as seen through their students' eyes and, second, that exemplary teachers typically create and maintain environments that are markedly more favourable than those of non-exemplary teachers (Fraser & Tobin, 1989).

In a study which focused on the subtle goal of higher-level cognitive learning, a team of six researchers thoroughly studied the grade 10 science classes of two teachers, Peter and Sandra, over a ten-week period (Tobin, Kahle, & Fraser, 1990). Each class was studied by several researchers, interviewing of students and teachers took place on a daily basis, and students' written work was investigated. The study also involved quantitative information from questionnaires assessing student perceptions of classroom psychosocial environment. Students' perceptions of the learning environment within each class were consistent with the observers' field records of the patterns of learning activities and engagement in each classroom. For instance, the high level of Personalisation perceived in Sandra's classroom matched the large proportion of time that she spent in small-group activities during which she constantly moved about the classroom interacting with students. The lower level of Personalisation perceived in Peter's class was associated partly with the larger amount of time spent in the whole-class mode and the generally public nature of his interactions with students.

Fraser's (1996) multilevel study of the learning environment of a science class in Australia incorporated a teacher-researcher perspective as well as the perspective of six university-based researchers. The research initiated with an interpretive study of a grade 10 science teacher's classroom learning environment at one school, which presented a challenging learning environment in that many students were from working class backgrounds, some were experiencing problems at home, and others had English as a second language. Qualitative methods involved several of the researchers visiting this class each time it met over five weeks, with student diaries, and interviewing the teacher-researcher, students, school administrators and parents. A video camera recorded activities during each lesson for later on analyses. Field notes were written during and soon after each observation, and team meetings took place three times per week. The qualitative component of the study was complemented by a quantitative component including the use of a questionnaire which linked three levels: the class in which the interpretive study was undertaken; selected classes from within the school; and classes distributed throughout the same State. This enabled a judgement to be made about whether this teacher was typical of other teachers at her school, and whether the school was typical of other schools within the State. Some of the features identified as salient in this teacher's classroom environment were peer pressure and an emphasis on laboratory activities.

3.6.3 Interview

In this study it was decided to complement the quantitative data with qualitative data obtained from interviews. Shortly after the pilot study interviews were conducted the interview came into place with two staff members and three students, who were involved in the courses. The staff members were interviewed individually and the students in a group. The interview information was needed in order to improve the questionnaire. (See Section 4.4 provides more detail on the improvement of the questionnaires.)

3.6.4 Statistical Analysis Procedures

The first step in the cross-validation of the ELEI and ATEQ questionnaires involved the generation of the Cronbach's alpha reliability coefficient as indices of the internal consistency of each scale of the ELEI and ATEQ questionnaires. Chapters 4 and 5 report the findings of the validation of the ELEI and ATEQ questionnaires for the pilot and main study, respectively. Interviews were used to provide qualitative data in this process.

Furthermore, to examine whether each of the classroom environment scale of the Actual version could differentiate significantly between the perceptions of students from different classrooms, a series of analyses of variance (ANOVAs) was undertaken, using class memberships as the independent variables. The scale means, scale standard deviations, average item means and average item standard deviations for questionnaires were also calculated. The mean standard deviation differences, t-test scores and standard error difference of the Actual and Preferred forms of the questionnaires were determined and plotted in graphical representations.

Relationships between students' perceptions of their electronics classroom environments, as assessed by the ELEI and their outcome measures, namely achievement (as measured by their final marks of their courses) and attitude (as assessed using the ATEQ) were investigated using simple correlations and regression analyses.

3.7 RESEARCH DESIGN

The research design in this thesis involved a series of steps including a pilot study, main study of administration of questionnaires, interview with staff and students.

In summary, the variables investigated in this research and their methods of assessment were:

a. Students perceptions of their electronics laboratory environment questionnaire with the following scales:
   - Student Cohesiveness, extent to which students know, help, and are supportive of each other.
   - Open-Endedness, extent to which the laboratory activities emphasise an open-ended divergent approach to experimentation.
   - Integration, extent to which the laboratory activities are integrated with non-laboratory and theory classes.
   - Technology Adequacy, extent to which the hardware and equipment is adequate for the tasks required.
   - Laboratory Availability, extent to which the laboratory is suitable and available for use.

b. Student's attitude towards electronics questionnaire with the following scales:
   - Anxiety, extent to which the student feels nervous or uncomfortable using a electronics laboratory facilities.
   - Enjoyment, extent to which the student enjoys using a laboratory facilities.
   - Usefulness of Electronics Systems, extent to which the student believes electronics system are useful.
   - Usefulness of Electronics Courses, extent to which the student found the course useful.

3.8 SUMMARY

This chapter has described the situation regarding the pilot study and the main study. 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 electronics laboratories. Suggestions for questionnaire revision were sought after the pilot study therefore interviews with staff and students. The next chapter describes the development and validation of the Electronics Laboratory Environment Inventory.

CHAPTER 4

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY

4.1 INTRODUCTION

This chapter explains the development of the Electronics Laboratory Environment Inventory (ELEI), an instrument for measuring aspects of an electronics laboratory classroom environment. Section 4.2 discusses the rationale and basis for the ELEI and how the original scales were chosen. Section 4.3 provides an analysis of the pilot study of the use of the ELEI with 16 laboratory assistants and eight alumni. Section 4.4 describes how the questionnaire was modified after getting feedback from the pilot study results. Section 4.5 presents the reliability and validity statistics for the main study sample of 353 students. Finally, section 4.6 summarises the chapter.

4.2 DEVELOPMENT OF THE ORIGINAL INSTRUMENT

The actual version of the personal form of the Science Laboratory Environment Inventory designed by Fraser, Giddings, and McRobbie (1991) and the Computer Laboratory Environment Inventory (CLEI) designed by Newby and Fisher (1998) were used as the basis from which to develop an instrument for assessing electronics laboratory environment. The SLEI has five scales Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. The CLEI which was derived from the SLEI also has five scales Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy and Laboratory Availability, and contains seven items per scale.

The initial development of the SLEI was guided by the following criteria. A review of the literature was undertaken to classify dimensions that were considered important in the unique environment of the science laboratory class. Guidance in categorising dimensions also was obtained by examining all scales contained in existing classroom environment instruments for non-laboratory settings (Fraser, 1994). By interviewing numerous science teachers and students at the senior high school level and asking them to comment on draft versions of sets of items, an attempt was made to make sure that the SLEI's dimensions and individual items were considered salient by teachers and students. In order to achieve economy in terms of the time needed for answering and scoring, the SLEI was designed to have a relatively small number of scales, each containing a fairly small number of items. A five-point response format Almost Never, Seldom, Sometimes, Often, Almost Always was used in the original version of the SLEI. Table 4.1 provides a description of the SLEI scales and information about the classification of the scales according to Moos' dimensions.

Table 4.1
Descriptive Information for the Scales of the Science Laboratory Environment Inventory (SLEI)

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

Adapted from Fraser, McRobbie, & Giddings (1993)

Initially, the SLEI had 72 items, with nine items in each scale. The SLEI was field tested and exposed to item and factor analysis. The field testing was carried out with a cross-national sample of secondary students in Australia, USA, Canada, England, Israel, and Nigeria. There were 3,227 students in 198 classes in 40 schools and 1,720 university students in 71 classes in 13 universities from six countries. This was followed by a series of statistical analyses, factor analyses, and one-way ANOVAs to determine whether the scales differentiated between classrooms. The Cronbach alpha coefficient which measures the internal consistency of each scale varied from 0.70 to 0.83, the mean correlation of one scale with all other scales varied from 0.07 to 0.37 demonstrating that there is a little overlap in what the scales are measuring. Also, it was shown that each scale of the instrument was able to distinguish between the perceptions of students in different classrooms.

The results of these analyses reduced the number of scales from eight to five and the number of items from 72 to 34. The SLEI also contains both an actual and a preferred version. Based on the 34-items, Fraser, Giddings, and McRobbie (1995) reported that the SLEI displayed satisfactory internal consistency reliability, discriminant validity and factorial validity, and it was capable of differentiating between perceptions of students in different classrooms. Fraser, Giddings, and McRobbie (1995) also validated the SLEI separately for the different countries. They found that comparable validity statistics were obtained in different countries, thus supporting its cross-national reliability and validity.

Fraser, Giddings, and McRobbie (1995) further refined the SLEI by administering a 35-item version to a sample of 1,594 chemistry students in 92 classes in 52 schools in Australia. (One extra item was added to the 34-item version so that all scales would have an equal number of items.) The results of this cross-validation replicated the cross-national validation discussed above.

The CLEI also was field tested and exposed to item factor analysis. The field testing was carried out in Australia, England, and USA. There are 387 students in 31 classes in five schools. The Cronbach alpha coefficients which measure the internal consistency of each scale varied from 0.80 to 0.90; the mean correlation with other scales varied from 0.49 to 0.63 demonstrating that there is little overlap in what the scales are measuring. Also, it was shown that the instrument was able to distinguish between the perceptions of students in different classrooms (Newby & Fisher, 1998).

Table 4.2 provides scale descriptions for the CLEI together with each scale's classification according to Moos' dimensions.

Table 4.2
Descriptive Information for the Scales of the Computer Laboratory Environment Inventory (CLEI)

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

Adapted from Newby & Fisher (1998)

Although there are similarities between science, computer, and electronics laboratories, there are also fundamental differences and this study is focused on the electronics field. However, given the reliability and validity of the SLEI and CLEI, it was decided to use them as the basis of the Electronics Laboratory Environment Inventory (ELEI).

Student cohesiveness in an electronics laboratory is important as often students work together. The relationship between electronics theory and practised laboratory work is also important. Also, the provision of electronics technology equipment and its adequacy is an important issue for each student (see Table 3.4.) is worthy of investigation.

The Laboratory Availability scale measures the extent to which the laboratory and laboratory equipment are available for use. This is understandable at the university level, where students are required to complete laboratory-based experiments to collect data and make a laboratory report. If the students find peculiar results in their analyses they will often re-examine the data by revisiting the laboratory. Therefore, it was decided to include the scales of Student Cohesiveness, Integration, Open-Endedness from the SLEI and Technology Adequacy and Laboratory Availability from the CLEI in the ELEI. In the present study, response alternatives are Almost Never, Seldom, Sometimes, Often and Very Often.

Table 4.3 provides descriptive information for the original version of the ELEI and Appendix A (English Version) and Appendix B (Bahasa Indonesia Version) contain the actual questionnaire.

Table 4.3
Descriptive Information for the Scales of the Original Version of the Electronics Laboratory Environment Inventory (ELEI)

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

4.3 PILOT STUDY

The original ELEI questionnaire was administered in a pilot study to a group of 16 laboratory assistants and eight alumni of the Computer Engineering Department of Bina Nusantara University. The Attitude Towards Electronics Questionnaire (ATEQ) (see Chapter 5) was also administered but minimal demographic data were collected. Table 4.4 shows some statistical information from this pilot study regarding reliability and discriminant validity. The Cronbach alpha coefficient varied from 0.35 to 0.78, showing that the internal consistency for at least three of the scales was reasonable. The mean correlation of one scale with the other four scales varies from 0.13 to 0.29 showing that there is little overlap in what the scales are measuring. The mean correlations are noticeably less than the reliability coefficients indicating that the scales do measure distinct aspects of the learning environment of the electronics laboratory.

Table 4.4
Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the ELEI in the Pilot Study

Scale Name	Alpha Reliability	Mean Correlation
Student Cohesiveness	0.75	0.29
Open-Endedness	0.35	0.19
Integration	0.78	0.13
Technology Adequacy	0.50	0.20
Laboratory Availability	0.62	0.17

The alpha reliability for Open-Endedness was low at 0.35, but this scale was consistently lower 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. The alpha reliability for Open-Endedness in Newby and Fisher's (1988) study is 0.60 which was again somewhat low. It was on these grounds it was decided to retain the Open-Endeness scale and check it again with the larger sample. However, it was decide to improve the questionnaire items by discussing them with staff and students as described in the following section.

4.4 QUESTIONNAIRE IMPROVEMENT

Discussions took place with both staff and students involved in the courses. From these discussions, it was clear that the physical environment of a electronics laboratory is of much less importance than other factors, in particular the availability of the laboratories for student use. Following the administration of the questionnaire pilot study, the findings were discussed with two staff members and three students. The staff members were interviewed individually and the students in a group.

A. Staff interview

Fictitious names are used in this thesis. The two staff members, Rusimin (RS) and Erwin Anggajaya (EA) made the following comments in responding to the questions.

1. What are the benefits of electronics laboratory classes being managed by the Hardware Technical Managing Unit and Electronics Laboratory?

   RS: As laboratory staff, I have more time to do some laboratory activities such as cross checking between calculation from theory and laboratory data and using special laboratory instruments (the digital storage oscilloscope and the modular production system) which students can not use freely. I have a better understanding in knowing that there are some discrepancies between what I found in the laboratory and the concept from the textbooks. I always exercise my analytical skill to solve problems I encountered in daily tasks. I also learn how to collaborate with other staff and students.

   EA: To be honest, I can understand theory better because of the laboratory experiments.

2. Do you have any suggestions for the Hardware Technical Managing Unit and Electronics Laboratory improvement?

   RS: I think the laboratory session should follow advances in electronics out there and not just be a basic or simple laboratory subject. Some laboratory sessions should have more time allocated especially for Microprocessor Application. The recruitment of new staff should be more selective and attractive so that the best students will be interested and join in learning process.

   EA: The laboratory class tutor should have more frequent collaboration with the lecturers to check the synchronisation between theory and laboratory subjects.

3. Do you have any suggestions for improving the questionnaire?

RS: Some questions such as number 2, 11, 52, and 58 should have better wording.

EA: It would be better to reduce the number of 'same' or repetitive questions, such as 7, 27 and 32.

B. Student interview

The students, Hayri (HR), Agus (AG) and Fernandus (FN) were interviewed together and they made the following comments.

1. What are the benefits of electronics laboratory classes being managed by the Hardware Technical Managing Unit and Electronics Laboratory?

   HR: Yes, the laboratory classes can help me to solidify my understanding about what I have learned in class.

   AG: I do not see many benefits for me.

   FN: Yes, I get to know the electronics components and how to check and measure them. I can compare my laboratory findings or measurements with my theory from the class and I learn how to draw conclusions from the laboratory findings.

2. Do you work in electronics field? Are the skills acquired from the Hardware Technical Managing Unit and Electronics Laboratory useful in your work?

   HR: Yes, I work as network engineer. My responsibilities are designing, implementing, and troubleshooting the network. Sometimes, I found what I learnt from the laboratory helpful. Mostly, though it is not much help especially with problems related to electricity and electronics systems.

AG: Yes, I work in the computer field not in the electronics. I feel that what I got from the laboratory is not applicable in my current job.

FN: I work as programmer in communication. Several times I must deal with microcontroller and RS-232 serial communication. I am helped quite a lot by what I experience in the laboratory and my Microprocessor Application and Interfacing theory. I can now develop and make some adjustments in my projects.

3. Do you have any suggestions for improving the questionnaire?

HR: I think question number 4, 9, and 54 need improvement.

AG: Yes, 10 and 38.

FN: I can understand all the questions with no problem. However, I want to make some suggestions for the laboratory to provide more equipment such as the universal programmer (that can write program into microcontroller, EPROM, and Programming Array Logic/ PAL), so when students finish their final year project their waiting time to use the equipment can be reduced.

From above discussions some items from four of the scales (Student Cohesiveness, Open Endedness, Technology Adequacy and Laboratory Availability) such as numbers 2, 4, 7, 9, 10, 11, 27, 32, and 58 for ELEI; and 38, 52 and 54 for ATEQ needed to be modified. Most of the modifications were necessary because of the ambiguity or not so clear meaning to the staff and students and they gave some suggestions on what changes were needed. Table 4.5 provides descriptions of the alterations that were made to some of the items in the ELEI and ATEQ questionnaires.

Appendix C (English Version) and Appendix D (Bahasa Indonesia Version) shows the revised questionnaire, along with the preferred version.

The revised ELEI was administered to 353 students taking courses within the Computer Engineering Department. There are eight courses that have laboratory component in both semester, these are Integrated Electronics, Electric Circuit Theory, Discrete Electronics, Digital System, Advanced Control System, Microprocessor Application, Digital Signal Processing and Robotics/ Mechatronics. The different courses were surveyed and each of these had its own characteristics, covering relationship between laboratory and non-laboratory classes, level of course, students' prior familiarity with the laboratory environment and expectation of staff regarding student's ability to work independently. Table 4.6 shows the characteristics for each of the courses involved in the study.

The number of students in each class varies from 60 to 80 and there were two or three classes for each courses. Sometimes one lecturer teaches one course for all classes. For each class there are seven groups of 12 students in each who have a laboratory session scheduled for each week. Thus, students attend a lecture and a formal laboratory class. The course content for the lecture is decided upon by the lecturer while the head of laboratory sets all laboratory experimentations. In this study a class means an electronics course subject.

The characteristics for each course have been obtained from knowledge of course objectives, course design, electronics 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 electronics laboratory environment, some directly such as Integration, others by a more indirect means. Based on these different characteristics and the way courses are organised, it was decided to use course as the unit of discrimination.

Table 4.5
The ELEI Item Alterations

Scale	Number	Previous	After
Student Cohesiveness	11	Members of this laboratory group help me. (*Anggota group praktikum membantu saya.*)	The members of this laboratory help each other. (*Sesama praktikan saling tolong menolong.*)
Open Endedness	2	There is opportunity for me to pursue my own electronics interest in this laboratory class. (*Saya memiliki kesempatan dalam mengejar ketertarikan/ hobbi elektronik di laboratorium.*)	I have the opportunity of doing my interests in electronic field. (*Saya berkesempatan menyalurkan minat saya pada bidang elektronik.*)
	7	In this laboratory group, I am required to design my own solutions to a given task. (*Pada group praktikum ini, saya diminta untuk merancang sendiri jawaban dari tugas yang diberikan.*)	In this laboratory group, the solution to a given task is from my own thinking. (*Pada group praktikum ini, jawaban untuk tugas yang diberikan merupakan hasil pemikiran saya sendiri.*)
	27	In my laboratory sessions, the instructor decides the best way for me to solve a given problem. (*Pada sesi praktikum, asisten memutuskan cara yang terbaik untuk menyelesaikan tugas.*)	In my laboratory sessions, the instructor decides the solution of the given problem. (*Pada sesi praktikum, cara penyelesaian tugas ditentukan oleh asisten.*)
	32	I decide the best way to proceed when developing a solution to a problem given in the laboratory sessions. (*Saya memutuskan cara terbaik untuk melakukan penyelesaian masalah yang diberikan pada sesi praktikum.*)	In my laboratory session, I decide the solution of the given problem. (*Pada sesi praktikum, cara penyelesaian tugas saya tentukan sendiri.*)
Technology Adequacy	4	The laboratory facilities are difficult to use. (*Fasilitas laboratorium sulit digunakan.*)	Operating the laboratory facilities are difficult. (*Pengoperasian fasilitas/ peralatan laboratorium sulit.*)
	9	The laboratory facilities works without problems. (*Fasilitas laboratorium berfungsi tanpa masalah.*)	The laboratory facilities work fine. (*Fasilitas laboratorium berfungsi dengan baik.*)
Laboratory Availability	10	The laboratory room is readily available. (*Ruangan laboratorium siap tersedia.*)	The laboratory room is readily available at any time. (*Ruangan praktikum dapat digunakan setiap saat.*)

Table 4.6
Characteristics of Courses Surveyed

Course	Close Integration	Level	Familiarity	Expectation
Integrated Electronics	Yes	General Introductory	Medium	High
Electric Circuit Theory	Yes	General Introductory	Low	High
Discrete Electronics	Yes	Specialist Intermediate	Medium	High
Digital System	Yes	General Intermediate	High	Medium
Advanced Control System	Yes	Specialist Intermediate	Low	Low
Microprocessor Application	Yes	Specialist Advanced	High	High
Digital Signal Processing	Yes	Specialist Advanced	Low	Low
Robotics / Mechatronic	Yes	Specialist Intermediate	Low	Medium

4.5 RELIABILITY AND DISCRIMINANT VALIDITY

The first research question in this study was as follows:

Is the Electronics Laboratory Environment Inventory (ELEI) a valid and reliable questionnaire for use in actual and preferred versions in tertiary electronics laboratories in Indonesia?

Table 4.7 reports the internal consistency of the ELEI. According to Nunnally (1967), a reliability coefficient of 0.60 or greater is acceptable, so the values for each scale indicate that they are satisfactory in terms of their internal consistency. The alpha reliability of Open-Endedness scale was still low at 0.36. However, it was apparent that item number 27 had the lowest correlation with the other items in this scale.

Table 4.7
Internal Consistency (Cronbach alpha reliability),Discriminant Validity (Mean correlation with other scales) and Ability to Differentiate Between Classrooms (ANOVA results) for the ELEI

Scale Name	Unit of Analysis	Alpha Reliability		Discriminant Validity		ANOVA Results eta^2
		Actual	**Preferred**	**Actual**	**Preferred**	
SC	Individual	0.64	0.62	0.29	0.52	0.31*
	Class	0.78	0.58	0.68	0.64	
OE	Individual	0.36	0.44	0.13	0.27	0.19*
	Class	0.87	0.62	0.31	0.51	
IT	Individual	0.69	0.68	0.26	0.44	0.34*
	Class	0.81	0.84	0.50	0.58	
TA	Individual	0.59	0.63	0.28	0.50	0.28*
	Class	0.79	0.74	0.67	0.73	
LA	Individual	0.51	0.69	0.28	0.55	0.25*
	Class	0.63	0.80	0.58	0.75	

* $p < 0.001$

Therefore, it was decided to recalculate the reliability of the Open-Endedness scale using six items (numbers 2, 7, 12, 17, 22, and 32). For the Actual Form of the ELEI, Table 4.8 shows that the Cronbach's alpha reliability figures now ranged from 0.50 to 0.69 when the individual student was used as the unit analysis and from 0.63 to 0.84 when the class mean was the unit of analysis. The alpha reliabilities for the Preferred Form ranged from 0.58 to 0.69 when the individual student was used as the unit of analysis and from 0.58 to 0.84 when the class mean was used.

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. The mean correlations of the scales of the Actual ELEI ranged from 0.18 to 0.29 for individual student and 0.24 to 0.68 for the class as the unit of analysis, indicating that there is little overlap in what they measure.

Table 4.8
Internal Consistency, Discriminant Validity and Ability to Differentiate Between Classrooms for the ELEI Without item 27

Scale Name	Unit of Analysis	Alpha Reliability		Discriminant Validity		ANOVA Results eta²
		Actual	Preferred	Actual	Preferred	
SC	Individual	0.64	0.62	0.29	0.52	0.31*
	Class	0.78	0.58	0.68	0.64	
OE	Individual	0.50	0.58	0.18	0.26	0.26*
	Class	0.84	0.65	0.24	0.50	
IT	Individual	0.69	0.68	0.26	0.44	0.34*
	Class	0.81	0.84	0.50	0.58	
TA	Individual	0.59	0.63	0.28	0.50	0.28*
	Class	0.79	0.74	0.67	0.73	
LA	Individual	0.51	0.69	0.28	0.55	0.25*
	Class	0.63	0.80	0.58	0.75	

$*p < 0.001$

The 34-item ELEI was also subjected to a series of one way analyses of variance using course as the grouping factor. As shown in Table 4.8, the eta^2 statistic ranged from 0.25 for Laboratory Availability to 0.34 for Integration. The eta^2 statistic measures the amount of the variance that can be attributed to the course group. The results show that each scale differentiated significantly ($p < 0.001$) between courses. This indicates that the ELEI is able to differentiate between students on the basis of the course being taken.

To examine differences between students' perceptions of the actual and preferred classroom environment, data were analysed with a one-way MANOVA for repeated measures. The set of ELEI scales constituted the dependent variables and the form of the questionnaire (actual/ preferred) was the repeated measures factor. Student responses to the actual and preferred forms were matched to allow the data collected from 353 students to be analysed. Because the multivariate test produced a statistically significant result (Wilks' lambda), a t-test for paired samples was used for each individual ELEI scale to investigate whether students had different perceptions of their actual and preferred classroom learning environments.

Table 4.9
t-test scores, Mean Differences, and Standard Error Difference of Actual and Preferred Form for the ELEI

Scale Name	F	t	Mean Difference	Std Error Difference
Student Cohesiveness (SC)	11.46*	-8.90	-2.64	0.30
Open Endedness (OE)	18.76*	-15.39	-4.00	0.26
Integration (IT)	45.68*	-8.11	-2.79	0.34
Technology Adequacy (TA)	29.58*	-16.48	-5.02	0.30
Laboratory Availability (LA)	54.18*	-18.19	-5.98	0.33

$^{*}p < 0.001$

Table 4.9 shows differences between the Actual and the Preferred Form were found to be statistically significant ($p < 0.001$) and vary from 8.9 to 18.19, 2.64 to 5.98 and 0.26 to 0.34 for t-test score, mean difference and standard error difference, respectively.

Figure 4.1 illustrates the profile of the average item scores for each scale for the Actual and Preferred Form. For the Actual Form students perceived moderately positive learning environments in Open-Endedness, Integration, Technology Adequacy and Laboratory Availability, and a highly positive environment on Student Cohesiveness. For the Preferred Form almost all scales have a highly positive environment. What is clear from Figure 4.1 is that students preferred a classroom environment to be more positive that the one perceived to be actually present for all scales. The important point is the fact that the students would prefer more on all scales.

4.6 SUMMARY

This chapter has described the development and validation of an instrument for measuring various aspects of a electronics laboratory environment. A pilot study was used to investigate the reliability and discriminant validity of an instrument which

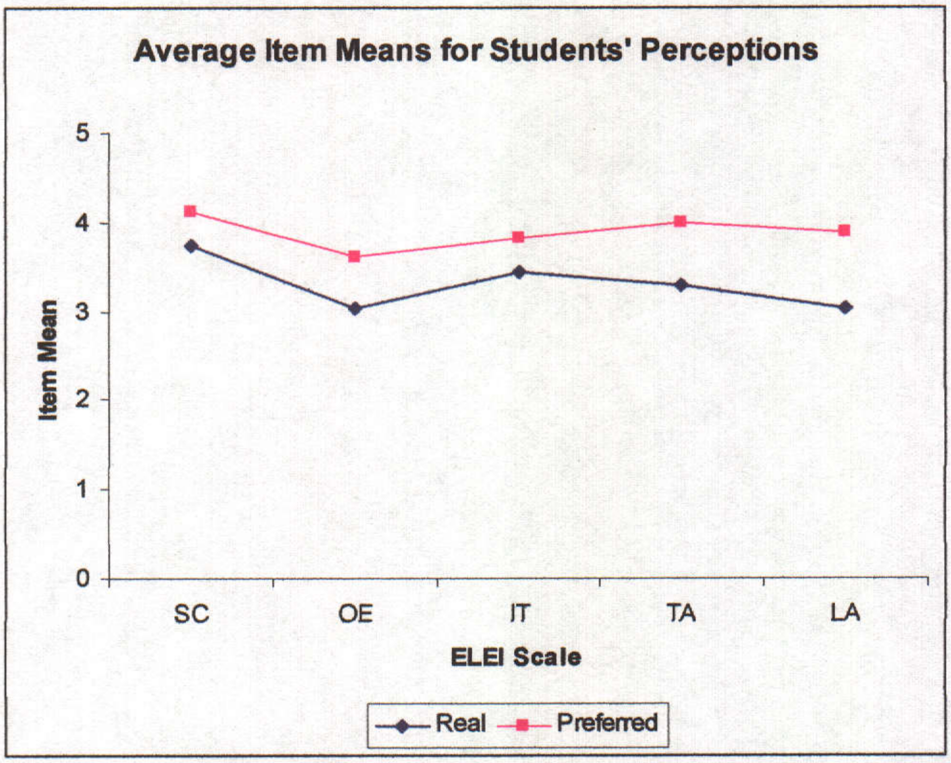

Figure 4.1. Profile of average item means for students' perception of the ELEI.

was closely based on the Computer Laboratory Environment Inventory and the Science Laboratory Environment Inventory. This study showed that the instrument could be improved by being modified. This was done following discussion with staff and students in interviews. In the modified version of the ELEI, 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 electronics 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 Electronics Courses Questionnaire (ATEQ) and the results of using the questionnaires are present in Chapter 6.

CHAPTER 5

THE ATTITUDE TOWARDS ELECTRONICS QUESTIONNAIRE

5.1 INTRODUCTION

This chapter contains an explanation of the development of an instrument, called the Attitude Towards Electronics Questionnaire (ATEQ), for measuring four aspects of a student's attitude towards electronics. Section 5.2 gives the background and philosophy underlying its design. Section 5.3 provides the results when it was administered to a pilot group of 24 respondents (16 laboratory assistants and eight alumni). Following the pilot study, the instrument was administered to 353 students from the Computer Engineering Department of Bina Nusantara University. Section 5.4 describes the reliability and discriminant validity of each of the scales. Finally, section 5.5 summarises the ATEQ.

5.2 DEVELOPMENT OF THE INSTRUMENT

The instrument for measuring the attitude towards electronics courses is based on a number of other instruments. As was described in Chapter 2 of this thesis, there are many instruments for measuring attitude and these contain a number of different scales. The instrument used as the basis for the Attitude Towards Electronics Questionnaire (ATEQ) was the Attitude towards Computers and Computing Courses Questionnaire (ACCC) (Newby & Fisher, 1998). This contains four scales which are Anxiety, Enjoyment, Usefulness of Electronics Courses and Usefulness of Electronics Systems.

The decision was made to restrict the number of scales for measuring aspects of attitude towards electronics to four. This was done on the basis of economy. Four chosen were the already existing scales. Anxiety was chosen as it has been included in almost all instruments for measuring electronics attitudes, and the use of technology would appear to be associated with anxiety (Rosen, Sears, & Weil, 1987). Both Enjoyment and perceived Usefulness of Electronics Systems were included as these are known to be associated with motivation (Levine & Donitsa-Schmidt, 1997). Because a major aspect of the study described in this thesis was the effectiveness of electronics laboratories as learning environments, a fourth scale is the Usefulness of the Course. Each scale consists of seven items with each item being measured on a Likert scale from 1 (Almost Never) to 5 (Almost Always), with some of the items being negatively scored. The ATEQ was given as the second part of the survey. The scales and thief descriptions are presented in Table 5.1. The questionnaire used for this purposes are shown in Appendix A for the English Version and Appendix B for the Bahasa Indonesia version.

Table 5.1
Descriptive Information for the Scales of the Attitude Towards Electronics Questionnaire(ATEQ)

Scale Name	Description
Anxiety	Extent to which the student feels nervous or uncomfortable using a electronics laboratory facilities
Enjoyment	Extent to which the student enjoys using a laboratory facilities
Usefulness of Electronics Systems	Extent to which the student believes electronics system are useful
Usefulness of Electronics Courses	Extent to which the student found the course useful

5.3 THE PILOT STUDY

The original ATEQ questionnaire was administered in a pilot study to a group of 16 laboratory assistants and eight alumni of the Computer Engineering Department of Bina Nusantara University along with the original version of the ELEI (see Chapter 4). Table 5.2 shows some statistical information from this study. The Cronbach alpha coefficient varied from 0.30 to 0.83, showing that the internal consistency for two of the scales is reasonable (Nunnally, 1967). The mean correlation with the other scales varies from 0.27 to 0.36 showing that there is some overlap in what the scales are measuring. However the mean correlations are noticeably less than the reliability coefficients indicating that the scales do measure distinct aspects of attitude.

Table 5.2
Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the ATEQ in the Pilot Study

Scale Name	Alpha Reliability	Mean Correlation
Anxiety	0.81	0.33
Enjoyment	0.83	0.46
Usefulness of Electronics Systems	0.30	0.27
Usefulness of Electronics Courses	0.42	0.36

5.4 RELIABILITY AND DISCRIMINANT VALIDITY

Together with the ELEI improvement (see Section 4.4) the ATEQ also was improved. Some questions were modified in order to improve the questionnaire's alpha reliability. Table 5.3 provides the descriptions of how some items of the ATEQ were changed. Using these slightly modified scales, the Cronbach alpha reliability and the mean correlations were again calculated this time with the sample of 353 students of the Computer Engineering Department of Bina Nusantara University. At this time both the Actual and Preferred classroom environment versions of the ATEQ were used.

The first reason for this administration of the ATEQ was to answer the following research question:

Is the Attitude Towards Electronics Questionnaire (ATEQ) a valid and reliable questionnaire for use in computer engineering students in Indonesia?

Table 5.3
The ATEQ Item Alterations

Scale	Number	Previous	After
Usefulness of Electronics Systems	38	Studying about electronics system is a waste of time. (*Mempelajari sistem elektronik adalah membuang-buang waktu saja.*)	The is no use to learn electronic system. (*Tidak ada gunanya mempelajari sistem elektronika.*)
	54	The use of Electronics Systems will increase in the future. (*Penggunaan sistem elektronika akan semakin meningkat di masa depan.*)	In the future the use of electronics sytem will increase. (*Di masa mendatang penggunaan sistem elektronika semakin meningkat.*)
Usefulness of Courses	52	The skills gained in these subject are too specific to be generally useful in the future. (*Ketrampilan yang didapatkan pada mata kuliah tersebut sangat spesifik untuk dapat digunakan pada masa mendatang.*)	The knowledge gained in these subjects are too specific so it will not relevant in the future. (*Ilmu yang didapat dari matakuliah tersebut terlalu spesifik, sehingga tidak relevan di masa depan.*)

The results of the analyses are shown in Table 5.4. These figures report some statistical information about the revised ATEQ. For actual attitude, the Cronbach alpha reliability coefficients presented in the Table 5.4 for the four scales with seven-item figures ranged from 0.63 for the Usefulness of Electronics Courses scale to 0.76 for Enjoyment scale using the individual students as the unit of analysis and from 0.56 for the Anxiety scale to 0.86 for Enjoyment scale when the class mean was used as the unit of analysis. 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.

Table 5.4

Internal Consistency (CronBach alpha reliability), Discriminant Validity (Mean correlation with other scales) and Ability to Differentiate Between Classrooms (ANOVA results) for the ATEQ

Scale Name	**Unit of Analysis**	**Alpha Reliability**		**Discriminant Validity**		**ANOVA Results**
		Actual	**Preferred**	**Actual**	**Preferred**	**eta^2**
Anxiety	Individual	0.68	0.74	0.44	0.58	0.33*
	Class	0.56	0.92	0.35	0.82	
Enjoyment	Individual	0.76	0.78	0.63	0.72	0.38*
	Class	0.86	0.95	0.43	0.79	
Usefulness of	Individual	0.72	0.74	0.52	0.61	0.35*
Electronics Systems	Class	0.65	0.78	0.40	0.83	
Usefulness of	Individual	0.63	0.66	0.54	0.68	0.30*
Electronics Courses	Class	0.61	0.70	0.33	0.77	

*$p < 0.001$

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. The mean correlations of the scales of the Actual ATEQ ranged from 0.44 for the Anxiety scale to 0.63 for the Enjoyment scale for individuals and from 0.33 for the Usefulness of Electronics Courses to 0.43 for the Enjoyment scale classes as the units of analysis, respectively, indicating that there is some overlap in what they measure. This is to be expected on such attitudinal measures. The mean correlations between the scales were also higher and more than the reliability coefficients.

On the other hand for preferred attitude, the Cronbach alpha reliability coefficients ranged from 0.66 for the Usefulness of Electronics Courses scale to 0.78 for the Enjoyment and the Usefulness of Electronics Systems scales using the individual students as the unit of analysis and from 0.70 for the Usefulness of Electronics Courses scale to 0.95 for the Enjoyment scale when the class mean was used as the unit of analysis. This figures were regarded as demonstrating.

The mean correlations of the scales of the Preferred ATEQ ranged from 0.58 for the Anxiety scale to 0.72 for the Enjoyment scale for individuals and from 0.77 for the Usefulness of Electronics Courses to 0.83 for the Usefulness of Electronics Systems scale classes as the units of analysis, respectively, indicating that there is overlap in what they measure. These high mean correlations on the Preferred Form are to be expected since the scales are known to be correlated and students answer using extreme value such as 1 or 5 for their preferred attitude.

The 28-item ATEQ was also subjected to a series of one way analysis of variance using course as the grouping factor. As shown in Table 5.4, the eta^2 statistic ranged from 0.30 for Usefulness of Electronics Courses to 0.38 for Enjoyment. The eta^2 statistic measures the amount of the variance that can be attributed to the course. The results show that each scale differentiated significantly ($p < 0.001$) between the courses. This indicates that the ATEQ is able to differentiate between students on the basis of the course being taken.

To examine differences between students' perceptions of the actual and preferred classroom environment, data were analysed with a one-way MANOVA for repeated measures. The set of ATEQ scales constituted the dependent variables and the form of the questionnaire (actual/preferred) was the repeated measures factor. Student responses to the actual and preferred forms were matched to allow the data collected from 353 students to be analysed. Because the multivariate test produced statistically significant results (Wilks' lambda), a t-test for paired samples was used for each individual ATEQ scale to investigate whether students had different perceptions of their actual and preferred classroom learning environments.

Table 5.5
t-test scores, Mean Differences, and Standard Error Difference of Actual and Preferred Form for the ATEQ

Scale Name	F	t	Mean Difference	Std. Error Difference
Anxiety (AX)	79.12*	5.42	2.14	0.40
Enjoyment (EJ)	21.25*	-10.24	-3.68	0.36
Usefulness of Electronics Systems (UE)	8.57**	-6.29	-2.25	0.36
Usefulness of Electronics Courses (UC)	51.10*	-12.43	-4.09	0.33

*$p < 0.001$, **$p < 0.005$

Table 5.5 shows differences between the Actual and the Preferred Form were found to be statistically significant ($p < 0.001$) for the Anxiety, Enjoyment, and Usefulness of Electronics Courses and ($p < 0.005$) for the Usefulness of Electronics Systems and vary from 5.42 to 12.43, 2.14 to 4.09 and 0.33 to 0.40 for t-test score, mean difference and standard error difference, respectively.

Figure 5.1 illustrates the profile of the average item scores for each scale for Actual and Preferred Forms. For Actual form students indicated moderately positive attitude on Enjoyment, Usefulness of Electronics Systems and Usefulness of Electronics Courses, and a lower attitude on Anxiety. The Preferred form indicated that students would prefer to have a very positive attitude.

5.5 SUMMARY

This chapter has described the development of the ATEQ. The analyses of the pilot study supported a structure of four scales and this was confirmed by analyses of the data from the main study. In the light of the analyses four of the scales, Anxiety, Enjoyment, Usefulness of Electronics Systems and Usefulness of Electronics Course from the original ATEQ were modified by rewording. This resulted in higher reliability coefficients. These results meant that the revised version of the ATEQ could be used with confidence in the rest of this study.

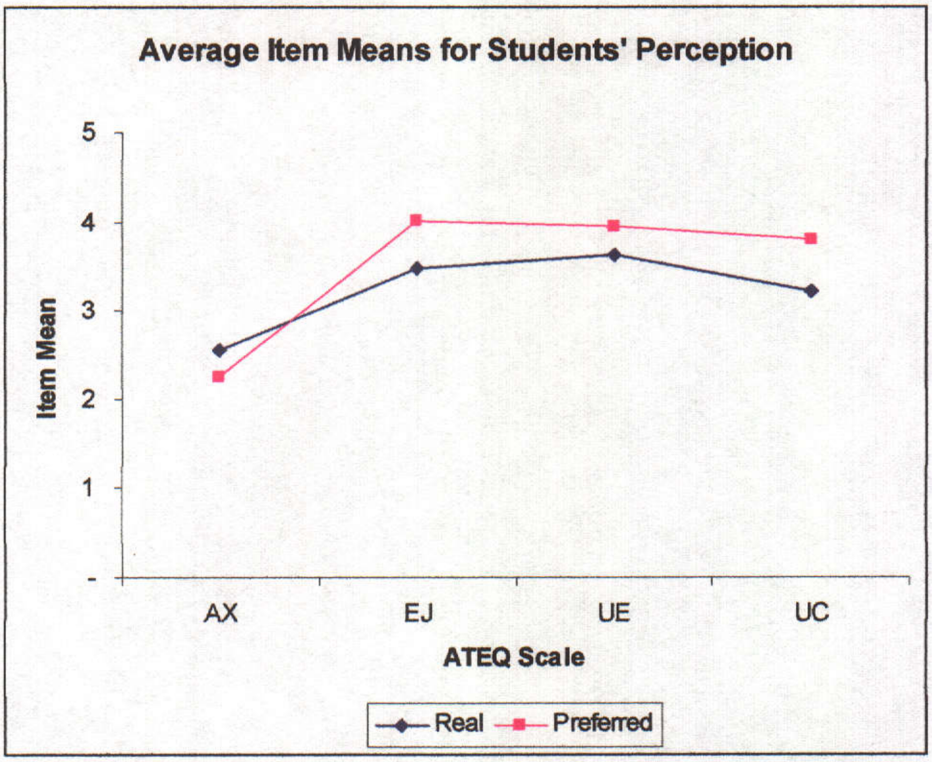

Figure 5.1. Profile of average item means for students' perception of the ATEQ.

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

CHAPTER 6

RESULTS OF APPLICATION OF ELEI AND ATEQ

6.1 INTRODUCTION

According to Fraser (1986, 1994) studies in learning environments have shown that the learning environment is associated with student outcomes, both achievement and attitudes. This chapter explains the results obtained when the ELEI and ATEQ were used with the sample of students at the Computer Engineering Department of Bina Nusantara University. The learning environment variables were Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability, and the attitudinal variables were Anxiety, Enjoyment, Usefulness of Electronics Courses, and Usefulness of Electronics Systems. This was done by summing the responses to individual items in each scale.

Section 6.2 discusses about results of means of ELEI and ATEQ. Section 6.3 provides simple correlation coefficients between the learning environment variables and the attitudinal variables. Section 6.4 gives the results of regression analyses in which the attitudinal scales were treated as dependent variables with the learning environment scales as the independent variables. Finally, in section 6.5, simple correlations between achievement measured by z-score with both environment and attitudinal variables are presented. It also gives the results of regression analyses with the z-score as the dependent variable and the learning environment and attitudinal variables as the independent variables.

6.2 RESULTS OF MEANS OF ELEI AND ATEQ

This section provides the results of the main study. The response options of the ELEI were scored as follows: Almost Never = 1, Seldom = 2, Sometimes = 3, Often = 4, Almost Always = 5. Hence, a score of 1 specifies a perception of a highly non-conducive or negative learning environment, while a score of 5 specifies a perception of a highly conducive or positive learning environment. Table 6.1 reports the scale mean and item mean of the scales of ELEI ATEQ and provides an answer to the second research question in this study was as follows:

What are students' perceptions of the Electronics Laboratory environment in an Indonesian University?

Table 6.1
Scale Means, Scale Standard Deviations, Average Item Means and Average Item Standard Deviations for the Actual Form of the ELEI

	No of items	Unit of Analysis	Scale Mean	Scale Std Dev	Avg Item Mean	Ave Item Std Dev
SC	7	Individual	26.20	3.66	3.74	0.20
		Class	26.56	0.89	3.80	0.22
OE	6	Individual	18.40	3.05	3.07	0.28
		Class	18.15	1.22	3.03	0.29
IT	7	Individual	24.02	4.00	3.43	0.10
		Class	24.10	1.34	3.44	0.10
TA	7	Individual	22.98	3.53	3.28	0.19
		Class	23.73	1.40	3.39	0.20
LA	7	Individual	21.27	3.73	3.04	0.16
		Class	21.74	1.11	3.11	0.18

Figures in Table 6.1, using the Actual Form and the individual student as the unit of analysis, show that average student scores ranged from 3.04 (approximately corresponding to Sometimes) to 3.74 (approximately corresponding to Often) for different scales. It appears that all scales have relatively similar means, except for Student Cohesiveness which has a greater mean and Open-Endedness and Laboratory Availability which have lower mean scores.

Table 6.2
Scale Means, Scale Standard Deviations, Average Item Means and Average Item Standard Deviations for the Preferred Form of the ELEI

	No of items	Unit of Analysis	Scale Mean	Scale Std Dev	Avg Item Mean	Ave Item Std Dev
SC	7	Individual	28.84	4.19	4.12	0.60
		Class	29.16	1.03	4.17	0.15
OE	6	Individual	22.40	3.81	3.73	0.63
		Class	22.87	0.86	3.81	0.14
IT	7	Individual	26.81	5.08	3.83	0.73
		Class	27.48	1.64	3.92	0.23
TA	7	Individual	28.00	4.51	4.00	0.64
		Class	28.77	1.34	4.11	0.19
LA	7	Individual	27.25	4.93	3.89	0.70
		Class	28.19	1.68	4.03	0.24

For the Preferred Form, the figures in Table 6.2, using the preferred individual student as the unit of analysis, show that average student scores ranged from 3.73 to 4.12 (approximately corresponding to Often) for different scales. It appears that all scales have relatively similar means, except for Student Cohesiveness which has a greater mean and Open-Endedness which have lower mean scores.

The response options of the ATEQ were scored as follows: Almost Never = 1, Seldom = 2, Sometimes = 3, Often = 4, Almost Always = 5. Hence, a score of 1 specifies a perception of a highly non-conducive or negative attitude, while a score of 5 specifies a perception of a highly conducive or positive attitude. Table 5.5 reports the scale means and item means for the scales for ATEQ and provides an answer to the fourth research question in this study was as follows:

What are students' attitudes towards their Electronics Laboratory Classes in an Indonesian University?

Table 6.3
Scale Means, Scale Standard Deviations, Average Item Means and Average Item Standard Deviations for the Actual Form of the ATEQ

	No of items	**Unit of Analysis**	**Scale Mean**	**Scale Std Dev**	**Avg Item Mean**	**Ave Item Std Dev**
AX	7	Individual	17.90	4.17	2.56	0.19
EJ	7	Individual	24.38	4.30	3.48	0.28
UE	7	Individual	25.44	4.32	3.63	0.28
UC	7	Individual	22.51	3.70	3.22	0.18

For the Actual Form, the figures in Table 6.3, using the individual student as the unit of analysis, show that average student scores ranged from 2.56 (approximately corresponding to Sometimes) to 3.63 (approximately corresponding to Often) for different scales. It appears that all scales have relatively similar means, except for one scale which has lower means (Anxiety) indicating that the students are not very anxious about the course.

Table 6.4
Scale Means, Scale Standard Deviations, Average Item Means and Average Item Standard Deviations for the Preferred Form of the ATEQ

	No of items	**Unit of Analysis**	**Scale Mean**	**Scale Std Dev**	**Avg Item Mean**	**Ave Item Std Dev**
AX	7	Individual	15.75	6.15	2.25	0.88
EJ	7	Individual	28.06	5.20	4.01	0.74
UE	7	Individual	27.69	5.15	3.96	0.74
UC	7	Individual	26.61	4.96	3.80	0.71

Figures in Table 6.4, for the Preferred Form, and using the individual student as the unit of analysis, show that average student scores ranged from 2.25 (approximately corresponding to Sometimes) for Anxiety scale to 4.01 (approximately corresponding to Often) for Enjoyment scale. It appears that all scales have relatively similar means, except for Anxiety which has a lower mean score as expected, because it would be surprising if the student wanted to be anxious when they learn.

6.3 CORRELATION BETWEEN LEARNING ENVIRONMENT AND ATTITUDINAL VARIABLES

The fifth research question in this study was as follows:

Are there associations between the student outcomes of (a) attitude in electronics laboratory classes and (b) achievement on the laboratory subjects and students perceptions of the laboratory classroom environment?

Simple correlations were calculated between all the scales of the ELEI and all the scales of the ATEQ. Table 6.5 shows the correlations between the scales of the ELEI and the ATEQ for the Computer Engineering Department of Bina Nusantara study involving 353 students.

Table 6.5
Correlations Between the Scales of the ELEI and the ATEQ

	Anxiety	Enjoyment	Usefulness of Electronics Systems	Usefulness of Electronics Courses
Student Cohesiveness	-0.37**	0.31**	0.27**	0.27**
Open-Endedness	-0.04	0.08	-0.01	0.13*
Integration	-0.16**	0.22**	0.35**	0.38**
Technology Adequacy	-0.25**	0.30**	0.21**	0.16**
Laboratory Availability	-0.15**	0.18**	0.08	0.20**

*$p < 0.05$, **$p < 0.01$

Table 6.5 shows that 16 out of a possible 20 correlations are significant. Each of Student Cohesiveness, Integration and Technology Adequacy are positively associated with Enjoyment, Usefulness of Electronics Systems and Usefulness of Electronics Courses and negatively with Anxiety. Laboratory Availability is positively associated with Enjoyment and Usefulness of Electronics Courses and again negatively with Anxiety.

6.3.1 Background Issues

Most non-significant associations involve the Open-Endedness scale indicating that this is not an important factor in influencing student attitudes except in perceived usefulness of the electronics courses.

Overall, these results imply that a laboratory class which is integrated with non-laboratory classes where the students are a more cohesive group, where the technology provided is suitable for the task at hand, and where the laboratory is readily available, will lead to a reduction in anxiety about electronics, an increase in enjoyment of electronics and a perception that the course is more useful.

Furthermore, because there are associations between student cohesiveness, course integration, 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 laboratory facilities that are adequate for the experiments assigned to students. This latter point also means that the lecturer running the course must take the availability of laboratory facilities into account when designing laboratory experiments as this impact on students' enjoyment and perceived usefulness of the electronics courses.

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

6.4 REGRESSION ANALYSIS OF LEARNING ENVIRONMENT AND ATTITUDINAL VARIABLES

The sixth research question in this study was as follows:

To what extent does laboratory environment influence student outcomes (attitudes and achievement)?

A multivariate regression analysis was carried out on the combined data using the learning 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 it would be a case which has an extreme value. A multivariate outlier is a case with an unusual combination of scores on two or more variables (Tabachnick & Fidell, 1996).

Outliers are known to affect regression analysis, therefore 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 these outliers, the regression analysis was carried out again, and this process was continued until no further outliers were found. Table 6.6 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 6.6
Outliers for Attitudinal Variables

Variables	**Outliers**
Anxiety	124, 154, 221, 272
Enjoyment	41, 285
Usefulness of Electronics Systems	41,52, 62, 81, 285, 320, 330, 342
Usefulness of Electronics Courses	41, 97, 225, 260, 285

6.4.1 Regression Analysis on Anxiety

A standard regression analysis 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 less the identified outliers. Table 6.7 shows the results from this analysis and the standardised regression coefficient (ß), multiple correlations R, 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.

Table 6.7

Standard Multiple Regression of Environment Variables on Anxiety

Variable	ß	sr^2
Student Cohesiveness	-0.33**	-0.294
Open-Endedness	0.05	0.049
Integration	-0.003	-0.003
Technology Adequacy	-0.14	-0.118
Laboratory Availability	-0.06	-0.054
R = 0.42		
$R^2 = 0.175$		
F(5,343) = 14.596**		

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

The R value was significantly different from zero, F(5,343) = 14.596, ($p < 0.001$). Only Student Cohesiveness independent variables contributed significantly to the prediction of Anxiety. Open-Endedness, Integration, Technology Adequacy and Laboratory Availability did not contribute at all. Altogether, 17.5% of the variance in Anxiety was predicted by the learning environment variables. The implication of this is that students' anxiety about their electronics course can be reduced by making sure there is a high level of student cohesiveness in the group.

The learning environment variables explained 17.5% of the variance of Anxiety with Open-Endedness accounting for 4.9%. This result suggests that reduced anxiety is associated with a more open-ended approach to laboratory classes.

6.4.2 Regression Analysis on Enjoyment

Table 6.8 displays the results for a standard Multiple Regression of the learning environment variables on Enjoyment for the combined sample with two outliers deleted. The multiple regression R was significantly different from zero, F(5,346) = 17.979, ($p < 0.001$). Two of the five independent variables contributed significantly to the prediction of Enjoyment with Student Cohesiveness and Technology Adequacy contributing most. Open-Endedness, Integration and Laboratory Availability did not contributed significantly. Altogether, 20.7% of the variance in Enjoyment was predicted by the learning environment variables.

Again, if the students are a cohesive group and the technology is adequate, then students will enjoy their class more.

Table 6.8

Standard Multiple Regression of Environment Variables on Enjoyment

Variable	ß	sr^2
Student Cohesiveness	0.22**	0.191
Open-Endedness	0.12	0.115
Integration	0.02	0.015
Technology Adequacy	0.31**	0.265
Laboratory Availability	-0.04	-0.035
$R = 0.45$		
$R^2 = 0.207$		
$F(5,346) = 17.979$**		

*$p<0.05$, *$p<0.01$, **$p<0.001$*

The learning environment variables explained 20.7% of the variance of Enjoyment with the main contribution coming from Technology Adequacy (26.5%), Student Cohesiveness (19.1%) and Open-Endedness (11.5%) and minor contributions from Integration (1.5%). This would indicate that courses whose laboratory classes are more up to date technology, more cohesiveness between students, and more open-endedness are perceived to be more useful.

6.4.3 Regression Analysis on Usefulness of Electronics Systems

Table 6.9

Standard Multiple Regression of Environment Variables on Usefulness of Electronics Systems

Variable	ß	sr^2
Student Cohesiveness	0.16*	0.143
Open-Endedness	0.13*	0.129
Integration	0.28**	0.249
Technology Adequacy	0.20**	0.173
Laboratory Availability	-0.20**	-0.178
$R = 0.48$		
$R^2 = 0.226$		
$F(5,339) = 19.816$**		

*$p<0.05$, *$p<0.01$, **$p<0.001$*

Table 6.9 displays the results for a standard Multiple Regression of the learning environment variables on the Usefulness of Electronics Systems for the combined sample with eight outliers deleted. The multiple regression R was significantly different from zero, F(5,339) = 19.816, ($p < 0.001$). Altogether, 22.6% of the variance in Usefulness of Electronics Systems was predicted by the learning environment variables. If the work student do in theory is integrated with their practical activities, technology is adequate and the laboratory is readily available, then student will feel the usefulness of electronics systems.

The learning environment variables explained 22.6% of the variance of Usefulness of Electronics Systems with the main contribution coming from Integration (24.9%), Technology Adequacy (17.3%), Student Cohesiveness (14.3%) and Open-Endedness (12.9%). It would seem that students' perceptions of the usefulness of electronics systems are dependent on other influences and their electronics laboratory environment does large to alter this perception.

6.4.4 Regression Analysis on Usefulness of Electronics Courses

Table 6.10
Standard Multiple Regression of Environment Variables on Usefulness of Electronics Courses

Variable	ß	sr^2
Student Cohesiveness	0.13	0.117
Open-Endedness	0.17**	0.170
Integration	0.30**	0.270
Technology Adequacy	0.09	0.079
Laboratory Availability	0.03	0.030
R = 0.48		
R^2 = 0.234		
F(5,342) = 20.949**		

*$p<0.05$, *$p<0.01$, **$p<0.001$*

Table 6.10 displays the results for a standard Multiple Regression of the learning environment variables on the Usefulness of Electronics Courses for the combined sample with five outliers deleted. The multiple regression R was significantly different from zero, F(5,342) = 20.949, ($p < 0.001$). Two of out the five independent variables contributed significantly to the prediction of Usefulness of Electronics Courses these being Open-Endedness and Integration. Altogether, 23.4% of the variance in Usefulness of Electronics Courses was predicted by the learning environment variables. The implication of this is that usefulness of electronics courses can more felt by making sure there is an open-endedness and the work student do in theory is integrated with their practical activities.

The learning environment variables explained 23.4% of the variance of Usefulness of Electronics Courses with the main contribution coming from Integration (27%), Open-Endedness (17%), Student Cohesiveness (11.7%), and minor contributions from Technology Adequacy (7.9%) and Laboratory Availability (3%). This would indicate that courses whose laboratory classes are more integrated with the non-laboratory classes, more open-ended and more cohesiveness between students are perceived to be more useful.

6.4.5 Discussion

This section try to explain how the learning environment variables contribute to the attitudinal variables, starts from the Student Cohesiveness, the Open-Endedness, the Integration, the Usefulness of Electronics Systems, and the Usefulness of Electronics Courses.

The regression analysis in general supported the results of the simple correlation analysis, though there were some discrepancies. The Student Cohesiveness scale correlated to some extent with all attitudinal variables, it would be valuable for students to offer or receive help/ support from their friends.

The Open-Endedness scale correlated to some extent with perceived useful Anxiety and gives students some freedom to analyse and compose their reports based on collected data from laboratory experiments.

The Integration scale correlated significantly with Usefulness of Electronics Systems and Usefulness of Electronics Courses. It is important to have theory aligned with laboratory experiments and support for their Electronics Systems projects.

The Technology Adequacy scale correlated significantly with all the attitudinal variables, but the regression analysis indicates that it contributes significantly to only two of them, Enjoyment and Usefulness of Electronics Systems. It seems student enjoys experiencing and using new technology or equipment for their laboratory experiments and for their Electronics Systems projects.

The Laboratory Availability scale 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 4. It could be summarised that this sample of students has enough access to laboratory facilities, either because they own one schedule or the laboratory opening hours are adequate for their needs.

6.4.6 Association Between Learning Environment and Attitudinal Variables

Associations between electronics laboratory environment and students' attitudes in electronics laboratory classes were explored by simple and multiple correlation analysis for two units of analysis (see Table 6.11).

Results of the simple correlation analyses show that seven out of 10 correlations were significant ($p < 0.05$) for students' attitudes in electronics laboratory classes. However, in order to get a clearer picture of these relationships, the multiple correlations (R) between the set of ELEI scales and students' attitudes were examined. The multiple correlation (R) was found to be 0.51 and significant ($p < 0.001$) at the individual level. In order to interpret this relationship, the standardised regression coefficients (ß) in the fourth column in Table 6.11 were examined. It was found that four of the five ELEI scales were independent predictors of students' attitudes in electronics laboratory classes at the individual level. These were Student Cohesiveness, Open-Endedness, Integration and Technology Adequacy. In this study, it seems that Laboratory Availability did not enhance students' attitudes in electronics laboratory classes. However, at the class level, the multiple correlations (R) was not significant, suggesting that students' attitudes in electronics laboratory classes were not influenced by set of ELEI scales.

Table 6.11
Correlation between ELEI scales and Attitudes in Terms of Simple Correlations (r), Multiple Correlation (R) and Standardised Regression Coefficients (β)

Variable	Unit of Analysis	Attitude	
		r	ß
Student Cohesiveness	Individual	0.24****	0.24****
	Class	0.68*	0.68
Open-Endedness	Individual	0.30****	0.30****
	Class	-0.39	-0.39
Integration	Individual	0.33****	0.33****
	Class	0.42	0.42
Technology Adequacy	Individual	0.37****	0.37****
	Class	0.81**	0.81*
Laboratory Availability	Individual	0.08	0.08
	Class	0.85***	0.85**
Multiple Correlation R	Individual		0.51****
	Class		0.85
F(5,336)	Individual		22.77****
F(5,2)	Class		1.01

*$p<0.05$, **$p<0.01$, ***$p<0.005$, ****$p<0.001$

6.5 CORRELATION AND REGRESSION WITH ACHIEVEMENT

6.5.1 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 ordered, this grade consisted of contributions from one or more of the following components: assignments, mid term exam and final term exam, and laboratory experiments (see Section 3.4.3, page 74). All courses with laboratory part involved all four components. Using means and standard deviations acquired for each course, the grade was converted into a z-score. All 353 students provided their student number allowing their grades to be determined. There are 10 respondents had been taken out because they were considered to be outliers.

6.5.2 Association Between Learning Environment and Achievement Variables

Associations between electronics laboratory environment and students' achievement in electronics are also reported in terms of simple and multiple correlation analyses in the last two column of Table 6.12. Results of the simple correlation analyses show that three out of 10 correlations were significant ($p < 0.05$) for students' achievement in electronics. Further, the multiple correlation (R) between the set of ELEI scales and students' achievement in electronics was 0.20 ($p < 0.05$) for the individual score as the unit analysis and 0.99 ($p < 0.005$) for the class mean as the unit of analysis.

Table 6.12
Correlation between ELEI scales and Achievement in Terms of Simple Correlations (r), Multiple Correlation (R) and Standardised Regression Coefficients (β)

Variable	Unit of Analysis	Achievement	
		r	ß
Student Cohesiveness	Individual	0.02	0.02
	Class	0.37	0.37
Open-Endedness	Individual	0.11*	0.11*
	Class	-0.27	-0.27
Integration	Individual	-0.08	-0.08
	Class	-0.20	-0.20
Technology Adequacy	Individual	0.02	0.02
	Class	0.62*	0.62
Laboratory Availability	Individual	-0.10*	-0.10*
	Class	0.38	0.38
Multiple Correlation R	Individual		0.20*
	Class		0.99***
F(5,336)	Individual		2.57*
F(5,2)	Class		50.40*

*$p<0.05$, **$p<0.01$, ***$p<0.005$, ****$p<0.001$

In order to interpret these joint relationships, the standardized regression coefficients (ß) in fourth column in Table 6.13 were examined. An examination of these coefficients (ß) for the individual students as the unit of analysis revealed that two of the five ELEI scales were independent predictors of students' achievement in electronics. It appears that Open-Endedness have positive relationships with students' achievement in electronics. In this study, students' achievement in electronics was independent of Student Cohesiveness, Integration and Technology Adequacy. It appears that Laboratory Availability have negative relationship with students' achievement in electronics.

All the attitudinal variables are significantly correlated (see Table 6.14). These results demonstrate that enjoyment, perceived usefulness of the electronics systems and perceived usefulness of the electronics courses contribute to achievement.

Table 6.13
Correlations between the Scales of the ATEQ

	Anxiety	Enjoyment	Usefulness of Electronics Systems	Usefulness of Electronics Courses
Anxiety	1.00	-0.58**	-0.33**	-0.41**
Enjoyment	-0.58**	1.00	0.67**	0.65**
Usefulness of Electronics Systems	-0.33**	0.67**	1.00	0.58**
Usefulness of Electronics Courses	-0.41**	0.65**	0.58**	1.00

**$p < 0.01$

6.6 SUMMARY

This chapter examined possible relationships between the learning 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 learning environment and attitudinal variables, and between attitudinal variables and achievement but only two weakly significant associations between environment and achievement. Discussions of the results are presented in Chapter 7. Also included in Chapter 7 are limitations of the study, implications of the findings in the Indonesia's context, and suggestions for future laboratory environment research in Indonesia.

CHAPTER 7

DISCUSSION AND CONCLUSION

7.1 INTRODUCTION

During the past 40 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; Newby & Fisher, 1998).

Education commands high stakes in Indonesia and there is a constant search to improve the existing good educational climate. Although various aspects of the field of psychosocial classroom and laboratory environments have been well established in numerous countries over the past 40 years, research on classroom and laboratory environment is still relatively new in Indonesia. In line with the continuous and relentless pursuit of academic excellence and achievement in the Indonesia education system, and spurred by the passion for learning and the desire to contribute to the educational arena in Indonesia, if not of the world, the researcher undertook the present study.

This study is unique for two reasons. Firstly, it involved the development of an instrument for measuring students' perceptions of an electronics laboratory environment, where the laboratory classes were part of a course in which electronics systems were the focus of the study. Secondly, the instrument was used to determine associations between the electronics laboratory environment and student outcomes, both in terms of attitude and achievement.

This chapter opens by providing an overview of the thesis in Section 7.2. The implications of findings from the study are summarised in Section 7.3. Section 7.4 probes the constraints and limitations of the study, the distinctive contributions of the study are discussed in Section 7.5, and in section 7.6 suggestions for future research in Indonesia are made.

7.2 OVERVIEW OF THE STUDY

This section provides an overview of the present study. The various chapters of the thesis are summarised in the sub-sections below.

7.2.1 Summary of Chapter 1

Chapter 1 on The Rationale for the Study discussed the background and the purposes of the present study and closed with an overview of the organisation of the various chapters in the thesis.

7.2.2 Summary of Chapter 2

Chapter 2 contained reviews of some of the important literature relating to previous research on learning environments, focussing on those studies which took place in university settings, laboratory settings or involved the use of electronics and attitudes towards electronics systems with particular emphasis on how attitudes were associated with student variables and student outcomes.

7.2.3 Summary of Chapter 3

The methodology employed in the study was given in Chapter 3. The types of courses run by different university departments were described, together with the way in which courses were organised, and laboratories integrated into them. 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 later in Section 6.5.2.

7.2.4 Summary of Chapter 4

In Chapter 4, the development of an instrument for measuring aspects of a electronics laboratory environment, the Electronics Laboratory Environment Inventory was described. It contains five scales: Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability. The Cronbach alpha coefficients, accepted as a measure of the internal consistency of the scales were found to vary between 0.50 for Open-Endedness to 0.69 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 was used as a measure of the extent to which the scales overlap, or discriminant validity varied from 0.18 for Open-Endedness to 0.29 for Student Cohesiveness. This indicated that the scales measured different aspects of the electronics laboratory environment. The results from an ANOVA showed that each scale differentiated significantly ($p < 0.001$) between courses. The eta^2 statistic measures the amount of the variance that could be attributed to the course, and it varied from 0.25 for Laboratory Availability to 0.34 for Integration. This indicated that the ELEI was 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 ELEI was a suitable instrument for measuring specific aspects of a electronics laboratory classroom environment.

7.2.5 Summary of Chapter 5

In Chapter 5, the development and validation of an instrument for measuring students' attitudinal outcomes, the Attitude Towards Electronics Questionnaire was described. This instrument had four scales: Anxiety, Enjoyment, Usefulness of Electronics Systems, and Usefulness of the Electronics Courses. These scales were found to be correlated. It was found that the Cronbach alpha coefficients varied from 0.63 for Usefulness of Electronics Courses to 0.76 for Enjoyment, showing very good internal consistency on each scale. The mean correlations with other scales varied from 0.44 for Anxiety to 0.63 for Enjoyment, thus indicating that the scales overlap. The results of this analysis showed that the ATEQ was a reliable instrument for measuring student attitudinal outcomes.

7.2.6 Summary of Chapter 6

Chapter 6 dealt with the associations between perceptions of aspects of a electronics laboratory classroom environment and student outcomes for the study. The results showed that most environment variables were associated significantly with attitudinal variables, but less so with achievement. However, achievement was shown to be associated with attitudinal variables.

7.3 MAJOR FINDINGS OF THE STUDY

The subsections that follow discuss implications of the findings in terms of the applications of the classroom instrument (ELEI questionnaire), associations between students; perception of classroom environments and their learning outcomes, and their perceptions of the classroom environments of electronics.

The major findings of the present study are discussed under the following headings:

7.3.1 Cross-Validation of the Electronics Laboratory Environment Inventory (ELEI) Questionnaire

The first research question is whether the Electronics Laboratory Environment Inventory (ELEI) a reliable and valid questionnaire for use in actual and preferred versions in tertiary electronics laboratories in Indonesia?

This study reports the development and use of an instrument for measuring the psychosocial environment of a electronics laboratory classroom. It was used in a university setting in courses involving electronics systems and laboratory equipments as an integral part of the course.

The Cronbach alpha reliability of the Actual Form of the ELEI ranged from 0.50 (Open-Endedness) to 0.69 (Integration) when the individual student was used as the unit analysis and from 0.63 (Laboratory Availability) to 0.84 (Open-Endedness) when the class mean was the unit of analysis. On the other hand, the alpha reliabilities for the Preferred Form of the ELEI ranged from 0.58 (Open-Endedness) to 0.69 (Laboratory Availability) when the individual student was used as the unit of analysis and from 0.58 (Student Cohesiveness) to 0.84 (Integration) when the class mean was used.

The discriminant validity (mean correlation of a scale with the other scales) of the Actual form of the ELEI ranged from 0.18 to 0.29 for individual student and 0.24 to 0.68 for the class as the unit of analysis, indicating that there is little overlap in what they measure.

The eta^2 statistic ranged from 0.25 for Laboratory Availability to 0.34 for Integration. The results show that each scale differentiated significantly ($p < 0.001$) between courses. This indicates that the ELEI is able to differentiate between students on the basis of the course being taken.

From the above figures it is concluded that the ELEI is reliable and valid for use with computer engineering students in tertiary classes in Indonesia. The availability of the ELEI for tertiary teachers in Indonesia is significant and it can be used by such teachers to describe and improve their own laboratory learning environments.

7.3.2 Students' Perception of the Electronics Laboratory Environment

The second research question is what are students' perceptions of the Electronics Laboratory environment in an Indonesian University?

Student perceptions according to the Actual Form and the individual student as the unit of analysis, show that average student scores ranged from 3.04 (approximately corresponding to Sometimes) to 3.74 (approximately corresponding to Often) for different scales. This result indicates that the students are happy in completing laboratory activities but submitting a weekly report becomes a burden. These duties, especially when students take two laboratory subjects in one semester, are really a problem because laboratory regulations state that if students are late in submitting these reports, their marks will be decreased.

For the Preferred Form, and the individual student as the unit of analysis, show that average student scores ranged from 3.73 to 4.12 (approximately corresponding to Often) for different scales. These results show that the students' expect more from their laboratory's physical facilities and they would like more time to do their own experiments.

It is concluded that students' perceptions of their Electronics Laboratory environment in an Indonesian University is that they would prefer their environment to be more positive than they perceive it to be at present. An important point is that students would prefer a more positive environment on all scales of the ELEI.

7.3.3 Cross-Validation of the Attitude Towards Electronics Questionnaire (ATEQ)

The third research question is whether the Attitude Towards Electronics Questionnaire (ATEQ) a valid and reliable questionnaire for use in computer engineering students in Indonesia?

This study reports the development and use of an instrument for measuring the student attitudes towards electronics laboratory classroom environment.

The Cronbach alpha reliabilities of the Actual Form of the ELEI ranged from 0.63 (Usefulness of Electronics Courses) to 0.76 (Enjoyment) when the individual student was used as the unit analysis and from 0.56 (Anxiety) to 0.86 (Enjoyment) when the class mean was the unit of analysis. On the other hand, the alpha reliabilities for the Preferred Form of the ELEI ranged from 0.58 (Anxiety) to 0.72 (Enjoyment) when the individual student was used as the unit of analysis and from 0.77 (Usefulness of Electronics Courses) to 0.83 (Usefulness of Electronics Systems) when the class mean was used.

The discriminant validity (mean correlation of a scale with the other scales) of Actual form of the ELEI ranged from 0.44 to 0.63 for individual student and 0.33 to 0.43 for the class as the unit of analysis, indicating that there is little overlap in what they measure.

The eta^2 statistic ranged from 0.30 for Usefulness of Electronics Courses to 0.38 for Enjoyment. The results show that each scale differentiated significantly ($p < 0.001$) between courses. This indicates that the ATEQ is able to differentiate between students on the basis of the course being taken.

From the above figures it is concluded that the ATEQ is reliable and valid for use in computer engineering students in an Indonesian University.

Most differences in students' perceptions of their electronics laboratory environment were found to be course 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 electronics related variables indicate the importance of the electronics systems and laboratory equipment and prior familiarity with it. This would imply that except in those cases where it is necessary to give students experience of electronics systems suitable laboratory equipment should be used for courses. Students with higher prior familiarity with the electronics system and laboratory equipment being used for the course, showed lower anxiety.

Cultural background would seem to play a role in how students perceive their electronics classroom environment, especially with respect to open-endedness and integration. Students from an Indonesian 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 electronics knowledge and how to use laboratory equipment being more structured than in later courses. Again, this is an area that needs further investigation.

7.3.4 Students' Attitude Toward the Electronics Laboratory Environment

The fourth research question is what are students' attitudes towards their Electronics Laboratory Classes in an Indonesian University?

This question is meant to measure students' perceptions on the subjects presented in class in relation to the material provided for laboratory experiments. Student perceptions according to the Actual Form show that average student scores ranged from 2.56 (approximately corresponding to Sometimes) to 3.63 (approximately corresponding to Often) for different scales. For the Preferred Form, average student scores ranged from 2.25 (approximately corresponding to Sometimes) for the Anxiety scale to 4.01 (approximately corresponding to Often) for Enjoyment scale.

7.3.5 Associations Between Students' Perceptions of Learning Environments and Their Learning Outcomes

The fifth research questions Are there associations between the student outcomes of (a) attitude in electronics laboratory classes and (b) achievement on the laboratory subjects and students perceptions of the laboratory classroom environment?

Simple correlation and multiple regression analysis were used to determine whether associations exist between students' perception of learning environments, and students' attitude towards their classes and their final achievement score. There are 16 out of a possible 20 correlations are significant between learning environment and attitudinal variables. Each of Student Cohesiveness, Integration and Technology Adequacy are positively associated with Enjoyment, Usefulness of Electronics Systems and Usefulness of Electronics Courses and negatively with Anxiety. Laboratory Availability is positively associated with Enjoyment and Usefulness of Electronics Courses and again negatively with Anxiety.

The relationships between environment variables and the attitudinal variables have implications for the lecturers who run courses that contain a laboratory component. The results show that electronics 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 anxiety, greater enjoyment, and more positive perceptions of the usefulness of electronics systems and the electronics courses. Each of these environment variables can be influenced by the Head of Department. 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 become better acquainted. This is something that can be achieved by appropriate timetabling. The other three variables concern the way in which the course materials, including lectures and laboratory experiments, are structured. To improve integration of theory and laboratory classes, it is important that some part of the laboratory class is spent reinforcing concepts dealt with in lectures. On the other hand, open-endedness would be increased by providing instructions that encourage more divergent and exploratory approaches. The need for adequate technology means that laboratory teachers must ensure that experiments must be able to be completed in a reasonable time using the equipment 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 electronics 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 electronics variables, but it is correlated with perceived usefulness of the electronics courses. This could be interpreted as students already having enough time to get the data for their analysis in one laboratory schedule.

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. These findings reinforce the importance of providing a positive electronics laboratory classroom environment, such as the availability of new hardware, as well as laboratory assistants who are willing to help them.

7.3.6 The Influences of Learning Environment to Student Outcomes

The sixth research questions To what extent does laboratory environment influence student outcomes (attitudes and achievement)?

The simple correlation analyses show that seven out of 10 correlations were significant ($p < 0.05$) for students' attitudes in electronics laboratory classes. The multiple correlation (R) was found to be 0.51 and significant ($p < 0.001$) at the individual level. Four of the five ELEI scales were independent predictors of students' attitudes in electronics laboratory classes at the individual level. These were Student Cohesiveness, Open-Endedness, Integration and Technology Adequacy. In this study, it seems that Laboratory Availability did not enhance students' attitudes in electronics laboratory classes. However, at the class level, the multiple correlations (R) was not significant, suggesting that students' attitudes in electronics laboratory classes were not influenced by set of ELEI scales.

Results of the simple correlation analyses show that three out of 10 correlations were significant ($p < 0.05$) for students' achievement in electronics. Further, the multiple correlation (R) between the set of ELEI scales and students' achievement in electronics was 0.20 ($p < 0.05$) for the individual score as the unit analysis and 0.99 ($p < 0.005$) for the class mean as the unit of analysis. Two of the five ELEI scales were independent predictors of students' achievement in electronics. It appears that Open-Endedness has a positive relationship with students' achievement in electronics. In this study, students' achievement in electronics was independent of Student Cohesiveness, Integration and Technology Adequacy. It also appears that Laboratory Availability has a negative relationship with students' achievement in electronics.

7.4 BENEFITS AND LIMITATIONS OF THE STUDY

The study has several benefits in the form of available two instrument that can be applied for:

1. measuring the students' perceptions on the electronic laboratories Therefore, we can improve which point got low score or the weakness of laboratory facilities.

2. measuring the students' emotional perception towards the electronic subject, whether they can be excited, discouraged, or motivated.

Also, the study has several limitations and therefore its findings should be generalized with caution. The limitations of the study include the following:

1. The most serious limitation to this study is the sample of students. The sample was drawn from students of Computer Engineering Department of

Bina Nusantara University. Although the sample represented 50% of the whole population of students taking eight electronics courses. Some of them already in final semester and have passed their all laboratory courses for a semester or two semesters ago.

2. Although the instruments were adapted to suit the context of the study, they were originally developed for students in Western countries. Therefore, interpretations of some items by students in Indonesia might not necessarily be similar to interpretations by students in Western countries. The reason for these differences could be that Indonesia has a highly centralized and examination-oriented education system and different culture.

3. Even though the wording of times in this instruments was in Bahasa Indonesia, students might have found difficulty in understanding the meanings of the items. To overcome this problem some changes in the wording of the items. Despite the effort, there is possibility that students could still have difficulties in understanding the meanings of items and therefore that students could have different meanings than the meanings originally intended.

4. 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 experiments. 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.

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

7.5 DISTINCTIVENESS AND CONTRIBUTIONS OF THE STUDY

The scope of the present study is extensive. The sample size is medium, consisting of 353 of 708 students from Computer Engineering Department of Bina Nusantara University, Jakarta, Indonesia. It should be noted that the group of students sampled represented about 50% of the all active student in Computer Engineering Department. It included an investigation of the Actual and Preferred Versions of Electronics Laboratory Environment Inventory and Attitude Towards Electronics Questionnaire. Thus , the validation involved the Actual and Preferred Versions for both instrument, and for two units of analysis both individual and class means.

The present study is therefore distinctive in that, by field-testing, refining, validating and using a final 34-item, five-scale version of the Electronics Laboratory Environment Inventory and a final 28-item, four-scale version of the Attitude Towards Electronics Questionnaire with 353 students of Computer Engineering Department of Bina Nusantara University, it has provided other researchers with a widely applicable, cost-conscious, valid and economical instrument for future use in assessing and monitoring students' perceptions of actual and preferred laboratory classroom learning environments.

Also, the present study is distinctive in that it is the first to employ the SLEI, which originally was validated with Science Classes, in Computer classes and in Chemistry classes. In so doing, the present study extended the horizon of the applications of SLEI in Electronics.

7.6 SUGGESTIONS FOR FUTURE RESEARCH

This section offers some suggestions for future research on laboratory environment which could further extend past research. Further work needs to done to confirm the factorial validity of both the Electronics Laboratory Environment Inventory and the Attitude Towards Electronics Questionnaire. This could be done by administering it to specialist electronics students and to non-specialist students in a number of countries, both English-speaking and non-English speaking.

The ELEI and ATEQ has two forms an actual and a preferred version have been developed to measure students' perceptions of their electronics laboratory environment from the viewpoint of the student's personal involvement in the class. In addition to the personal form of the ELEI, 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 ELEI. 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 did not touch gender issues differences in students' perceptions of their classroom environment or in their outcomes, because almost 96% are male students.

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 study were in Bina Nusantara University in Indonesia. English speaking countries tend to have different educational cultures. It would be useful to conduct studies into the associations between perceptions of laboratory environment and student outcomes in 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 electronics laboratory environment.

7.7 SUMMARY

In this research, two instruments were elaborated, the Electronics Laboratory Environment Inventory (ELEI) and the Attitude Towards Electronics Questionnaire (ATEQ). The ATEQ is based on a number of existing instruments with one original scale to gauge students' perceptions of the usefulness of the electronics courses. This instrument is a useful addition to those that measure electronics attitude. Although the ELEI is based on an existing instrument, it is used in a completely new setting, the electronics laboratory classroom. The development of the ELEI and ATEQ are one of the most significant outcomes from this research. Its scales have been shown to have acceptable reliability and discriminant validity in this study. 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 electronics laboratory environment affects attitude which in turn impact 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 electronics laboratories be seen as an expensive overhead by educational administrators, and electronics laboratory classes as a component of a course requiring little preparation. Electronics laboratory classes have been shown to be an important part of university electronics courses, and should be planned with as much care as would be given to lectures. The results from the study described in this thesis should convince educators and educational administrators of the value of and necessity for electronics laboratory classes.

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Appendix A

**ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI)
AND**

ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

ACTUAL AND PREFERRED FORMS

(English Version)

Appendix A

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI) AND ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

ACTUAL AND PREFERRED FORM
(English Version)

DIRECTIONS

- This is NOT a test.
- Your participation in this survey is voluntary
- The data collected will remain confidential.
- The questionnaire should take about 15 minutes to complete.
- This questionnaire contains statements about practices which could take place in ***your actual and preferred laboratory class.***
- There are no 'right' or 'wrong' answers. Your opinion is what is wanted.
- These questionnaires contain statements about practices that could take place in your class. You will be asked how often each practice takes place. The **'Actual'** column is to be used to describe how often each practice actually takes place in this class. The **'Preferred'** column is to be used to describe how often you would like each practice to take place (a wish list).
- Draw a circle around

  1. if the practice takes place Almost Never
  2. if the practice takes place Seldom
  3. if the practice takes place Sometimes
  4. if the practice takes place Often
  5. if the practice takes place Almost Never

- Do not worry if some statements in this questionnaire are fairly similar.
- Give your opinion to all statement.
- If you change your mind on a number, simply cross out the number and circle another number.

EXAMPLE

Statement: I get on well with students in this laboratory group.

You would need to decide whether your thought that you get on well with students in this laboratory group.

'Almost Never', 'Seldom', 'Sometimes', 'Often' or 'Almost Always'.

If you selected 'Often', you would circle the number 4 on your questionnaire.

Student Number : ______________

Course : *) ☑ for course name when questionnaire is taken.

☐ 1. Integrated Electronics
☐ 2. Electric Circuit Theory
☐ 3. Discrete Electronics
☐ 4. Digital System
☐ 5. Advanced Control System
☐ 6. Microprocessor Application
☐ 7. Digital Signal Processing
☐ 8. Robotics / Mechatronic

Batch year : _____

Class : _____

Have build electronics system : yes/ no

If yes, which system(s):
☐ power supply
☐ amplifier
☐ radio
☐ else, ______________________________

Definition:

- Laboratory facilities include power supply, multi meters, oscilloscope, signal generator, digital signal processing board, experiment board, microprocessors board, etc.
- Electronics system includes minimum system, motor servo, electric circuits, etc.

No.	Statement	Actual					Preferred				
		Almost Never	Seldom	Some Times	Often	Almost Always	Almost Never	Seldom	Some Times	Often	Almost Always
	PART I (ELEI)										
1	I get on well with students in this laboratory group.	1	2	3	4	5	1	2	3	4	5
2	There is opportunity for me to pursue my own electronics interest in this laboratory class.	1	2	3	4	5	1	2	3	4	5
3	What I get from the lecture is unrelated to my laboratory work.	1	2	3	4	5	1	2	3	4	5
4	The laboratory facilities are difficult to use.	1	2	3	4	5	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the laboratory.	1	2	3	4	5	1	2	3	4	5
6	I have a little chance to get to know other students in this laboratory group.	1	2	3	4	5	1	2	3	4	5
7	In this laboratory group, I am required to design my own solutions to a given task.	1	2	3	4	5	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	1	2	3	4	5
9	The laboratory facilities work without problems.	1	2	3	4	5	1	2	3	4	5
10	The laboratory room is readily available.	1	2	3	4	5	1	2	3	4	5
11	Members of this laboratory group help me.	1	2	3	4	5	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions that I do for the same problem.	1	2	3	4	5	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5	1	2	3	4	5
14	The laboratory facilities are adequate enough to cope with the laboratory tasks.	1	2	3	4	5	1	2	3	4	5
15	Outside my normal laboratory schedule, I have to wait if I want to use laboratory room.	1	2	3	4	5	1	2	3	4	5
16	I get to know students in this laboratory group well.	1	2	3	4	5	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigation on my own.	1	2	3	4	5	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5	1	2	3	4	5
19	The available laboratory facilities enables student to make good use of the laboratory.	1	2	3	4	5	1	2	3	4	5
20	I can gain access to the laboratory outside my normal schedule.	1	2	3	4	5	1	2	3	4	5
21	I am able to rely on other students for help during laboratory session.	1	2	3	4	5	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	1	2	3	4	5
23	The topics covered in lectures are quite different from	1	2	3	4	5	1	2	3	4	5

No.	Statement	Actual					Preferred				
		Almost Never	Seldom	Some Times	Often	Almost Always	Almost Never	Seldom	Some Times	Often	Almost Always
	topics which I deal in laboratory sessions.										
24	The laboratory facilities are in good working condition.	1	2	3	4	5	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	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/ her name in this laboratory group.	1	2	3	4	5	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	1	2	3	4	5
28	What I do in laboratory sessions helps me to comprehend the theory covered in lectures.	1	2	3	4	5	1	2	3	4	5
29	The laboratory facilities are suitable for testing the electronics system I am required to use.	1	2	3	4	5	1	2	3	4	5
30	It is difficult for me to find a free time slot when I want to use the laboratory room.	1	2	3	4	5	1	2	3	4	5
31	I work cooperatively in these laboratory sessions.	1	2	3	4	5	1	2	3	4	5
32	I decide the best way to proceed when developing a solution to a problem given in the laboratory sessions.	1	2	3	4	5	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5	1	2	3	4	5
34	When I make mistake, the laboratory facilities does not damage (except the fuse of digital multi meters).	1	2	3	4	5	1	2	3	4	5
35	There are enough laboratory facilities for student to use.	1	2	3	4	5	1	2	3	4	5
	PART II (AEQ)										
36	I do not think I will ever use what I learned in these subjects.	1	2	3	4	5	1	2	3	4	5
37	I feel comfortable when a conversation turns to electronics system.	1	2	3	4	5	1	2	3	4	5
38	Studying about electronics system is a waste of time.	1	2	3	4	5	1	2	3	4	5
39	It is fun to find out how electronics systems work.	1	2	3	4	5	1	2	3	4	5
40	These subjects provided me with skills I expect to use in the future.	1	2	3	4	5	1	2	3	4	5
41	I feel at ease when I am around laboratory.	1	2	3	4	5	1	2	3	4	5
42	My future career will require knowledge of electronics system.	1	2	3	4	5	1	2	3	4	5
43	I enjoy using laboratory facilities.	1	2	3	4	5	1	2	3	4	5
44	These subjects have increased my technical skills.	1	2	3	4	5	1	2	3	4	5
45	Working with electronics system design makes me very nervous.	1	2	3	4	5	1	2	3	4	5
46	In the future there are many devices will embodded with electronics system.	1	2	3	4	5	1	2	3	4	5

No.	Statement	Actual					Preferred				
		Almost Never	Seldom	Some Times	Often	Almost Always	Almost Never	Seldom	Some Times	Often	Almost Always
47	I think designing electronics system would be enjoyable and stimulating.	1	2	3	4	5	1	2	3	4	5
48	I gained few useful skills from these subjects.	1	2	3	4	5	1	2	3	4	5
49	I get a sinking feeling when I think about trying to design electronics system.	1	2	3	4	5	1	2	3	4	5
50	Electronics systems are one of important factors in the success of an entrepreneur.	1	2	3	4	5	1	2	3	4	5
51	The challenge of creating electronics system does not appeal me.	1	2	3	4	5	1	2	3	4	5
52	The skills gained in these subjects are too specific to be generally useful in the future.	1	2	3	4	5	1	2	3	4	5
53	Electronics system makes me feel uncomfortable.	1	2	3	4	5	1	2	3	4	5
54	The use of electronics system will increase in the future.	1	2	3	4	5	1	2	3	4	5
55	I would like to work with laboratory facilities.	1	2	3	4	5	1	2	3	4	5
56	These subjects helped develop my problem-solving skills.	1	2	3	4	5	1	2	3	4	5
57	Electronics system makes me feel uneasy and confused.	1	2	3	4	5	1	2	3	4	5
58	All tertiary students need a course about electronics system.	1	2	3	4	5	1	2	3	4	5
59	I enjoy learning electronics system.	1	2	3	4	5	1	2	3	4	5
60	As a result of these subjects I feel confident about tackling unfamiliar problems involving electronics.	1	2	3	4	5	1	2	3	4	5
61	I feel aggressive and angry toward electronics system.	1	2	3	4	5	1	2	3	4	5
62	Knowledge of the use electronics system will help me get a job.	1	2	3	4	5	1	2	3	4	5
63	Learning about electronics system is boring.	1	2	3	4	5	1	2	3	4	5

Appendix B

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI) AND

ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

ACTUAL AND PREFERRED FORMS

(Indonesian Version)

Appendix B

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI)
AND
ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

ACTUAL AND PREFERRED FORM
(Indonesian Version)

PETUNJUK

- Ini bukan sebuah test.
- Partisipasi anda dalam survey ini adalah sukarela.
- Data yang dikumpulkan akan tetap menjadi rahasia.
- Kuesioner ini hanya membutuhkan waktu 15 menit untuk menyelesaikannya.
- Pernyataan- pernyataan berikut ini membahas mengenai ***'kenyataan' dan 'harapan'*** pada pelaksanaan kegiatan laboratorium yang telah anda ikuti.
- Tidak ada jawaban ***'benar'*** atau ***Salah*** . Yang diharapkan adalah ***'Pendapat'*** anda.
- Kuesioner berikut berisi pernyataan tentang kenyataan yang terjadi pada laboratorium anda. Anda akan diminta untuk menjawab seberapa sering kejadian tersebut terjadi. Kolom **'Aktual'** untuk menerangkan seberapa sering hal tersebut **benar-benar terjadi**. Sedangkan kolom **'Harapan'** adalah untuk menerangkan harapan yang anda inginkan terjadi (semacam daftar keinginan).
- Lingkarilah angka-angka sebagai berikut:
  1. Apabila pada kenyataan Hampir tidak pernah
  2. Apabila pada kenyataan Jarang
  3. Apabila pada kenyataan Kadang-kadang
  4. Apabila pada kenyataan Sering
  5 Apabila pada kenyataan Hampir selalu
- Jangan menjadi ragu apabila ada beberapa pernyataan yang hampir sama.
- Berikan pendapat anda pada semua pernyataan yang ada.
- Apabila anda berubah pendapat, berilah ***'tanda silang'*** pada angka yang dibatalkan dan ' ***lingkarilah*** ' angka pengganti yang
- anda pilih.

CONTOH

Pernyataan: Saya dapat bersahabat dengan praktikan lainnya pada group praktikum ini..

Yang perlu anda lakukan adalah mempertimbangkan apakah anda dapat bersahabat dengan praktikan lainnya pada group praktikum ini.

'Hampir tidak pernah', Jarang , 'Kadang-kadang', Sering', 'Hampir selalu'.

Apabila anda berpendapat hal itu Sering terjadi, maka lingkarilah angka 4 pada kuestioner yang anda isi.

Nomor Induk Mahasiswa : ______________

Matakuliah : *) ☑ pilih nama matakuliah ketika pengambilan kuesioner ini.

☐ 1. Elektronika Terpadu

☐ 2. Teori Rangkaian Listrik

☐ 3. Elektonika Diskrit

☐ 4. Sistem Digital

☐ 5. Sistem Pengaturan Lanjutan

☐ 6. Aplikasi Mikroprosesor

☐ 7. Pemrosesan Sistem Digital

☐ 8. Robotika / Mekatronika

Angkatan : _____

Kelas : _____

Pernah membuat sistem elektronik : ya/ tidak

Jika Ya, sistem: ☐ power supply

☐ amplifier

☐ radio

☐ Sebutkan,

____

Definisi:

- Fasilitas Laboratorium termasuk power supply, multi meter, oscilloscope, signal generator, papan digital signal processing, papan-papan eksperimen, modul mikroprosesor/ mikrokontroler, dan lain-lain.
- Sistem Elektronika termasuk sistem minimum, rangkaian elektronika, motor servo, atau proyek elektronik untuk tugas rancang laboratorium, proyek kelas, dll.

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
	PART I (ELEI)										
1	Saya dapat bersahabat dengan praktikan lainnya pada group praktikum ini.	1	2	3	4	5	1	2	3	4	5
2	Saya memiliki kesempatan dalam mengejar ketertarikan/ hobbi elektronik di laboratorium.	1	2	3	4	5	1	2	3	4	5
3	Apa yang saya dapatkan di kuliah tidak berkorelasi dengan materi praktikum.	1	2	3	4	5	1	2	3	4	5
4	Fasilitas laboratorium sulit digunakan.	1	2	3	4	5	1	2	3	4	5
5	Laboratorium sangat padat ketika saya menggunakannya.	1	2	3	4	5	1	2	3	4	5
6	Saya tidak banyak kesempatan untuk mengenali praktikan lain pada group praktikum ini.	1	2	3	4	5	1	2	3	4	5
7	Pada group praktikum ini, saya diminta untuk merancang sendiri jawaban dari tugas yang diberikan.	1	2	3	4	5	1	2	3	4	5
8	Materi praktikum tidak berhubungan dengan topik yang sedang dipelajari di perkuliahan.	1	2	3	4	5	1	2	3	4	5
9	Fasilitas laboratorium berfungsi tanpa masalah.	1	2	3	4	5	1	2	3	4	5
10	Ruangan laboratorium siap tersedia.	1	2	3	4	5	1	2	3	4	5
11	Anggota group praktikum membantu saya.	1	2	3	4	5	1	2	3	4	5
12	Pada sesi praktikum, praktikan lainnya memberikan solusi yang berbeda pada masalah yang sama.	1	2	3	4	5	1	2	3	4	5
13	Materi kuliah terintegrasi dengan kegiatan laboratorium.	1	2	3	4	5	1	2	3	4	5
14	Fasilitas laboratorium cukup memadai untuk tugas praktikum.	1	2	3	4	5	1	2	3	4	5
15	Di luar jadwal praktikum, saya harus menunggu bila ingin menggunakan ruangan laboratorium.	1	2	3	4	5	1	2	3	4	5
16	Saya mengenali setiap praktikan pada group praktikum dengan baik.	1	2	3	4	5	1	2	3	4	5
17	Saya didorong untuk berkreasi di luar materi praktikum yang diberikan, dan melakukan penelitian sendiri.	1	2	3	4	5	1	2	3	4	5
18	Saya menggunakan teori perkuliahan selama kegiatan praktikum.	1	2	3	4	5	1	2	3	4	5
19	Fasilitas laboratorium yang tersedia dapat digunakan praktikan.	1	2	3	4	5	1	2	3	4	5
20	Saya dapat meminjam ruangan laboratorium di luar jadwal normal saya.	1	2	3	4	5	1	2	3	4	5

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
21	Saya dapat mengandalkan rekan praktikan lainnya untuk membantu selama sesi praktikum.	1	2	3	4	5	1	2	3	4	5
22	Pada sesi praktikum, saya menyelesaikan soal yang berbeda-beda dibandingkan dengan praktikan lainnya.	1	2	3	4	5	1	2	3	4	5
23	Topik yang dipelajari pada perkuliahan sangat berbeda dengan topik yang dihadapi di laboratorium.	1	2	3	4	5	1	2	3	4	5
24	Fasilitas laboratorium dapat berfungsi baik.	1	2	3	4	5	1	2	3	4	5
25	Tersedia cukup waktu kosong dalam seminggu agar saya bisa menyelesaikan semua pekerjaan laboratorium dengan nyaman.	1	2	3	4	5	1	2	3	4	5
26	Membutuhkan waktu yang lama agar saya dapat mengenali setiap orang dengan namanya pada group praktikum.	1	2	3	4	5	1	2	3	4	5
27	Pada sesi praktikum, asisten memutuskan cara yang terbaik untuk menyelesaikan tugas.	1	2	3	4	5	1	2	3	4	5
28	Apa yang saya lakukan di sesi laboratorium membantu saya dalam memahami teori yang dibahas di kelas.	1	2	3	4	5	1	2	3	4	5
29	Fasilitas laboratorium cocok untuk menguji sistem elektronik yang saya butuhkan.	1	2	3	4	5	1	2	3	4	5
30	Sangatlah susah bagi saya untuk menemukan waktu kosong ketika ingin menggunakan ruangan laboratorium.	1	2	3	4	5	1	2	3	4	5
31	Saya bekerja sama secara kooperatif pada sesi praktikum.	1	2	3	4	5	1	2	3	4	5
32	Saya memutuskan cara terbaik untuk melakukan penyelesaian masalah yang diberikan pada sesi praktikum.	1	2	3	4	5	1	2	3	4	5
33	Kegiatan laboratorium dan materi perkuliahan tidak saling berhubungan.	1	2	3	4	5	1	2	3	4	5
34	Ketika saya melakukam kesalahan, fasilitas laboratorium tidak rusak (kecuali sikring pada multi meter digital).	1	2	3	4	5	1	2	3	4	5
35	Tersedia banyak fasilitas laboratorium yang dapat digunakan mahasiswa.	1	2	3	4	5	1	2	3	4	5

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
	PART II (AEQ)										
36	Saya tidak berpikir akan menggunakan apa yang sudah saya pelajari di mata kuliah-mata kuliah tersebut.	1	2	3	4	5	1	2	3	4	5
37	Saya merasa nyaman ketika diskusi mengarah pada sistem elektronika.	1	2	3	4	5	1	2	3	4	5
38	Mempelajari sistem elektronik adalah membuang-buang waktu saja.	1	2	3	4	5	1	2	3	4	5
39	Adalah menyenangkan bila dapat mengetahui cara kerja suatu sistem elektronik.	1	2	3	4	5	1	2	3	4	5
40	Mata kuliah tersebut memberikan saya keahlian yang saya butuhkan di masa mendatang.	1	2	3	4	5	1	2	3	4	5
41	Saya merasa tidak tegang ketika berada di lingkungan laboratorium.	1	2	3	4	5	1	2	3	4	5
42	Karir di masa depan akan membutuhkan pengetahuan tentang sistem elektronik.	1	2	3	4	5	1	2	3	4	5
43	Saya suka memanfaatkan fasilitas labotarotium.	1	2	3	4	5	1	2	3	4	5
44	Mata kuliah tersebut telah meningkatkan kemampuan teknikal saya.	1	2	3	4	5	1	2	3	4	5
45	Bekerja dengan perancangan sistem elektronika membuat saya sangat tegang.	1	2	3	4	5	1	2	3	4	5
46	Di masa mendatang banyak peralatan yang menggunakan sistem elektronika.	1	2	3	4	5	1	2	3	4	5
47	Saya berpikir merancang sistem elektronik akan menyenangkan dan menantang.	1	2	3	4	5	1	2	3	4	5
48	Saya mendapatkan hanya sedikit kemampuan pada mata kuliah tersebut.	1	2	3	4	5	1	2	3	4	5
49	Saya merasa berat hati ketika mencoba merancang sistem elektronik.	1	2	3	4	5	1	2	3	4	5
50	Sistem elektronik adalah salah satu faktor penting dalam keberhasilan berwiraswasta.	1	2	3	4	5	1	2	3	4	5
51	Tantangan untuk membuat sistem elektronik tidak menarik.	1	2	3	4	5	1	2	3	4	5
52	Ketrampilan yang didapatkan pada mata kuliah tersebut sangat spesifik untuk dapat digunakan pada masa mendatang.	1	2	3	4	5	1	2	3	4	5
53	Sistem elektronik membuat saya merasa tidak nyaman.	1	2	3	4	5	1	2	3	4	5
54	Penggunaan sistem elektronika akan semakin meningkat di masa depan.	1	2	3	4	5	1	2	3	4	5

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
55	Saya senang bekerja dengan fasilitas laboratorium.	1	2	3	4	5	1	2	3	4	5
56	Mata kuliah tersebut membantu mengembangkan kemampuan pemecahan masalah saya.	1	2	3	4	5	1	2	3	4	5
57	Sistem elektronik membuat saya gelisah dan bingung.	1	2	3	4	5	1	2	3	4	5
58	Semua mahasiswa yang kurang berprestasi memerlukan kursus sistem elektronik.	1	2	3	4	5	1	2	3	4	5
59	Saya menikmati belajar sistem elektronik.	1	2	3	4	5	1	2	3	4	5
60	Sebagai akhir dari pembelajaran matakuliah ini, saya merasa yakin mampu menangani masalah yang berhubungan dengan elektronik.	1	2	3	4	5	1	2	3	4	5
61	Saya merasa agresif dan marah terhadap sistem elektronik.	1	2	3	4	5	1	2	3	4	5
62	Pengetahuan penggunaan sistem elektronik akan membantu saya dalam mendapatkan pekerjaan.	1	2	3	4	5	1	2	3	4	5
63	Mempelajari topik sistem elektronik adalah membosankan.	1	2	3	4	5	1	2	3	4	5

Appendix C

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI) AND

ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

REVISED

ACTUAL AND PREFERRED FORMS

(English Version)

Appendix C

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI) AND ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

ACTUAL AND PREFERRED FORM (English Version)

DIRECTIONS

- This is NOT a test.
- Your participation in this survey is voluntary
- The data collected will remain confidential.
- The questionnaire should take about 15 minutes to complete.
- This questionnaire contains statements about practices which could take place in ***your actual and preferred laboratory class.***
- There are no 'right' or 'wrong' answers. Your opinion is what is wanted.
- These questionnaires contain statements about practices that could take place in your class. You will be asked how often each practice takes place. The **'Actual'** column is to be used to describe how often each practice actually takes place in this class. The **'Preferred'** column is to be used to describe how often you would like each practice to take place (a wish list).
- Draw a circle around

  1. if the practice takes place Almost Never
  2. if the practice takes place Seldom
  3. if the practice takes place Sometimes
  4. if the practice takes place Often
  5. if the practice takes place Almost Never

- Do not worry if some statements in this questionnaire are fairly similar.
- Give your opinion to all statement.
- If you change your mind on a number, simply cross out the number and circle another number.

EXAMPLE

Statement: I get on well with students in this laboratory group.

You would need to decide whether your thought that you get on well with students in this laboratory group.

'Almost Never', 'Seldom', 'Sometimes', 'Often' or 'Almost Always'.

If you selected 'Often', you would circle the number 4 on your questionnaire.

Student Number : ______________

Course : *) ☑ for course name when questionnaire is taken.

☐ 1. Integrated Electronics

☐ 2. Electric Circuit Theory

☐ 3. Discrete Electronics

☐ 4. Digital System

☐ 5. Advanced Control System

☐ 6. Microprocessor Application

☐ 7. Digital Signal Processing

☐ 8. Robotics / Mechatronic

Batch year : ______

Class : ______

Have build electronics system : yes/ no

If yes, which system(s): ☐ power supply

☐ amplifier

☐ radio

☐ else,

____

Definition:

- Laboratory facilities include power supply, multi meters, oscilloscope, signal generator, digital signal processing board, experiment board, microprocessors board, etc.
- Electronics system includes minimum system, motor servo, electric circuits, etc.

No.	Statement	Actual					Preferred				
		Almost Never	Seldom	Some Times	Often	Almost Always	Almost Never	Seldom	Some Times	Often	Almost Always
	PART I (ELEI)										
1	I get on well with students in this laboratory group.	1	2	3	4	5	1	2	3	4	5
2	I have the opportunity of doing my interests in electronic field.	1	2	3	4	5	1	2	3	4	5
3	What I get from the lecture is unrelated to my laboratory work.	1	2	3	4	5	1	2	3	4	5
4	Operating the laboratory facilities are difficult.	1	2	3	4	5	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the laboratory.	1	2	3	4	5	1	2	3	4	5
6	I have a little chance to get to know other students in this laboratory group.	1	2	3	4	5	1	2	3	4	5
7	In this laboratory group, the solution to a given task is from my own thinking.	1	2	3	4	5	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	1	2	3	4	5
9	The laboratory facilities work fine.	1	2	3	4	5	1	2	3	4	5
10	The laboratory room is readily available at any time.	1	2	3	4	5	1	2	3	4	5
11	The members of this laboratory help each other.	1	2	3	4	5	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions that I do for the same problem.	1	2	3	4	5	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5	1	2	3	4	5
14	The laboratory facilities are adequate enough to cope with the laboratory tasks.	1	2	3	4	5	1	2	3	4	5
15	Outside my normal laboratory schedule, I have to wait if I want to use laboratory room.	1	2	3	4	5	1	2	3	4	5
16	I get to know students in this laboratory group well.	1	2	3	4	5	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigation on my own.	1	2	3	4	5	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5	1	2	3	4	5
19	The available laboratory facilities enables student to make good use of the laboratory.	1	2	3	4	5	1	2	3	4	5
20	I can gain access to the laboratory outside my normal schedule.	1	2	3	4	5	1	2	3	4	5
21	I am able to rely on other students for help during laboratory session.	1	2	3	4	5	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	1	2	3	4	5

No.	Statement	Actual					Preferred				
		Almost Never	Seldom	Some Times	Often	Almost Always	Almost Never	Seldom	Some Times	Often	Almost Always
23	The topics covered in lectures are quite different from topics which I deal in laboratory sessions.	1	2	3	4	5	1	2	3	4	5
24	The laboratory facilities are in good working condition.	1	2	3	4	5	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	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/her name in this laboratory group.	1	2	3	4	5	1	2	3	4	5
27	In my laboratory sessions, the instructor decides the solution of the given problem.	1	2	3	4	5	1	2	3	4	5
28	What I do in laboratory sessions helps me to comprehend the theory covered in lectures.	1	2	3	4	5	1	2	3	4	5
29	The laboratory facilities are suitable for testing the electronics system I am required to use.	1	2	3	4	5	1	2	3	4	5
30	It is difficult for me to find a free time slot when I want to use the laboratory room.	1	2	3	4	5	1	2	3	4	5
31	I work cooperatively in these laboratory sessions.	1	2	3	4	5	1	2	3	4	5
32	In my laboratory session, I decide the solution of the given problem.	1	2	3	4	5	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5	1	2	3	4	5
34	When I make mistake, the laboratory facilities does not damage (except the fuse of digital multi meters).	1	2	3	4	5	1	2	3	4	5
35	There are enough laboratory facilities for student to use.	1	2	3	4	5	1	2	3	4	5
	PART II (AEQ)										
36	I do not think I will ever use what I learned in these subjects.	1	2	3	4	5	1	2	3	4	5
37	I feel comfortable when a conversation turns to electronics system.	1	2	3	4	5	1	2	3	4	5
38	There is no use to learn electronic system.	1	2	3	4	5	1	2	3	4	5
39	It is fun to find out how electronics systems work.	1	2	3	4	5	1	2	3	4	5
40	These subjects provided me with skills I expect to use in the future.	1	2	3	4	5	1	2	3	4	5
41	I feel at ease when I am around laboratory.	1	2	3	4	5	1	2	3	4	5
42	My future career will require knowledge of electronics system.	1	2	3	4	5	1	2	3	4	5
43	I enjoy using laboratory facilities.	1	2	3	4	5	1	2	3	4	5
44	These subjects have increased my technical skills.	1	2	3	4	5	1	2	3	4	5
45	Working with electronics system design makes me very nervous.	1	2	3	4	5	1	2	3	4	5

No.	Statement	Actual					Preferred				
		Almost Never	Seldom	Some Times	Often	Almost Always	Almost Never	Seldom	Some Times	Often	Almost Always
46	In the future there are many devices will embedded with electronics system.	1	2	3	4	5	1	2	3	4	5
47	I think designing electronics system would be enjoyable and stimulating.	1	2	3	4	5	1	2	3	4	5
48	I gained few useful skills from these subjects.	1	2	3	4	5	1	2	3	4	5
49	I get a sinking feeling when I think about trying to design electronics system.	1	2	3	4	5	1	2	3	4	5
50	Electronics systems are one of important factors in the success of an entrepreneur.	1	2	3	4	5	1	2	3	4	5
51	The challenge of creating electronics system does not appeal me.	1	2	3	4	5	1	2	3	4	5
52	The knowledge gained in these subjects are too specific so it will not relevant in the future.	1	2	3	4	5	1	2	3	4	5
53	Electronics system makes me feel uncomfortable.	1	2	3	4	5	1	2	3	4	5
54	In the future the use of electronics system will increase.	1	2	3	4	5	1	2	3	4	5
55	I would like to work with laboratory facilities.	1	2	3	4	5	1	2	3	4	5
56	These subjects helped develop my problem-solving skills.	1	2	3	4	5	1	2	3	4	5
57	Electronics system makes me feel uneasy and confused.	1	2	3	4	5	1	2	3	4	5
58	All tertiary students need a course about electronics system.	1	2	3	4	5	1	2	3	4	5
59	I enjoy learning electronics system.	1	2	3	4	5	1	2	3	4	5
60	As a result of these subjects I feel confident about tackling unfamiliar problems involving electronics.	1	2	3	4	5	1	2	3	4	5
61	I feel aggressive and angry toward electronics system.	1	2	3	4	5	1	2	3	4	5
62	Knowledge of the use electronics system will help me get a job.	1	2	3	4	5	1	2	3	4	5
63	Learning about electronics system is boring.	1	2	3	4	5	1	2	3	4	5

Appendix D

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI) AND

ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

REVISED

ACTUAL AND PREFERRED FORMS

(Indonesian Version)

Appendix D

ELECTRONICS LABORATORY ENVIRONMENT INVENTORY (ELEI)
AND
ATTITUDES TOWARDS ELECTRONICS QUESTIONNAIRE (ATEQ)

ACTUAL AND PREFERRED FORM
(Indonesian Version)

PETUNJUK

- Ini bukan sebuah test.
- Partisipasi anda dalam survey ini adalah sukarela.
- Data yang dikumpulkan akan tetap menjadi rahasia.
- Kuesioner ini hanya membutuhkan waktu 15 menit untuk menyelesaikannya.
- Pernyataan- pernyataan berikut ini membahas mengenai ***'kenyataan' dan 'harapan'*** pada pelaksanaan kegiatan laboratorium yang telah anda ikuti.
- Tidak ada jawaban ***'benar'*** atau ***Salah*** . Yang diharapkan adalah ***'Pendapat'*** anda.
- Kuesioner berikut berisi pernyataan tentang kenyataan yang terjadi pada laboratorium anda. Anda akan diminta untuk menjawab seberapa sering kejadian tersebut terjadi. Kolom **'Aktual'** untuk menerangkan seberapa sering hal tersebut **benar-benar terjadi**. Sedangkan kolom **'Harapan'** adalah untuk menerangkan harapan yang anda inginkan terjadi (semacam daftar keinginan).
- Lingkarilah angka-angka sebagai berikut:
  1. Apabila pada kenyataan Hampir tidak pernah
  2. Apabila pada kenyataan Jarang
  3. Apabila pada kenyataan Kadang-kadang
  4. Apabila pada kenyataan Sering
  5 Apabila pada kenyataan Hampir selalu
- Jangan menjadi ragu apabila ada beberapa pernyataan yang hampir sama.
- Berikan pendapat anda pada semua pernyataan yang ada.
- Apabila anda berubah pendapat, berilah ***'tanda silang'*** pada angka yang dibatalkan dan ' ***lingkarilah*** ' angka pengganti yang
- anda pilih.

CONTOH

Pernyataan: Saya dapat bersahabat dengan praktikan lainnya pada group praktikum ini..

Yang perlu anda lakukan adalah mempertimbangkan apakah anda dapat bersahabat dengan praktikan lainnya pada group praktikum ini.

'Hampir tidak pernah', Jarang , 'Kadang-kadang', Sering', 'Hampir selalu'.

Apabila anda berpendapat hal itu Sering terjadi, maka lingkarilah angka 4 pada kuestioner yang anda isi.

Nomor Induk Mahasiswa : ______________

Matakuliah : *) ☑ pilih nama matakuliah ketika pengambilan kuesioner ini.

☐ 1. Elektronika Terpadu

☐ 2. Teori Rangkaian Listrik

☐ 3. Elektonika Diskrit

☐ 4. Sistem Digital

☐ 5. Sistem Pengaturan Lanjutan

☐ 6. Aplikasi Mikroprosesor

☐ 7. Pemrosesan Sistem Digital

☐ 8. Robotika / Mekatronika

Angkatan : ______

Kelas : ______

Pernah membuat sistem elektronik : ya/ tidak

Jika Ya, sistem: ☐ power supply

☐ amplifier

☐ radio

☐ Sebutkan, ______________________________

Definisi:

- Fasilitas Laboratorium termasuk power supply, multi meter, oscilloscope, signal generator, papan digital signal processing, papan-papan eksperimen, modul mikroprosesor/ mikrokontroler, dan lain-lain.
- Sistem Elektronika termasuk sistem minimum, rangkaian elektronika, motor servo, atau proyek elektronik untuk tugas rancang laboratorium, proyek kelas, dll.

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
	PART I (ELEI)										
1	Saya dapat bersahabat dengan praktikan lainnya pada group praktikum ini.	1	2	3	4	5	1	2	3	4	5
2	Saya berkesempatan menyalurkan minat saya pada bidang elektronik.	1	2	3	4	5	1	2	3	4	5
3	Apa yang saya dapatkan di kuliah tidak berkorelasi dengan materi praktikum.	1	2	3	4	5	1	2	3	4	5
4	Pengoperasian fasilitas/ peralatan laboratorium sulit.	1	2	3	4	5	1	2	3	4	5
5	Laboratorium sangat padat ketika saya menggunakannya.	1	2	3	4	5	1	2	3	4	5
6	Saya tidak banyak kesempatan untuk mengenali praktikan lain pada group praktikum ini.	1	2	3	4	5	1	2	3	4	5
7	Pada group praktikum ini, jawaban untuk tugas yang diberikan merupakan hasil pemikiran saya sendiri.	1	2	3	4	5	1	2	3	4	5
8	Materi praktikum tidak berhubungan dengan topik yang sedang dipelajari di perkuliahan.	1	2	3	4	5	1	2	3	4	5
9	Fasilitas laboratorium berfungsi dengan baik.	1	2	3	4	5	1	2	3	4	5
10	Ruangan praktikum dapat digunakan setiap saat.	1	2	3	4	5	1	2	3	4	5
11	Sesama praktikan saling tolong menolong.	1	2	3	4	5	1	2	3	4	5
12	Pada sesi praktikum, praktikan lainnya memberikan solusi yang berbeda pada masalah yang sama.	1	2	3	4	5	1	2	3	4	5
13	Materi kuliah terintegrasi dengan kegiatan laboratorium.	1	2	3	4	5	1	2	3	4	5
14	Fasilitas laboratorium cukup memadai untuk tugas praktikum.	1	2	3	4	5	1	2	3	4	5
15	Di luar jadwal praktikum, saya harus menunggu bila ingin menggunakan ruangan laboratorium.	1	2	3	4	5	1	2	3	4	5
16	Saya mengenali setiap praktikan pada group praktikum dengan baik.	1	2	3	4	5	1	2	3	4	5
17	Saya didorong untuk berkreasi di luar materi praktikum yang diberikan, dan melakukan penelitian sendiri.	1	2	3	4	5	1	2	3	4	5
18	Saya menggunakan teori perkuliahan selama kegiatan praktikum.	1	2	3	4	5	1	2	3	4	5
19	Fasilitas laboratorium yang tersedia dapat digunakan praktikan.	1	2	3	4	5	1	2	3	4	5
20	Saya dapat meminjam ruangan laboratorium di luar	1	2	3	4	5	1	2	3	4	5

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
	jadwal normal saya.										
21	Saya dapat mengandalkan rekan praktikan lainnya untuk membantu selama sesi praktikum.	1	2	3	4	5	1	2	3	4	5
22	Pada sesi praktikum, saya menyelesaikan soal yang berbeda-beda dibandingkan dengan praktikan lainnya.	1	2	3	4	5	1	2	3	4	5
23	Topik yang dipelajari pada perkuliahan sangat berbeda dengan topik yang dihadapi di laboratorium.	1	2	3	4	5	1	2	3	4	5
24	Fasilitas laboratorium dapat berfungsi baik.	1	2	3	4	5	1	2	3	4	5
25	Tersedia cukup waktu kosong dalam seminggu agar saya bisa menyelesaikan semua pekerjaan laboratorium dengan nyaman.	1	2	3	4	5	1	2	3	4	5
26	Membutuhkan waktu yang lama agar saya dapat mengenali setiap orang dengan namanya pada group praktikum.	1	2	3	4	5	1	2	3	4	5
27	Pada sesi praktikum, cara penyelesaian tugas ditentukan oleh asisten.	1	2	3	4	5	1	2	3	4	5
28	Apa yang saya lakukan di sesi laboratorium membantu saya dalam memahami teori yang dibahas di kelas.	1	2	3	4	5	1	2	3	4	5
29	Fasilitas laboratorium cocok untuk menguji sistem elektronik yang saya butuhkan.	1	2	3	4	5	1	2	3	4	5
30	Sangatlah susah bagi saya untuk menemukan waktu kosong ketika ingin menggunakan ruangan laboratorium.	1	2	3	4	5	1	2	3	4	5
31	Saya bekerja sama secara kooperatif pada sesi praktikum.	1	2	3	4	5	1	2	3	4	5
32	Pada sesi praktikum, cara penyelesaian tugas saya tentukan sendiri.	1	2	3	4	5	1	2	3	4	5
33	Kegiatan laboratorium dan materi perkuliahan tidak saling berhubungan.	1	2	3	4	5	1	2	3	4	5
34	Ketika saya melakukan kesalahan, fasilitas laboratorium tidak rusak (kecuali sikring pada multi meter digital).	1	2	3	4	5	1	2	3	4	5
35	Tersedia banyak fasilitas laboratorium yang dapat digunakan mahasiswa.	1	2	3	4	5	1	2	3	4	5

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
	PART II (AEQ)										
36	Saya tidak berpikir akan menggunakan apa yang sudah saya pelajari di mata kuliah-mata kuliah tersebut.	1	2	3	4	5	1	2	3	4	5
37	Saya merasa nyaman ketika diskusi mengarah pada sistem elektronika.	1	2	3	4	5	1	2	3	4	5
38	Tidak ada gunanya mempelajari sistem elektronika.	1	2	3	4	5	1	2	3	4	5
39	Adalah menyenangkan bila dapat mengetahui cara kerja suatu sistem elektronik.	1	2	3	4	5	1	2	3	4	5
40	Mata kuliah tersebut memberikan saya keahlian yang saya butuhkan di masa mendatang.	1	2	3	4	5	1	2	3	4	5
41	Saya merasa tidak tegang ketika berada di lingkungan laboratorium.	1	2	3	4	5	1	2	3	4	5
42	Karir di masa depan akan membutuhkan pengetahuan tentang sistem elektronik.	1	2	3	4	5	1	2	3	4	5
43	Saya suka memanfaatkan fasilitas labotarotium.	1	2	3	4	5	1	2	3	4	5
44	Mata kuliah tersebut telah meningkatkan kemampuan teknikal saya.	1	2	3	4	5	1	2	3	4	5
45	Bekerja dengan perancangan sistem elektronika membuat saya sangat tegang.	1	2	3	4	5	1	2	3	4	5
46	Di masa mendatang banyak peralatan yang menggunakan sistem elektronika.	1	2	3	4	5	1	2	3	4	5
47	Saya berpikir merancang sistem elektronik akan menyenangkan dan menantang.	1	2	3	4	5	1	2	3	4	5
48	Saya mendapatkan hanya sedikit kemampuan pada mata kuliah tersebut.	1	2	3	4	5	1	2	3	4	5
49	Saya merasa berat hati ketika mencoba merancang sistem elektronik.	1	2	3	4	5	1	2	3	4	5
50	Sistem elektronik adalah salah satu faktor penting dalam keberhasilan berwiraswasta.	1	2	3	4	5	1	2	3	4	5
51	Tantangan untuk membuat sistem elektronik tidak menarik.	1	2	3	4	5	1	2	3	4	5
52	Ilmu yang didapat dari matakuliah tersebut terlalu spesifik, sehingga tidak relevan di masa depan.	1	2	3	4	5	1	2	3	4	5
53	Sistem elektronik membuat saya merasa tidak nyaman.	1	2	3	4	5	1	2	3	4	5
54	Di masa mendatang penggunaan sistem elektronika semakin meningkat.	1	2	3	4	5	1	2	3	4	5
55	Saya senang bekerja dengan fasilitas laboratorium.	1	2	3	4	5	1	2	3	4	5
56	Mata kuliah tersebut membantu mengembangkan	1	2	3	4	5	1	2	3	4	5

No.	Statement	Kenyataan					Harapan				
		Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu	Hampir tak pernah	Jarang	Kadang-kadang	Sering	Hampir Selalu
	kemampuan pemecahan masalah saya.										
57	Sistem elektronik membuat saya gelisah dan bingung.	1	2	3	4	5	1	2	3	4	5
58	Semua mahasiswa yang kurang berprestasi memerlukan kursus sistem elektronik.	1	2	3	4	5	1	2	3	4	5
59	Saya menikmati belajar sistem elektronik.	1	2	3	4	5	1	2	3	4	5
60	Sebagai akhir dari pembelajaran matakuliah ini, saya merasa yakin mampu menangani masalah yang berhubungan dengan elektronik.	1	2	3	4	5	1	2	3	4	5
61	Saya merasa agresif dan marah terhadap sistem elektronik.	1	2	3	4	5	1	2	3	4	5
62	Pengetahuan penggunaan sistem elektronik akan membantu saya dalam mendapatkan pekerjaan.	1	2	3	4	5	1	2	3	4	5
63	Mempelajari topik sistem elektronik adalah membosankan.	1	2	3	4	5	1	2	3	4	5

Appendix E

SHORT DESCRIPTIONS OF ELECTRONICS COURSES

Table E1. Course Descriptions

No	Course Name	Credits (Theory/ Laboratory)	Description
1	Integrated Electronics	2/1	To give basic knowledge of how the operational amplifier (OP-AMP) works and its applications. Covers: summing and non-inverting amplifier, OP-AMP circuit design, non ideal effect of OP-AMP, frequency response, active filter (low pass filter, band pass filter, band stop filter, high pass filter), integrator and differentiator, oscillator, schmitt triger, multivibrator, and power amplifier.
2	Electric Circuit Theory	2/1	Gave the foundations of knowledge of the series of electricity to the students so as the student it was hoped was able to understand the method of analysing the series and his application of electricity, understood the LRC series procedure. Covers: Ohm's law, Kirchoff's law, resistance, inductance, conductance,
3	Discrete Electronics	4/1	To give basic knowledge of discrete electronics to student, so they can understand the works of electronics component and its applications. Covers: semiconductor theory; diode PN Junction; half wave and full wave rectifier circuit; filter and voltage regulators; bipolar transistor; equivalent circuits, forward bias voltage, DC load line of transistor; Common Emitter Amplifier, Common Collector Amplifier, Common Base Amplifier; Class A, B, and C Power Amplifier; JFET and MOSFET characteristics; JFET and MOSFET amplifier; Thyristor Characteristics, UJT, 4 layer diode, SCR, DIAC, and TRIAC.
4	Digital System	4/1	To give basic concept of combinatory circuit design, asynchronous and synchronous segmental digital system design in designing digital system theoretically and practically using various logic components. Covers: logic and digital definition, logic equation simplification, combinatorial logic circuit design, logic gate component, sequential circuit principles, asynchronous sequential circuit, synchronous sequential circuit.

5	Advanced Control System	4/2	To give basic principles of analog control system, digital control system, sensor, actuator, analog to digital converter, digital to analog converter, z transform, stability and stabilisation of discrete system, digital controller, state space, analysis. Covers: The introduction to Discrete Time Control System and the Sampling Theory, Z transformation, characteristics of the Z transformation, inverse of z transformation, configuration of the discrete control system, realisation of digital controller / digital filter, analysis of stability in Z field, analysis model state space system.
6	Microprocessor Application	4/1	The students could understand the use of the microprocessor and microcontroller as well as could connect it with various sorts peripheral, so as to be able to develop intellect to draft and complete problems that they're dealing with. Covers: The microprocessor and the memory, the microprocessor and interface, the microprocessor and input / output, programmable peripheral interface, programmable timer, programmable interrupt controller, the censor and ADC-DAC, the application of the microprocessor for the regulation, input / output, multiprocessor communication, and microcontroller MCS 51.
7	Digital Signal Processing	2/1	To give the students fundamental knowledge of Digital Signal Processing in order the students know the Techniques of Digital Signal Processing. Covers: Introduction, representation of the convolution, quoting process, ADC and DAC, Discrete Fourier Transformation, signal reconstruction, Fast Fourier Transformation (FFT), Finite Impulse Response Filter, Infinte Filter, Impulse Response, Digital Controller.

8	Robotics/ Mechatronics	2/2	To study the field mechatronics covering the foundation mechatronics, the electric and mechanics systems modelling, control system, sensing system and vision. Covers: General comprehension of mechatronics, mathematics and mechanics as aiding tools, System Element and Physical Modelling, kinematics, dynamics, tracks, control, Motivator Element and Censor, computer based control, mobile robot, vision.

Adapted from Anonymous (2003)

Appendix F

HISTORY OF ELECTRONICS AND ITS APPLICATIONS

Table F1. History of Electronics and its Applications

Electronic	
600 B.C.	Thales of Miletus writes about amber becoming charged by rubbing - he was describing what we now call static electricity.
1600	English scientist, William Gilbert first coined the term "electricity" from the Greek word for amber. Gilbert wrote about the electrification of many substances in his "De magnete, magneticisique corporibus". He also first used the terms electric force, magnetic pole, and electric attraction.
1660	Otto von Guericke invented a machine that produced static electricity.
1675	Robert Boyle discovered that electric force could be transmitted through a vacuum and observed attraction and repulsion.
1729	Stephen Gray's discovery of the conduction of electricity.
1733	Charles Francois du Fay discovered that electricity comes in two forms which he called resinous(-)and vitreous(+). Benjamin Franklin and Ebenezer Kinnersley later renamed the two forms as positive and negative.
1745	Dutch physicist, Pieter van Musschenbroek invented the "Leyden Jar" the first electrical capacitor. Leyden jars store static electricity.
1747	Benjamin Franklin experiments with static charges in the air and theorized about the existence of an electrical fluid that could be composed of particles.
1747	William Watson discharged a Leyden jar through a circuit, that began the comprehension of current and circuit.
1747	Henry Cavendish started measuring the conductivity of different materials.
1752	Benjamin Franklin invented the lightening rod - he demonstrated lightning was electricity.
1784	Charles Coulomb demonstrates the force between charges
1786	Italian physician, Luigi Galvani demonstrated what we now understand to be the electrical basis of nerve impulses when he made frog muscles twitch by jolting them with a spark from an electrostatic machine.
1791	Luigi Galvani reveals electricity in every animal
1799	First electric battery invented by Alessandro Volta. Volta proved that electricity could travel over wires.
1820	Relationship of electricity and magnetism confirmed by Hans Christian Oersted who observed that electrical currents effected the needle on a compass
1820	Andre Ampere demonstrates that a current carrying conductor has a magnetic effect and conductors can attract or repel each other. Marie Ampere, who discovered that a coil of wires acted like a magnet when a current is passed thorough it .
1820	D. F. Arago invented the electromagnet.
1821	First electric motor by Faraday.
1823	Sturgeon made an electromagnet by winding wires carrying an electric current around iron
1826	Ohms Law (Georg Simon Ohm) - "conduction law that relates potential, current, and circuit resistance"
1827	Joseph Henry's electromagnetic experiments lead to the concept of electrical inductance. Joseph Henry built one of the first electrical motors.
1831	Michael Faraday demonstrated principles of electromagnetism induction, generation and transmission.
1831	Henry made an electric bell in the US and described how to make a practical electric motor
1840	A rechargeable Galvanic battery was devised, with metal or carbon plates in weak acid
1841	J. P. Joule's law of electrical heating published.
1850's	Gustav Robert Kirchhoff introduced a series of laws of voltage and current
1862	James Clerk Maxwell developed the equations to describe Faradays work and much more
1873	James Clerk Maxwell wrote equations that described the electromagnetic field, and predicted the existence of electromagnetic waves traveling with the speed of light.
1873	Scientists May and Smith experiment with selenium and light, this opens the door for inventors to transform images into electronic signals.
1880	Windmills produced electricity in the US

1883	Transformer invented.
1884	Steam turbine invented.
1886	William Stanley develops transformer and Alternating Current electric system.
1886	Frank Sprague builds first American transformer and demonstrates use of step up and step down transformers for long distance AC power transmission in Great Barrington, Massachusetts.
1888	Rotating field AC alternator invented by Nikola Tesla.
1888	Heinrich Rudolph Hertz showed that Maxwell's predictions were correct
1895	Wilhelm Rontgen discovered X-rays
1897	Electron discovered by J. J. Thomson.
by 1900	the equations, laws and relationships had been established – now electronics, power generation and calculating equipment could be developed.
1902	French physicist George Claude invents neon light.
1903	William Coolidge invents ductile tungsten used in lightbulbs.
1907	Lee De Forest invented the electric amplifier.
1908	Edison invented a new kind of dry cell battery using Leclanche's 1866 idea to produce a disposable energy storage device
1910	Ernest R. Rutherford measured the distribution of an electric charge within the atom.
1913	Robert Millikan measured the electric charge on a single electron.
1924	Kattan invented a propeller-like water turbine for hydro electric power stations
1925	Maxfield perfected an electrical system of recording using a microphone
1932	Chadwick discovered the neutron, a chief particle of the atom with no electric charge
1940s	Printed circuits made of copper wire and insulating board began to be used in electronic equipment throughout the decade
1954	The solar cell invented by Chaplin, Fuller and Pearson.
1958	Gordon Gould invents the laser.
1960	The halogen lamp invented.
1970	The liquid-crystal display (LCD) invented by James Fergason.
1977	Magnetic resonance imaging invented by Raymond V. Damadian.
1979	Molecules in a semi liquid state were used for LCD (Liquid Crystal Display)
1986	A high-temperature super-conductor invented by J. Georg Bednorz and Karl A. Muller.
1988	High temperature superconductors were used to make Peoppel's electric 'meissner motor' and in Moon and Raj's frictionless bearings, the first practical uses found for superconductors

Radio and telecommunication

1831	Joseph Henry's and Michael Faraday's work with electromagnetism makes possible the era of electronic communication to begin
1837	Morse invented the electric telegraph and the Morse code
1862	Abbe Giovanna Caselli invents his "pantelegraph" and becomes the first person to transmit a still image over wires.
1876	Bell patented the telephone
1877	Edison invented the phonograph to record and playback sound, using a needle on a tin foil cylinder
1880	Inventors like Bell and Edison theorize about telephone devices that transmit image as well as sound. Bell's photophone used light to transmit sound and he wanted to advance his device for image sending. George Carey builds a rudimentary system with light-sensitive cells.
1883	Thomas Edison invents the valve
1887	Heinrich Hertz transmits a radio wave
1896	Guglielmo Marconi sends telegraph signals through the air
1896	Aleksander Popov sends first radio message
1901	Heaviside predicted the existence of a layer of the atmosphere which reflects radio signals
1901	Marconi establishes radio communication across the Atlantic
1904	Korn used Elster's photoelectric cell to scan photographs and send them by telegraph wire
1906	Lewis Nixon invents the first sonar like device.
1906	Fessenden invented AM Radio and made the first spoken radio broadcast

1912	Edwin Armstrong built the first regenerative circuit and first nonmechanical oscillator
1915	Radio signals transmitted across USA
1918	The superheterodyne radio circuit invented by Edwin Howard Armstrong. Today, every radio or television set uses this invention.
1919	Short-wave radio invented.
1920	The allies perfected ASDIC-an echo-sounder to locate underwater objects and U-boats (now call sonar)
1923	The Marcony company brought out an electronic valve hearing aid
1924	The dynamic loudspeaker invented by Rice and Kellogg.
1931	Wilkins and Walton-Watt used radio waves to detect distant aircraft-radio detection finding
1931	Rowe and De Armond found a way of electrically converting the vibrations of guitar strings into amplified sound
1933	Frequency modulation (FM radio) invented by Edwin Howard Armstrong.
1937	Reber built a radio telescope to study newly discovered radio waves from space
1939	Randall and Boot created a cavity magnetism, a powerful microwave generator used in radar and microwave ovens
1939	Two-way radio communication by 'walkie-talkie' began with military use
1947	Mobile phones first invented. Although cell phones were not sold commercially until 1983, AT&T came up with the idea way back.
1948	Cable television is introduced in Pennsylvania as a means of bringing television to rural areas. A patent was granted to Louis Parker for a low-cost television receiver.
1955	Optic fiber invented.
1956	The modem invented.
1962	The audio cassette invented.
1963	NASA's geostationary satellite allowed pictures and sounds to be transmitted from almost any point on the Earth's surface
1966	Xerox invents the Telecopier - the first successful fax machine.
1969	ARPANET - the first Internet started.
1971	VCR or videocassette recorder invented.
1971	The USSR and US setup space stations. Information and superb pictures have been sent by distant space probes using digital transmissions, which converts signals into binary code
1973	The ethernet (local computer network) invented by Robert Metcalfe and Xerox.
1957	A moveable radio telescope with a 76 metre dish, was built at Joderell Bank England
1958	Olsen built the first electronic music synthesiser for RCA
1977	Fibre optic telephone cables could transmit 30 times more signal than copper wires
1979	First cellular phone communication network started in Japan..
1980	Sony Walkman invented.
1988	Digital cellular phones invented.
1988	Doppler radar invented by Christian Andreas Doppler.
1990	The World Wide Web/Internet protocol (HTTP) and WWW language (HTML) created by Tim Berners-Lee.
1994	American government releases control of internet and WWW is born - making communication at lightspeed.

Television

1876	Boston civil servant George Carey was thinking about complete television systems and in 1877 he put forward drawings for what he called a "selenium camera" that would allow people to "see by electricity." Eugen Goldstein coins the term "cathode rays" to describe the light emitted when an electric current was forced through a vacuum tube.
1884	Paul Nipkow sends images over wires using a rotating metal disk technology calling it the "electric telescope" with 18 lines of resolution.
1900	At the World's Fair in Paris, the 1st International Congress of Electricity was held, where Russian, Constantin Perskyi made the first known use of the word "television.
1906	Lee de Forest invents the "Audion" vacuum tube that proved essential to electronics. The Audion was the first tube with the ablity to amplify signals. Boris Rosing combines Nipkow's disk and a cathode ray tube and builds the first working mechanical TV system.

1907	Campbell Swinton and Boris Rosing suggest using cathode ray tubes to transmit images - independent of each other, they both develop electronic scanning methods of reproducing images.
1924 – 1925	American Charles Jenkins and John Baird from Scotland, each demonstrate the mechanical transmissions of images over wire circuits. Jenkin's Radiovisor Model 100 circa 1931, sold as a kit. Baird becomes the first person to transmit moving silhouette images using a mechanical system based on Nipkow's disk. Vladimir Zworykin patents a color television system.
1925	Logie Baird's mechanical TV system and Zworykin's electronic iconoscope device heralded the start of TV
1926	John Baird operates a 30 lines of resolution system at 5 frames per second.
1927	John Logie Baird transmits TV over telephone lines
1927	Bell Telephone and the U.S. Department of Commerce conduct the first long distance use of TV, between Washington D.C. and New York City on April 9th. Secretary of Commerce Herbert Hoover commented, "Today we have, in a sense, the transmission of sight for the first time in the world's history. Human genius has now destroyed the impediment of distance in a new respect, and in a manner hitherto unknown." Philo Farnsworth files for a patent on the first complete electronic television system, which he called the Image Dissector.
1928	Baird transmits TV over radio waves
1929	Vladimir Zworykin demonstrates the first practical electronic system for both the transmission and reception of images using his new kinescope tube. John Baird opens the first TV studio, however, the image quality was poor.
1930	Charles Jenkins broadcasts the first TV commercial. The BBC begins regular TV transmissions.
1930	Baird transmits pictures and sound
1932	NBC installs first TV antenna
1936	About 200 hundred television sets are in use world-wide. The introduction of coaxial cable, which is a pure copper or copper-coated wire surrounded by insulation and an aluminum covering. These cables were and are used to transmit television, telephone and data signals. The 1st "experimental" coaxial cable lines were laid by AT&T between New York and Philadelphia in 1936. The first "regular" installation connected Minneapolis and Stevens Point, WI in 1941. The original L1 coaxial-cable system could carry 480 telephone conversations or one television program. By the 1970's, L5 systems could carry 132,000 calls or more than 200 television programs.
1939	RCA begins regular broadcasting
1940	Peter Goldmark invents a 343 lines of resolution color television.
1941	The FCC releases the NTSC standard for black and white TV.
1946	Peter Goldmark, working for CBS, demonstrated his color television system to the FCC.
1953	Successful colour TV transmissions were made in US
1960s	Colour TV over the world
1969	July 20, first TV transmission from the moon and 600 million people watch.
1981	NHK demonstrates HDTV with 1,125 lines of resolution.
1984	Stereo TV broadcasts approved.
1988	Pocket-sized TV sets became available
1996	Web TV invented.

Computers

1642	Blaise Pascal creates mechanical adding and subtracting machine
1673	Gottfried Wilhelm von Leibniz adds multiplication and division
1823	Charles Babbage adds trigonometric functions
1911	Monroe invented a compo metre calculator which could multiply and divide by the turn of a handle
1937	IBM joins computer industry
1942	John Atanasoff and Clifford Berry built the first electronic digital computer.
1943	Colossus I, the first programmable electronic-computer, was built in the UK to decipher wartime enemy codes

1946	University of Pennsylvania creates first electronic computer
1948	A stored-program computer write a 'memory' was made by von Neumann
1956	The first computer hard disk used.
1965	The compact disk invented by James Russell.
1967	The electronic hand-held calculator was invented at Texas Instrument by Jack Kilby, Jerry Merryman, and James Van Tassel.
1968	The computer mouse invented by Douglas Engelbart.
1968	Robert Dennard invented RAM (random access memory).
1970	The floppy disk invented by Alan Shugart.
1970	The daisy-wheel printer invented.
1971	The 4004 was Intel's first microprocessor by Faggin, Hoff and Mazor. This breakthrough invention powered the Busicom calculator and paved the way for embedding intelligence in inanimate objects as well as the personal computer.
1971	The computer floppy disc invented.
1972	The 8008 was twice as powerful as the 4004. A 1974 article in Radio Electronics referred to a device called the Mark-8 which used the 8008. The Mark-8 is known as one of the first computers for the home --one that by today's standards was difficult to build, maintain and operate.
1975	The laser printer invented.
1976	The ink-jet printer invented.
1978	The 8088 the brains of the IBM PC invented.
1979	Cray supercomputer invented by Seymour Cray.
1984	The CD-ROM invented.
1993	The pentium processor invented.
1999	The Pentium III invented.
2000	The Pentium 4 processor. The processor debuted with 42 million transistors and circuit lines of 0.18 microns. Intel's first microprocessor, the 4004, ran at 108 kilohertz (108,000 hertz), compared to the Intel Pentium 4 processor's initial speed of 1.5 gigahertz (1.5 billion hertz). If automobile speed had increased similarly over the same period, you could now drive from San Francisco to New York in about 13 seconds.
2003	The Intel Pentium M processor, the Intel 855 chipset family, and the Intel PRO/Wireless 2100 network connection are the three components of Intel Centrino mobile technology. Intel Centrino mobile technology is designed specifically for portable computing, with built-in wireless LAN capability and breakthrough mobile performance. It enables extended battery life and thinner, lighter mobile computers.

Solid- State Era

1904	John Ambrose Fleming creates first diode
1906	Lee De Forest invented the triode valve, used in amplifiers until the transistor replaced it
1947	William Shockley, John Bardeen and Walter H. Brattain invent the transistor
1958	Texas Instruments develops the first integrated circuit (IC)
1961	Fairchild Instruments makes first commercial IC
1962	Kirby's 1958 silicon chip, the first integrated circuit, was patented by Texas Instrument
1970s	Microprocessor chips were increasingly used as microcomputers to regulate the working of engines, machines, and machine tools, making them more efficient
1972	Intel Corporation makes the first microcomputer
From 1972	Many companies made microchip pocket calculators, miniature computers
1976	The Cray I supercomputer was the first 'number cruncher' capable of 150 million arithmetical operations/ second. It contains half a million transistors in a single chip

Miscellaneous

1901	Hubert Booth invents a compact and modern vacuum cleaner.
1902	Willis Carrier invents the air conditioner.
1906	Fisher designed an electric washing machine
1913	Electric refrigerator.
1921	John Larson invented the lie detector.
1931	Knoll and Ruska's electron microscope could magnify matter by up to 12,000 times

1937	Chester F. Carlson invents the photocopier.
1939	The electron microscope invented.
1941	Enrico Fermi invents the neutronic reactor.
1946	The microwave oven invented by Percy Spencer.
1952	Mullin and Johnson demonstrated an experimental video-tape recorder with stored TV pictures on magnetic tape
1961	The American Company Unimation, introduced industrial robots into factories
1973	Video first entered the home in the form Philips N1500 video recorder
1980s	Electronically controlled kitchen appliances, such as microwaves, washing machines, air conditioners, and dish washers widely available
1988	The 'fly-by-wire' Airbus A 320 had a computer to handle the controls
1991	The digital answering machine invented.

(Adapted from various sources)