Science and Mathematics Education Centre

Problem-based Learning at the Polytechnic Level in Singapore: Learning Environment, Attitudes and Self-Efficacy

Rodney Wong

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Declaration

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

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

Signature:

Date: 30 Jan 2016

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Abstract

Problem-based learning is a pedagogy in which students learn about a subject through engaging with a problem and generating hypotheses. Although problem-based learning was initially used in the fields of medical sciences and technology, it has since been incorporated into almost all fields of study and education levels. Just over 10 years ago a polytechnic was opened in Singapore, in which problem-based learning was implemented, institution-wide, as its main method of instruction. To enable this, a purpose-built campus, designed to facilitate the use of problem-based learning across all disciplines and schools, was constructed. The problem-based learning model used at McMaster University was modified to make it suitable for the polytechnic level. This new model, with the philosophical underpinnings of problem-based learning, was named One-Day, One-Problem™.

The overarching aim of this study was to examine the effectiveness of problem-based learning at the polytechnic level, in terms of students' perceptions of their newly-created learning environment, and their own attitudes and self-efficacy. The study involved a mixed-method approach in which both quantitative and qualitative data were collected. Quantitative data were collected using two surveys, one to assess students' preferences and perceptions of their learning environment, and the other to assess student attitudes towards the pedagogy and academic efficacy. Important qualitative information, used to help to explain the quantitative overview, was gathered using semi-structured focus group meetings and telephone interviews.

The sample involved a total of 447 graduates (graduated within the last two years) who had been exposed to problem-based learning (n=260) and lecture-based instruction (n=187). The two groups of graduates were comparable in terms of their education level, competency in English, age and demographics. From the sample of 260 graduates who had been exposed to problem-based learning, 42 graduates volunteered to participate in the focus group and telephone interviews.

To examine whether relationships existed between the graduates' perceptions of their learning environment and attitudes, simple correlation and multiple regression were used. The results of the simple correlation analysis indicated that all eight of

the learning environment scales were positively and significantly related to both of the attitude scales. The interpretation of the standardised regression weights indicated that three of the scales, Student Cohesiveness, Task Orientation and Personal Relevance, were significant independent predictors of both Attitudes Towards the Pedagogy ($p<0.01$) and Academic Efficacy ($p<0.01$); and one scale, Involvement, was a significant independent predictor of Academic Efficacy ($p<0.01$).

To examine the effectiveness of problem-based learning, differences in graduates' perceptions of their learning environment and their attitudes were compared for the two instruction types (problem-based and instruction-based). To do this, a one-way multivariate analysis of variance (MANOVA) was performed, with the instruction types as the independent variable and the eight learning environment scales and two outcome scales as the dependent variables. The results indicated that there were statistically significant differences for five of the eight learning environment scales: Student Cohesiveness ($p<0.05$, $F=7.38$, effect size=-0.35); Involvement ($p<0.01$, $F=43.09$, effect size=0.62); Task Orientation ($p<0.01$, $F=9.18$, effect size=0.29); Cooperation ($p<0.05$, $F=4.97$, effect size=0.21); and Young Adult Ethos ($p<0.05$, $F=5.16$, effect size = 0.22). Statistically significant differences were also found for both of the outcome scales, namely Attitude Towards the Pedagogy ($p<0.05$, $F=4.42$, effect size=0.21), and Academic Efficacy ($p<0.01$, $F=19.07$, effect size=0.38). With one exception, Student Cohesiveness, graduates who had been exposed to problem-based learning scored higher than their counterparts who had been exposed to lecture-based instruction. For the exception, Student Cohesiveness, graduates from the lecture-based learning environment scored lower than their counterparts who were exposed to lecture-based instructions.

Analysis of the qualitative data provided insights into the quantitative findings. The findings for Student Cohesiveness were surprising, given that problem-based learning relies heavily on interactions between group members. The findings from the qualitative data indicated that the lower scores could, in part, be related to personality differences, a lack of interpersonal skills within the groups as well as a lack of understanding of the roles of facilitators and students.

Overall, the qualitative information indicated that, in a problem-based learning environment, there was a strong sense of cooperation and teamwork. In addition, the approach used in problem-based learning provided students with direction and focus. Some graduates felt that problem-based learning encouraged self-directed learning, as an approach where learners take responsibility for their own learning process. They were, however, not always clear on what was expected of them and, in some cases, felt that they were not confident that they were doing the right thing.

To examine whether there were differences in terms of the person-environment fit for the graduates exposed to the different instruction type, an analysis of covariance (ANCOVA) was used. The results indicated that, after adjustment for the preferred learning environment, there was a statistically significant difference for four of the eight learning environment scales: Student Cohesiveness (F=4.93, p<0.05); Involvement (F=6.86, p<0.01); Task Orientation (F =5.60, p<0.05); and Young Adult Ethos (F=4.97, p<0.05). When adjusting for the preferred learning environment, all scales with a statistically significant difference, with the exception of Student Cohesiveness, scored higher for those graduates who had been exposed to a problem-based learning environment when compared to those from a more lecture-based learning environment.

The research reported in this thesis is significant in a number of ways. First, the study is one of only a handful of studies in the field of learning environments that has been carried out at the polytechnic level. Second, the study is, to the best of my knowledge, the first learning environment study to be carried out in a problem-based setting in Singapore. The results are timely as the institution is still in its early stages of development and they could, therefore, provide valuable insights towards the implementation of problem-based learning in the local context of post-secondary education in Singapore.

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CHAPTER 1
Introduction

1.1 Introduction

Problem-based learning has become commonplace as an educational and training method in medical schools around the world (Woods, 2000). More recently it has been used in a range of educational settings outside of medicine. Problem-based learning requires students to use scenarios in which they define their own learning objectives and find ways to understand and meet the critical demands of the problem. In doing so, students are required to think critically about the nature of the problem, generate ideas and acquire the knowledge and skills required for a better understanding of the problem. As an instruction style, problem-based learning has been found to lead to improved performance in examinations as well as in dealing with people in their work life (Barrows & Kelson, 2001). The study reported in this thesis examines the effectiveness of problem-based learning at the polytechnic in Singapore, in terms of graduates' perceptions of the learning environment and attitudes. It is underpinned by a post-positivist view and used an explanatory mixed-method approach towards the study. With this in mind, Chapter 1 sets the tone for the study, providing the context (in terms of the country and education practices) and the pedagogy (problem-based learning). The chapter is organised into the following sections:

- Use of terminologies (Section 1.2);
- Education in Singapore (Section 1.3);
- Problem-based learning: Theory and practice (Section 1.4);
- Objectives of the study (Section 1.5);
- Significance of study (Section 1.6); and
- Overview of the thesis (Section 1.7).

1.2 Use of Terminologies

To avoid confusion, this section defines and explains three terminologies used throughout this thesis: pedagogy (as opposed to andragogy), problem-based learning and lecture-based learning.
For simplicity and consistency and to avoid confusion between the use of the words pedagogy and andragogy, the word pedagogy will be used throughout this thesis to encapsulate the art and science of teaching and learning. The rationale for this choice is as follows.

At the Penn State World Campus Resources Centre, pedagogy was defined as a term associated with teaching children, but it is often used interchangeably with andragogy (Moore & Shattuck, 2001). Andragogy is an approach to education that is based on assumptions about adult learning which suggest that adults: need to know why they need to learn something; need to learn experientially; need to approach learning as problem-solving; and learn best when the topic is of immediate value (Knowles, Holton, Elwood & Swanson, 2012).

Andragogy is a theory of adult education that was developed by Knowles (1984), who asserted that andragogy (Greek: 'man-leading') should be distinguished from the more commonly used term pedagogy (Greek: 'child-leading'). Knowles later changed his position on whether andragogy applied only to adults and decided that pedagogy and andragogy represented a continuum, ranging from teacher-directed to student-directed learning, and that both approaches were appropriate with children and adults, depending on the situation (Merriam, Caffarella & Baumgartner, 2012). As such, the terms pedagogy and andragogy do not represent a transition in time or a continuum from young learners to adult learners. Rather, the terms are considered to be more a situational event that could occur at any age.

For these two reasons, and for simplicity, I have elected to use the term pedagogy to refer to the art and science of teaching and learning. In addition, the term pedagogy refers to how teaching occurs, the approach to teaching and learning, the way content is delivered and what students learn because of these processes. Accordingly, this thesis investigates the pedagogical landscape with reference to the situation rather than to changes in learning patterns overtime.

Throughout the thesis, references are made to two forms of instructional practices, problem-based learning or problem-based instruction, and lecture-based instruction, both of which are considered to be types of instruction. In the context of this study, problem-based learning is an instructional type in which the teaching and learning is highly student centred. The practice of problem-based learning is detailed in Section 1.4.1, and a review of literature is provided in Section 2.2.

Lecture-based instruction, on the other hand, refers to the more traditional form of instruction that is teacher-centred, involving formal lectures that are supplemented with tutorials or some other forms of group learning activities. These activities are generally held in classrooms and are used to varying degrees by teachers and academics.

1.3 Education in Singapore

This section provides the context for the research, describing the background to the socio-political and economic climate that supports and influences Singapore's educational landscape. The section begins with a description of Singapore in terms of its achievements as a developed nation (Section 1.3.1). This is followed by an overview of Singapore's education system (Section 1.3.2) and the policy initiatives from the government that have influenced the education landscape (Section 1.3.3). The final section provides a rationale for Singapore's decision to build a new polytechnic that offers problem-based learning as an institution-wide pedagogical practice (Section 1.3.4).

1.3.1 Singapore: Achievements and Perspectives

Singapore, officially known as the Republic of Singapore, is a modern city state that lies off the southern tip of the Malaysian Peninsula. Based on the data from an official website reporting statistical information generated by the Singapore government (Singapore Government, 2015), Singapore has been, for the last 10 years, one of the world's major commercial hubs, the fourth largest financial centre and one of the top two busiest container ports. Singapore is placed high in international rankings, with respect to standard of living, healthcare, education and economic competitiveness. At the time of writing this thesis, it was the only Asian country to hold an AAA financial rating, from global credit rating agencies such as Standards and Poor's, Moody's, and Fitch.

By the end of 2014, Singapore's population was recorded at approximately 5.5 million people, of which 2.1 million was comprised of foreign nationals. As such, Singapore is considered to be an immigrant country, with nationals from around the world living together, and is one of the world's most globalised countries.

1.3.2 The Education System

The Singapore education system is primarily organised and managed by the Ministry of Education. The Ministry controls the development and administration of the state schools which receive government funding. In addition, the Ministry also takes an advisory and supervisory role with respect to private schools and learning institutions. For both private and state schools, there are variations in the extent of autonomy in their curriculum, scope of government aid and funding, tuition burden on the students, and admission policy (Goh & Gopinathan, 2008).

The Singapore education system has been tailored from the British Education system, stemming from the days when Singapore was a British colony (from 1819 till 1959). In 1960, the local government in Singapore introduced a bilingual policy and English became the official language for both integration and utilitarian purposes. The Singapore education system involves a 10 year structure of basic education. The education system starts at pre-school, where children attend kindergarten for two years, up to the age of six. Students then proceed to primary school at seven years of age. At the end of six years of primary school education, students sit a national examination, known as the Primary School Leaving Examination (PSLE). The results determine the secondary school that they are able to access.

At the secondary school level, students can choose to attend an express stream (four years of secondary education) or a normal stream (five years of secondary education). A minority of students may target specialised schools that cater for special needs or integrated programs (such as the International Baccalaureate diploma program). At the end of their secondary education (either four or five years depending on the stream they were enrolled in) students take the GCE O-level examination. Performance in this examination not only determines whether students continue with further studies or enter the work force, but also their access to junior colleges, polytechnics and local universities.

For those students who are eligible to go on to further studies, the transition to tertiary education after their O level examinations takes two to three years. Students can choose to attend two years at a junior college (leading to an A-level qualification and entry to a university) or three years at a polytechnic (leading to a diploma qualification and entry to a university with advanced standing as an option). Advance standing allows students to access the second year of a university program or have selective exemptions on specific subjects.

For students who fall out of mainstream education at this stage, there are alternate pathways within private education where they can achieve their education goals. These alternative routes provide a means for students to achieve a university degree by obtaining a diploma from a private education provider (offering foreign university degrees) that has been approved by the Singapore Ministry of Education. Alternative pathways have also been developed where working adults with work experience can apply for recognition of prior learning to help them achieve a university degree. These alternative routes can provide advanced standing pathways that are accepted in the United Kingdom (UK), Australia, New Zealand and private universities in the United States.

Within Singapore, there are also two universities that students can choose to attend. The National University of Singapore (NUS) is Singapore's flagship university and is ranked first in Asia, as listed in the Quacquarelli Symonds (QS) ranking for Asian Universities, and twelfth in the annual World University Ranking for 2015/16 (QS World University Rankings®, 2015). Singapore’s second university, the Nanyang

Technological University, is ranked thirteenth on the same scale (QS World University Rankings®, 2015). The McKinsey Report (Mourshed, Chijioke & Barber, 2010), which examines the characteristics of school systems that consistently produce students who perform well in international benchmarking tests, placed Singapore high on its list of the world's best-performing school systems. The World Economic Forum's Global Competitiveness Report 2011/2012 (Schwab, 2012) also ranked Singapore fourth in the world for the quality of its education system. A third university, Singapore Management University opened in 2000, followed by two other public universities, the Singapore Institute of Technology (in 2009) and the Singapore University of Technology and Design (in 2012).

1.3.3 The Changing Education Landscape

In 1965, Singapore broke away from Malaysia and became an independent republic. It was of key importance to the government, at that time, to build an education system that would meet the demands for a skilled labour force relevant to its industrial skills requirements, and to introduce a common language (English) for both local and international business. By the 1980s, Singapore's economy began to grow and prosper. In 1997, the republic was faced with the challenge of supporting its growing demands for human capital. At this time, the Ministry decided to strategically intervene to help schools to stay relevant (Goh & Gopinathan, 2008). New methods in science and technology were making some qualifications redundant (for example, big data trends and the use of predictive analytics, bio-informatics, robotics, nanotech and material sciences and wireless technology). Further, as with many countries around the world, there was an increasing need for students to have the ability to continuously learn so that they would be equipped to cope with the increasing rate of change in technology and processes (Tan, Sharan & Lee, 2007). It was also becoming apparent that the range of skills needed in industry at the end of the twentieth century was not going to be the same as in the next century.

In 1997, the Ministry of Education (Singapore) launched the 'Thinking Schools, Learning Nation' initiative (Kozma, 2005; Tan, 2005). The initiative signalled a shift in the education policy in Singapore. As part of this initiative, the Ministry of Education fostered greater autonomy at the school level, particularly in regard to curriculum development and implementation (Kozma, 2005). The 'Thinking Schools Learning Nation' policy provided an important blueprint that was designed to meet the changing trends of this century, and to describe the outcomes of education at each stage of a citizen's development (Ministry of Education, Singapore, 2009). These outcomes of education included: 1) being a confident person (one who has a strong sense of right and wrong, is discerning in judgment); 2) a self-directed learner (one who takes responsibility for their own learning, who questions, reflects and perseveres in the pursuit of learning); 3) an active contributor (one who is able to work effectively in teams, exercises initiative and innovation); and 4) a concerned citizen (a citizen with a strong civic consciousness, is informed, and takes an active role in bettering the lives of others around him) (Ministry of Education, Singapore, 2009). It was at this time that problem-based learning was considered to be one of the methods that could potentially move the teaching and learning initiative for a 'Thinking Schools Learning Nation' into practice (Tan, 2005).

Subsequently, in 2004, the 'Teach Less, Learn More' vision was introduced by the Prime Minister in his National Day Rally speech. The key thrust of the 'Teach Less, Learn More' vision, was to improve the quality of interaction between teachers and learners so that there was less emphasis on rote learning and repetitive testing, and more emphasis on experiential and discovery learning, differentiated teaching, and the development of lifelong skills and character (Lateef, 2010). The vision was also a means of continuing the government's drive for innovation and enterprise for national development (Ng, 2008). This new vision was intended to complement the earlier 'Thinking Schools, Learning Nation' initiative.

1.3.4 Building a New Polytechnic

Singapore's former Minister of Education, Mr Teo Chee Hean, explained in an interview that, with the increasing numbers of students choosing to enrol in polytechnic-level education (Lau, 2007), it had become necessary to look at how Singapore should respond to this segment of the population. A decision needed to be made as to whether Singapore would emulate what other countries had done (by increasing the intake numbers at the current polytechnics) or building new polytechnics. The minister reasoned that in countries such as the UK and Hong

Kong, which had converted polytechnics to universities, there were limited options for students to pursue further education. For example, in Hong Kong, a country with an economy comparable to Singapore, only 18 per cent of the top young people were provided with places within the universities. Mr Teo pointed out that students in Hong Kong who were leaving school after their O levels had limited opportunities and choices for further education. In the UK, attempts to fill the vocational training gap left by the polytechnics (that were amalgamated into universities), created difficulties for both academics and students. For example, the introduced units that were more vocational and hands on such as tourism and hospitality were difficult to convert into A-level examination subjects, as they did not fit well. Drawing on the experiences of other countries, educational planners anticipated that converting polytechnics to universities would create a gap in an important segment for training and limit the education opportunities for young people.

The Singapore government looked to the US, where there was a system that provided comparable access to further education. For example, the Californian system had three tiers of tertiary education. In this system, post-secondary education included two universities (the University of California which took 12 to 15 per cent of the cohort, and the California State University which took 25 to 30 per cent of the cohort), and community colleges (which took a further tier of the cohort). The system was comparable to the Singapore education system, insofar as polytechnic graduates received a diploma, equivalent to an associate degree, and they could proceed to a university. A study carried out by Mr Teo's ministry indicated that, by strengthening both the university and the polytechnic sector, Singapore would be able to put approximately 20 per cent of eligible students through its university system and 40 per cent of eligible students through the polytechnic systems, thus, providing 60 per cent of students with tertiary education and greater choices of careers for post-secondary graduates.

In 2001, it was decided to retain the polytechnic pathway in Singapore. The question then was whether to increase student capacity at existing polytechnics by 25 per cent or build another polytechnic. It was thought that expanding the existing four polytechnics would create overcrowded facilities that were already at capacity and propagate more of the same practices. It was decided, therefore, that a new polytechnic would be built and would include a new and innovative teaching method, known as problem-based learning (Lau, 2007). While problem-based learning was not a new idea, it was the first time that a major educational institution was to apply it in a systemic and pervasive way in Singapore.

The new polytechnic was intended to be an expression of Singapore's strategic initiative to stay ahead in the global field of education, and was in line with both the 'Teaching Schools Learning Nation' initiative (Sale, 2000) and the 'Teach Less, Learn More' vision (Lateef, 2010). As such, the new polytechnic was to make teaching and learning "more relevant and to develop exceptional strengths among Singaporeans" through creating "a great place for young people to cultivate their talents, particularly for those who prefer to learn through application and practice" (Lau, 2007, p. 6). At the opening of the polytechnic in 2007, Mr Tharman Shanmugaratnam, Minister for Education, said "while problem-based learning has been used in varying degrees in existing polytechnics, at Republic Polytechnic however, it was going to be what defines the curriculum" (Lau, 2007, p. 18).

1.4 Problem-based Learning: Theory and Practice

This section is divided into two parts. The first, Section 1.4.1, defines the theoretical perspectives of problem-based learning, and the second, Section 1.4.2, describes how problem-based learning is applied and used in a post-secondary education institution.

1.4.1 Theoretical Perspectives

Problem-based learning is a methodology that uses problems as the triggers for learning. The philosophy behind problem-based learning is based on the importance of collaboration in problem solving and personal reflection. At the polytechnic level, problem-based learning is intended to educate students in core subjects while enhancing their knowledge outside the traditional lecture-based instruction type of teaching and learning. More details with respect to problem-based learning are provided in Chapter 2.

Problem-based learning began in the mid-1960s at McMaster University's Medical School in Canada (Neufeld & Barrows, 1974) when students were found to have difficulties with some of the first year courses, were not motivated and did not see the relevance of the issues discussed in these courses (Barrows & Tamblyn, 1980). In a bid to address this, the medical school began to use realistic medical problems that students were required to deal with in their courses. According to Barrows (1996), introducing the problems in the courses was not the innovative element but, rather, making them the starting point in the learning process (for students), before any other curriculum input is taught or learnt. According to Savin-Baden and Major (2004), Donald Woods of McMaster University was the first to use the term problem-based learning to describe the pedagogy. Since then, problem-based learning can be considered one of the few curriculum-wide educational innovations developed in the nineteen-sixties (Schmidt, Cohen-Schotanus & Arends, 2009)

Barrows and Kelson (2001) describe problem-based learning as both a curriculum and a process. That is, the curriculum consists of carefully selecting and designing problems that demand from the learner the acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies and team participation skills.

An important point related to the problems that are crafted for use in problem-based learning is that it is not the same as using cases or issues for problem solving. Problem solving involves students 'receiving' knowledge from sources such as lectures, ideas, or hand-outs, and subsequently applying this knowledge to a problem (Savin-Baden, 2000). For example, this process is tantamount to making a cake when one is provided both the recipe and the ingredients. The defining characteristic of problem-based learning, on the other hand, is that students are presented with a problem at the start of the learning process. Taking the cake analogy again, problem-based-learning might involve the challenge of preparing a celebratory meal for which there are no ideas of a cake, any recipes, or any of the ingredients suitable for a celebratory event. Elements of prior knowledge, habits, rituals, practices, sharing of knowledge and experiences begin the learning process, with a facilitator guiding its progress.

Yew and Schmidt (2011) described the components of a problem-based learning model as having the following features. The learning is student-centred, and learning takes place in small groups of no more than 10 people. The problem stimulates the learning process and the facilitators guide, rather than teach, their students. The problem becomes the vehicle for learning problem-solving skills and methods, and stimulates the students' cognitive abilities and curiosity through peer pressure, which reinforces the learning process.

1.4.2 Problem-based Learning in Practice

The application of problem-based learning at Republic Polytechnic, the new polytechnic, was drawn from established principles taken from the work of renowned authors in the field of problem-based learning. These concepts included challenging the students to: connect prior knowledge with new knowledge; explore knowledge concepts in different contexts and settings (Spiro, Feltovich, Jacobson & Coulson, 1992); experiment with how to use knowledge in various contexts which support the viability of their ideas (von Glasersfeld, 1995, 2001); and appreciate how they personally construct knowledge and make meaning of these ideas (Mayer, 1996). Given that most examples of problem-based learning were at the university level, the use of problem-based learning required modification before it could be used at the polytechnic level.

The fundamental structure of the problem-based learning model used at Republic Polytechnic was adapted from the work of Woods (1985, 1994, 2000) while he was at McMaster University. The problem-solving model at McMaster involved three meetings that were spread over a period of one week (Hamilton, 1976). It comprised a goal meeting, which established the scope and expectations of the problem under investigation, and a period for investigation and research. This was interjected with a teaching and learning meeting and an elaboration/feedback meeting at the end of the week (Woods, 1994). Research and study periods by students were organised between each of these meetings. At the end of each week, students were expected to submit a report or a reflective journal intended to demonstrate the students' competency in synthesising the information they had learned and using feedback and the sharing of information from other group members to finalise and present their results. At the end of the week, it was anticipated that students would share the research that they had undertaken, the literature that they reviewed, and significant findings that they have discovered in the process.

At the Republic Polytechnic, however, the 'problems' used were reduced in scope and size and the methodology developed to provide one problem per day. The development and implementation of problem-based learning at Republic Polytechnic adopted three key features that were important in bringing the different aspects of the pedagogy into a single, operational, learning environment (Sockalingam & Schmidt, 2012). These features include:

- The 'crafting' of the problem statement or 'Problem Crafting' (described in Section 1.4.2.1);
- Modifying the structure of the three meetings over a week into a day of teaching and learning, labelled as One-day, One-problem™ (described in Section 1.4.2.2); and
- Modifying the assessment methods used to support the teaching and learning framework (described in Section 1.4.2.3).

Each of these is elaborated below.

1.4.2.1 Problem Crafting

At the heart of problem-based learning at the Republic Polytechnic is the purposeful 'crafting' of a problem. A suitable problem is strategically designed to anchor the knowledge to be learnt around the problem and involves taking a constructivist approach towards solving the problem (Yew & O'Grady, 2012). The module chairperson and curriculum designer essentially blend the problem with the curriculum, and translate the curriculum into daily teaching and learning methods that include practical problems and exercises.

The problems are designed to enable students to build new knowledge through discovery, sharing and building on prior knowledge (Sockalingam & Schmidt, 2012). To this end, the Republic Polytechnic has developed significant expertise in the science of ‘problem crafting’, which brings together all the elements of problem-based learning (Sockalingam & Schmidt, 2012; Yew & O'Grady, 2012).

The curriculum controls the scope of the problem for each class. As an example, students could be doing experiential learning, such as running round a mountain to observe certain practices of the tribesmen in the mountain, or going to a factory to observe facets of how workers do things in the factory. In problem-based learning, the problem comes first. The problem is thus created around the mountain or in the factory. This allows the curriculum designers and academics to anchor the knowledge that they want the students to learn through designing a problem, or a series of problems, that may occur on the mountain or in the factory. These problems based on the curriculum are designed to engage students. Problem ‘crafting’ is thus a skill shared by the curriculum designer and the module chair, with feedback from facilitators who collectively translate the curriculum into a daily framework for teaching and learning, in a structure called One-day, One-problem™ (described in the next section).

1.4.2.2 One-Day, One-Problem™

One-Day, One-Problem™ is the method used to administer the pedagogical practices of problem-based learning at the Republic Polytechnic. Students are challenged each day with a problem that has been crafted from their curriculum (as described above). The concept of the three meetings and a reflection journal at McMaster University, developed by Woods, formed the fundamental framework leading to the structure of the One-day, One-problem™ methodology (Yew & O'Grady, 2012). To make problem-based learning suitable for the polytechnic education level (as opposed to university), the three meetings that were spread over a week at McMaster University were reduced to problems that could be solved in one day. To enable this, the problems were reduced in complexity.

Each module at the Republic Polytechnic lasts one semester (about 16 weeks), with five modules being taught each semester. A student takes up to five different modules a week in one semester or ten modules a year for a three-year polytechnic diploma. The class sizes in all modules and disciplines are restricted to a maximum of 25 students.

The students work in groups of five and are required to work with the same group for the day (Yew & Schmidt, 2012). The selection of students in each group depends on the facilitator, who endeavours to ensure that the combination will present the best learning outcomes for all team members. Some facilitators may try to balance the strengths of the members in each group while others may allow students to migrate between groups and find their best fit for group members.

The students are required to study up to five subject modules a week. For each subject module, the classes generally start at around 9:00 am and end between 3:30 and 4:30 pm. These daily sessions are summarised in Table 1.1 below. The sessions included three meetings that are interspersed with two study periods. These are expanded on below.

Table 1.1 One-Day, One Problem™ Class Routine

Learning Period*	Duration**	Description of learning activities
Meeting 1	1 hour	Exploration of problem and learning methods.
Study period 1	1 hour	Self-directed research and collaborative learning.
Meeting 2	1 hour	Facilitators provides feedback and guidance. Formulation of possible responses to problem and overcoming learning obstacles.
Study period 2	2 hours (inclusive of lunch break)	Group consolidates ideas, finalises responses to the problem.
Meeting 3	2 hours	Group presentations and critique. Facilitators provide feedback and summary of learning points and issues. Daily assessments are held after Meeting 3.

Adapted from Yew and O'Grady (2012)

* Sequences for Meetings 2 and 3 may be interchanged by the facilitator subject to the topic and intended learning for the day

** Durations are approximate and subject to change depending on the situation.

The first meeting of the day typically begins by breaking the students into their designated groups. The facilitator then presents them with a 'problem pack' that includes pre-planned worksheets, the problem statement, guides, and resources needed to understand the problem.

During the discussion time at the first meeting, the facilitator moves between the various groups to provide guidance and support and to encourage students to share their initial responses to the problem by recalling any prior knowledge and assumptions they think could be brought to the table for review and discussion. This first meeting usually ends with the students in each group taking away ideas and approaches that they might use to solve the problem. In some instances, where important specific prior knowledge is required, mini lectures are incorporated into the sessions.

Following the first meeting, students move into the first study period, during which the group members investigate and discuss the problem and decide upon the research that will be needed. This research may be carried out either independently or collectively. The students usually stay in close proximity to their group members so that they can be actively involved in discussions, negotiations, peer teaching, and the sharing of information and ideas that emerge. During this study period, students use physical or on-line library resources, assign responsibilities, work out an action plan, and share information with one another.

From this first study period, students then regroup for the second meeting, where difficult topics might be explained by the facilitator. This meeting provides opportunities for students to elaborate upon ideas that were discussed during the study period and to explore different points of view. During this meeting, the facilitator helps students to clarify misunderstandings or difficulties and to facilitate the building of their conceptual understanding. The facilitator also suggests additional areas that they can research that might assist them in their learning. As students relate and discuss their findings and their learning from the study period (with the facilitator and other class members), the facilitator asks questions that guide students in connecting their ideas, and encourage them to think more critically about specific areas related to their work and how they might usefully progress. Where appropriate, the facilitator makes use of scaffolding tools, such as questions in work sheets, resource materials, and/or web information to help direct students to alternative sources of information.

From this meeting, students move to the second study period that usually lasts for two hours, including a lunch break. This study period is generally used to finalise the team's response to the problem and to prepare and rehearse a presentation for the final meeting. During this study period, students develop a learning artefact that represents how they solved the problem and a verbal explanation that is used to demonstrate their understanding of the problem.

During the third meeting, which is held in the afternoon, each group is expected to provide a response to the problem statement that was defined in the first meeting. The meeting provides an opportunity for members to present either as individuals or as a group. This reporting phase allows the students to demonstrate their understanding of the problem and the facilitator to assess their understanding. During this phase, the facilitator plays an important role in providing a learning environment that is conducive to class discussion and for sharing ideas.

This third meeting ends with the facilitator presenting how an expert would have approached the problem, including the sources of information that would have been most helpful, how he or she would have analysed the information, and the recommended solution to the problem. An important task of the facilitator during this meeting is to consolidate the ideas generated by all of the teams and to reinforce and share the learning for the day.

1.4.2.3 Assessing Learning at the Republic Polytechnic

At the Republic Polytechnic, the academic achievement of students aims to reflect the students' process skills level and their capacity to understand, as opposed to the recall of content (Magdeleine, Lew & Schmidt, 2012). To capture the level of achievement in problem-based learning, multiple assessment methods are used throughout the semester. These include, but are not restricted to, the assessment of the students' presentations and participation in class. In this way, the module grade provides a reflection of students' continuous effort, rather than a one-off occurrence (such as an examination).

In addition to the presentations made at the end of the day, assessment also includes daily tests that are completed online. These tests are similar to quizzes and are made up of multiple-choice and short answer-type questions designed to gauge students' recall of the day's learning. As there are 14 to 16 learning activities per module, each student receives daily grades for each module. These assessments, designed to complement the One-day, One-problem™ methodology, take into account a student's engagement with knowledge, their ability to use or situate theory in practice and their participation in collaborative learning.

The capacity to understand the subject matter that was included in each module is assessed using four half-hour tests, known as Understanding Tests. These four tests are carried out at different points during the semester.

The final module grade is determined by using the sum of the average of the best 14 out of 16 daily grades and the average of the best three out of four understanding test grades. Although modifications have taken place over the years, the fundamental purpose of the tests and daily grades has remained the same, that is, to create a holistic assessment of the student that reflects their process skill level and their capacity to understand.

To increase confidence and to assure parents that problem-based learning using the conceptual learning process of One-day, One-problem™ is unique, the Ministry of Education trademarked the methodology to protect its application. It was anticipated that such trademark protection would prevent confusion in the market should another institution decide to introduce a different teaching method with the same label.

The following section provides the specific objectives of the study, the significance of the study to the education community of Singapore, and an overview of the structure of the thesis.

1.5 Objectives of the Study

The overarching aim of the study reported in this thesis was to examine the effectiveness of problem-based learning in terms of learning environments, perceptions, attitudes and self-efficacy. To address this aim, four research objectives were delineated.

As a first step, it was necessary to develop an instrument that could be used to assess students' perceptions of the learning environment created in this unique problem-based setting. Also, given that many attitude surveys have been developed for use at the high school level, it was necessary to modify a survey method from existing instruments that could be used with graduates from the polytechnic level, in order to assess students' attitudes towards the pedagogy and its academic efficacy. To ensure that these instruments were reliable when used with my sample, the first research objective was:

Research Objective 1

To develop and validate instruments suited for use with graduates at the polytechnic level, to assess:

a. Perceptions of their learning environment; and,
b. Attitudes and academic efficacy.

While past studies have claimed that the learning environment could improve students' attitudes (Barr & Tagg, 1995; Major & Palmer, 2001; Schmidt, Dauphinee & Patel, 1987), it is only natural that administrators, course planners, academics and parents in Singapore would want to clarify what aspects of the learning environment are likely to improve student outcomes. To examine these relationships, the second research objective was delineated.

Research Objective 2

To determine whether there are associations between the natures of polytechnic-level learning environments and graduates':

a. Attitudes, and,

b. Academic efficacy.

The introduction of problem-based learning at post-secondary level is relatively new. Up until the opening of Republic Polytechnic, the institution-wide use of problem-based learning was unheard of in Singapore. Before this time, the use of problem-based learning was relatively ad hoc or set up solely in response to a specific classroom situation or problem. As indicated earlier, it was unclear whether exposing students to problem-based learning for all of their subjects would bring shifts in their perceptions of the learning environment or improvements in their attitudes. Given the governments' investment in the infrastructure, coupled with the lack of evidence about such a learning approach, it was considered important to determine whether the use of problem-based learning was perceived as effective in terms of the learning environment and attitudes. Further, if this was the case, then it was important to determine causal explanations for the differences and whether these were linked to problem-based learning. With this in mind, the third research objective was developed.

Research Objective 3

To investigate the effectiveness of problem-based learning in terms of graduates':

a. Perceptions of the learning environment,
b. Attitudes towards the pedagogy, and,
c. Academic efficacy.

Person-environment fit is the degree to which individual and environmental characteristics match. Past research in education settings has found substantial variations between the environments of different settings. Person-environment congruence refers to the extent to which the preferences of individuals are in keeping with the perceived or actual environment (Fraser & Fisher, 1983b; Moos, 1987). In theory, then, the environmental demands are likely to impact on a range of outcomes. Therefore, this study sought to examine the person-environment fit for graduates exposed to problem-based learning when compared to those who were not. Accordingly, the fourth research objective was defined.

Research Objective 4

To examine the effectiveness of problem-based learning in terms of person-environment fit.

1.6 Significance of the Study

This study is significant in a number of ways. This section provides a brief outline of the significance of the present study, which is expanded on in Chapter 5.

- First, this study is significant in that it is the first learning environment study to assess graduates' preferences and perceptions of problem-based learning, and whether there were statistically significant differences in perceptions and preferences when compared with a lecture-based instruction type.

- Second, the results of the study are likely to be of significance to a range of stakeholders, including policy makers at the polytechnics, curriculum designers, and local administrators, academics and facilitators.

- Third, the study is anticipated to have important theoretical and practical implications for administrators, academics and facilitators in knowing whether the problem-based learning instruction method (created for the polytechnic students) is associated with more positive student attitudes and better academic efficacy.

- Fourth, the study provides methodological contributions through its development of two questionnaires, one to assess preferences and perceptions of the learning environment at the polytechnic level, and another to assess students' outcomes in their learning environment in terms of their attitudes towards the pedagogical practices and their academic self-efficacy. As such, the study makes available a practical, economical and reliable questionnaire that can be used by institutions of higher learning. The data collected can be used as a basis for them to review current professional development, examine the effects and determinants of the learning environment, and help to guide improvements.

1.7 Overview of the Thesis

This thesis is organised into five chapters, which are summarised below. Chapter 1 provides an introduction and background information for the present study. It begins with an overview of the research site, describing the country's economic achievements in education and its bold initiative to introduce problem-based learning into post-secondary education at the polytechnic level. With this background, the chapter outlines the purpose and objectives of the study and how the results from the research can be of significance to a range of stakeholders, including academics and curriculum planners. The chapter closes with a brief overview of each chapter in the study.

Chapter 2 reviews the literature pertinent to the study. It focusses on an in-depth review of literature related to problem-based learning before reviewing the literature pertaining to the field of learning environments. The chapter concludes with a discussion of research into person-environment fit, before reviewing literature related to student attitudes and efficacy.

Chapter 3 details the research design and methods used in the study. It describes the steps taken in the development of the new questionnaire that was used. The chapter goes on to detail the sample and the sampling techniques. The chapter then describes the ways in which the data were collected and then analysed to address each of the research objectives. The chapter ends with a description of the ethical considerations made and steps taken to ensure that risks were minimised and no harm was done to the participants.

Chapter 4 reports the findings of the four research objectives of the study. The first research objective provides evidence of the validity and reliability of the instruments to provide support for the results of subsequent questions. The second research objective reports whether the learning environment was associated with more positive student attitudes and efficacy for polytechnic graduates in Singapore. The third research objective assesses the effectiveness of problem-based learning in terms of the learning environment, attitudes and self-efficacy. The final research objective reports the person-environment fit for graduates exposed to problem-based learning compared to those who were not.

Chapter 5, the concluding chapter, provides a summary and discussion of the study's findings, and brings together the implications of the study. The chapter expands on the contributions of the research and its findings, and points out the limitations of the study. The chapter concludes by offering recommendations as a basis for guiding practical improvements in the continued implementation of problem-based learning.

CHAPTER 2
Literature Review

2.1 Introduction

Whereas the previous chapter provided the context and background for the study and identified the specific research objectives, this chapter provides a review of the literature pertinent to this study and is organised under the following headings:

- Problem-based learning (Section 2.2);
- Field of learning environments (Section 2.3);
- Person-environment fit research (Section 2.4);
- Role of attitudes in learning (Section 2.5); and
- Academic efficacy
- Chapter summary (Section 2.6)

2.2 Problem-based Learning

Chapter 1 defined problem-based learning as a learner-centred approach to teaching and learning, and provided information about its philosophical underpinnings and how it was applied in practice in Singapore under a methodology known as One-Day, One-Problem™. This section provides a description of the events that influenced the development of problem-based learning (Section 2.2.1); an overview of problem-based learning and its characteristics and features (2.2.2); a summary of the different approaches used in problem-based learning (Section 2.2.3); and, empirical evidence related to the effectiveness of problem-based learning (Section 2.2.4).

2.2.1 Precursors to Problem-based Learning

Schmidt (2012) identified three key sources of influence that he described as precursors of problem-based learning. The first was the work of Dewey (1938), who developed the idea that learning would be more interesting if the learner was actively involved in his or her own learning (Section 2.2.1.1). The second source of influence was the book by Jerome Bruner's (1961) *Learning by Discovery*, which suggested that a problem could be the starting point where learning and discovery begins (Section 2.2.1.2). The third source of influence was the case method used at Harvard University in the 1930s, where complex real-life cases were presented to students for solutions (Section 2.2.1.3).

2.2.1.1 Dewey's Learning Through Problem Solving

In 1938 John Dewey (1933, 1938), an American philosopher, psychologist and educational reformer, proposed a carefully developed theory of experience and its relationship to education. The philosophical underpinning of Dewey's theory was: first, that experience arises from the interaction of two principles, continuity and interaction; and, second, that education was the reconstruction of experience.

Dewey, together with several educators of his time, developed this idea into practice by using project-based methods as part of the learning curriculum in classroom activities that were constructivist in nature. Dewey established an experimental laboratory school at the University of Chicago that was based on the philosophy that learning was more effective if the learners participated in the process. At the school, children worked on small group projects to solve problems, thus engaging in active learning. It was anticipated that by involving students in their own learning, they would develop an intrinsic interest in the subject, thereby developing self-directed learning.

In his learning theory, Dewey emphasised learning-by-doing through hands-on projects, expeditionary learning and experiential learning. These all were based on the principal that people, including children, were not blank slates waiting to be filled, but rather, they develop fact-based comprehension through prior knowledge, personal thoughts that influence their thinking, and prior experiences, preconceptions and knowledge. As such, the educators' role was to create educative experiences rather than stand at the front of the room providing information to passive students. In his pedagogic creed, Dewey (1929) asserted that the teacher was a partner in the learning process, guiding students to discover meaning independently within the subject area.

2.2.1.2 Bruner's Learning by Discovery

Jerome Bruner developed learning by discovery as a method of instruction (Bruner, 1959). Bruner's work addressed the formation of concepts in learning, in which he theorised that when people try to give meaning to aspects of reality or to understand new information, they do so by creating an understanding grounded in prior knowledge. Bruner contended that learning by discovery was achieved by challenging students with problems, during which they clarified their doubts, learned through questioning and discussion with peers and drew on prior knowledge. It was anticipated that this approach stimulated a deeper insight into reality, increased skills in thinking, fostered intrinsic motivation to learn, and facilitated the assimilation and retention of information that was of personal significance to the learner.

Bruner is often credited with originating discovery learning. However, some educationists see his ideas as similar to those of earlier writers (such as Dewey). Bruner argues that the practice of discovering for one's self teaches one to acquire information in a way that makes it more available in problem solving (Bruner, 1961). According to Bruner (1961), the self-discovery process enables learners to understand the information better and to find the information more workable in solving the problem. Bruner (1961) further suggested that learning by discovery during problem-solving situations enables the learner to draw on their own experience and prior knowledge. This process engages students to interact with their environment by exploring and manipulating objects or issues, wrestling with questions and controversies, or performing experiments to discover new knowledge, better ideas, or better understanding of the problem and develop more viable solutions.

2.2.1.3 The Harvard University Case Method

Problem-based learning also has its roots in the case method. This instruction method involves a teaching and learning approach where students are presented a case, thus placing them in the role of a decision maker facing a problem (Hammond, 2002). The (Harvard) case method was first introduced at the Faculty of Health Sciences at McMaster University in Canada in 1969, and was later adapted for use in a variety of disciplines in addition to medicine (Barrows, 1996).

In the case method classroom, both the instructor and the student are active in different ways. Each is dependent on the other to bring about teaching and learning. Instructors are generally experts, but they rarely deliver their expertise directly. The case method typically offers a description of the situation or problem relevant to the professional practice and feeds a process of decision-making. Very often, the pertinent information is accompanied by irrelevant details to avoid giving away the solution. The role of the student is to outline an optimal policy, considering all limiting conditions, and to demonstrate why the adopted policy is rational. In this respect, the case method, according to Fraser (1931), was not based on any theoretical notion regarding the nature of human learning and understanding, but is rooted in the practical experiences of lecturers, as in the Law Faculty of Harvard University and the Harvard Business School.

When the case method was initially introduced, there was little research carried out to establish its effectiveness (Schmidt, Rotgans & Yew, 2011). Further, according to Beckman (1972), research that was related to the case method was related to affective and attitudinal outcomes, and the researchers found that students preferred the case method to other forms of education.

The use of the case method did not draw much attention until it underwent modifications and was re-introduced as problem-based learning at Harvard Medical School in 1987 (Kaufman, 1998). At the medical school, students were presented with a clinical problem that they could solve only by learning the relevant medical knowledge. Since its successful implementation at that time, a number of other medical schools have officially adopted the approach. These include McMaster

Medical School, Harvard Medical School, University Of Missouri School Of Medicine, Monash University Faculty of Medicine and the University of Berkeley and University of San Francisco joint medical program, and several more worldwide medical school programs (Barrows, 1996). Currently, 70 per cent of medical faculties in the US use problem-based learning in the pre-clinical years (Albanese & Mitchell, 1993).

The following section provides a summary of how problem-based learning evolved from the time it started at McMaster University.

2.2.2 Overview of Problem-based Learning

Woods (2000) described problem-based learning as the integration of problem solving and personal reflection. As a teaching and learning method, problem-based learning seeks to engage the student in the core subject while, at the same time, providing them a learning experience outside of the traditional lecture-based schooling system. Schmidt (2012) goes further to describe problem-based learning as a curriculum delivery system that recognises the need to develop problem solving skills as well as helping students acquire knowledge and skills.

Expanding on the definitions of problem-based learning, this section provides an overview of the origins of problem-based learning (Section 2.2.2.1), its key features and characteristics (Section 2.2.2.2), as well as a description of problem-based learning in curricula (Section 2.2.2.3). Finally the section reviews past studies that have examined the effectiveness of problem-based learning (Section 2.2.2.4).

2.2.2.1 Origins

As mentioned earlier, the origins of problem-based learning were in the mid-1960s at the Medical School in McMaster University, Canada (Neufeld & Barrows, 1974). Students at the medical school were experiencing difficulties with some of the first year courses and were, in many cases, failing to see the relevance of the courses (Barrows & Tamblyn, 1980). To remedy these problems, the medical school used medical problems that involved real-life clinical problems as a stimulus for teaching and learning (Schmidt, 2012). According to Barrows (1996), the decision to introduce problems into the courses was made not because it was innovative but, rather, to ensure that the content was more relevant to students. According to Savin-Baden and Major (2004), Donald Woods of McMaster University was the first to use the term 'problem-based learning' to describe the pedagogy that was implemented. Since that time, problem-based learning is considered to be one of the few curriculum-wide educational innovations that was developed in the 1960s.

Fifty years later, problem-based learning become popular in many countries and across many disciplines. Curricula based on the principles and methods of problem-based learning have been adopted in Australia (Sanson-Fisher & Lynagh, 2005), Europe, and Asia (Antepohl & Herzig, 1999; Khoo, 2003; O'Neill, Morris & Baxter, 2000; Tiwari, Lai, So & Yuen, 2006). Moreover, it has been adopted across disciplines such as economics and business (Gijselaer, Tempelaar, Keizer, Blommaert, Bernard & Kasper, 1995), engineering (Dahlgren & Dahlgren, 2002), psychology (Loyens, Rikens & Schmidt, 2007), law (Moust & Nuy, 1987), and biology (Kendler & Grove, 2004).

In today's context, problem-based learning has shifted its focus from the acquisition of knowledge through problem-based learning to problem-based learning as an instrument for learning to reason and to solve problems (Schmidt, 2012). With the advent of the internet and the pervasiveness of information online and new technology, it is little wonder that these changes in education trends are happening. The goals of problem-based learning are now used to help students to develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills, and intrinsic motivation (Hmelo-Silver, 2004).

2.2.2.2 Characteristics and Features of Problem-based Learning

In spite of the many variations of problem-based learning that have evolved out of medical education, a core model to which others can be compared was developed by Barrows (1996). Barrows proposed six key characteristics that were common to all problem-based learning situations. These characteristics are outlined below.

1) *Learning is student centred*. In student centred learning, students receive guidance from a tutor, take responsibility for their own learning, identify what they need to know to better understand the lesson, manage the problem that they are working on and determine where they are able to get the information they need (from books, journals, on-line resources, facilitators' support etc.). This allows each student to personalise learning so as to concentrate on areas of limited knowledge or understanding and to pursue areas of interest.

2) *Learning occurs in small groups*. Groups are generally made up of five to eight students (Barrows, 1996) who are expected to share information and practices in solving the problem. Involvement of small groups is intended to give students experience with working intensively and effectively with a variety of different people. The size of the groups is intended to allow effective interaction among group members (Schmidt, 2012).

3) *Facilitators or tutors guide students rather than teach*. The role of a facilitator or tutor in problem-based learning is to guide students to think about the kinds of questions that they should be asking themselves so that they are better able to understand and manage the problem. It is anticipated that eventually students will take on this role themselves, challenging others in their groups.

4) *The problem forms the focus that stimulates learning*. In problem-based learning, the problem is the first input that students encounter. In the process of understanding the problem, students realise what they will need to learn. The problem thus gives students a focus for integrating information from the many disciplines. The problem also represents the challenge students will face in practice, thereby providing the relevance and motivation for learning.

5) *The problem is a vehicle for developing problem solving skills.* For a problem to be a vehicle for developing problem solving skills, it needs to be presented in the same way that it would occur in the real world. The format of the problem should also permit the students to ask questions, carry out necessary investigations and research or explore different sources for information (including internet searches) as they work their way through the problem. This

series of tasks prepares the students to take a proactive position, to organise themselves in responding to the problem and learning how they can delegate information gathering, identify causes and effects, share responsibilities and consolidate their findings and importantly, solve problems in groups.

6) *New knowledge is obtained through self-directed learning*. In problem-based learning students are expected to accumulate knowledge and expertise. Students are expected to learn in the same way that practitioners would, through independent learning, carrying out investigations and accumulating expertise by virtue of their own study and research. During such self-directed learning periods, students work together to discuss, compare, review and deliberate what they have learned to solve the problem.

The learning process, when using problem-based learning, thus always begins with a problem that describes an observable phenomena or event, as described by Schmidt (2012). Schmidt (2012) further describes that, before receiving any input (such as curriculum content), students are required to discuss the problem drawing on their prior knowledge. During this stage, students are encouraged to generate ideas and different perspectives and to organise the ideas that will form the basis for their research. From here, students examine relevant literature to help them to better plan their learning activities. In this process, students engage in knowledge construction and in sharing and evaluating their findings with members in the group.

2.2.2.3 Innovations in curricula

As discussed in the previous section, at the curriculum level, the starting point of students' learning experience is the problem. It is important, therefore, that the problem is structured and designed in ways that build on the prior knowledge of the students and elicits discussion between students, thereby stimulating self-directed learning and encouraging knowledge integration and transfer (Loyens, Kirshchner & Paas, 2011). Each of these points is expanded below.

The problem. At the heart of problem-based learning is the content of the curriculum, that is, the problem is what defines the curriculum (Lau, 2007). Effectively, students learn the fundamentals of the curriculum through looking at the problem from many different facets found in the problem – all of which are related to the curriculum. In medical subjects, these problems have traditionally originated from professional medical cases. In non-medical subjects, they can relate to problems or events of a particular domain of study (Barrows, 1996; Norman & Schmidt, 1992). To ensure that the problem is understood, in terms of their underlying theoretical explanations, there needs to be sufficient scaffolding for the brainstorming, the formulation of learning issues and students' self-study activities.

Building on prior knowledge. Anderson (1990) suggests that prior knowledge influences the quantity and quality of any new knowledge acquired. To participate effectively in the group discussions, students will need to be acquainted with at least part of this knowledge in order to understand and solve the problem or carry out the exercises. Where problems are too difficult (and prior knowledge is minimal or non-existent), students are likely to become frustrated or demotivated and, as a result, learning will be limited. If the problem is too easy, then students will be insufficiently challenged. Thus, the complexity of the problem needs to take into account the level of prior knowledge (Kirschner, Paas & Kirschner, 2009). Problems thus must be constructed so that students can draw on their prior knowledge and engage in discussion.

Eliciting discussion. For a problem to be effective, it must be constructed so that it not only stimulates students' prior knowledge, but, also elicits discussion. Problems are more likely to elicit discussion if they include cues such as opposing viewpoints which allow students to generate arguments and discuss which is best. Loosely structured problems are considered preferable to well-structured ones, as the latter leads to only one solution and the application of a limited set of rules. Moreover, loosely-structured problems often represent problems that are encountered in daily life and are thus more realistic and relevant.

Stimulating self-directed learning. In problem-based learning, the format and sequence of the teaching and learning process needs to be constructed in line with the intended learning objectives for the session (Majoor, Schmidt, Snellen-Balendong & Stalenhoef-Halling, 1990). The development of relevant learning issues involves the use of questions, concerns and activities that generate ideas and suggestions during the tutorial group sessions. These are used to guide students in self-directed learning activities (Hmelo-Silver, 2004).

Encouraging knowledge transfer. The problems used in problem-based learning need to encourage students to assimilate their acquired knowledge so that they can apply what they have learned to new situations. In other words, a problem needs to stimulate knowledge integration and transfer (Dolmans, Snellen-Balendong & van der Vleuten, 1997).

Relevance and application. Finally, to enhance student motivation, the problems used need to be relevant to the students' future profession (Loyens, Magda & Rikers, 2008). In doing so, students are more likely to view what they are learning as relevant to them. Such problems are also thought to narrow the gap between the learning situation and praxis.

Typically, all problem-based learning classes will begin with a problem that describes one or more observable phenomena or event (Schmidt, 1983). Students discuss these problems, their causes or their effects, drawing on prior knowledge.

In their groups, students work together to build an understanding of the problem and to discuss possible explanations or brainstorm the causes of the problem or event. They research the topics and examine relevant literature, plan their study activities and, optimally, prepare themselves for the next group meetings and discussion sessions. The interval between meetings and study periods varies between organisations and educational levels and can be a matter of hours (such as at the Republic Polytechnic under its One-Day, One-Problem™ methodology) or up to a week for each problem. In the process, students are engaged in knowledge construction during their preparation for meetings, self-study periods, and discussions (Hmelo-Silver, 2004; Schmidt 1983). Prior knowledge is triggered by the initial problem and during preparation and discussion, and new findings are interpreted to complement this knowledge. These meetings are generally guided by a facilitator or coach whose role is to stimulate discussion and learning areas, making sure all content information is correct, and to facilitate the progress of the groups towards their findings. At the same time, the facilitator will monitor the extent of involvement of each group member and how he or she contributes to the groups' work (Schmidt, Loyens, Van Gog & Pass, 2007).

2.2.3 Approaches when Applying Problem-based Learning in Practice

Over the years, problem-based learning has taken different forms and approaches to meet the requirements and educational objectives of the institutions that have adopted its use. It has evolved into three different strands or types: constructing mental models (Section 2.2.3.1); a simulation of professional practices (Section 2.2.3.2); and a tool for learning how to learn (Section 2.2.4.3). Each of these is associated with a different type of curriculum, as explained below.

2.2.3.1 Constructing Mental Models

Constructing mental models is considered to be a Type 1 curriculum. This curriculum type originated from Maastricht University (known at that time as the University of Limburg) in the Netherlands where problem-based learning has been used extensively. The Type 1 curricula also featured in curriculum design at McMaster University (Neville & Norman, 2007).

In 1974, Maastricht University was confronted with the task of developing problem-based learning curricula for law and economics. It was unclear what problems would look like in a curriculum where there were no patients to diagnose and treat. Careful observations and analysis of numerous tutorial sessions by Schmidt (2012), led to the following. A problem in its most general form can be considered the description of a set of phenomena or events. These phenomena and possibly events (according to Schmidt, 2012), could be for example:

- At the Amsterdam airport, we observed a Boeing 747 taking off effortlessly although the plane weighs hundreds of tones. Or,
- A 55-year old woman lies on the floor crawling in pain. The pain emerges in waves and extends from the right lumbar region to the groin, and the front of the right leg. Or,

- Industrialisation in China has led to high levels of inflation.

Once given the problem, the facilitators' role is to take students through the problem to make sense of the phenomena described, constructing a mental model or theory that explains the phenomena. The students' task in each case is to: understand how it is possible for the plane to take off effortlessly and what conditions need to be fulfilled for an object to overcome gravity; decide what is happening in the body of the woman that is causing so much pain, or why the pain extends to the groin; examine why industrialisation might lead to inflation and which economic mechanism would be responsible for this phenomenon. The students' task in each of these cases is to construct a mental model or theory that explains the event or phenomena described (Schmidt, 1983; Schunk, 1990).

Problem-based learning, conceptualised this way, is a collaborative form of learning in which there is an active construction of knowledge, rather than the simple processing of information. It is also a form of contextualised learning, because principles, ideas and mechanisms are not studied in abstract but, rather, in a concrete situation that can be recognised as relevant and interesting. This type of curriculum aims to help students to build flexible mental models (Hmelo-Silver, 2004; Schmidt, 1994). The problem represents the situation that must be understood and the small group discussions and self-study helps students to construct a theory that explains the problem in terms of its underlying structure or conceptual relationships (Schmidt, 1983). A curriculum that regards problem-based learning as construction of a mental model is classified as a Type 1 curriculum.

2.2.3.2 Simulating Professional Practices

In cases where problem-based learning is a simulation of instances in professional practice, content from the curriculum is required to provide an educated prognosis for problem solving. This is called a Type 2 curriculum. Barrows and Mitchell (1975) introduced the simulated patient in medical education and the idea of 'problem boxes', where patients and associated medical problems and information in line with the curriculum were categorised for use on different occasions. These problems involve groups of students who are working on a problem to mimic the thinking process of a clinician. Based on a limited number of cues provided in the problem, students generate multiple hypotheses. They then apply inquiry strategies in the form of questions, examinations and tests to refine, rank or eliminate unlikely scenarios or hypotheses. The outcome is to make a diagnostic or therapeutic decision in order that these solutions can be evaluated and learned (Barrows & Tamblyn, 1980).

The role of the facilitator in the Type 2 curriculum is to help students to think their way through the various steps, and to act as a role model by guiding students in acquiring academic and clinical reasoning skills and procedures. The underlying objectives of the facilitators are to concentrate on teaching the skills required in inquiry, with the aim of helping students to: learn and improve their use of the process; improve their reasoning and time taken in self-directed learning; and generate new approaches (rather than focusing on content).

Problem-based learning, conceptualised this way, is a collaborative form of learning in which active construction of knowledge, rather than simple processing of information, is the focus of the activity. Examples of Type 2 curriculum include the McMaster curriculum (Sibley, 1989) and the curriculum of the medical faculty of the University of Newcastle, Australia (Neame, 1989).

2.2.3.3 Learning How to Learn

The Type 3 curriculum suggests that all students using problem-based learning have some autonomy in their choices of resources to help them in their studies and understanding (Silén & Uhlin, 2008). As such, problem-based learning is considered to be a tool for learning how to learn (Schmidt, 2012). This aspect of the learning process is considered important in today's context, particularly given the increasing rate of change. In many cases, by the time a student graduates, much of their learning may be outdated or replaced by new information (Silén & Uhlin, 2008). It is important, therefore, that students acquire the ability to learn, research, reason and apply the skills. This curriculum, which emphasises the acquisition of self-directed learning skills and helps to foster lifelong learning, is known as Type 3 curriculum. One of the best-known examples of the Type 3 curriculum is perhaps the Harvard

New Pathways curriculum, which is based on active, adult learning through problem-based learning and faculty-facilitated small-group tutorials (Feletti, 1989).

These three types of problem-based learning practices allow institutions that are practising this pedagogy to select different approaches, depending on the learning outcomes that they want to achieve. Alternatively, institutions may use a combination of types in their modules.

2.2.4 Past Research Related to the Effectiveness of Problem-based Learning

Much past research has been undertaken to examine the efficacy of problem-based learning in medical education. As noted earlier, the goals of problem-based learning are not restricted to the acquisition of content knowledge, but include the development of higher-order thinking, communication and collaboration skills (Ertmer & Simons, 2006; Goodnough & Casion, 2006). This section reviews past studies that have examined the impact of problem-based learning on a range of cognitive and affective outcomes.

In many past studies it would appear that although the use of problem-based learning made no appreciable difference to students' content knowledge, there was an impact on students' ability to integrate, apply and transfer information across different disciplines (Capon & Kuhn, 2004; Dochy, Segers, Van den Bossch & Gijbels, 2003). Research by Bigelow (2004) and Cindy and Hmelo-Silver (2004) suggests that problem-based learning not only enhances content knowledge, but simultaneously fosters and develops students' communication skills, critical thinking, collaboration and self-directed learning abilities.

In contrast, some research has found that the quality and quantity of material learned in problem-based learning may vary, and in some cases, may be less than that covered in conventional lecture-based settings (Sarkar, Choudhury, Biswas & Saha, 2014; Schmidt, Rotgans & Yew, 2011). Schmidt, Rotgans and Yew (2011) reported that because problem-based learning could be challenging to implement, it was difficult for facilitators and academics to gauge the extent or level of curriculum that they are expected to deliver and should be incorporated into the sessions. These problems can result in inconsistencies and variations in the quantity of knowledge that students receive in different classes. Sarkar, Choudhury, Biswas and Saha (2014) suggest that problem-based learning may not be able to cover as much material as conventional lecture-based learning.

Other research has found that exposure to problem-based learning can increase students' conceptual understanding and competence (de Volder, Schmidt, Moust and de Grave 1986; O'Grady & Choy, 2006). However, the reasons identified for this increased conceptual understanding would appear to differ between studies. For example, O'Grady and Choy (2006) found that conceptual understanding was increased because students spend much time discussing their understandings when they are engaged in problem-based learning. This finding has been supported by other studies on problem-based learning. On the other hand, de Volder, Schmidt, Moust and de Grave (1986) found that students who were exposed to problem-based learning became more interested in the subject and, therefore, were more likely to study the relevant literature than students in instruction-type classrooms.

When compared to a traditional teaching approach, the results of past studies show problem-based learning to be comparable in terms of student's acquisition of content, but having gains in terms of motivation, engagement and long term knowledge retention (Ertmer & Simons, 2006; Savery, 2006; Strobel & van Barneveld, 2009). Recent studies by Rotgans & Schmidt (201) suggest problem-based learning can create situational interest that triggers a motivational response to a perceived knowledge deficit, thus motivating learning.

Past research has found that problem-based learning developed skills related to self-directed learning (Loyens, Magda & Rikers, 2008; Schmidt & van der Molen, 2001; Severiens & Schmidt, 2009). In their study, Loyens, Magda and Rikers (2008) defined self-directed learning as a process in which individuals take the initiative in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate strategies, and learning to evaluate learning outcomes. They found that, by inviting students into the learning process, students were also encouraged to take responsibility for their learning, which led to an increase in self-directed learning opportunities. Schmidt and van der

Molenn (2001) also found that problem-based learning stimulates students to become self-directed learners, with graduates rating themselves as better prepared than colleagues who were trained with conventional curricula.

Past research has indicated that as a learning method, problem-based learning can promote the development of critical thinking skills (Masek & Yamin, 2011; Sendag & Ferhan, 2009). Findings indicate that during problem-based learning, students learn how to analyse a problem, identify relevant facts and generate hypotheses, identifying relevant information and knowledge for solving the problem, and making responsible judgements about solving the problem. Masek and Yamin (2011), in their study on the effects of problem-based learning on critical thinking abilities, concluded that the processes involved in problem-based learning support students' critical thinking and development. The study provides evidence to suggest that problem-based learning requires long term exposure to foster students' critical thinking ability, and that there are several predictors that could influence the relationship of problem-based learning and critical thinking, including, age, gender, academic achievement and educational background. One study by Tiwari, Lai, So and Yuen (2006) found that although students' exposure did not influence their critical thinking skills, the deficits in the students' critical thinking were identified and targeted for improvement.

Past research has found that when students acquire knowledge through problem-based learning, they are more likely to retain that knowledge over a long period of time and more likely to use the concepts in different situations (Norman & Schmidt, 1993; Savin-Baden & Wilkie, 2004). Studies by Savin-Baden and Wilkie (2004) and Norman and Schmidt (1993) compared problem-based and lecture-based learning. Their findings indicated that students were more likely to use their new-found knowledge spontaneously to solve new problems than individuals who acquired the same information and knowledge under the more traditional lecture-based instruction methods. Further, a study by Uden and Beaumont (2006) suggested that students developed stronger thinking and problem solving skills, effective communication skills and sense of personal responsibility than did students who attended lectures.

Past studies have found that problem-based learning, when compared to lecture-based learning, can improve students' confidence in their ability in a subject (Gregson, Laura & Lawrence, 2010; Mergendoller, Maxwell & Bellisimo, 2006). For example, Gregson, Laura and Lawrence (2010) found that problem-based learning led to a better understanding of pharmacology concepts, and greater confidence in the pharmacology knowledge.

Wilder (2015), however, argues there is a lack of empirical evidence that problem-based learning achieves all the goals it is purported to achieve. Many studies have lacked rigour and quality (see for example, Hung, 2011 and Strobel & van Barneveld, 2009). Further, a systematic review of quasi-experimental studies by Newman (2005) has suggested that the outcomes for students in problem-based learning groups were, in many cases, less favourable. For example, of the 39 studies included in the review, 23 favoured the lecture based learning and 16 favoured problem-based learning. Newman (2005) and Parton and Bailey (2008) suggest that one of the problems associated with problem-based learning is that there is no single unanimous position about the theoretical basis for or practice of problem-based learning, and that there is no agreement about whether there should be one type of problem-based learning or many variants. This has resulted in confusion about how problem-based learning instruction is to be delivered in the classroom for best results. More research is needed to identify best practices for students' performances.

Hung (2011) suggests that existing evidence regarding the effectiveness of problem-based learning may not be trustworthy because of the vast number of variables affecting students' learning and outcomes that may not have been considered when conducting the investigations. Hung argues that the use of problem-based learning in medical schools and engineering, as a method to develop future problem solving skills, is a questionable concept.

Notwithstanding these negative findings, past research in the medical field has prompted the implementation of problem-based learning in a range of other educational settings, including polytechnics, as in the case in Singapore. To date, there is a dearth of literature related to the use of problem-based learning at the polytechnic level around the world. Therefore, this research is timely and fills this gap. The research reported in this thesis builds on these past studies by examining the impact of problem-based learning on the academic efficacy and attitudes of students.

2.3 Field of Learning Environments

Learning takes place in many different settings and the environment created within the settings can be structured or unstructured. Fraser and Fisher (1982) propose that, apart from classroom and school environments, learning environments also include home, science centres, media and information technology.

Within a classroom, according to Fraser (1998a, 1998b), the learning environment encompasses the overall climate in the classroom, the culture (the classroom norms), ambience and atmosphere in which learning takes place. The learning environment comprises two aspects: the human environment and the physical environment. The human environment includes the students and teachers and the interactions between them. The physical environment includes the learning resources, lighting and physical setting that make it conducive for learning. The practical pedagogy takes into account both of these key elements. For example, a problem-based learning curriculum requires small group learning to allow participation and interaction between students and students and facilitators. To support this physically, the learning environment requires a large enough classroom to accommodate tables and chairs for five to six students per group (for about 25 students), rather than a traditional lecture hall.

A report by the United Nations Educational Scientific and Cultural Organisation (UNESCO) defines the learning environment as “the complete physical, social and pedagogical context in which learning is intended to occur, and the factors embedded within the shared physical and social environment and its influence on the learning processes” (UNESCO, 2012, p. 12). In this respect, the learning environment goes beyond aspects related to human and classroom facilities to include the interaction with technology and e-technology as well (UNESCO, 2012).

This section is divided into four parts: the history of the field of learning environments (Section 2.3.1); Moos’s (1976) framework for classifying human environments (Section 2.3.2); past instruments used in learning environment research

(Section 2.3.3); and past research in the field of learning environments (Section 2.3.4).

2.3.1 History of the Field of Learning Environments

The concept of a learning environment goes back as far as 1936, when Kurt Lewin (1936) proposed that human behaviour was the result of the interaction between the individual and his or her environment. To this end he developed the formula B=*f* (P, E), in which human behaviour is a function of the personality (P) of the individual, and his or her environment (E). Lewin's study recognised that both the environment and its interactions with the personality of the individual are potent determinants of human behaviour and its outcomes.

Building on Lewin's theory, Murray (1938) proposed a needs-press model to describe an individual's behaviour resulting from the interaction between their needs and their external environment. These personal needs were described as being motivated by personality characteristics, which represented an individual's tendency to move in the direction of certain goals. The environmental press referred to a situation external to the person that either supported or frustrated the expression of internalised personal needs. Murray used the term 'alpha press' to describe the environment as viewed by an external observer, and the term 'beta press' to describe the environment as perceived by members of that environment.

Stern, Stein and Bloom (1956) suggest that the same learning environment can be perceived differently by different entities, individuals, groups and external observers of the environment. They developed Murray's needs-press model further by dividing beta press into 'private' beta press (the individual student's view of his or her environment) and 'consensual' beta press (the view held by the entire class as a group). The study reported in this thesis utilised both the private beta press and the consensual beta press of students for the data collected during the focus group meetings and the telephone interviews.

Walberg's (1981) theory of educational productivity proposed a nine-factor model to make education more productive and to improve student outcomes. Walberg described: the first three factors (ability, motivation, and age) to reflect characteristics of the student; the fourth and the fifth factors to reflect the type of instruction (quantity and quality); and the final four factors (classroom climate, home environment, peer group, and exposure to media), to represent aspects of the psychological environment. The model holds that no single factor alone has a significant impact on learning, and when attempting to help students achieve and improve their abilities to learn, several factors need to be aligned and raised simultaneously. Nevertheless, Fraser, Walberg, Welch and Hattie (1987) found that the psychosocial environment was a strong predictor of both achievement and attitudes, even when a comprehensive set of other factors was held constant.

In the 1960s, the first two psychosocial learning environment instruments were developed independently of each other, one by Herbert Walberg (1981) and the other by Rudolf Moos (1979). Walberg and Anderson (1968) developed the widely-used Learning Environment Inventory (LEI), while Moos began developing the first of his social climate scales that eventually led to the development of the Classroom Environment Scale (CES) (Moos, 1979; Moos & Trickett, 1974). The important pioneering work of Walberg and Moos on perceptions of classroom environment developed into major studies that have spawned many other research programs relevant to the study of classroom learning environments (Fraser, 2012).

Building on this early work, over the past five decades an extensive range of learning environment research has assisted in the conceptualisation of the psychological and social aspects of the classroom and their influence on student outcomes (Fraser, 2007, 2012). *Learning Environments Research: An International Journal* (Fraser, 1998a) was started in 1998 to document the work carried out in this field of research. In the last decade, more books have been written to inform the worldwide education community of the importance of the study of classroom learning environments. Examples of the many books published recently include *Studies in educational learning environments* (Goh & Khine, 2002), *Outcomes-focussed learning environments* (Aldridge & Fraser, 2008), *Contemporary approaches to research on learning environments* (Fisher & Khine, 2006), *Investigating the use of student perception data for teacher reflection and classroom improvement* (Bell & Aldridge,

2014) and *Associations between the classroom learning environment and student engagement in learning* (Cavanagh, 2011; 2012)

2.3.2 Moos's Framework for Classifying Human Environments

Moos (1976) described three types of psychosocial learning environment dimensions that have been used, in more recent research, as a framework for classifying human environments. Vastly different social environments, including educational ones, can be investigated using these social climate dimensions (Moos, 1991). These include: (1) the Relationship Dimensions; (2) the Personal Development Dimensions; and (3) the System Maintenance and System Change Dimensions. Moos (1991) convincingly argues that these three dimensions underpin all socially created environments, including educational environments. Moos's studies have since drawn significant interest in learning environments research as they have been identified as important areas in the social learning climate that will help more students succeed. Each of the three dimensions are described below.

Moos's Relationship Dimension relates to the nature and intensity of personal relationships between members in the environment. It assesses an individual's involvement in the environment, how they help one another and whether there is free exchange of ideas among members. In a classroom setting, this refers to the interaction between the teacher and the students and between students. Key behaviours in this dimension include body language as well as the tone in which we speak to one another.

Moos's Personal Development Dimension in the human environment assesses "the basic directions along which personal growth and self-enhancement tend to occur in the particular environment" (Moos, 1976, p. 331). It plays a substantial role in affecting students' satisfaction with the teacher, lecturers or facilitators, as is addressed in this study. This in turn affects the students' ability to do well in the subject, and their motivation to be involved in the learning process. Personal growth involves: how much the group encourages independent action and the expression or interaction between members when responding to the task at hand; the orientation of group members in completing the task; how decisions are made; and how much the group encourages members' discussion and disagreements to take place in the group (Moos, 1976).

The System Maintenance and System Change Dimensions describe the extent to which the environment is orderly and clear in its expectations, maintains control and responds to change, and yet does not stifle the interactions and relationships between the groups or class individuals within an education setting. This dimension is characterised by the system and structure in the learning environment that supports teaching and learning activities (Moos, 1976).

Moos suggests that the measurement of classroom climate could be determined by the weight of each of the three dimensions of the environment (Moos, 1991). The key point of his model was the mediation effect between the components in each dimension (Mayer, 1975; Shulman & Keislar, 1966). For example, the System Maintenance and System Change Dimensions serve as a mediator between the Personal Development Dimensions and the Relationship Dimensions, which can bring stability or change in the learning environment. That is, the organisational system could be an obstacle that limits personal growth or creates competition over cooperation in the use of organisational resources.

Moos's three dimensions thus co-exist in all human environments including educational environments. They have been used extensively by researchers in the construction of learning environment instruments (Fraser, 2007; Walker & Fraser, 2005) and in the classification of individual scales. In the present research, Moos's dimensions were drawn upon in the development of the new learning environment instrument, where it was used to help to identify the type and classification of the scales in order to have a balance of scales covering all the three dimensions in the learning environment.

2.3.3 Instruments Assessing Classroom Environment

Over the past 40 to 50 years, perceptual measures have been the most widely-used method of investigating learning environments. Within the field of learning environments, a variety of economical, valid and widely applicable questionnaires have been developed by researchers to assess students' perceptions of the learning environment (Fraser, 2007, 2012). In this section, nine historically significant and contemporary learning-environment research instruments are reviewed: Learning Environments Inventory (Section 2.3.3.1); Classroom Environment Scale (Section 2.3.3.2); Individual Classroom Environment Questionnaire (Section 2.3.3.3); My Class Inventory (Section 2.3.3.4); College and University Classroom Environment Inventory (Section 2.3.3.5); Questionnaire on Teacher Interaction (Section 2.3.3.6); Science Laboratory Environment Inventory (Section 2.3.3.7); Constructivist Learning Environment Survey (Section 2.3.3.8); and What Is Happening In this Class? Questionnaire (Section 2.3.3.9). Table 2.1 provides, for each of the nine instruments listed above: the education level for which the instrument was intended to be used (primary, secondary or higher education); the number of items in each scale; and the classification of each scale according to Moos' (1974) scheme for classifying human environments (described in Section 2.3.1).

2.3.3.1 Learning Environment Inventory (LEI)

The Learning Environment Inventory (LEI) was developed and validated in the late 1960s in conjunction with the evaluation and research related to the Harvard Project Physics (Fraser, 1998a; Walberg & Anderson, 1968). The LEI assesses the students' perceptions of the social climate of their high school classrooms. The LEI is made up of 105 statements, used to describe typical school classes at that time. The statements are categorised into 15 scales: Cohesiveness, Friction, Favouritism, Cliquishness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Description, Disorganisation, and Democracy. There are seven items in each scale which are presented in a cyclic order and are responded to using the four alternatives of Strongly Disagree, Disagree, Agree, or Strongly Agree. Example statements include "The pace of the class is rushed" under the scale for Speed, and "All students know each other very well" for the Cohesiveness scale.

Table 2.1 Overview of Scales in Relation to Moos's (1974) Scheme Included in Nine Classroom-Learning Environment Instruments

Instrument	Level	Items Per scale	Scales classified under Moos's Scheme: Relationship Dimensions	Personal Development Dimensions	System Maintenance and System Change Dimensions
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Cliquishness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisation Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation	Order & Organisation Rule Clarity Teacher Control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Primary	6-9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Tertiary	7	Personalisation Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation
Questionnaire on Teacher Interaction (QTI)	Secondary Primary	8-10	Helpful/ Friendly Understanding Dissatisfied Admonishing		Leadership Student Responsibility and Freedom Uncertainty Strict
Science Laboratory Environment Inventory (SLEI)	Secondary	7	Student Cohesiveness	Open-Endedness Integration	Rule clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What Is Happening In this Class? (WIHIC)	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity

Table adapted from Fraser (1998a) with permission

The LEI was known to be lengthy and included rather complex language, and the scales focused on a more traditional teacher-centred classroom environment. Although the LEI had been validated in a study involving 1048 students, and was reported to have alpha reliability coefficients ranging between 0.54 and 0.85 (Fraser, Anderson & Walberg, 1982), the factor structure was not established.

2.3.3.2 Classroom Environment Scale (CES)

The Classroom Environment Scale (CES) was developed to identify how positive the classroom climate was. The CES evaluates the effects of course content, teaching methods, teacher personality, class composition, and characteristics of the overall classroom environment. Prior to the development of the CES, Moos created questionnaires for assessing a variety of human environments which included psychiatric hospitals, prisons, university residences, and work environments (Moos, 1974). The original version of the CES contained 242 items grouped into 13 conceptual dimensions (Moos & Trickett, 1974; Trickett & Moos, 1973). The final version was reduced to nine scales with 10 items in each, which were responded to using a True-False format (Moos & Trickett, 1974).

The scales in the final version of the CES were Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organization, Rule Clarity, Teacher Control and Innovation. Items in this instrument include “The teacher takes a personal interest in the student” for the Teacher Support scale, and “There is a clear set of rules for students to follow” for the Rule Clarity scale.

The findings from research involving the CES showed that teachers and students in the same classroom could have different perceptions of the classroom environment. One study also revealed that the classroom environment affects students’ achievement (Fisher & Fraser, 1983b). However, support for the 10-scale structures has not been established and the use of the true-false response scale has been criticised as it may not provide an accurate gauge of perceptions. About half of the items adopted a reverse scoring method and the CES used separate forms for actual perceptions (to assess students’ experiences of their actual learning environments) and preferred perceptions (to describe the learning environment that students would prefer).

2.3.3.3 Individualised Classroom Environment Questionnaire (ICEQ)

The ICEQ was developed by Rentoul and Fraser (1979) to assess dimensions of the learning environment that differentiate conventional classrooms from enquiry-based classrooms or classrooms that emphasise individualisation. The final version of the ICEQ, after a series of classroom refinements and field trials, consists of 50 items, with 10 items in each of the following five scales: Personalisation, Participation, Independence, Investigation, and Differentiation.

The ICEQ can be used to assess student or teacher perceptions of their actual environment (perceived environment) and their preferred environment (the learning environment that they would prefer). Participants respond to items using a five-point frequency scale of Almost Never, Seldom, Sometimes, Often, and Very Often. Example items include “The teacher considers students’ feelings” for the Personalisation scale and “Different students use different books, equipment, and materials” for the Differentiation scale. A weakness of the ICEQ is that it lacks factorial validity for its scales.

2.3.3.4 My Class Inventory (MCI)

The MCI is a simplified version of the LEI instrument, which was developed for use with children aged 8-12 years (Fraser, Anderson & Walberg, 1982). To make the instrument more manageable for young children and for easy reading, the items were simplified. First, to minimise fatigue among younger children, Fraser et al. (1982) reduced the MCI to five of the original 15 scales of the LEI. Second, the wording was simplified to enhance readability among this group of children. Third, the four point response format of the LEI was reduced to a two point, Yes-No response format. Fourth, students responded on the questionnaire itself to avoid errors in transferring responses from one sheet to another.

The final version of the MCI has 35 items allocated to the five scales of Cohesiveness, Friction, Satisfaction, Difficulty, and Competitiveness. Example items included “The children seem to like the class” for the Satisfaction scale, and “The children are always fighting with each other” for the Friction scale.

While the MCI is a simplified version of the LEI, which was originally developed for students in primary schools or junior high, it has several advantages over the LEI. It is a third as long as the original LEI and has greater readability, thereby minimising fatigue in respondents. There has, however, been criticism with respect to the use of the Yes-No format and past research has reported mixed results with respect to the factor structure, with a few studies reporting a five-scale structure. Further, the MCI has been criticised for its use of a satisfaction scale as part of the learning environment.

2.3.3.5 College and University Classroom Environment Inventory (CUCEI)

The CUCEI was developed by Fraser, Treagust and Dennis (1986) to fill the void for research instruments available for use in higher education classrooms. The instrument was designed to assess the environment of higher education classrooms and includes seven psychosocial dimensions, these being Personalisation, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation and Individualisation. The CUCEI is available in both actual and preferred forms. Each item is responded to using a four point Likert-type scale of Strongly Agree, Agree, Disagree, and Strongly Disagree. The polarity is reversed for approximately half of the items (Goh & Khine, 2002). Example items include “Activities in this class are clearly and carefully planned”, for the Task Orientation scale and “Teaching approaches allow students to proceed at their own pace”, for the Individualisation scale.

2.3.3.6 Questionnaire on Teacher Interaction (QTI)

The development of the Questionnaire on Teacher Interaction (QTI) began in the Netherlands with research carried out by Wubbels, Creton and Hooymayers (1992). The QTI was developed to assess teacher-student interaction in the classroom. The

QTI was adapted from the work of Leary (1957) on interpersonal teacher behaviour, which suggested that the behaviour of students might affect the teacher's interactions with them. Similarly, the teachers' interactions with students might affect the students' behaviour. These two ideas suggest a symbiotic relationship. The QTI measures students' perceptions of eight behavioural aspects: Leadership, Helping/Friendly, Student Responsibility, Freedom, Uncertainty, and Dissatisfied, Admonishing, and Strict behaviours. The original version of the QTI consists of 77 items divided between the 8 scales. A short version also contains eight scales with six items each for a total of 48 items. Responses to items on the QTI are made using a five-point frequency scale ranging from Never to Always (Wubbels & Levy, 1993).

Wubbels' research has shown that students' perceptions of their teacher-student interpersonal behaviour are strongly related to student achievement and motivation in all subject areas and that healthy teacher-student interpersonal relationships are a pre-requisite for engaging students in learning activities (den Brok, Brekelmans & Wubbels, 2004). Researchers have also found that healthy interpersonal relationships between teachers and students have a positive correlation with teachers' satisfaction with their profession.

The validity and reliability of the QTI has been demonstrated in numerous studies from around the world including Singapore (Goh & Fraser, 1996, 1998; Quek, Wong & Fraser, 2005), Brunei Darussalam (Khine & Fisher, 2002) and Indonesia (Fraser, Aldridge & Soerjaningsih, 2010). The QTI has been translated into different languages including standard Malay, Korean, and Indonesian, and cross validated at different grade levels in the US (Wubbels & Levy, 1993), Australia (Henderson, Fisher & Fraser, 2000), Korea (Kim, Fisher & Fraser, 1999), Brunei (den Brok, Fisher & Scott, 2005) and Indonesia (Fraser, Aldridge & Soerjaningsih, 2010).

2.3.3.7 Science Laboratory Environment Inventory (SLEI)

The SLEI was one of the first subject-specific surveys to be developed in the field of learning environments. The SLEI was developed by Fraser, Giddings and McRobbie (1995) to assess the unique features of learning environments created in laboratory settings in science education. The initial version of the SLEI contained 72 items in the seven scales of Teacher Supportiveness, Student Cohesiveness, Open-Endedness, Integration, Organisation, Rule Clarity, and Material Environment. The final version includes 35 items in the five scales of Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. The items are responded to using a five-point frequency-response format of Almost Never, Seldom, Sometimes, Often and Very Often. There are two forms, the personal form and the class form, of which both have actual and preferred versions (Fraser, Giddings & McRobbie, 1995). Typical items used in the questionnaire include "I use the theory from my regular science class sessions during laboratory activities", for the Integration scale, and "We know the results that we are supposed to get before we commence a laboratory activity", for the Open-Endedness scale.

The initial version of the SLEI that took the class form for measuring an individual student's perceptions of the whole class was field tested and validated in six countries: the USA, Canada, England, Israel, Australia, and Nigeria (Fraser et al., 1995). The SLEI was made available in a personal form which measures the students' perceptions of their own role within the class. The personal form was then cross-nationally tested and validated in a field test with a sample of over 5,447 students in 269 classes in six countries and was cross-validated with 1,594 Australian students in 92 classes (Fraser et al., 1995). The SLEI was also cross-validated with 1,594 Australian students in 92 classes (Fraser et al., 1995) and 1,529 grade 10 chemistry students in Singapore (Wong & Fraser, 1996).

2.3.3.8 Constructivist Learning Environment Survey (CLES)

The CLES was developed by Taylor, Fraser, and Fisher (1997) to assess the extent to which a classroom environment conforms to the constructivist approach to teaching and learning, and to help teachers to reflect on their teaching practices. The CLES has 36 items each allocated to one of five scales: Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The CLES was one of the first learning environment instruments to arrange items in groups according to the scales. This arrangement provided contextual cues for the respondents, thereby increasing the reliability. The items are responded to using a five-point frequency response format of Almost Never, Seldom, Sometimes, Often, and Almost Always.

Example items include "I learned that Science has changed over time" for the Uncertainty scale, and "It's ok for me to express my opinions" for the Critical Voice scale. The CLES has been shown to have strong psychometric properties in a number of studies in several countries including Korea (Kim, Fisher & Fraser, 1999), Taiwan (Aldridge, Taylor, Fraser & Chen, 2000) and the US (Nix, Fraser and Ledbetter, 2005).

2.3.3.9 What Is Happening In this Class? (WIHIC) Questionnaire

The WIHIC questionnaire was originally developed by Fraser, Fisher and McRobbie (1996). The development of the survey sought to consolidate the best features of existing surveys to include scales of contemporary relevance. The scales selected for use had all been shown to be predictors of student outcomes in past research. The original version of the WIHIC contained 90-items and nine scales, but this was refined using statistical data from 355 junior high school science students complemented by extensive interviews. The final version of the WIHIC consists of seven scales with eight items each, making 56 items in all. Table 2.2 below provides a scale description and sample item for each scale in the WIHIC.

The WIHIC has been used to assess students' preferences and perceptions in the field of learning environments in many studies. The robust nature of the WIHIC questionnaire, in terms of its reliability and validity, has been widely reported for different subject areas, age levels, and in different countries. These include: Singapore, where it was used on a sample of 2,310 Secondary Four (Grade 10) students in 75 classes from 38 schools (Chionh & Fraser, 2009); Taiwan and Australia, involving 1,081 Grade 8 and 9 general science students from 50 classes in Western Australia, and 1,879 Grade 7-9 science students from 50 classes in Taiwan (Aldridge, Fraser & Huang, 1999); the US, with a sample of 1,720 eighth-grade science students from 65 classes in 11 middle schools (Rickards, Bull & Fisher, 2001); and India, with a sample 1,021 students in 32 science classes in seven co-educational private schools (Koul & Fisher, 2003).

Past studies have strongly supported the international applicability of the WIHIC as a valid and reliable instrument, making it an ideal starting point for the development of the new instrument. As such, the WIHIC was selected to be the platform on which the design and development of the new instrument used for purpose of this study. Section 3.5.1 of the following chapter describes the development of a modified WIHIC that was used for purpose of this study.

Table 2.2 Scale description of the WIHIC and a sample item for each scale

Scale	Description	Sample Item
Student Cohesiveness	The extent to which students are friendly and supportive of each other.	I make friendships among students in this class.
Teacher Support	The extent to which the teacher helps, befriends, and is interested in students.	The teacher takes a personal interest in me.
Involvement	The extent to which students have attentive interest, participate in class and are involved with other students in assessing the viability of new ideas.	I discuss ideas in class.
Investigation	The extent to which there is emphasis on the skills of inquiry and their use in problem solving and investigation.	I carry out investigations to test my ideas.
Task Orientation	The extent to which it is important to complete planned activities and stay on the subject matter.	Getting a certain amount of work done is important.
Cooperation	Extent to which students cooperate with each other during activities.	I cooperate with other students when doing assignment work.
Equity	The extent to which the teacher treats students equally, distributing praise among class members, distributes questions among students, and provides opportunities for all to be included in discussions.	The teacher gives as much attention to my questions as to other students' questions.

Table adapted from Fraser (1998a) with permission

2.3.4 Learning Environment Research: Progress and Possibilities

For more than 50 years, learning environment research has contributed substantially to the field of learning environments for teaching and learning. As mentioned earlier, numerous learning environment questionnaires have been developed involving different areas of research and approaches that led to the study of different aspects of classroom environments. These questionnaires have the potential to provide a wide range of information about preferences and perceptions of different aspects of classroom environments, from learner-centred to teacher-centred teaching and learning environments, to preferences for participative learning, collaborative work, and/or didactic classrooms. They cover whether teachers are approachable and student interests are considered, to whether students have choices in the way they are taught, the choice of assessment methods, and if they can study at a different pace through on-line or distance learning approaches (Fraser, 2007).

Fraser (2007, 2012) has delineated many applications and identified 10 types of research into classroom learning environments: associations between student outcomes and learning environments; evaluation of educational innovations; differences between students' and teachers' perceptions of the same classroom; whether students achieve better when in their preferred learning environments; teachers' practical attempts to improve their classroom climates; combining quantitative and qualitative methods; school psychology; links between educational environments; cross-national studies; and transition from primary to secondary education.

Research into other aspects of classroom learning environments have included: assessing cultural differences involving the race of teachers in Brunei (Khine, 2002); whether students were science or humanities oriented (Lee, Fraser & Fisher, 2003); cross-national studies carried out for the purpose of gaining new insights into teaching methods and pedagogical practices (Aldridge & Fraser, 2000); the evaluation of educational innovations (Martin-Dunlop & Fraser, 2008; Wolf & Fraser, 2008); teacher action research (Aldridge & Fraser, 2008; Aldridge, Fraser, Bell & Dorman, 2012; Aldridge, Fraser & Sebela, 2004; Bell & Aldridge, 2014); differences between students' and teachers' perceptions of actual and preferred environment (Fisher & Fraser, 1983a; Fraser & McRobbie 1995); combining quantitative and qualitative methods (Aldridge, Fraser & Huang, 1999); school psychology (Sink & Spencer, 2005); links between educational environments (Aldridge, Fraser & Laugksch, 2011; Fraser & Kahle, 2007); cross-national studies (Aldridge, Fraser & Huang, 1999; Fraser, Aldridge & Adolphe, 2010; Fraser, Aldridge & Soerjaningsih, 2010); transition between different levels of schooling (Ferguson & Fraser, 1998); and determinants of classroom environment (Moos, 1978, 1979; den Brok, Telli, Cakiroglu, Taconis & Tekkaya, 2010; Rickards, den Brok & Fisher, 2005). For this study, two areas were identified to be of particular relevance to this study: associations between the learning environment and student outcomes (reported in Section 2.3.4.1); and the use of educational research for educational innovations (reported in Section 2.3.4.2).

2.3.4.1 Environment-outcome Association

Since the late 1960s, numerous studies have been carried out in the field of learning environments. One of the strongest themes emerging from these studies has been investigations involving associations between students' cognitive and affective learning outcomes and their perceptions of their psychosocial learning environment. Fraser (1999) reported that the strongest aspect of past research into learning environments was that the learning environment was consistently and strongly associated with the students' cognitive and affective outcomes. Fraser (1994) tabulated 40 past studies that showed associations between outcome measures and classroom environment perceptions that were replicated across a variety of cognitive and affective outcome measures. Fraser (2007) suggested that teachers and lecturers who wanted to improve teaching in schools and universities should not ignore the strong influences that the learning environment has on students' behavioural and attitudinal outcomes. Other recent studies have shown that the more favourable students perceived their classroom-learning environments to be, the better were their attitudes towards learning (Chionh & Fraser, 2009; Martin-Dunlop & Fraser, 2008).

These findings thus suggest that learning environments are strong predictors of both student achievement and attitudes even when a comprehensive set of factors are held constant (Fraser, 2012). Later in this chapter, literature related to associations between the learning environments is reviewed in respect to students' attitudes (Section 2.5) and academic efficacy (Section 2.6).

2.3.4.2 Evaluation of Educational Innovations

In past research, classroom environment instruments have been used as a source of process criteria in the evaluation of educational innovations. As such, learning environment instruments have been used to evaluate curriculum change, educational programmes and innovations (Fraser, 2012).

In places around the world, new curricula have been introduced as part of reform efforts. In some cases, studies have successfully used learning environment dimensions to examine the success of these reform efforts. For example, in Australia (Aldridge & Fraser, 2008) and South Africa (Aldridge, Laugksch, Seopa & Fraser, 2006), researchers have used learning environment instruments as a source of process criteria in evaluating the introduction of outcomes-focused curricula in science. In another example, Kim, Fisher and Fraser (1999) used learning environment dimensions to evaluate whether the introduction of new curricula designed to be more constructivist has influenced the classroom learning environment. The study suggested that efforts at curriculum reform had produced some positive effects, and found statistically significant relationships between classroom environment and student attitudes.

Learning environment instruments have been used to evaluate educational programs. For example, Lightburn and Fraser (2007) used the Science Laboratory Environment Inventory (SLEI) to evaluate the effectiveness of using anthropometric activities in Science education. The results of their study involving a sample of 761 high school students provided support for the positive influence of using anthropometric activities to create better student attitudes and classroom learning environments.

In another study, Martin-Dunlop and Fraser (2008) used the scales from the SLEI and the WIHIC to monitor the effectiveness of an innovative science course for prospective teachers. Using a pre-post design with a sample of 525 university students in 27 classes in California, students showed significant improvements on all five SLEI scales. The largest gains observed were for the Open-Endedness and Material Environment scales, with effect sizes of 6.74 and 3.82 standard deviations respectively.

Classroom environment scales have also been used to evaluate different education approaches. For example, in an evaluation of the use of a computerised database using learning environment scales, Maor and Fraser (1996) found that students perceived their classes as more inquiry-oriented during the use of the new approach. In Singapore, classroom environment instruments were used to evaluate educational innovations such as computer assisted learning and computer courses for adults (Khoo & Fraser, 2008).

The present study drew on and extended this past research to examine the effectiveness of using problem-based learning at the polytechnic level in Singapore. The study extended past learning environment research by developing an instrument that would be suitable to compare problem-based and lecture-based learning environments. The study is, to the best of my knowledge, one of the first in the field of learning environments to examine problem-based learning at the polytechnic level, thereby filling a gap in the research.

2.4 Person-environment Fit Research

Given that this study examined the person-environment fit to assess the effectiveness and teaching and learning environments for different instruction types (problem-based learning or lecture-based instruction), this section reviews literature related with this area of study. Kristof-Brown, Zimmerman, and Johnson (2005) broadly defined person-environment fit as the degree to which the individual’s personal and environmental characteristics match. Personal characteristics may include an individual’s biological or psychological needs, values, goals, abilities, or personality, while environmental characteristics may include intrinsic and extrinsic rewards, the demands of a job or role, cultural values, or characteristics of other individuals and collectives in the person's social environment (Kristof-Brown & Guay, 2011).

Person–environment fit has also been linked to a number of affective outcomes, including job satisfaction, organisational commitment, and in some instances, a person’s intention to quit their job or the project/activity they are working on (Kristof-Brown & Guay, 2011). On the other hand, stress as an outcome of the activity a person is involved in has been recognised as a consequence of poor person-environment fit, resulting in poor attitudes and sub-optimal performance (Edwards, 2008).

In measuring person-environment fit, Kristof-Brown and Guay (2011) proposed that they can be measured directly or indirectly. A direct measure requires the individual to report on the fit that they believe exists against that which they would prefer or expect. However, such responses can involve a degree of bias, as different people have different experiences and what is good for one person may not be the case for another. Indirect measures, on the other hand, assess the individual and the environment separately. The individual characteristics are measured through self-reports, while the environment characteristics can be reported by another person or the organisation (Amy, Kristof, Zimmerman & Johnson, 2005). Technically, the same people who indicate their actual perceptions tend to be more objective in their preferred versions, so separate assessors for the actual and preferred items may polarise views and may not reflect the actual or preferred aspects of the learning environment (Plous, 1993). Plous (1993) termed this as confirmatory bias or 'my side' bias, as the tendency of people to favour information that confirms their beliefs or hypotheses. People, he concluded, generally displayed this bias when they gather or remember information selectively, or when they interpret it in a biased way without having to look at different perspectives or having a base line to start their assessment (Westerman & Cyr, 2004). In this research, the person-environment fit used a direct approach, where respondents indicate their perceptions of their actual environment as well as their preferred learning environment.

In the educational context, past research into person-environment fit has indicated that students generally prefer a more positive classroom environment than what is actually experienced (Fraser & Fisher, 1983b). In this respect, the person-environment fit could provide information about students' expectations of their classroom, and if the discrepancies between students' actual and preferred learning environments can be reduced, one would anticipate that their outcomes and performance would be improved (Fraser & Fisher, 1983b; 1983c).

In summary, the person-environment fit has important implications for academics, administrators and the organisation. Establishing and maintaining a 'good fit' between students' and their learning environment can mediate the relationship of group-specific experiences and learning outcomes. For purposes of this study, the person-environment fit was applied to the fit between students' perceptions of their learning environment (using problem-based learning and lecture-based instruction) and the learning environment that they would prefer, to identify whether there were significant differences between institutions using different instruction types.

2.5 Role of Attitudes in Learning

Psychologists have defined attitudes as a learned tendency to evaluate things in certain ways. These could include the evaluation of people, issues, objects, or events and experiences encountered (Cherry, 2010). While perceptions of the learning environment is the process by which students interpret and organise sensations to produce a meaningful experience (Lindsay & Norman, 2013), an attitude refers to a positive or negative evaluation of people, objects, processes that affect them, or just about anything within that environment (Zimbardo & Leippe, 1991). Such evaluations can also be expressed as positive or negative or uncertain at times and are often expressed as having mixed feelings (Cherry, 2010).

Scott (2011) cited perfectionist tendencies, pessimism, excitability and enjoyment, poor fit for the task and environment, and lack of belief in what they are doing, as some of the personal traits that manifest in one's attitudes. Research carried out at Yale University (Pajares, 1996) suggests that personality traits and political attitudes vary across issue domains and can depend on contextual factors that can affect the meaning of the stimuli. For example, conscientiousness and openness, the two traits most consistently associated with one's ideology, may represent one's overall conservatism and reticence, or one's sense of liberalism, tolerance, and broad-mindedness. These can determine one's attitudes in learning and interacting with people in the process of learning.

Marzano (1992) proposed that, without positive attitudes and perceptions, students have little chance of learning proficiently. He identified two key important factors of attitudes and perceptions that affect learning, 1) students' attitudes and perceptions about the learning climate; and 2) students' attitudes and perceptions about the classroom task. How teachers influence these two important factors will determine how students respond with positive attitudes that can determine their perceptions and motivation to learn in the environment that is created. According to Martin-Dunlop and Fraser (2008), paying attention to the role of attitudes resulting from students' perceptions and preferences in their classroom learning environment is one of the most important elements in managing the learning environment. Attitudes represent an outcome of the learning environment which are not tangible or quantifiable, being made up of values, attitudes, and actions. It is thus not surprising that many past studies have indicated that the learning environment created by teachers is likely to influence students' attitudes (Fraser, 2007).

Students' attitudes towards a subject or towards a specific classroom characteristic such as the pedagogy have been a subject of much controversy. Historically, the study of students' affective outcomes has been the cause of definition problems, and the terms are associated with words such as interest, attentiveness and attitudes, which are often used loosely and without clarification (Peterson & Carlson, 1979). Gardner (1975) defined these attitudes as a learned disposition to evaluate in certain ways the objects, people, actions, situations or propositions involved in learning. This learned disposition refers to the way students regard the subject or, in the case of this study, the pedagogy, as interesting, boring, dull or exciting. Positive student attitudes, then, are measured by the degree of motivation and interest reported by the student.

A further review of past studies revealed a large pool of attitude scales measuring different attitudes such as: Attitudes Towards a Subject and Attitudes Towards Computer Use (Aldridge & Fraser, 2008); Attitudes Towards Science Enquiry (Gogolin & Swartz, 1992; Fraser, 1981); and Enjoyment of Science Lessons (Fraser, 1978). My review of literature indicated, however, that there were no scales that addressed students' attitudes towards the pedagogy. This study therefore extends past research by examining students' attitudes towards this aspect of the learning. The measurement of students' attitudes to the pedagogy poses similar but distinct challenges as those encountered in the above attitude scales in measuring the outcomes of the learning environment and, as in the case of this study, of problem-based learning. Thus, for the purpose of this study, the scale (Enjoyment of Science Lessons Scale) was adapted from an existing scale from the Test of Science-Related Attitudes (TOSRA, Fraser, 1981), to assess students' positive or negative feelings and their perceptions of the pedagogy (problem-based learning or lecture-based instruction methods).

2.7 Academic Efficacy

The notion of academic efficacy is drawn from the field of research related to self-efficacy, a central study in Bandura (1986) social cognitive theory. Bandura (1993) defined self-efficacy as a sense of confidence, or the belief that an individual possesses about their performance; it is concerned not with the skills they have, but with the judgement of what they can do with the skills that they possess. Self-efficacy, thus, refers specifically to the extent to which a student is confident in his or her ability in a particular domain.

Jinks and Morgan (1999) defined the notion of academic self-efficacy as the confidence that individuals have to successfully complete an academic task or achieve academic success. Individuals with high academic efficacy beliefs have been found to approach difficult or challenging tasks more willingly and with greater confidence. A study by Schunk and Pajares (2002) further suggested that students with high levels of academic self-efficacy are more likely to put in the required effort, use a range of learning strategies, and implement strategies which assist them to evaluate and self-regulate their learning. To this, however, Jinks and Morgan (1999) added a caveat that students who are generally confident and able in a particular area may nevertheless not engage in the classroom if they feel the teacher or lecturer dislikes them. It follows then that students' perceptions of their learning environment and academic efficacy are critical elements in their engagement and motivation in the classroom.

Research by Jinks and Morgan (1999) has indicated that a link exists between self-efficacy and academic performance. These findings suggest that there is a reciprocal relationship between academic efficacy, motivation and effort; motivation and effort are influenced by the students' academic efficacy beliefs and vice versa (Schunk & Pajares, 2002).

The present study has extended past research by examining the relationship between factors related to academic efficacy and the learning environment created at polytechnic level. Further, the study examines whether self-reports of academic efficacy differ for graduates who have been exposed to problem-based learning and lecture-based instruction.

2.6 Chapter Summary

This chapter has provided a review of literature relevant to this study. It explores the four main areas pertinent to this research: problem-based learning; the field of learning environments; person-environment fit research; role of attitudes in learning; and academic efficacy.

The review of the literature related to problem-based learning began with its origins or precursors that have led to the method currently known as problem-based learning. It included a brief history of development and the different approaches that are currently used in problem-based learning. The section also reviewed literature about empirical research that has been carried out to investigate the effectiveness of problem-based learning.

As the present study draws on the field of learning environments, a section is devoted to reviewing the literature about this topic. The review begins with a brief history of the field of learning environments and its association with Moos's framework for classifying human environments. The section explains how Moos's three-dimensional framework of social environments, including educational environments, can be investigated using these social climate dimensions. In particular, the review focusses on learning environment-outcome associations and the evaluation of educational innovations using learning environment dimensions as process criteria.

Given that this study examines the person-environment fit, the following section is devoted to a review of the literature related to this topic. The review suggests that a 'good fit' between students and their learning environment could mediate the relationship of group-specific experiences and positive learning outcomes.

As problem-based learning was introduced in all subjects across the curriculum at the educational institution that the research was carried out, it was important to examine the attitudinal outcomes with respect to how students regard the pedagogy involved and their academic efficacy or the extent to which they rate themselves as likely to succeed and do well in their courses.

CHAPTER 3
Research Methods

3.1 Introduction

As described in Chapter 1, the main purpose of this study was to examine the effectiveness of a problem-based learning environment in terms of graduates' perceptions of the learning environment, attitudes and self-efficacy. This chapter provides details about the research methods used to address the research objectives using the following headings:

- Research objectives (Section 3.2);
- Research design (Section 3.3);
- Samples (Section 3.4);
- Phase one: Collecting quantitative data (Section 3.5);
- Phase two: Gathering qualitative data (Section 3.6);
- Analysis of quantitative data (Section 3.7);
- Analysis of qualitative data (Section 3.8);
- Ethical considerations (Section 3.9); and
- Chapter summary (Section 3.10).

3.2 Research Objectives

The research objectives introduced in Chapter 1 are reiterated below.

Research Objective 1

To develop and validate instruments suited for use with graduates at the polytechnic level, to assess:

a. Perceptions of their learning environment, and,
b. Attitudes and academic efficacy.

Research Objective 2

To determine whether there are associations between the natures of polytechnic-level learning environment and graduates:

a. Attitudes towards the pedagogy, and,
b. Academic efficacy.

Research Objective 3

To investigate the effectiveness of problem-based learning in terms of graduates':

a. Perceptions of the learning environment,
b. Attitudes towards the pedagogy, and,
c. Academic efficacy.

Research Objective 4

To examine the effectiveness of problem-based learning in terms of person-environment fit.

3.3 Research Design

The research reported in this thesis involved a mixed-methods approach in which qualitative data were used to help provide insights into and explain the quantitative results, as recommended by Creswell and Plano Clark (2007). A mixed-method design was considered appropriate for this study, as it would not only allow triangulation of the data but also provide complementary data that would ensure more depth and understanding in the findings (Creswell, 2003; Jick, 1979; Tobin & Fraser, 1998). The sequential two-stage design adopted for purposes of this study involved the collection of quantitative data during the first phase, and the gathering of qualitative data during the second phase. This approach has been used in numerous past learning environment studies with much success and considerable benefits (Aldridge, Fraser & Huang, 1999, Bell & Aldridge, 2014; Tobin & Fraser, 1998). In my study, greater weight was given to the quantitative component as opposed to the qualitative component (Creswell, 2003; Onwuegbuzie, Johnson & Collins, 2011; Tashakkori & Creswell, 2007). The following section provides details about the sample used at each stage of the data collection.

3.4 Sample

This section describes the research participants involved at each stage of the study. The sample for pilot testing the instruments is described in Section 3.4.1, and the sample used to field test the on-line instruments is described in Section 3.4.2. The research participants for phase one of the study (involving the collection of quantitative data) are described in Section 3.4.3 and the research participants selected for phase two (involving the collection of qualitative data) are described in Section 3.4.4.

3.4.1 Sample for Pilot Testing the Instruments

The sample for the pilot testing of the instruments was drawn from a pool of polytechnic graduates who were employed part-time at the Republic Polytechnic. Five of these graduates had studied in a problem-based learning environment and four had studied in a lecture-based learning environment. These volunteers all had graduated from their respective polytechnics less than two years previously and, thus were considered to be similar to those involved in main study. The nine participants volunteered to provide feedback about the readability and flow of the questionnaires and to be interviewed to help to ascertain whether the items were interpreted in ways that were intended by the researcher. On completion of the pilot testing, the instruments were field tested in an online environment (the sample for which is described in the next section).

3.4.2 Sample for Field Testing the Online Version of the Instruments

The instruments were field tested to examine the technical aspects, including the computer-based delivery platform of the online version of the instrument and the administration procedures. The sample used to field test the online version comprised 42 recent graduates, of whom 15 were females and 27 were males. All of these volunteers had recently graduated, having completed a minimum of six semesters of study or three years at the polytechnic level. Their demographics were considered to be similar to the participants involved in the main study.

3.4.3 Sample for Phase One

The sample for phase one of the study (the collection of quantitative data) involved graduates from two different institutions. The first group was made up of graduates who had attended a polytechnic which used problem-based learning, as described previously in Chapter 1. The second group was made up of graduates who had attended a polytechnic with a more traditional approach to teaching and learning based, for the most part, on instruction by lectures.

The selection of graduates, rather than current students, was made for three reasons. First, it was anticipated that using graduates would provide homogeneity and consistency among respondents, as graduates would all have experienced six semesters (or three years) at either of the polytechnics. Second, it was anticipated that graduates, as opposed to students currently enrolled at the institutions, would provide more independent views (as some students may be reluctant to record responses that were not positive). Finally, given that my research was not sponsored by the Ministry through the Polytechnic, I had limited freedom to access students, resources and facilities at either of the institutions other than via the data bases of their graduates.

Both groups of graduates were similar in terms of their educational background, as both institutions required students' to have a minimum of six years of primary education and four years of secondary education. Graduates in both groups had passed the national General Certificate Examination, the GCE 'O' Levels (prior to their admission to the polytechnic), were similar in terms of age (which ranged between 19 to 21 years) and had similar levels of English language proficiency (required for admission into the polytechnics). In this respect, the two groups were considered to be comparable and therefore, were appropriate samples for purposes of this study.

The selection of the graduates to be included in the study was purposive, insofar as only those who were within two years of graduating were invited to respond to the survey. Within this group, however, the selection was random, with participants being recruited via an email invitation that was sent out to 2500 graduates from each institution. Of these invitations, 260 responses were received from graduates who had been exposed to problem-based learning (response rate=10.40%), and 187 responses were received from graduates who had been exposed to lecture-based learning (response rate=7.48%). These response rates were considered reasonable, given that PeoplePulse^{TM} report that an average response rate for online surveys was less than 10% (Quinn, 2009). The participants included both male (*n*=174) and female (*n*=231) graduates, a breakdown of which is provided in Table 3.1

Table 3.1 Break down of sample in terms of gender

Polytechnic	Main Survey		Total
	Male	Female	
Problem-based institution	80	138	260
Lecture-based institution	94	93	187

3.4.4 Sample for Phase Two

The second phase of the study involved the gathering of qualitative information. The sample used for this phase included the 42 graduates who were involved in the field-testing of the on-line instruments. These graduates had completed three years or six semesters in a problem-based learning environment and, therefore, their background and experiences were considered to be similar to the larger sample.

All 42 graduates participated in the focus group meetings and 40 of these volunteered to be involved in a follow-up telephone interview. Of these 40 graduates, a total of 33 of them were interviewed, of whom 17 were female and 16 were male. The 33 interviewees were randomly selected from the 40 volunteers.

3.5 Phase One: Collection of Quantitative Data

This section describes the development of the two instruments, the Problem-Based Learning Environment survey, (PeBLEs) (Section 3.5.1), and the Attitude Outcomes Questionnaire (the AOQ) (Section 3.5.2), that were used to collect the quantitative data. The following sections describe the pilot testing of the instruments (Section 3.5.3), then the field testing of the on-line version of the PeBLEs and the AOQ (Section 3.5.4) and finally, the administration of the questionnaires to the main sample (Section 3.5.5).

3.5.1 Developing the PeBLEs

Given that there were no instruments available to assess graduates' perceptions of their learning environment that were suitable for both problem-based learning and lecture-based instruction, it was necessary to develop a new survey. The development of the new instrument, the Problem-Based Learning Environment survey (the PeBLEs) involved several stages, as recommended by Fraser (1986) and Jegede, Fraser and Fisher (1995). These stages included: the identification and selection of the salient scales for the use in PeBLEs (described in Section 3.5.1.1); the review and modification of the items in the scales (Section 3.5.1.2); and designing the response format and organisation and layout of the instruments (Section 3.5.1.3).

3.5.1.1 Identifying and Selecting Salient Scales

The present study drew on many precedents for adapting and modifying existing scales (see for example, Aldridge, Dorman & Fraser, 2004; Trinidad, Aldridge & Fraser, 2005) as well as for creating new scales or modifying scale items to measure specific types of learning environment (see for example, Aldridge, Fraser, Bell & Dorman, 2012). In selecting the scales for the new instrument, a major criterion was to ensure that they provided a balance of coverage across the three types of human environment suggested in Moos's (1974) scheme.

The selection of the scales for the PeBLEs began with a review of literature and of previously developed learning environment instruments, as recommended by Fraser (2012). Scales relevant to both problem-based and lecture-based instruction types were identified in three instruments that had been previously validated: the What Is Happening In this Class? (WIHIC) questionnaire (developed by Fraser, Fisher and McRobbie, 1996); the Technology-Rich Outcomes-focused Learning Environment Inventory (TROFLEI) (developed by Aldridge and Fraser, 2008); and the Constructivist Learning Environment Survey (CLES) (developed by Taylor, Fraser and Fisher, 1997). In total, eight scales were selected from these three instruments. Six of the scales were drawn from the WIHIC: Student Cohesiveness, Teacher Support (renamed Lecturer/Facilitator Support in the new instrument), Involvement, Task Orientation, Cooperation, and Equity. One scale was selected from the TROFLEI, the Young Adult Ethos scale, and one scale was selected from the CLES, the Personal Relevance scale. A description of what each scale assesses and a justification for the inclusion of each of these scales is provided in the following sub-section. Table 3.2 provides for each scale: the origins of the scales; a description of the scale and what meaning it holds; a sample of an item in each scale; and its relationship with Moos's (1974) scheme for socially created human environments.

Student Cohesiveness. The Student Cohesiveness scale, modified from the WIHIC, assessed the extent to which graduates felt that the students helped and supported one another. Such norms and social acceptance by members are important to class cultures as they create an environment that is supportive for graduates' learning (William, Duray & Reddy, 2006). A supportive environment allows students to make mistakes without running the risk of being ridiculed. Thus, the extent to which students are cohesive is considered to be important, particularly in problem-based learning. This scale falls under Moos's Relationship Dimensions (Fraser, 1998a), which relates to the nature and intensity of peer relationships within the learning environment.

Table 3.2 Moos's Category, Origin, Scale Description, and Sample Item for each PeBLEs Scale

PeBLEs scale	Moos's category	Origin	Scale description	Sample item
			The extent to which graduates felt that ...	
Student Cohesiveness	R	WIHIC	… students were friendly and supportive of each other.	Members in my class were my friends.
Lecturer/ Facilitator Support	R	WIHIC	… the lecturer/facilitator helped, and showed interest in students' learning needs.	The lecturer/tutor helped me when I had trouble with my work.
Involvement	P	WIHIC	… students' demonstrated interest, participated in class and were involved with other students in assessing the viability of new ideas.	I gave my opinions during my class discussions.
Task Orientation	S	WIHIC	… it was important to complete planned activities and to stay on the subject matter.	I helped to set learning goals in my class.
Cooperation	R	WIHIC	… students cooperated with each other during class activities.	I worked in groups in my class.
Equity	S	WIHIC	… students perceived their lecture/facilitator treated students fairly, distributed questions, and provided opportunities for all to be included.	The lecturer/facilitator gave as much attention to my questions as the other students.
Young Adult Ethos	P	TROFLEI	… the lecturer/facilitator gave students responsibility and treated them like young adults.	I was trusted with responsibilities.
Personal Relevance	P	CLES	… students perceived the learning that took place to be relevant to their lives outside the classroom.	What I learned was relevant to my day-to-day life.

R: Relationship Dimensions; P: Personal Development Dimensions; S: System Maintenance and System Change Dimensions
WIHIC: What Is Happening In this Class?; TROFLEI: Technology Rich Outcomes-focused Learning Environment Inventory; CLES: Constructivist Learning Environment Survey.
Table adapted from Aldridge, and Fraser, (2008).with permission.

Lecturer/Facilitator Support. The Lecturer/Facilitator scale was modified from the Teacher Support scale of the WIHIC. To reduce confusion among respondents who know teachers as facilitators or (faci for short) in problem-based learning and lecturers in lecture-based instruction classes, the word teacher was changed to lecturer/facilitator. The Lecturer/Facilitator Support scale assessed the extent to which graduates felt that the lecturer or facilitator helped and befriended the students and was interested in their problems. The lecturer's or facilitator's relationships with their students can be pivotal in creating the right attitudes in the learning environment. These relationships can lead to students developing positive or negative attitudes towards the subject and to classroom activities, and can be influential in motivating students to learn. It was with this in mind that the lecturer/facilitator support scale was selected to determine the level of support in the different pedagogical learning environments. As with the Student Cohesiveness Scale, Moos's Relationship Dimensions also falls into this scale (Fraser, 1998a).

Involvement. The Involvement scale, modified from the WIHIC, assessed the extent to which graduates felt that they were given opportunities to participate in discussions and to be involved in classroom teaching and learning activities. Research indicates that students who are involved in their own learning will find it more meaningful and that they have a more conscious intention to make sense of their own ideas or experiences (Fletcher, 2005). Involved students try to make sense of new ideas or experiences and improve their own knowledge and capabilities, as compared to those who simply try to remember and reproduce their learning (Cindy & Hmelo-Silver, 2004). The selection of this scale was important in determining the extent to which graduates perceived that the pedagogy provided them with the opportunity to participate in the class and the extent which they were involved in the learning process. This scale falls within Moos's Personal Development Dimensions (Moos, 1974) which assess the extent to which the learning environment provides activities for students to engage with concepts that they develop in their classes.

Task Orientation. The Task Orientation scale, modified from the WIHIC, assessed the extent to which the graduates felt that it was important for students to complete planned activities and to stay on the subject matter. This scale refers to both short-term and long-term goals, which, if made clear and relevant, are more likely to provide students with the motivation and purpose to be engaged in their learning (Killen, 2006; Spady, 1994). Viewed in this light, students given clear goals are more likely to expend the effort needed to attain the necessary outcomes or classroom goals (Blumenfeld, 1992). Given that learning at the post-secondary polytechnic level is largely student driven, this scale was considered to be important. This scale falls within Moos's System Maintenance and System Change Dimensions (Aldridge & Fraser, 2008), which assess the extent to which the environment is clear in its expectations, especially in the task the class is expected to carry out.

Cooperation. The Cooperation scale, which was modified from the WIHIC, assessed the extent to which graduates felt that students cooperated rather than competed with one another during class activities. Past research has found that the creation of a cooperative learning environment provides students with opportunities to work collaboratively with one another and to contribute in various ways (Johnson, Johnson & Smith. 2007). Typically, a competitive environment creates win-lose relationships, while a cooperative environment refers to winning as a team (Tan, Sharan & Lee, 2007). One benefit of encouraging cooperation is that students are more likely to help one another rather than put colleagues down in order to stay ahead (Johnson, Johnson & Smith, 2007; Tan, Sharan & Lee, 2007). This scale was identified as important for assessing the level of collaboration between students exposed to both instructional types. The scale is classified under Moos's Relationship Dimensions (Aldridge & Fraser, 2008) that assess the extent to which the learning environment supports students and the extent to which students help and cooperate with one another to learn.

Equity. The Equity scale, modified from the WIHIC, assesses the extent to which graduates felt their facilitator/lecturer treated students fairly in terms of distributing praise and questions among class members and in providing opportunities for students to be included in discussions. The learning environment should provide an atmosphere in which all students feel that they are treated in ways that are fair and equitable (Spady, 1994) This perception of fairness goes a long way in providing encouragement and motivation for students to be involved in their learning (Chory-Assad & Rebecca, 2002). Given that the notion of fairness is important at any level of education, this scale was selected for inclusion. The Equity scale falls under Moos's System Maintenance and System Change Dimensions (Fraser, 1998a) which assess the extent to which the environment provides a level playing field (or system) for all students, and is clear in expectations with equal opportunities for students to do well.

Young Adult Ethos. The Young Adult Ethos scale, modified from the TROFLEI, assesses the extent to which graduates felt that teachers gave their students responsibility for their own learning and treated them as young adults (Aldridge & Fraser, 2008). Hiemstra (1999) proposed that, with the speed of change, the continuous creation of new knowledge and an ever-widening access to information, much of the learning will have to take place at the learner's initiative, even if available through formal settings. Self-directed learning, therefore, is seen as an initiative that schools and institutions of higher learning must develop in order to encourage students and enable them to keep up with changes. Given the importance of self-directed learning, it was considered to be important to assess differences in perceptions of this dimension of learning between different pedagogical styles. This scale was adapted from the TROFLEI and modified for purposes of this study.

Personal Relevance. The Personal Relevance scale, modified from the CLES, assesses the extent to which graduates felt that the learning was relevant to their lives outside of the classroom. Findings of past research suggest that high personal relevance creates a more positive attitude towards learning, while low personal relevance has the opposite effect (Liberman & Chaiken, 1996). Establishing personal relevance in teaching and learning is considered to be a key component that intrinsically motivates student learning (Kember, Ho & Hong, 2008). According to Simons and Klein (2007), most students who see their efforts as relevant to their lives are more motivated to participate in the learning activities. In learning environments that have both personal and real-world relevance, students are provided with an important opportunity to relate the course subject matter to the world around them and to assimilate it with their previously held beliefs and assumptions. Such linkages motivate the teaching and learning processes and allow students to experience theory in practice. Given these findings, the inclusion of this scale was considered to be important for students at the polytechnic level. The scale is classified under Moos's Personal Development Dimensions that assess the opportunities for personal growth and self-enhancement that are provided in the graduates' learning environment.

3.5.1.2 Reviewing and Modifying the Individual Items

Given that the scales selected were all developed in Western countries and for high school classes, the items of the scales were examined to ensure their relevance to the context of the study by the researcher and, later, with students and academics. The items were also examined with respect to the scale description, to ensure that they represented the construct that they were purported to assess and were readable and not ambiguous. Where necessary, selected items were identified for refinement or were reworded. For all scales, two items were removed to make the survey more economical. The selection of items for removal was made in consultation with the expert review panel.

In reviewing the selected scales, two members of the academic staff from each of the problem-based and lecture-based settings, were invited to be part of an expert panel. These academics were consulted based on the purpose of the instrument, their understanding of the scales and their opinion of the relevance of the scales to the stated academic purposes (as opposed to political or any other reasons).

In reviewing the selected scales with the panel members, it was suggested that one scale (not included in the description provided earlier), Investigation, might not be relevant to lecture-based learning. Although the term Investigation was used regularly in problem-based learning it was not necessarily familiar in the lecture-based setting. It was felt, therefore, that the inclusion of this scale might imply a bias towards problem-based learning. As a result, this scale was removed.

The expert panel also identified 'double-barrelled' items. For example, one item, "I worked with other students on my assignments and presentations", was asking students to respond to separate activities in the same item (assignments and presentations). As these two types of work were both graded and could be responded to differently, the item was changed to "I worked with other students on presentations in my class".

3.5.1.3 *Response Format, Organisation and Layout*

Numerous past studies have examined students' perceptions of both the actual and preferred learning environment. In these studies, the 'actual' response assessed students' perceptions of the environment that they were experiencing and the 'preferred' response assessed students' perceptions of their preferred or ideal classroom environment (Fraser, 2007). Historically, researchers have administered the two versions (actual and preferred) separately. In more recent studies however, researchers have successfully used a side-by-side response format, pioneered in the Technology Rich Outcomes Focused Learning Environment Inventory (TROFLEI) survey instrument (Aldridge & Fraser, 2008). In this format, the two responses scales are positioned adjacent to each other and on the same page. As this allows for a quick response to each item, this response format was used in the present study, as illustrated in Figure 3.1.

A. Student Cohesiveness	ACTUAL					PREFERRED				
	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
1. Members in my class are my friends.	◉	○	○	○	○	○	○	○	○	◉
2. I know other students in my class.	◉	○	○	○	○	○	○	○	○	◉

Figure 3.1 Side-by-Side Response Format for Actual and Preferred Items in the PeBLEs.

In more recent learning environment studies, researchers have also successfully grouped together items that belong to the same scale. This was found to be useful in providing contextual cues that could minimise confusion among students (Aldridge et al., 2000). Taking these findings into account, this format was used in the present study.

Items of the PeBLEs were responded to using a five point frequency response format of Almost Always, Often, Sometimes, Seldom and Almost Never. A copy of the final version of the PeBLEs, used in this study, can be found in Appendix 1.

3.5.2 Developing the AOQ

In addition to the learning environment scales, two outcome scales were selected and modified from existing instruments, to form the Attitude Outcomes Questionnaire (AOQ). The first scale, the Attitudes Towards the Pedagogy, was modified from a scale from TOSRA, the Test of Science-Related Attitudes (Fraser, 1981), and is described in Section 3.5.2.1. The second scale, Academic Efficacy, was modified from the Morgan-Jinks Student Efficacy Scale (Jinks and Morgan, 1999) and is described in Section 3.5.2.2. The response format, organisation and layout of the AOQ are described in Section 3.5.1.3.

3.5.2.1 Attitudes Towards the Pedagogy Scale

For the purpose of this research, a definition based on an affective component (feelings regarding the object, such as like or dislike), was used to examine the way in which students might regard a given subject in terms of whether it was interesting or exciting. Given that the pedagogy involved in problem-based learning is very different to lecture-based learning, it was considered important to assess whether this affected the participants' attitudes.

The Attitude Towards the Pedagogy scale was adapted from one of the scales (Enjoyment of Science Classes) of the TOSRA, the Test of Science-Related Attitudes (Fraser, 1981), The scale was modified to assess graduates' attitudes towards the pedagogy. In some Asian cultures, enjoying a lesson might not represent serious teaching and learning. Further, examining attitudes towards the pedagogy rather than the enjoyment of lesson was considered appropriate as it was desirable to assess the sentiments towards and acceptability of problem-based learning among polytechnic graduates. Therefore, the decision to use the term Attitudes Towards the Pedagogy was considered to be prudent. The word 'enjoyment' used in the original scale was replaced with the word 'attitudes towards the pedagogy'. Wording of individual items of the TOSRA scale were modified so that they did not relate to science classes but rather, to the teaching and learning environment. To avoid confusion the wordings of items were also changed to ensure that all items were positive. Further, given that the samples involved graduates and not students, the tense used in the statements for the items were changed. For example, the item *I enjoy science classes* was changed to *I enjoyed the activities carried out in my class*.

Given that the response items for the original TOSRA (Likert Scale) were different to the PeBLEs (frequency-response format), the wording was changed to accommodate the new response format. Typical items in this scale included “I looked forward to attending class daily” and “I was interested to do better work in my class all the time”.

3.5.2.2 Academic Efficacy Scale

The second scale of the AOQ assessed students’ academic efficacy. Self-efficacy refers to beliefs about one’s capabilities of learning or performing at designated levels (Bandura, 1997). Much research shows that self-efficacy influences academic motivation, learning, and achievement (Pajares, 1996; Schunk, 1995). Learners appraise their self-efficacy in terms of their actual performances, their vicarious experiences, the learnings they received from their interactions with each other, and their physiological reactions. Self-efficacy beliefs influence task choice, effort, persistence, resilience, and achievement (Bandura, 1996; Schunk, 1995). Students’ beliefs about their competence could, according to Lorsbach and Jinks, (1999), have important implications for improving learning. Therefore, this study investigated whether graduates’ beliefs about their academic competence were different for those who were enrolled in a problem-based learning environment when compared to those enrolled in a lecture-based learning environment.

To assess academic efficacy, items were modified from a scale originally developed by Jinks and Morgan (1999) and later adapted by Aldridge and Fraser (2008). For the purposes of this study, the eight items in the scale modified by Aldridge and Fraser (2008) was reduced to six items. Typical items in the Academic Efficacy scale include “I was competent in performing the task” and “I was challenged to think and apply what I learned in my class”.

Items in the Academic Efficacy scale used the same five point frequency response format as the rest of the survey, these being Almost Always, Often, Sometimes, Seldom and Almost Never, as with the PeBLEs. (The final version of the AOQ can be found in Appendix 2.)

3.5.3 Pilot Testing PeBLEs and the AOQ

The PeBLEs and the AOQ, after consultation with the expert panel, were pilot tested on a sample of nine graduates (the selection of which is described in Section 3.4.1). Their feedback was used to refine the wordings and interpretation of various words and terminologies used in the PeBLEs and the AOQ. Reported below are the findings.

During interviews with graduates, it was identified that items ending with ‘this class’ could be problematic. For example, it was identified that the items “I set my learning goals in this class,” and “I learn from other students in this class”, could refer to a particular class that the graduates had been in. Given that students move between groups and classes in both problem-based and lecture-based settings, it was considered sensible to change the wording from ‘this class’ to ‘my class’ for all items.

A second point raised by the graduates was the use of the word ‘lecturer’ (in the items of the Equity scale). They felt that this might be confusing in problem-based settings, where teachers were known as ‘Faci’, short for Facilitators. Items containing these words, such as “The lecturer considers my feelings”, or “The lecturer talks to me”, which may be unfamiliar to graduates from a problem-based setting were, thus, replaced with “lecturer/facilitator” as this term suited respondents from either setting. Taking this feedback into account, a new draft was written and field tested with 42 graduates in an online environment, as described in the following section

3.5.4 Field Testing the Online Version of PeBLEs and the AOQ

Unlike the full scale administration of the survey, where the graduates would be accessing the online portal from their own locations, the administration of the field test was conducted in a classroom to allow me (the researcher) to observed and respond to concerns, queries or difficulties assessing or understanding the online survey located on the portal. The sample for the field test involved 42 graduates (described in Section 3.4.2). The purpose of the field test was to:

- obtain information about the time taken to complete the questionnaires;
- observe whether the graduates had difficulty responding to the questions on-line;
- identify and ratify electronic glitches or online difficulties;
- identify and ensure that completing or submitting multiple responses online was not possible; and
- examine whether the output of the data collected, using the online survey, would be produced as intended.

A major concern was the possibility of electronic glitches that might result from the built-in security features in the program, or excessively high security in the domain server. Such glitches might create ‘stop’ points that would not allow respondents to proceed to the next question without completing an earlier one, or difficulties with firewalls. Other likely electronic glitches included time-out features that could be activated on the internet domain that was housing the survey. These incidents could cause delays or slow responses that would distract respondents and cause them to give up completing the survey. Throughout the field test, there were no incidents or reports of electronic glitches from the graduates or any system irregularities.

A challenge of electronic surveys was the possible submission of multiple entries, especially if respondents were to complete several copies randomly. Such surveys could skew the data and render the findings less reliable. To alleviate this concern, all respondents were encouraged to take part in a lucky draw, which served two purposes. The first was to encourage as many returns by different respondents as possible. Second, respondents were asked to include their mobile phone number (in order to be informed if they won) and their unique school registration number. Should they win, they would be contacted by the mobile number and matched to their school registration number.

A further concern was related to the effect of a high load on the portal. The load factor was tested with two batches of twenty or more respondents who were asked to complete the online survey at the same time. Both batches experienced no problems completing the survey and the integrity of the web portal was maintained, even when all 42 participants responded to the survey simultaneously. On average, the time taken to complete the survey online was recorded as between 20 and 30 minutes.

3.5.5 Administering the Surveys

With the field testing completed, an invitation to participate in the main survey was emailed to 5,000 graduates (2,500 had attended the polytechnic with problem-based instruction, and 2,500 of whom had attended the polytechnic with lecture-based instruction). These contacts were accessed through the alumni data base of each institution. The email that was sent out to these graduates contained information that described the purpose of the survey, an assurance of anonymity, the approval of the survey by the ethics committee at Curtin University and the research site in Singapore, the voluntary nature of the questionnaire, and the closing date. There was also information regarding the conditions for participating in the lucky draw, and the URL of the web-site where the questionnaires for the survey could be found. (Details of the invitation letter to participate in the survey can be found in Appendix 3.)

The emails were sent in two batches, less than one week apart. The graduates were given six weeks in which to respond to the survey. Most of the research participants responded within two weeks of receiving the email, with a few responding in the third and fourth week and a spike in respondents on the final day, just before the survey closed.

3.6 Phase Two: Gathering Qualitative Data

The second phase of the study involved the gathering of qualitative data using focus group meetings and telephone interviews with graduates who had been exposed to the problem-based learning environment. The gathering of qualitative data was carried out in two phases, through focus group meetings (Section 3.6.1), and telephone interviews (Section 3.6.2).

3.6.1 Focus Groups Meetings

The Qualitative Research Consultancy Association (QRCA) (n.d) defines a focus group meeting as "a moderator-led discussion among a group or groups of individuals who share a need, habit, or life circumstance relevant to the research issue(s) at hand." Eight groups of five or six graduates who had been exposed to problem-based learning were involved in the focus group meetings, providing a total of 42 graduates. Ten open-ended questions, carefully developed, as recommended by Morgan, Kreuger, and King (1998) and Krueger and Casey (2009), were used to increase the likelihood of generating discussion and different points of views and opinions (Greenbaum, 1999).

At the commencement of the focus group meeting, graduates were broken into their groups. At this stage participates were provided with information about the research both verbally and on an information sheet. Participants were given time to read the information note before being asked to sign the informed consent form (copies of both the information sheet and consent form can be found in Appendix 4). Each group was then asked to appoint a scribe who would be responsible for recording comments and contributions by members during the meeting, as well as to appoint a group leader who would facilitate the group's dynamics (under my guidance) and generate opinions and comments along the lines of the ten open-ended questions (provided in Appendix 5). The leader was also responsible for transcribing the group's points onto a slide show for their group's presentation to be collected at the end of the meeting.

The focus group meetings lasted no more than one and a half hours, as recommended by Krueger and Casey (2009), as longer sessions would be likely to cause participants to lose their concentration or interest.

Written notes collected during the focus group meetings came from two sources. The first came from individuals' comments and notes that were recorded before or during the course of the meeting. At the commencement of the focus group meeting graduates were given five to ten minutes to write down their experiences in the classroom during the time they had spent engaged in problem-based learning. They were also encouraged to jot down ideas and comments that came to mind as they went through the ten questions individually and as a group.

The second source was provided by the appointed scribes in each group, who recorded ideas, suggestions and comments during the group meetings. This approach was considered to be a useful source of information that would help to maintain the formality of the meeting while also minimising the loss of information that might be considered important at a later time (Nickerson, 1998). The recorded notes were collected from the scribes at the end of the meeting.

3.6.2 Telephone Interviews

During the focus group meetings, graduates were invited to be involved in telephone interviews. As described in Section 3.6.1, 40 graduates volunteered to be interviewed and provided their telephone numbers with the written notes. Of these, I contacted 33 participants by telephone. The telephone interviews followed a semi-structured format, allowing me to encourage the participants to talk freely but with reference to the original list of questions to ensure consistency between interviews. (A copy of the questions used in the interviews is provided in Appendix 5.) This structure allowed participants to add information and depth which helped me to further understand the issues or questions raised (Groves, Biemer, Lyberg, Massey, Nicholls & Waksberg, 1988). In this way, information could be re-visited to clarify the accuracy of my understanding and to re-confirm the analysis of the data. These telephone interviews, combined with the earlier focus group meetings, were used to gain a more complete picture of the experiences and sentiments of the research participants during the time that they used problem-based learning. In particular, the interviews helped me to understand the issues related to the scales that were found to be statistically significant during the qualitative analysis.

3.7 Quantitative Data Analysis

This section describes how the quantitative data were analysed to address each of the research objectives. Section 3.7.1 describes the analysis used to provide evidence for the reliability and validity of the PeBLEs and the AOQ. Section 3.7.2 describes the analysis used to examine relationships between the two student outcomes and the eight classroom environment scales. Section 3.7.3 describes the analysis used to examine the effectiveness of problem-based learning in terms of graduates' perceptions of their learning environment and their attitudes and academic efficacy. Finally, Section 3.7.4 discusses the analysis used to examine the person-environment fit.

3.7.1 Research Objective 1

The first research objective sought to provide evidence for the reliability and validity of the newly developed PeBLEs and the AOQ. Analysis involved examining the factor structures of each instrument and internal consistency reliability for each scale.

Exploratory factor analyses were carried out separately for each version of the PeBLEs (actual and preferred) and the AOQ. Principal axis factoring was used to extract the factors and, in order to reduce the complexity of the factors extracted, varimax rotation was utilised. The criteria for retaining an item was that it should load at 0.40 or more on its own scale and less than 0.40 on any other scale (as recommended by Field (2009) and Thompson (2004). While factor loading indicated how strongly each item was related to each factor, the eigenvalues provided an indication of the relative importance of each factor, and the cumulative variance was used to check whether a sufficient number of factors were retained (Field, 2009; Thompson, 2004).

To ensure that the items in a scale were measuring the same construct, the Cronbach alpha reliability coefficient was calculated as an estimate of internal consistency. The internal consistency was computed separately for the actual and preferred versions of the PeBLEs.

Finally, an estimate of the discriminant validity was calculated, using the mean magnitude of the correlation of a scale with the other scales in the same instrument as a convenient index. A scale that possesses discriminant validity assesses the extent to which a scale is unique in the dimension it covers (Aldridge & Fraser, 2008).

3.7.2 Research Objective 2

The second research objective examined the associations between the two student outcomes and the eight classroom environment scales. To examine these relationships, simple correlation and multiple regression analyses were used. Simple correlations were used to examine the bivariate relationship between each student attitude outcome with each learning environment scale. Multiple correlation analyses were used to investigate the joint influence of the whole set of environment scales on each attitude outcome. The beta (β) was computed to provide more information about the bivariate association between each learning environment scale and each student outcome. The beta (β) describes the influence of a particular learning environment variable (identified in PeBLEs) on an outcome when all other environment variables in the regression analysis are mutually controlled.

3.7.3 Research Objective 3

The third research objective examined the effectiveness of problem-based learning in terms of learning environment perceptions and student attitudes and efficacy. To determine whether differences exist between graduates exposed to problem-based learning and those exposed to lecture-based learning, a one-way multivariate analysis of variance (MANOVA) was used. The independent variable was the type of instruction (problem-based or lecture-based) and the dependent variable was the learning environment and attitude scales. Since the one-way MANOVA yielded significant results, using Wilk’s Lambda criteria (Everitt & Dunn, 2001), the univariate one-way ANOVAs were interpreted for each learning environment and attitude scale to investigate whether statistically significant differences exist between the problem-based and lecture-based learning environments. To describe the magnitude or educational importance of those differences, effect size was calculated using the following formula:

$$\text{Cohen's d} \quad = M_1\text{-}M_2/\sqrt{[(\sigma_1^2+\sigma_2^2)/2]},\ r_{Y\lambda}=d/\sqrt{(d^2+4)}.$$

Qualitative information was used to add depth to these findings, the analysis of which is described in Section 3.9.

3.7.4 Research Objective 4

The fourth research objective examined the person-environment fit for graduates exposed to problem-based learning. To do this, a one-way analysis of covariance (ANCOVA) was used. In the analyses the actual response to each learning environment scale was the dependent variable, the corresponding preferred response to each learning environment scale was the covariate and the instruction-type was the independent variable. This analysis allowed the instruction types to be compared on each of the learning environment scales while controlling for the preferences of the research respondents.

3.8 Qualitative Data Analysis

To provide insights that would help to address Research Objective 3, qualitative information was gathered. The analysis of the qualitative data involved a number of steps: transcribing and organising the data (Section 3.9.1); coding the data (Section 3.9.2); classification of the data (Section 3.9.3); developing the themes (Section 3.9.4); and selecting the themes (Section 3.9.5). Each of these is described below.

3.8.1 Transcribing and Organising the Data Collected

At this stage of the analysis, the raw data compiled from the focus group sessions, written comments and telephone interviews, was transcribed into a written form and classified into different categories. The data was read several times in order to start the development of potential codes and finding the representation of each code that would assist in the search for meaning and patterns in the data set. A set of criteria for the data set were established to aid the classification and interpretation of the raw data. The data were eventually organised into different pages, based on the type of data, the questions they originated from and their relationship to the scales in PeBLEs.

3.8.2 Coding the Data

The initial list of items from the data set, with recurring patterns, was placed into categories that were related to the list of questions (provided in Appendix 4). The coding process used was evolved through inductive analysis and a cyclical process (Braun & Clarke, 2006). The cyclical process involved going back and forth between phases of data analysis until I was satisfied with the final classification. Much time was spent going beyond the surface meaning to make sense of the data and to understanding the underlying meaning of what the data meant. As such, the data classification codes were refined by adding, subtracting, combining or splitting potential codes into their different categories. The data were eventually coded under the eight main scales in the PeBLEs. Done this way, the coding facilitated my ability to locate pieces of the type of data representing the label, for detection and identification of their source and referral back for interpretation of their meaning (Guest, 2012). This stage allowed me to reorganise the data according to the ideas and the different viewpoints developed over the process, pigeon hole them to the different 'folders' and reduce the breadth of the data available, as suggested by Coffey and Atkinson (1996).

3.8.3 Classification of the Data

With the initial phase of the coding process completed, the next step was to assess whether there were any means for classifying the data with broad analytical codes to reduce the data to more manageable amounts for more efficient analysis. At this stage the data were classified according to their relationships along the five respective scales in the PeBLEs that were found significant in the quantitative analysis. As a result, some of the data were reconceptualised and given a new context in the classification. This marked the beginning of the development of the themes. It was important, at this stage, to describe exactly what the theme would mean and to identify how the quantitative results (related to the five statistically significant scales) fitted with these themes.

3.8.4 Developing the Themes

Developing the themes allowed me to analyse the potential codes again and to assess how the codes combined to form the overarching themes of the data. Each data set was tested with the themes to examine what worked and what did not work. At this stage, I focused on broader patterns in the data and tried to match or combine data with the proposed themes. I also considered whether there were relationships between the codes and themes and between themes, and whether changes in the labels given to themes were necessary, as recommended by Braun and Clark (2006).

The themes developed at this stage consisted of phrases or sentences that related to the set of data that were coded under its classification. Finding the right labels for the themes helped to convey the appropriate perspectives. At this phase of the development of the themes, several possible themes that could apply were compared and analysed to find the one most representative of the data under its classification.

3.8.5 Selecting and Naming the Themes

At this stage of the analysis, I identified the themes that would best relate to the data that had been classified. Therefore, I revisited the data sets and searched for data that supported or refuted the themes. This allowed me to expand or revise the potential themes. I reviewed the set of potential themes determined earlier, and reworked the associations of the data set and the themes, and cancelled some of them or changed the themes. I started to re-list or modify the themes and began focussing on broader patterns in the data, combining the coded data with the proposed themes. I also considered relationships in the codes and the themes, and tried narrowing down the potential themes to select the ones that would add more depth into the scales found significant in the quantitative analysis. The result of the qualitative analysis was the development of three themes, as described in Chapter 4.

3.9 Ethical Considerations

This section describes the ethical considerations undertaken at each stage of the study, including the approvals and ethical considerations made prior to the collection of the data (Section 3.9.1); informed consent (Section 3.9.2); anonymity and confidentiality (Section 3.9.3); and the voluntary nature of the research (Section 3.9.4).

3.9.1 Approvals Prior to Collection of the Data

Prior to the collection of the data, permission to conduct this study was approved by the Human Research Ethics Committee at Curtin University (see Appendix 5 for the letter of approval). This was followed by approval from the institution using problem-based learning, which granted the permission and approval code to access their data base and survey the graduates. (See Appendix 6 for the letter of approval.) The institution that involved lecture-based learning did not require any formal permission other than to be kept informed, as they considered their alumni as ex-students and this survey as a voluntary exercise.

3.9.2 Informed Consent

Informed consent was obtained from research participants during each of the two phases in the data collection.

In the first phase of the data collection, which involved the administration of PeBLEs and the AOQ, a letter accompanying instructions for the survey, included information about purpose of the survey, the voluntary nature of the survey, and their rights as participants should they agree to be involved. It also contained the contact details for myself and my supervisor at Curtin University, should they wish to contact either of us for clarification or for any issues that arose. Participants were required to acknowledge their understanding of the information and provide their consent to participate. (A copy of the letter is provided in Appendix 3.)

The second phase involved gathering the qualitative information. Prior to the commencement of the focus group meetings, participants were provided with, an information sheet regarding the research, the voluntary nature of the study and their right to withdraw without penalty. The sheet included information about the nature of the qualitative data collection and what is expected of them should they be involved.

Contact details of the researcher and his supervisor at Curtin University were also provided. A copy of the information and consent sheet is provided in Appendix 4.

An incentive was provided for the completion of the survey (Phase One of the study), which involved a lucky draw. Participants were advised that taking part in the lucky draw was strictly voluntary, and that they need only submit an email address with a pseudonym and/or their mobile phone number when they were prompted on the screen (soon after submitting their survey on-line). They were assured that this number would only be used to contact the participant if they won the prize. There was no link between the survey and the mobile telephone numbers or emails, as they were collected using separate systems, the latter one being activated with a prompt on screen only after the submission of the survey was recorded.

3.9.3 Anonymity and Confidentiality

Throughout this study, every effort was made to ensure the anonymity and confidentiality of participants. At all stages, no information or records were kept that could identify the research participants. The data collected from the focus group meetings and telephone interviews were coded and did not include names associated with participants. Mobile telephone numbers, provided by participants on a voluntary basis, were kept separately and were destroyed after the telephone interviews.

3.9.4 Voluntary Participation

Involvement in the study was strictly on a voluntary basis and respondents were informed that they were under no obligation to participate in any aspect of the study. Participants taking part in the survey and focus group sessions had all completed their diploma courses and had graduated. They were therefore not under any pressure to participate. The lucky draw was perceived as a bonus and a motivator, in return for their time and effort in completing the survey.

3.10 Chapter Summary

This chapter describes the research methods undertaken for this study. The study was carried out in two phases. The first phase involved the collection of quantitative data and the second phase the gathering of qualitative data.

In collecting quantitative data, two instruments were developed. The first, the Problem-based Learning Environment survey (PeBLEs), comprised eight scales: Student Cohesiveness, Lecturer/Facilitator Support, Involvement, Task Orientation, Cooperation, Equity, Young Adult Ethos, and Personal Relevance. Each scale included six items, making a total of 48. The second instrument, the Attitude Outcomes Questionnaires (AOQ) was used to assess student outcomes and comprised two scales, Attitudes Towards the Pedagogy and Academic Efficacy. Each scale of the AOQ had six items, making a total of 12.

A pilot test was carried out with nine graduates, five from a problem-based environment and four from a lecture-based environment. Their feedback pertaining to the development of the PeBLEs and the AOQ was used to examine whether the items were interpreted in ways intended by the researcher.

With the success of the field test (used to ensure that the online version of the survey was acceptable), large-scale administration of the survey was undertaken. Five thousand graduates (2,500 from each institution) were invited to participate in the survey. Of these, 218 graduates who had been exposed to problem-based learning and 187 graduates who had been exposed to a lecture-based instruction responded. As there were no unusual occurrences or abnormalities recorded in the field test, the 42 responses from the field test were included in the final sample, providing a total of 260 graduate samples that were exposed to problem-based learning.

Students' responses to the PeBLEs and the AOQ were analysed to provide evidence for the reliability and validity of the surveys, including the factor structure and alpha reliability discriminatory validity.

The second research objective was to investigate which learning environment factors were important in determining student outcomes. Simple correlations were used to examine the bivariate relationship between each student attitude outcome with each learning environment scale. Multiple correlation analyses investigated the joint influence of the whole set of environment scales on each attitude outcome.

The third research objective was to investigate the effectiveness of problem-based learning in terms of learning environment perceptions, attitudes and academic efficacy. A one-way multivariate analysis of variance (MANOVA) was used to examine differences between the two learning environments (problem-based and lecture-based) and the dependent variables were the learning environment and attitude scales. ANOVAs were used to interpret for each of the learning environment and attitude scales to investigate whether there were statistical significant differences between the problem-based and lecture-based learning environment.

The fourth research objective examined the person-environment fit. An analysis of covariance (ANCOVA) was conducted with each learning environment scale as the dependent variable, the corresponding preferred scale as the covariate, and the instruction type as the independent variable. This allowed the actual scores on the learning environment scales to be referenced against the preferred scores and then compared between the two learning environments.

The second phase of the study involved the collection of information using focus group meetings and telephone interviews. The data included written notes from individuals and documentation from the appointed scribes in each group. Semi-structured telephone interviews were carried out with 33 of the participants to provide more in-depth information. The feedback from the written comments and telephone interviews was analysed and coded before it was organised and classified into potential themes.

Finally, ethical considerations were taken into account in ensuring that informed consent was obtained from research participants during each of the two phases during the focus group meetings and the follow-up telephone interviews. Participants were assured of the approvals from the various institutions, informed about whom they could voice their concerns to, and about their anonymity and confidentiality, and were made fully aware of the voluntary nature of the study.

The next chapter reports the results of the present study.

CHAPTER 4
Analysis and Results

4.1 Introduction

Chapter 3 discussed the research methods and the sample involved; this chapter reports the results of the analysis for both phases of the study, using the following headings:

- Validity and reliability of the PeBLEs (Section 4.2);
- Validity and reliability of the AOQ (Section 4.3);
- **E**nvironment-outcome associations (Section 4.4);
- Effectiveness of problem-based learning (Section 4.5);
- Person-environment fit (Section 4.6); and,
- Chapter summary (Section 4.7).

4.2 Validity and Reliability of the PeBLEs

As described in Section 3.4, the PeBLEs was used to assess the perceptions of graduates who had studied using the two instruction types, problem-based learning (*n*=260) and lecture-based instruction (*n*=187). The data collected from a total of 447 graduates was used to examine the factor structure (Section 4.2.1), internal consistency reliability (Section 4.2.2) and discriminant validity (Section 4.2.3) of the PeBLES.

4.2.1 Factor Structure

To ensure that the PeBLEs was indeed the multi-scale questionnaire that it was designed to be, principal axis factor analysis with varimax rotation was used to examine the factor structure. Separate analyses were carried out for the actual and preferred data. The criteria for retaining an item was based on Stevens (2001) and Field (2009) recommendation, this being that it must have an absolute value of at least 0.40 on its own scale and less than 0.40 on any other scale. Using this criterion led to the removal of four items for both the actual and preferred versions: Item 11 for the Lecturer/Facilitator Support scales, Items 19 and 21 for the Task Orientation scale, and Item 27 for the Cooperation scale. These items were omitted from all further analysis.

Removal of these items led to a refined structure that comprised 44 items in the eight *a priori* scales for both the actual and preferred versions. These 44 items had a factor loading of at least 0.40 on their *a priori* scale and on no other scale for both the actual and preferred version of the instrument. The factor loadings of individual items are reported in Table 4.1.

The percentage of variance, reported at the bottom of Table 4.1, for the actual version ranged from 4.51% to 9.61% for the different scales, with a total variance of 56.53%. For the preferred version, the percentage of variance ranged from 5.02 % to 10.11%, with a total variance of 60.56%. For the actual version, the eigenvalues varied from 2.17 to 4.61 for the different scales and for the preferred version, the eigenvalues ranged from 2.41 to 4.85 for the different scales. The eigenvalues were greater than one, implying that the scores on the respective component were reliable (Kaiser, 1960).

4.2.2 Internal Consistency Reliability

In developing the questionnaire, it was important to establish that the items in a given scale assessed a common construct. If this were the case, then the scales could be considered sufficiently homogenous or having acceptable internal consistency. To provide an estimate of the internal consistency reliability, the Cronbach alpha coefficient was calculated.

Table 4.1 Factor Loadings for Items of the PeBLEs for both the Actual and Preferred Versions

	Factor Loadings															
	Student Cohesiveness		Lecturer/ Facilitator Support		Involvement		Task Orientation		Cooperation		Equity		Young Adult Ethos		Personal Relevance	
Item	Act	Pref	Act	Pref	Act	Pref	Act	Pref	Act	Pref	Act	Pref	Act	Pref	Act	Pref
1	0.62	0.58														
2	0.60	0.58														
3	0.57	0.68														
4	0.53	0.63														
5	0.59	0.65														
6	0.64	0.63														
7			0.54	0.48												
8			0.62	0.47												
9			0.66	0.61												
10			0.73	0.67												
12			0.56	0.47												
13					0.84	0.74										
14					0.78	0.79										
15					0.72	0.72										
16					0.70	0.75										
17					0.68	0.67										
18					0.60	0.71										
20							0.53	0.59								
22							0.71	0.66								
23							0.71	0.69								
24							0.67	0.55								
25									0.61	0.71						
26									0.50	0.63						
28									0.46	0.65						
29									0.44	0.59						
30									0.50	0.53						

31											0.65	0.67				
32											0.68	0.70				
33											0.69	0.73				
34											0.73	0.71				
35											0.77	0.71				
36											0.78	0.75				
37													0.53	0.53		
38													0.55	0.49		
39													0.50	0.69		
40													0.57	0.68		
41													0.72	0.74		
42													0.63	0.62		
43															0.65	0.61
44															0.75	0.73
45															0.74	0.71
46															0.81	0.81
47															0.60	0.70
48															0.61	0.64
% Variance	6.90	7.09	5.98	5.02	9.61	10.11	5.97	5.87	4.51	7.33	8.93	9.45	6.58	7.09	8.05	8.60
Eigenvalue	3.31	3.40	2.88	2.41	4.61	4.85	2.86	2.82	2.17	3.52	4.29	4.54	3.17	3.40	3.87	4.13

Factor loading smaller than 0.40 omitted

N=447 graduates

Using the refined 44-item version of the PeBLEs, the internal consistency reliability for each scale was generated separately for the actual and the preferred versions of the instrument. The scale reliability estimates reported in Table 4.2 ranged from 0.80 to 0.91 for the actual version and 0.82 to 0.93 for the preferred version for the individual scales. Given that an Alpha coefficient of 0.70 or above is widely considered to be an acceptable value (Nunnaly, 1978), these estimates were considered to be satisfactory. Further, these reliability estimates were comparable to those of past studies that have used the WIHIC (from which the majority of scales were drawn) (Aldridge & Fraser, 2000; 2003).

Table 4.2 Internal consistency reliability for the modified PeBLEs

Scale	No. of Items	Alpha Reliability	
		Actual	Preferred
Student Cohesiveness	6	0.82	0.82
Lecturer/Facilitator Support	5	0.86	0.83
Involvement	6	0.90	0.92
Task Orientation	4	0.83	0.86
Cooperation	5	0.80	0.85
Equity	6	0.91	0.93
Young Adult Ethos	6	0.86	0.90
Personal Relevance	6	0.89	0.92

N =447 graduates

4.2.3 Discriminant Validity

Discriminant validity assesses the extent to which a scale is unique in the dimension that it covers, implying that the construct is not included in another scale of the instrument. Using the data collected from 447 students, the mean correlation of a scale with the other scales was used as a convenient measure of discriminant validity for the eight scales. These figures, reported in Table 4.3, ranged from 0.37 to 0.48 for different scales in the actual version and from 0.37 to 0.53 for different scales in the preferred version. According to Calkins (2005) these results indicate a range of low (0.30 to 0.50), to moderate (0.50 to 0.70) correlations. Whilst these results indicate that the raw scores from the PeBLEs assess somewhat overlapping aspects of the learning environment, the factor analysis supports the independence of the factor scores on the eight scales.

Table 4.3 Discriminant Validity (mean correlation with other scales) for the modified PeBLEs

Scale	No. of Items	Mean Correlation with Other Scales	
		Actual	Preferred
Student Cohesiveness	6	0.37	0.37
Lecturer/Facilitator Support	5	0.43	0.49
Involvement	6	0.41	0.46
Task Orientation	4	0.40	0.51
Cooperation	5	0.47	0.50
Equity	6	0.41	0.52
Young Adult Ethos	6	0.48	0.53
Personal Relevance	6	0.41	0.48

N=447 graduates

4.3 Validity and Reliability of the AOQ

This section reports the evidence used to support the reliability and validity of the AOQ. The survey included two scales, one to assess participants' attitudes towards the pedagogy and another to measure their academic efficacy in the respective environments. Data collected from the 447 respondents were used to examine the factor structure (Section 4.3.1) and internal consistency reliability (Section 4.3.2) of the AOQ.

4.3.1 Factor Structure

Principal components factor analysis followed by varimax rotation resulted in a refined version of the two scales of the AOQ. Two items (Item 3 for the Attitude towards the Pedagogy scale and Item 11 for the Academic Efficacy scale) did not meet the criterion recommended by Field (2009) and Stevens (2001), and were omitted from all further analysis.

The remaining 10 items, as reported in Table 4.4, all had a factor loading of at least 0.40 on its own scale and less than 0.40 on the other scales. The percentage of variance for the two scales was 27.41% for Attitudes Towards the Pedagogy and 27.54% for Academic Efficacy, with the total variance accounted for being 55.95%. The eigenvalues were both greater than one, implying that the scores on the respective component were reliable (Kaiser, 1960).

Table 4.4 Factor Loadings for Student Attitude and Academic Efficacy Scales

Item	Factor Loading	
	Attitude towards the Pedagogy	Academic Efficacy
1	0.79	
2	0.75	
4	0.68	
5	0.68	
6	0.52	
7		0.79
8		0.68
9		0.67
10		0.67
12		0.64
% variance	27.41	27.54
Eigenvalue	3.31	3.29

Factor loadings smaller than 0.40 have been omitted
N=447 graduates

4.3.2 Internal Consistency Reliability

The Cronbach alpha coefficient, used as an index of internal consistency reliability for each of the two scales, is reported in Table 4.5. The scale reliability estimate was 0.86 for the Attitude Towards the Pedagogy scale and 0.87 for the Academic Efficacy scale and were considered to be acceptable, based on Nunnaly's (1978) criteria.

Table 4.5 Internal Consistency Reliability (Cronbach Alpha Coefficient), for Student Attitude towards the Pedagogy and Academic Efficacy Scales

Scale	Number of items	Alpha reliability
Attitude towards the Pedagogy	5	0.86
Academic Efficacy	5	0.87

N=447 graduates

Overall, the AOQ exhibited a good factor structure. The internal consistency for both scales exceeded 0.80, providing strong support for the reliability and validity of the instrument.

4.4 Environment-outcomes Association

The second research objective was to examine whether learning environments using problem-based learning are associated with more positive student attitudes and academic efficacy. Simple correlation was used to examine bivariate relationships between the eight learning environment scales and each of the two outcomes (Attitudes Towards the Pedagogy and Academic Efficacy). Then multiple correlation analysis with the scales of the PeBLEs as independent variables and each scale of the AOQ as the dependent variable was used. This analysis provided a more parsimonious assessment of the joint influence of correlated environment dimensions on outcomes, and reduced the Type 1 error rate associated with the simple correlation analysis. The results are reported separately for each outcome (Attitudes Towards the Pedagogy and Academic Efficacy) in Table 4.6. The standardised regression coefficient were used to identify which of the individual learning environment scales were significant independent predictors of Attitude Towards the Pedagogy and Academic Efficacy.

Table 4.6 Simple Correlation and Multiple Regression Analyses for Associations between the Learning Environment and Attitudes Towards the Pedagogy and Academic Efficacy

Scale	Environment-outcomes Association			
	Attitude towards the Pedagogy		Academic Efficacy	
	r	*β*	*r*	*β*
Student Cohesiveness	0.41**	0.13**	0.40**	0.11**
Lecturer/Facilitator Support	0.46**	0.07	0.43**	0.07
Involvement	0.44**	0.08*	0.58**	0.35**
Task Orientation	0.48**	0.17**	0.48**	0.22**
Cooperation	0.50**	0.06	0.44**	0.01
Equity	0.46**	0.08	0.39**	0.02
Young Adult Ethos	0.50**	0.03	0.46**	0.01
Personal Relevance	0.61**	0.36**	0.47**	0.17**
Multiple Correlation (*R*)		0.71**		0.69**

*p<0.05 **p<0.01
N= 449 graduates.

4.4.1 Attitude Towards the Pedagogy

The simple correlations for Attitude Towards the Pedagogy reported in Table 4.6 indicate that all eight of the learning environment scales (Student Cohesiveness, Lecturer/Facilitator Support, Involvement, Task Orientation, Cooperation, Equity, Young Adult Ethos and Personal Relevance) were statistically significantly (p<0.01) and positively related to graduates' attitude towards the pedagogy.

The multiple correlation (R) for the set of eight learning environment scales reported at the bottom of Table 4.6 was 0.71 and was statistically significant (p<0.01) for the Attitude Towards the Pedagogy scale. To identify which learning environment scales contributed to the variance in graduates' Attitudes Towards the Pedagogy, standardised regression weights were examined. These results provide information about the unique contribution of each learning environment scale to Attitudes Towards the Pedagogy scores when the other seven PeBLEs scales were mutually controlled. Table 4.6 indicated that four of the eight PeBLEs scales (Student Cohesiveness, Involvement, Task Orientation and Personal Relevance) uniquely account for a significant (p<0.01) amount of variance in graduates' Attitude Towards the Pedagogy. As indicated earlier, all statistically significant univariate and multivariate relationships were positive in direction.

4.4.2 Academic Efficacy

The results of the simple correlation analysis reported in Table 4.6 indicate that all eight PeBLEs scales were statistically significantly (p<0.01) and positively related to Academic Efficacy. The multiple correlation (R) between the eight learning environment scales and their academic efficacy was 0.69 and was statistically significant (p<0.01). The results reported in Table 4.6 indicate that four of the eight PeBLEs scales uniquely accounted for a significant proportion of variance: Student Cohesiveness (p<0.01), Involvement (p<0.01), Task Orientation (p<0.01) and Personal Relevance (p<0.05). All statistically significant relationships were positive for both the simple correlation and multiple regression analyses.

4.5 Effectiveness of Problem-based Learning Environments

The third research objective sought to investigate the effectiveness of problem-based learning in terms of perceptions of the learning environment, attitudes and self-efficacy. This section reports the results in two parts. The first part reports the results of the large-scale administration of the surveys (Section 4.5.1) and the second part reports the results pertaining to the analysis of the qualitative information (Section 4.5.2).

4.5.1 Large-scale Quantitative Overview

To determine whether the differences in scores for the problem-based and traditional learning environments were statistically significant, a one-way MANOVA was used. For the MANOVA, the independent variable was the instruction type (problem-based or lecture-based) and the dependent variables were the eight learning environment instrument scales (PeBLEs) and two attitude scales (AOQ). As the multivariate test yielded significant results in terms of Wilk's lambda criterion, the univariate ANOVA results were interpreted. Table 4.7 reports the average item mean, average item standard deviation, effect size and the MANOVA/ANOVA results.

4.5.1.1 Difference in Learning Environment Perceptions

The ANOVA results, reported in the far right column of Table 4.7 (below), show that there were statistically significant differences for five of the eight learning environment scales: Student Cohesiveness (F= 7.38, p<0.05), Involvement (F= 43.09, p<0.01), Task Orientation (F= 9.18, p<0.01), Cooperation (F= 4.97, p<0.05) and Young Adult Ethos (F= 5.16, p<0.05). The means reported in the first two columns of Table 4.7 indicate that with the exception of Student Cohesiveness, the scores for those scales with a statistically significant difference were higher for graduates who had been exposed to problem-based learning than for their counterparts who had been exposed to lecture-based instruction. For Student Cohesiveness, graduates who had been exposed to lecture-based instruction, scored higher than their counterparts who had been exposed to problem-based learning.

Whereas MANOVA was used to investigate the statistical significance of the differences between the two institutions, effect sizes were used to describe the magnitude, or educational importance, of those differences, as recommended by Thompson (2004). The effect size was calculated by taking the difference in the means divided by the pooled standard deviation. The effect sizes for the five scales that had statistically significant differences (Student Cohesiveness, Involvement, Task Orientation, Cooperation, and Young Adult Ethos) ranged from approximately one-third (-0.35) of a standard deviation (for Student Cohesiveness) to almost two-thirds (0.62) of a standard deviation (for Involvement) .

Based on Cohen's criterion (Cohen, 1992), for which magnitudes of 0.10 are classified as a small effect, 0.30 as a medium effect, and 0.50 as a large effect, the effect sizes were considered to be small to medium for differences in Student Cohesiveness (effect size = -0.35), Task Orientation (effect size = 0.29 standard deviations), Cooperation (effect size = 0.21 standard deviations) and Young Adult Ethos (effect size = 0.22 standard deviations). The effect size for differences in Involvement (effect size = 0.62 standard deviations), however, was considered to be large, suggesting educationally important differences. As mentioned earlier, with the exception of Student Cohesiveness, the graduates exposed to problem-based learning scored higher than their counterparts exposed to lecture-based instruction for all of these scales.

4.5.1.2 Differences in Attitudes and Efficacy

For the scales of the AOS, there was a statistically significant difference between the responses of graduates who had been exposed to different instruction types for both the Attitude Towards the Pedagogy (p<0.05, F= 4.42) and Academic Efficacy (p<0.01, F=19.07) scales. In both cases, graduates from the problem-based environment scored higher than their counterparts from the lecture-based learning environment. The effect size, calculated to provide an indication of the magnitude of the differences, was 0.21 standard deviations for Attitudes Towards the Pedagogy scale and 0.38 standard deviations for Academic Efficacy. These effect sizes, according to Cohen's (1992) criteria, can be considered small for Attitudes Towards the Pedagogy and moderate for Academic Efficacy.

Table 4.7 Average Item Mean, Average Item Standard Deviation, Effect Size, and Differences for Instruction Types (Effect Size and MANOVA Results) For PeBLEs and AOQ

Scales	Average Item Mean[a]		Average Item Standard Deviation		Difference	
	Problem-based	Lecture-based	Problem-based	Lecture-based	Effect Size	*F*
PeBLEs						
Student Cohesiveness	3.76	3.92	0.60	0.65	-0.35	7.38*
Lecturer/ Facilitator Support	3.45	3.38	0.68	0.71	0.10	1.16
Involvement	3.50	3.00	0.75	0.87	0.62	43.09**
Task Orientation	4.01	3.80	0.66	0.78	0.29	9.18**
Cooperation	3.77	3.63	0.64	0.71	0.21	4.97*
Equity	3.72	3.81	0.67	0.79	-0.12	1.83
Young Adult Ethos	4.09	3.95	0.62	0.65	0.22	5.16*
Personal Relevance	3.50	3.40	0.80	0.74	0.13	1.87
AOQ						
Attitude Towards the Pedagogy	3.61	3.46	0.71	0.72	0.21	4.42*
Academic Efficacy	3.62	3.35	0.70	0.73	0.38	19.07**

*p<0.05 **p<0.01
N=260 graduates from a problem-based learning environment and 187 graduates from a lecture-based learning environment
[a] Average item mean=scale mean divided by the number of items in that scale.

In summary, the effect sizes suggest educationally important differences between the learning environments perceived by graduates exposed to the different instruction types. Graduates exposed to problem-based learning perceived more Involvement, Task Orientation, Cooperation, and Young Adult Ethos. Further, the graduates exposed to problem-based learning had statistically significantly (p<0.05) higher scores for both the Attitude Towards the Pedagogy and Academic Efficacy scale. It was interesting to note, however, that, for the Student Cohesiveness scale, graduates exposed to lecture-based learning scored statistically significantly (p<0.05) higher than their counterparts exposed to problem-based learning. Given that, in a problem-based learning environment, the students' ability to work together is an important factor, this finding was unexpected. The next section provides the results of analysis of the qualitative data and insights into the quantitative overview.

4.5.2 Insights into the Quantitative Overview

In the light of the quantitative findings, focus group meetings and telephone interview sessions (described in Chapter 3) were used to provide insights into the results. When the qualitative data were analysed (as described in Chapter 3) three overarching themes emerged. The selection of the themes presented below was based on the contribution that the qualitative data could make to explain those scales that were found to be statistically significant. These themes are described under the following headings: relationships and rapport (Section 4.5.2.1); student involvement and cooperation (Section 4.5.2.2); and task orientation and independent learning (Section 4.5.2.3).

4.5.2.1 Theme 1: Relationships and Rapport

The results of the quantitative data analysis indicate that graduates who were exposed to lecture-based instruction perceived statistically significantly more Student Cohesiveness (p<0.05, effect size = 0.13 standard deviation) than their counterparts who had been exposed to problem-based learning. Past studies have shown that one of the key tenets for an effective learning environment, particularly in an interactive learning environment (such as problem-based learning) where the pedagogical demands require group interactions, is the presence of nurturing relationships and rapport among group members (Dörnyei, 2007; William, Duray & Reddy, 2006). The level of cohesiveness among students indicates the cooperative atmosphere and whether students feel that they are supported by their peers and, in turn, support and help one another. It was thus anticipated that for problem-based learning to be successful, a cohesive environment would be required to enable students to interact and cooperate to meet their learning objectives. Analysis of the qualitative data helped to explain the unexpectedly low scores of the graduates exposed to problem-based learning, including personality differences, lack of clarity with respect to their roles, and the expectations of the students.

Analysis of the data suggests that the graduates exposed to problem-based learning experienced personality differences between members of the groups. Many of these differences may have stemmed from a lack of interpersonal skills (such as diplomacy, respect, and understanding) on the part of the student, or a lack of maturity in dealing with responses to peers, particularly in stressful situations. In this respect, one graduate commented "It was difficult to get along with some people", and another said, "Sometimes people don't realise what they say", and another said, "Some people think that they know everything". It would appear that some of these students lacked the interpersonal skills required in a learning environment that was participative and required students to build on consensus.

Analysis of the data also suggests that in the problem-based learning environment, students and facilitators may not always have been clear about their roles. One graduate commented "Our faci prefers to give us a mini-lecture so we all understand the same information before we solve the problem". Another commented that one of the facilitators remarked, "I am not supposed to tell you the answer, I am a facilitator". According to some graduates, the roles that they were expected to play during the problem-based learning process were not clear, and this reduced their confidence in whether they were doing the right thing. For example, one graduate commented, "I didn't know what I was supposed to do", and another said, "I didn't have much say in how we should divide the work". It would appear that this lack of clarity with respect to the responsibility of the roles created tensions among students, with some graduates explaining that it often resulted in an unfair distribution of the work. For example, one graduate said, "Some students did not contribute and yet they hoped to benefit from others".

Further analysis of the data indicates that some students came to the sessions with expectations that did not fit into a group ethos of cooperative learning creating another source of tension and conflict between students during group work. According to the graduates, some students were indifferent or did not participate in the group discussions for various reasons. For example, one graduate explained that, “Sometimes members came unprepared”, while another said, “There always seemed to be a member of our team who did not contribute. There was always one that held back and stayed silent”. Other students complained that there were team members who were disinterested, lacked enthusiasm or were not keen to participate. In some cases, the graduates went so far as to complain that there were members of the group that were prepared to allow other members to complete the task. For instance, one graduate said, “There were some [group members] who hoped to get through the session riding on the work of others in the group”.

It would appear that three overarching factors may have influenced the graduates’ experience of student cohesiveness or lack of it in the problem-based learning environment. These factors were students’ lack of interpersonal skills at the polytechnic, a lack of clarity with respect to roles, and the unwillingness of some students to do their share.

4.5.2.2 Theme 2: Student Involvement and Cooperation

The results of the analytical overview indicate that students who were exposed to problem-based learning experienced statistically significantly more cooperation ($p<0.05$, effect size = 0.11 standard deviations) and involvement ($p<0.01$, effect size = 0.30 standard deviations) than their counterparts exposed to lecture-based learning. Intuitively, these differences make sense, given the different pedagogical styles of the two learning environments. One would anticipate that given the necessity for groups or team work to complete the tasks in a problem-based learning classroom, there would be more opportunities for cooperation and involvement than in a learning environment where the pedagogical style is largely lecture-based. Analysis of the qualitative data helped to better understand these differences in terms of the cooperative class culture and the learning structures in problem-based learning.

Analyses of the qualitative data suggests that in a problem-based learning environment (notwithstanding the poor relationships mentioned above), graduates generally felt that the structure used in the One-Day, One-Problem™ methodology gave them clear guidelines about what they were expected to do. For example, one graduate said, “The learning method [One-Day, One-Problem™] helped us to organise our learning and to understand how we could support our group's findings during our presentations". Some graduates commented that even when the work was difficult, the One-Day, One-Problem™ method gave them the structures needed to work together to achieve the common goal. For example, one graduate said, "I knew what I had to do every day and what was expected of me". Another commented, "The meetings and study periods provided a structure to help us to focus on the task. The structure helped us to know when to work as a team and when to work independently". Interviews with graduates indicated that they appreciated the design of the learning structure in the One-Day, One-Problem™ schedule, as it helped them to organise and manage themselves during each of the teaching and learning activities that were required during the day. For example, one graduate commented, "Some of the workload was difficult but we were able to achieve our goals when we worked together during the meetings and study periods" (referring to the sessions built into the One-Day, One-Problem™ methodology). In particular, the graduates referred to the importance of cooperating and working together to "get a good daily grade".

On the whole, the graduates who were interviewed agreed that in order to accomplish the tasks that were set in the problem-based setting, it was important for them to collaborate. In general, the graduates felt that the learning environment in the class promoted a strong desire to work well together. As one graduate explained, "we wanted to get good grades, so there was a common goal that encouraged us to work together." This view was shared by other graduates. Many of the graduates said that even though the tasks they were involved in were difficult, because they were able to work in groups and share the responsibility, the task became easier. For example, one graduate commented, "It was hard work but I found it beneficial working and learning as a group". This notion of distributing the work to help to accomplish the tasks that were set each day was shared by all of the graduates who were interviewed.

The problem-based learning environment provided challenges that required students to participate in the learning activities in order to achieve their goals at the end of each day. As a graduate commented, "We generally work well together, and we want to get good grades. So we work towards a common goal in giving a good presentation for the day". To accomplish the outcome, students were required to work in groups or teams.

Further, these teams were allocated a group mark, based on their presentation at the end of the day. As one graduate said, “Every day we had a common goal to achieve, to make a good presentation. Therefore, we had to work hard together and we depended on each other”.

To be effective, the teaching and learning strategies adopted in problem-based learning need to build strong work groups and promote team building among the students. All of the graduates who were interviewed felt that the methods used in the problem-based learning environment achieved this. For example, one graduate commented, “We have to work in groups and when we share some responsibilities it becomes easier”. Others commented “We learn a lot from our group meetings and become friends fast”; “It [problem-based learning] is hard work but I found it beneficial working in groups”. Finally, one graduate commented on the benefits of problem-based learning: “I learn more working in the groups than what I used to get from a lecture”.

4.5.2.3 Theme 3: Task Orientation and Self-Directed Learning

The results of the quantitative data analysis indicate that graduates who were exposed to problem-based learning perceived that the pedagogy enabled statistically significantly more Task Orientation ($p<0.01$, effect size = 0.14 standard deviations) and Young Adult Ethos ($p<0.05$, effect size = 0.11 standard deviations) than did their counterparts who had been exposed to lecture-based instruction. Analysis of the quantitative data indicated that in the problem-based setting, students were given opportunities to take responsibility for their learning and were required to be self-directed.

Analysis of the interviews with graduates suggests that problem-based learning forced them to take responsibility for their own learning. As one graduate commented, “Every day we had to present our solution after we consolidated our own research with the groups. This arrangement required us to be prepared and to learn from our research and the group’s analysis”. Another commented, “During each session or meeting [over the course of the day], the facilitators moved between groups frequently, to help us with different ideas and concepts to research in order that we could learn how to apply it to the problem”. Another graduate commented, the “active brainstorming session during the study periods [referring to the One-Day, One-Problem™ sessions] and discussion carried out during the meeting sessions helped us to understand the learning issues to carry out our own learning and to research to contribute to the group for the end-of-day presentation". It would appear that this constant intervention and input by the facilitators provided both guidance and different perspectives. Further, the information shared among members of the different groups formed an integral part of the instructional style that gave students opportunities to take responsibility for their learning. As one graduate commented, "The One-Day, One-Problem™ was task focused and, as such, helped to keep us focused on what we had to do. In this way, we were forced to take responsibility for our research and how we would present our findings in the presentation at the end of the day".

Analysis of the data also indicated that, because the facilitators helped students to set their learning objectives on what is needed to be learned (e.g. based on the problem), they were better able to be self-directed in their learning and to use their initiative to find ways to solve the problem. For example one graduate said "Our facilitators helped us to clarify the important points of the problem and what we needed to do to move forward. This was very helpful as it helped us to search for the right information and to learn how to put the ideas together". Another graduate commented, "Our facilitators respected our views and encouraged us to actively be involved in taking initiative in our research and deciding how we wanted to solve the problem".

Interviews with graduates suggested that the nature of the One-Day, One-Problem™ version of problem-based learning (involving three meetings and two study periods), helped to keep students focused and on task. With reference to the task-oriented nature of the teaching and learning style laid out in the One-Day, One-Problem™ structure, the graduates generally agreed that the structure helped to keep them focused on the learning objectives for the day. One graduate commented that "The One-Day, One-Problem guided us to formulate goals that we wanted to achieve in the study and what we needed to do for our research and to solve the problem".

4.6 Person-Environment Fit

Whereas the previous section reported the MANOVA results and effect sizes to examine whether differences existed in terms of graduates' perceptions of the two instruction types, this section reports the results pertinent to Research Objective 4, which sought to identify whether differences exist in terms of the person-environment fit.

To examine the differences in the person-environment fit, an analysis of covariance (ANCOVA) was used. In this analysis, responses to the actual version were used as the dependent variables, the corresponding responses to the preferred version were the covariate, and the instruction type (problem-based or lecture-based) was the independent variable. The ANCOVA allowed actual scores on the learning environment scales to be referenced against preferred scores and then compared between the two learning environments, allowing a comparison of person-environment fit.

After adjustment for preferred learning environment, there were statistically significant differences (reported in Table 4.9) between the two instruction types for four of the learning environment scales: Student Cohesiveness (F= 4.93, p<0.05), Involvement (F= 6.86, p<0.01), Task Orientation (F= 5.60, p<0.05), and Young Adult Ethos (F= 4.97, p<0.05). For all of the scales, with the exception of Student Cohesiveness, the mean score (reported in Table 4.9) was higher for the problem-based learning environment than for the lecture-based learning environment. For Student Cohesiveness, after adjustment for preferred score, the mean score was higher for the lecture-based learning environment than for the problem-based learning environment. The magnitude of these differences (shown in Table 4.8) are reported as effect sizes (assessed using eta^2 to provide a measure of the variance in actual items, excluding the variance explained by the preferred item means) which were all small when based on Thalheimer and Cook (2002) rule of thumb.

Table 4.8 Adjusted and Unadjusted Means and Variability for Actual Learning Environment with Preferred Learning Environment as a Covariate

Scale	Problem-based				Lecture-based			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	Mean	SD	Mean	SE	Mean	SD	Mean	SE
Student Cohesiveness	3.76	0.60	3.78	0.03	3.92	0.65	3.90	0.04
Lecturer/Facilitator Support	3.45	0.68	3.44	0.04	3.38	0.71	3.40	0.05
Involvement	3.50	0.75	3.36	0.04	3.00	0.87	3.20	0.04
Task Orientation	4.01	0.66	3.97	0.04	3.80	0.78	3.85	0.04
Cooperation	3.77	0.64	3.73	0.03	3.63	0.71	3.69	0.04
Equity	3.72	0.67	3.72	0.03	3.81	0.79	3.81	0.04
Young Adult ethos	4.09	0.62	4.08	0.03	3.95	0.65	3.97	0.04
Personal Relevance	3.50	0.80	3.51	0.04	3.40	0.74	3.39	0.05

N= 260 graduates from a problem-based learning environment and 187 graduates from a lecture-based learning environment.

Table 4.9 Difference between Actual Scores for Scales of the PeBLEs after Adjustment for Preferred Scores

Scale	Difference between instruction types	
	Effect Size	*F*
Student Cohesiveness	0.01	4.93*
Lecturer/Facilitator Support	0.01	0.38
Involvement	0.02	6.86**
Task Orientation	0.01	5.60*
Cooperation	0.01	0.77
Equity	0.01	3.00
Young Adult ethos	0.01	4.97*
Personal Relevance	0.01	3.32

*p<0.05, **p<0.01
N= 260 graduates from a problem-based learning environment and 187 graduates from a lecture-based learning environment.

4.7 Chapter Summary

This chapter reports the findings from the quantitative and qualitative data collected from the sample of 447 polytechnic graduates, of which 260 had been exposed to problem-based learning and 187 had been exposed to lecture-based instruction during their three year study course at the polytechnics.

To meet the first research objective, evidence is provided to support the reliability and validity of the instruments used to collect the data. The data collected from the sample of 447 graduates is used to examine the factor structure, internal consistency reliability and discriminant validity of both instruments.

For the PeBLEs, a series of items and factor analysis led to a refined 44-item version. For both the actual and preferred versions of the PeBLEs, all of the remaining items had a factor loading of 0.40 on their *a priori* scale and on no other scale. The total percentage of variance accounted for was 56.53% for the actual version and 60.56% for the preferred version. The scale reliability estimates for the different scales ranged between 0.80 to 0.91 for the actual version and 0.82 to 0.92 for the preferred version. The mean correlation of a scale with other scales was used as a convenient measure of discriminant validity for the eight scales of the PeBLEs. The results ranged from 0.37 to 0.48 for the actual version and from 0.37 to 0.53 for the preferred version of the instrument.

In addition to the PeBLEs, two 6-item attitude scales were used to assess students' Attitude Towards the Pedagogy and Academic Efficacy. A series of item and factor analyses led to a revised 10-item instrument with all items loading more than 0.40 on their own scale and on no other scale. The total variance accounted for the two attitude scales was 55.95%. The internal consistency reliability was 0.86 for the Attitudes Towards the Pedagogy scale and 0.87 for the Academic Efficacy scale. These results for both the PeBLEs and the AOQ support the factorial validity and internal consistency reliability for the two instruments, suggesting that the results of subsequent research objectives can be interpreted with confidence.

The second research objective sought to examine the associations between the two attitude scales and the students' perceptions of their learning environment. The analysis involved simple correlations and multiple regressions using the sample of 447 graduates.

The results of the simple correlations *(r)* indicate that all eight of the learning environment scales were statistically significantly ($p<0.01$) and positively related to both scales (Attitude Towards the Pedagogy and Academic Efficacy). The multiple correlations (*R*) between the students' perception of the set of eight PeBLEs scales was 0.71 for students' Attitudes Towards the Pedagogy, and 0.69 for Academic

Efficacy. Both correlations were statistically significant ($p<0.01$). The results of the standardised regression analysis indicates that four of the eight PeBLEs scales (Student Cohesiveness, Involvement, Task Orientation, and Personal Relevance) accounted for a significant amount of variance in students' Attitudes Towards the Pedagogy. All of the statistically significant relationships were positive.

For the Academic Efficacy scale, the results indicate that four of the PeBLEs scales (Student Cohesiveness, Involvement, Task Orientation, and Personal Relevance) independently account for a significant proportion of variance. Again, all statistically significant relationships are positive for both the simple and multiple regression analyses.

The third research objective examined the effectiveness of the problem-based learning environment in terms of graduates' perceptions of their learning environment and attitudes. A one-way multivariate analysis of variance (MANOVA), with the instruction type as the independent variable and the learning environment and attitude scales as the dependent variables, was used. The results indicate that graduates who had been exposed to problem-based learning perceived statistically significantly more Involvement, Task Orientation, Cooperation, and Young Adult Ethos than did graduates who had been exposed to lecture-based instruction. The effect size of the four scales ranged from 0.11 standard deviations to 0.30 standard deviations, which are considered to be small to medium effects. For the Student Cohesiveness scale, however, graduates who had been exposed to lecture-based instruction scored statistically significantly higher than their counter parts that were exposed to problem-based instruction.

The results of the MANOVA for Attitudes Towards Pedagogy and Academic Efficacy scales indicate that graduates who had been exposed to problem-based learning scored statistically significantly ($p <0.05$) higher for both scales than those who had been exposed to lecture-based instruction.

To help to explain these results, focus group meetings and telephone interviews were conducted. Analysis of the qualitative information indicates that there were three overarching reasons for the statistically significant differences. Three thematic constructs, namely, relations and rapport, student involvement and cooperation, and task orientation and self-directed learning, were developed.

The fourth research objective examined differences in the person-environment fit for the graduates who had been exposed to the different instruction types. An analysis of covariance (ANCOVA), with the actual learning environment scales as the dependent variables, the corresponding preferred learning environment scale as the covariate, and the polytechnic type as the independent variable, was used. The findings indicated that there was a significant difference ($p<0.05$) for four scales, Task Orientation, Young Adult Ethos, Involvement and Student Cohesiveness. There was no significant difference ($p>0.05$) between the polytechnics for Teacher Support, Cooperation, Equity and Personal Relevance when controlling for preferred scores.

The next chapter discusses the findings that were reported in this chapter. Further, the chapter provides recommendations based on the findings with respect to how the problem-based learning environments at the polytechnic-level might be improved to maximise teaching and learning outcomes.

CHAPTER 5
Conclusions and Implications

5.1 Introduction

The overarching aim of this study was to examine the effectiveness of problem-based learning by assessing graduates' preferences and perceptions of their learning environment, attitudes and academic efficacy. The research was underpinned by a post -positivist view and used an explanatory mixed-method approach that involved two phases.

The first phase comprised the collection of quantitative data using two newly-developed instruments; the Problem-based Learning Environment survey (PeBLEs), to assess students' perceptions of the learning environment, and the Attitude Outcome Questionnaire (AOQ), to assess students' attitudes towards the pedagogy and academic efficacy. The sample used for this phase of the study involved 260 graduates who had been exposed to problem-based learning and 187 graduates who had been exposed to lecture-based instruction. All of the participants had graduated within two years and had spent six semesters (or three years) at their respective institutions.

The second phase involved gathering qualitative data using focus group meetings and telephone interviews. This phase sought to gain causal insights to help to explain the quantitative findings. The sample for the qualitative study comprised 42 graduates who had been exposed to problem-based learning.

This chapter is organised under the following headings:

- Summary and discussion of major findings (Section 5.2);
- Limitations of the study (Section 5.3);
- Significance of the results (Section 5.4);
- Recommendations (Section 5.5);
- Practical implications (Section 5.6); and
- Concluding remarks (Section 5.7).

5.2 Summary and Discussion of Major Findings

This section provides a summary of the major results pertaining to the four research objectives.

5.2.1 Research Objective 1

The first research objective was:

> To develop and validate instruments suited for use with graduates at the polytechnic level, to assess their:

a. Perceptions of their learning environment, and,
b. Attitudes and academic efficacy.

This section summarises the development of the two surveys and the evidence provided to support their reliability and validity. The development of the first instrument, the Problem-based Learning Environment survey (PeBLEs) began with a literature review to help to identify aspects of the learning environment considered important in the assessment of both a problem-based learning environment and a lecture-based learning environment. In developing the questionnaire, a careful selection of scales was made to ensure coverage of Moos's (1974) scheme for classifying the dimensions of any human environment. The PeBLEs drew extensively on six scales of the What Is Happening In this Class? (WIHIC) questionnaire and a scale from the Technology Rich Outcomes Focused Learning Environment Inventory (TROFLEI) questionnaire, and another from the Constructivist Learning Environment (CLES) questionnaire. The final version of the PeBLEs comprised eight scales: Student Cohesiveness, Lecturer/Facilitator Support, Involvement, Task Orientation, Cooperation, Equity, Young Adult Ethos and Personal Relevance. Each of the eight scales had six items, providing a total of 48 items. Items of the PeBLEs were responded to using a five-point frequency response format of Almost Never, Seldom, Sometimes, Often and Almost Always.

The second instrument, the Attitudes Outcomes Questionnaire (the AOQ), included two scales (each with six items): the Attitudes Towards the Pedagogy scale, adapted from the TOSRA, the Test of Science Related Attitudes, and the Academic Efficacy scale, adapted from the Morgan-Jinks Student Efficacy Scale (MJSES). The items in these two scales were modified to the same five-point frequency response scale as the PeBLEs to avoid confusion.

Using the sample of 447 graduates (260 who had been exposed to problem-based learning and 187 who had been exposed to lecture-based instruction), statistical analysis was carried out to provide evidence of the validity and reliability for each of the instruments. The results are summarised below.

5.2.1.1 Reliability and Validity of the Problem-based Learning Environments Survey (PeBLEs)

Analysis, conducted separately for the actual and preferred version, was used to examine the factor structure, internal consistency reliability, and discriminant validity. The key findings are summarised below.

- Factor analysis confirmed a refined 44-item version (after the removal of four of the 48 items) of the PeBLEs for both the actual and preferred versions.
- All of the retained items had a factor loading of at least 0.40 on their *a priori* scale and no other scale. The total percentage of variance accounted for was 56.53% for the actual version and 60.56% for the preferred version.
- The eigenvalues for the different scales varied from 2.17 to 4.61 for the actual version and 2.41 to 4.85 for the preferred version. All items scored greater than one, implying that the components in the items were reliable (Kaiser, 1960).
- The internal consistency reliability (Cronbach alpha) for each PeBLEs scale ranged from 0.80 to 0.91 for the actual version and 0.82 to 0.93 for the preferred version.
- The discriminant validity for the eight scales of the PeBLEs ranged from 0.37 to 0.48 for the actual version and 0.37 to 0.53 for the preferred version.

The results were similar to the findings of other studies that have used the WIHIC, or modified versions of it, in countries round the world. For example, Dorman, Joan and Janet (2003), used a sample of 3,602 students from Australia, the United Kingdom and Canada to investigate mathematics classroom environment using the modified WIHIC and academic efficacy. The WIHIC was also been used in the US (Allen & Fraser, 2007; Martin-Dunlop & Fraser, 2008; Ogbuehi & Fraser, 2007; Wolf & Fraser, 2008), and Taiwan (Aldridge & Fraser, 2000). The instrument has also been used across a range of subjects, including mathematics (Ogbuehi & Fraser, 2007) and science (Aldridge & Fraser, 2000; Wolf & Fraser, 2008) and computing (Zandvliet & Fraser, 2004; 2005). In each of these cases, the WIHIC has been found to be a robust and reliable instrument.

These results provide evidence to support the validity and reliability of the PeBLEs in terms of its factor structure, internal consistency reliability and discriminant validity, providing some assurance that the PeBLEs was acceptable for use in addressing the remaining research objectives.

5.2.1.2 Validity of the Attitude Outcomes Questionnaires (AOQ)

Key findings for the reliability and validity of the AOQ for the sample of 447 graduates are summarised below.

- Factor analysis confirmed a refined 10-item structure for the AOQ. All of the items that were retained had a factor loading of at least 0.40 on their *a priori* scale and no other scale.
- The percentage of variance for the two scales was 27.41% for Attitudes Towards the Pedagogy and 27.54% for Academic Efficacy. The total percentage of variance accounted for being 54.95%.
- The internal consistency reliability (Cronbach alpha coefficient) of each attitude scale was 0.86 (for Attitude Towards the Pedagogy) and 0.87 (for Academic Efficacy).

The internal consistency reliability of the two attitude scales with a Cronbach's alpha reliability, with the individual as the unit of analysis, fell in the good range (according to George and Mallery's rule of thumb, 2003), as discussed earlier for the scales in PeBLEs. These findings were comparable to those of past studies that have used similar attitude scales (Aldridge & Fraser, 2008; Bell, 2013; Bell & Aldridge, 2014; Schunk & Rice, 1993).

Overall, the results provide evidence to support the validity and reliability of both the PeBLEs and the AOQ, and thus support the use of the instruments for the purpose of this study.

5.2.2 Research Objective 2

The second research objective was:

> To determine whether there are associations between the natures of polytechnic-level learning environments and graduates':
>
> a. Attitudes, and,
> b. Academic efficacy.

In past research and literature reviews, a common line of past learning environment research has been to examine the association between the learning environment and student outcomes. When studying any learning environment, it is common for administrators, academics, facilitators (as in the case of this research), and parents to want to know whether the learning environment is related with more positive student outcomes. Consequently, this research objective shaped the investigation of the associations between the learning environment created at the polytechnic level and two affective outcomes. The results are summarised below, separately for Attitudes Towards the Pedagogy and Academic Efficacy.

5.2.2.1 Attitudes Towards the Pedagogy

- All eight PeBLEs scales were statistically significant and positively related to students' Attitude towards the Pedagogy (p<0.01).
- The multiple correlation (R) between students' perception of the eight PeBLEs scales and Attitudes towards the Pedagogy was statistically significant (p<0.01).
- Three PeBLEs scales were statistically significant (p<0.01) independent predictors of students' Attitudes Towards the Pedagogy. These scales include Student Cohesiveness, Task Orientation and Personal Relevance.

All of the statistically significant relationships were positive, suggesting that the classroom learning environment was likely to influence the students' attitudes towards the pedagogy. These findings add weight to studies conducted over the last thirty to forty years which have shown the classroom environment to be a strong and consistent determinant of student attitudes (Fraser, 2012). The findings of this study corroborate those of other similar studies carried out at the high school level in Singapore (Fraser & Chionh, 2000; Goh & Fraser, 1998; Wong & Fraser, 1996). This study extends these past studies by examining these relationships in a post-secondary, polytechnic setting.

5.2.2.2 Academic Efficacy

- The simple correlation showed that all eight of the learning environment scales positively and statistically significantly (p<0.01) related to Academic Efficacy. The correlations ranged from 0.39 to 0.58 for different scales.
- The standardised regression coefficient shows that four scales had statistically significant and positive relationships with Academic efficacy: Student Cohesiveness (p<0.01), Involvement (p<0.01), Task Orientation (p<0.01) and Personal Relevance (p<0.05).
- The multiple correlation (R) was 0.71 and was statistically significant (p<0.01).

These results are consistent with past studies that found students' perceptions of their learning environment were positively related to Academic Efficacy (Aldridge & Fraser, 2008; Bell, 2013). For example, a study by Dorman and Fraser (2009) found that while improving classroom environment has the potential to improve student outcomes, academic efficacy mediated the effect of several classroom environment dimensions on attitudinal outcomes.

As all statistically significant relationships were positive for the simple correlation and multiple regression analyses, these findings suggest that the learning environment at the polytechnic level has important implications for student learning. Given that past research findings suggest that academic efficacy is an important determinant of student outcomes, *it is recommended that facilitators and lecturers at the polytechnic level use these findings to improve important dimensions of the learning environment (Recommendation 1).*

Although much research has been carried out at the high school level, this is one of the first learning environment studies to be carried out at the polytechnic level. Therefore, these findings extend past research in the field of learning environments and fill an important gap. The results, which indicate that the learning environments created by facilitators and lecturers can influence the affective outcomes of their students, *highlight the need to be aware of those aspects of the environment that are likely to promote positive attitudinal outcomes of students (Recommendation 2).*

5.2.3 Research Objective 3

The third research objective was:

> To investigate the effectiveness of problem-based learning in terms of graduates':

a. Perceptions of the learning environment,
b. Attitudes towards the pedagogy, and,
c. Academic efficacy.

In light of the fact that it has been more than ten years since the introduction of problem-based learning at a polytechnic in Singapore, it was considered timely to examine the effectiveness of this approach in terms of its impact on graduates' perceptions of the learning environment, attitudes and academic efficacy. A summary of the findings are provided below.

- Graduates exposed to a problem-based learning setting perceived statistically significantly more Involvement ($p<0.01$), Task Orientation ($p<0.01$), Cooperation ($p<0.05$) and Young Adult Ethos ($p<0.05$), than did graduates exposed to lecture-based instruction.
- Graduates exposed to the problem-based setting scored statistically significantly higher for Attitudes Towards the Pedagogy ($p<0.05$) and Academic Efficacy ($p<0.01$) than did graduates exposed to lecture-based instruction.
- Graduates exposed to lecture-based instruction scored statistically significantly higher for Student Cohesiveness ($p<0.05$) than did the graduates exposed to problem-based learning.

To provide insights into the quantitative overview, qualitative information was gathered using focus group meetings and telephone interviews. The qualitative information was used to help to explain the statistically significant differences reported by graduates. The sample involved 42 graduates, all of whom had three years of experience using problem-based learning. The following sections summarise the key findings for each of the overlapping themes and is followed by a discussion of each: relationship and rapport (Section 5.2.3.1); student involvement and cooperation (Section 5.2.3.2); and task orientation and independent learning (Section 5.2.3.3).

5.2.3.1 Theme 1: Relationship and Rapport

Key findings from this theme suggest that:

- The role of the student and/or facilitator was, for some graduates, unclear. It would appear that, in some cases, the graduates were not always confident that they were doing the right thing during the sessions. Further, in some cases, this lack of clarity led to a feeling among some students that there was an unfair distribution of the work.

- Personality differences related to a lack of interpersonal skills may have influenced the scores on the Student Cohesion scale.
- The graduates were not always clear on the expectations of the individual students in the group and the degree to which they were expected to participate.

The findings of the quantitative overview for the Student Cohesiveness scale were unexpected, given that a fundamental premise of the problem-based learning requires that student groups be in unity as they work towards their goals. It would appear that several issues might have led to the lower reports of student cohesion in the problem-based learning environment, as described above. These results support the research by Hartman, Moberg and Lambert (2013), which found that problem-based learning teams were likely to have lower levels of cohesion among the team members if there were distractions or limited opportunities for self-reflection; both of these might cause lack of tolerance for ambiguity and coping skills. It is possible that these issues could also be related to the nature of the pedagogy, as students are suddenly exposed to a student-centred learning environment very different from the more familiar one of the lecture-based instruction classroom. They may therefore not have the maturity to interact effectively in groups and between groups.

The results of this study suggest a need for facilitators to help learning teams that are experiencing low cohesion to develop techniques for team building, in order to improve morale, goal development, coping skills, and team building and commitment skills. It is recommended that facilitators and curriculum developers consider this important developmental component of students' high level of participation and intense interaction in their learning. These interpersonal problems (reflected in the results) may be intensified by the maturity level of polytechnic-level students. If this is the case, then *direct intervention could be used to assist students to develop interpersonal skills that will enable then to deal more effectively with personality differences (Recommendation 3).* Further, it is recommended that facilitators initiate learning structures that assist students to understand their roles and the expectations of individuals as they work together during the One-Day One-Problem methodology.

5.2.3.2 Theme 2: Student Involvement and Cooperation

Key findings from this theme suggest that:

- Graduates generally felt that the learning structure provided within the One-Day, One-Problem™ methodology was supportive.
- Graduates felt that the One-Day, One-Problem™ methodology required students to work together effectively to achieve the overall goal and to achieve good grades.
- The group marks allocated at the end of the daily sessions encouraged group work and a high level of cooperation among students in the group.
- The nature of the problems and the structure of the One-Day, One-Problem™ methodology encouraged team building.

The findings of both the qualitative and quantitative data analysis suggest that the nature of problem-based learning (as administered in the One-Day, One-Problem™ methodology) has created a class culture in which students are involved in their learning and encouraged to work together in the spirit of cooperation. The finding that the structures used in problem-based learning foster a collaborative learning environment in which students work together to fulfil their daily learning goals corroborates those of other studies (Choo, 2012; Yew & O'Grady, 2012). For example, Goh (2006) found that problem-based learning was powerful in motivating students to become actively engaged in their learning and empowered them to take ownership of their learning. Further, her study found that problem-based learning provides a learning experience that enables students to exercise their skills in working and cooperating in groups and communicating with each other, as well as developing themselves as a community of self-learners.

The findings provide support for the One-Day, One-Problem™ methodology in terms of the benefits of structures that facilitate and support student involvement in their learning and foster group collaboration and cooperative effort. *The findings also suggest that focusing on building a strong class culture that leads to improved group working skills,* *understanding their roles and team performance is an important strength of problem-based learning that can be built on in the future (Recommendation 4).*

5.2.3.3 Theme 3: Task Orientation and Self-Directed Learning

Key findings from this theme suggest that:

- Using problem-based learning encourages students to be self-directed and to take responsibility for their own learning.
- Although greater responsibility is required of learners, the goal-oriented nature and structure of the One-Day, One-Problem™ methodology helps students to stay focused and on track.

These findings support those of Loyens, Magda and Rikers (2008) who suggested that the use of problem-based learning nurtures the development of self-directed learning in which students take the initiative in diagnosing their learning needs, formulating their learning goals, identifying the resources they need and appropriate learning strategies, and making independent decisions. Further, given the higher scores for self-efficacy and attitudes reported by graduates from the problem-based setting, it would appear that by making the students part of the learning process, they view themselves as taking responsibility for their own learning and are thus more motivated (Severiens & Schmidt, 2009). *It is recommended therefore that the development of self-directed learning in which the learner takes ownership of his or her own learning, is important at the polytechnic level and that this aspect of the learning environment be considered and, where appropriate, implemented in other polytechnics (Recommendation 5).*

Dynneson and Gross (1999) found that an orientation towards learning is an important aspect of effective teaching, because it relates to how much time the teacher actually spends on a designated instructional task. As a rule, the more time spent concentrating on a learning task, the higher the possibility of learning successfully. In other words, students are most likely to learn (improve their comprehension) through their focus on the task. A study by Killen (2006) found that task orientation is a key feature of direct instruction, because it places an emphasis on clear goal setting, active teaching, close monitoring of student progress, and teacher responsibility for student learning. A task orientation to learning is thus essential for the engagement of students in their learning, student self-regulation, higher-order thinking, and deeper understanding of elements in quality teaching and learning (Spady, 1994). Given that statistically significant differences were found for the Task Orientation scale, with graduates exposed to problem-based learning perceiving more of this scale (effect size = 0.14 standard deviation), this is a notable difference.

Young Adult Ethos refers to the classroom practices that encourage students to take responsibility for their own learning (Aldridge & Fraser, 2008). The findings suggest that the learning structures provided in problem-based learning using the One-Day, One-Problem™ methodology provide opportunities to students to be responsible. According to Guldbaek, Vinkel and Broens (2011), providing opportunities for students to be autonomous and to take responsibility for their own learning sets the tone for the dispositional norms in the classroom and the groups, motivating learning, and transforming the pedagogical ethos.

This important qualitative information provides insights that helped to explain the quantitative data. Whilst this section has examined the important differences resulting from the different instruction types, the next section examines these differences in terms of person-environment fit.

5.2.4 Research Objective 4

The final research objective was:

> To examine the effectiveness of problem-based learning in terms of person-environment fit.

The sample for this research objective comprised 260 graduates from the institution using problem-based learning and 187 graduates from the institution using lecture-based instruction. To examine the person-environment fit for the graduates who had been exposed to different instruction types, an analysis of covariance (ANCOVA) was conducted, with each actual learning environment scale being the dependent variable, the corresponding preferred scale being the covariate variable, and the instruction type (problem-based or lecture-based) being the independent variable. The ANCOVA allowed actual scores on the learning environment scales to be referenced against preferred scores and then compared between the two instruction types. This allowed a comparison of person-environment fit between the two learning environments. Thekey findings of the ANCOVA are summarised below.

- There were no significant differences ($p>0.05$) between instruction types for four of the eight learning environment scales (Lecturer/Facilitator Support, Cooperation, Equity and Relevance) when controlling for preferred scores.
- There was a statistically significant difference for Student Cohesiveness ($p<0.05$) with graduates exposed to lecture-based instruction scoring higher than their counterparts exposed to problem-based learning™ types.
- There was a statistically significant difference for Involvement ($p<0.01$), Task Orientation ($p<0.05$) and Young Adult Ethos ($p<0.05$), with graduates exposed to problem-based learning scoring higher than their counterparts exposed to lecture-based instruction.

Person-environment fit has important implications for academics and planners, because it is critical for them to establish and maintain a ‘good fit’ between students and their learning environment. In addition, studies have shown that high levels of ‘fit’ can lead to positive outcomes and confirm the universal relevance of the fit phenomenon (Kristof-Brown & Billsberry, 2013).

In this study, the personal environment fit for Involvement ($p<0.01$), Task Orientation and Young Adult Ethos ($p<0.05$) were found to be statistically significantly greater in a problem-based learning classroom when the preferred scores were taken into consideration. Each of these is discussed below.

Involvement is a scale that assesses the extent to which the learning experiences encourage students to be active in the learning process (Aldridge & Fraser, 2008). To understand the long-term implication of this fit, it can be helpful to categorise the fit as supplementary or complementary in the application of problem-based learning. Muchinsky and Monahan (1987) and Kristof-Brown (1996) describe a supplementary fit as related to whether the pedagogy and the students drive the environment, or those within the environment have little choice. Complementary fit on the other hand involves the extent to which the person and environment each provide what the other requires. In the case of the problem-based learning environment which the results show as having a more positive fit, it would appear that the latter holds. Given that the physical learning environment was custom built for the purpose of problem-based learning, and that a positive person-environment fit was reported by graduates exposed to this instructional setting, a problem-based learning environment is likely to have more positive, and possibly longer term effects on students.

Task Orientation ($p<0.05$) refers to the extent that purposeful learning is enhanced by making clear the long term outcomes expected from students' engagement with the learning experiences provided (Aldridge & Fraser, 2008). The results of the person-environment fit found the scores for the scale to be statistically significant, and higher for graduates who had been exposed to problem-based learning. Given that the nature of problem-based learning is task focused, these findings support the pedagogical process and show a complementary fit with the expectations of the students.

Young Adult Ethos refers to classroom practices that encourage students to take responsibility for their own learning and the extent of independence given to students to determine their own outcomes (Reynolds, 1993). A study by Greguras and Diefendorff (2009) suggests that the person-environment fit with respect to the Young Adult Ethos scale is related to the 'self-determination theory'. This theory posits that when students are given opportunities to determine their own outcomes, they will develop their fullest potential and function optimally. Students' desire for autonomy and need to exercise control over their actions are reflected in the results of the person-environment fit; in problem-based learning, they are given many opportunities to take responsibility, such as during group meetings, daily outcomes, daily presentations and daily grades.

The high scores of Young Adult Ethos for graduates exposed to problem-based learning suggest a complementary fit for a problem-based learning environment.

In the case of Student Cohesiveness, it was statistically significantly higher for graduates exposed to lecture-based instruction. These findings were discussed at length in the last section and the findings are reinforced in these results.

Past research has suggested that by creating a learning environment that is more closely aligned to what students prefer, purposeful learning can be enhanced. This study found significant differences in the person-environment fit for four of the eight learning environment scales. For three of these scales, graduates exposed to problem-based learning had a more positive person-environment fit. These findings add support to the use of problem-based learning at the polytechnic level.

5.3 Limitations of the Study

This section acknowledges the limitations in this study and the actions that were taken to minimise the effects. The report is organised in two sections, the first covering the methodological limitations, and the second acknowledging the researcher's limitations.

The sample involved polytechnic graduates, of which 260 had been exposed to a problem-based learning environment, and 187 exposed to a lecture-based learning environment. Although every attempt was made to include a larger sample, it is recognised that this sample is not representative of the graduate population at the polytechnic level of Singapore. The sample of graduates from the problem-based setting represented about 5 per cent of the annual cohort (of about 5,000 students from each polytechnic), and about 4 per cent of the institution involving lecture-based instruction.

Given the time constraints of a doctoral study, the sample included only graduates who had attended one of two polytechnic institutions in Singapore. With this restriction, the generalisation of any results to other institutions or contexts should be made with caution. As each of these polytechnics implements different degrees of participative learning and deviations from a solely lecture-based learning format, assessing their learning environment against a problem-based learning instruction type could reveal different teaching and learning perceptions and preferences among students and teachers. *Given that there are five polytechnics in Singapore, it is recommended that future studies include participants from the other polytechnics (Recommendation 6)*

Given the range of constraints placed upon me by the two institutions, the sample had to include graduates rather than students from each of the institutions. Although careful selection ensured that participants had not graduated more than two years ago (to ensure that their experiences were still relatively fresh), it is acknowledged that a sample of students might provide a fresher picture of the comparative value of their perceptions and preferences. *It is recommended therefore, that future studies include students as well (Recommendation 7). It is also recommended that a longitudinal study be used to examine changes in participants' perceptions and outcomes over the duration of the course (Recommendation 8).*

It is acknowledged that the range of outcomes included in the study may be a limitation. *It is recommended therefore that future studies consider the inclusion of other dimensions such as self-directed learning, responsibility, and independence (see Recommendation 6). Given the importance of student achievement to the effectiveness of an education institution, it is recommended that future studies include measures of achievement (Recommendation 9).*

5.4 Recommendations

This section draws together the following recommendations made in this chapter.

Recommendation 1: Given that past research provides evidence to suggest that academic efficacy is an important determinant of student outcomes, it is recommended that facilitators and lecturers at the polytechnic level use these findings to improve important dimensions of the learning environment.

Recommendation 2: Given that the learning environments created at the polytechnic level are likely to influence students' affective outcomes, it is recommended that lecturers and facilitators be aware of the aspects that are likely to promote positive attitudinal outcomes.

Recommendation 3: Student Cohesiveness is central to problem-based learning in which groups are involved in high levels of participation and intense interaction. Since interpersonal problems were experienced by polytechnic level students (which could have impacted on scores related to Student Cohesiveness), it is recommended that skills clinics be set up within the institutions to help students and facilitators to develop interpersonal skills.

Recommendation 4: The findings suggest that a strength of problem-based learning is the involvement of students in the learning process. However, in some cases, where students have spent 10 years of schooling in a lecture-based setting, the move to problem-based learning can be problematic. It is recommended, therefore, that facilitators be given more assistance to understand their roles and to manage groups in problem-based settings so as to avoid situations where sessions are treated as mini-lectures.

Recommendation 5: It is recommended that the development of self-directed learning, in which the learner takes ownership of his or her learning, be implemented across all polytechnics.

Recommendation 6: Given that there are five polytechnics in Singapore practising different versions of participative learning (such as project based learning, case studies, variations of problem-based learning etc.), in addition to their lecture sessions, it is recommended that future studies include participants from other institutes.

Recommendation 7: It is recommended that future studies examining the effectiveness of problem-based learning at the polytechnic involve students as well as graduates in the sample.

Recommendation 8: It is recommended that a longitudinal study be used to examine changes in students' perceptions and outcomes over the three years of their studies.

Recommendation 9: Given the importance of achievement to the effectiveness of the education institution and its instruction type, it is recommended that future studies include this important variable.

5.5 Significance of the Results

The study reported in this thesis is significant to the field of learning environments. It is the first study in Singapore to examine students' preferences and perceptions of their learning environment and outcomes in evaluating the effectiveness of problem-based learning. Further, the research has provided evidence to support the sound psychometric properties of a newly-developed instrument, the PeBLEs, which can be used to assess the learning environment at the polytechnic level. Finally, although much learning environment research has been carried out at the high school level, a limited amount has been carried out at the post-secondary level. To the best of my knowledge, this is the first study within the field of learning environments to be undertaken at the polytechnic level.

The results of the study have provided timely and valuable insights regarding the effectiveness of problem-based learning in the local context of polytechnics in Singapore. The data collected using the PeBLEs and the AOQ showed statistically significant differences in students' perceptions and preferences for their classroom environments that could provide useful information for curriculum planners, facilitators, and lecturers.

The findings of this research could be of strategic importance to academics and curriculum planners, as they suggest that students do not necessarily perceive more cohesiveness because the pedagogy causes them to interact and work together. This finding suggests that intervention strategies could be put in place to reduce problems associated with interpersonal relationships, and to promote social and academic cohesion and harmony in cooperative learning.

The results of this study are of significance to educators, researchers and administrators, particularly those working in a problem-based learning environment, who are considering whether the One-Day, One-Problem™ methodology (or variations) is a worthy synergistic model that could improve teaching and learning in a problem-based learning environment.

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APPENDIX 1

Problem-based Learning Environment Survey (PeBLEs)

Source of scales:

Cohesiveness, Lecturer Support, Involvement, Task Orientation, Cooperation, and Equity – Modified from the WIHIC (Fraser, Fisher and McRobbie, 1996),

Young Adult Ethos - TROFLEI (Aldridge & Fraser, 2008)

Personal Relevance- CLES (Taylor, Fraser & Fisher, 1997)

All scales were used and included in this thesis with the permission of their authors.

Problem-based **Learning Environment Survey (PeBLES)**

A. Student Cohesiveness	ACTUAL: Almost Never	Seldom	Some times	Often	Almost Always	PREFERRED: Almost Never	Seldom	Some times	Often	Almost Always
1. Members in my class are my friends.										
2. I know other students in my class.										
3. I make new friends among students in my class.										
4. I am friendly to members of my class.										
5. I work well with other class members.										
6. Students in my class like me.										

B. Lecturer/Facilitator Support	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
7. The L/F* considers my feelings.										
8. The L/F helps me when I have trouble with my work.										
9. The L/F talks with me.										
10. The L/F takes an interest in my progress.										
11. The L/F moves about my class to talk with me.										
12. The L/F questions help me to understand.										

C. Involvement	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
13. I discuss ideas in my class.										
14. I give my opinions during my class discussions.										
15. I lead in class discussions.										
16. My ideas and suggestions are used during my classroom discussions.										

	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
17. I explain and/or present my ideas to other students in my class.										
18. I am asked to explain how I solve problems in my class.										

D. Task Orientation	ACTUAL					PREFERRED				
	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
19. Getting a certain amount of work done in my class is important to me.										
20. I am ready to get my class started on time.										
21. I help set learning goals in my class.										
22. I pay attention during my class.										
23. I try to understand the work in my class.										
24. I know how much work I have to do in my class.										

E. Cooperation	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
25. I like working in groups in my class.										
26. When I work in groups in my class, there is teamwork.										
27. I work with other students on presentations in my class.										
28. I cooperate with other students in my class activities.										
29. I share my books, resources, & ideas with other students in class work.										
30. I learn from other students in my class.										

F. Equity	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
31. The L/F gives me as much attention to my questions as with other students'										
32. I get the same amount of help from the L/F as do other students.										

	Actual: Almost Never	Actual: Seldom	Actual: Some times	Actual: Often	Actual: Almost Always	Preferred: Almost Never	Preferred: Seldom	Preferred: Some times	Preferred: Often	Preferred: Almost Always
33. I have the same amount of say in my class as other students.										
34. I receive the same encouragement from the L/F as other students.										
35. I get the same opportunity to contribute to discussions in my class as other students.										
36. I get the same opportunity to present and discuss in my class.										

	ACTUAL					PREFERRED				
G. Young Adult Ethos	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
37. I am treated like a young adult in my class.										
38. I am trusted with responsibilities in my class.										
39. I am considered mature.										
40. I am regarded as reliable										
41. I am given the opportunity to be independent.										
42. I am encouraged to take control of my learning.										

H. Personal Relevance	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
43. I relate what I learn in my class to my life outside of the Polytechnic.										
44. What I learn in my class is relevant to my day-to-day life.										
45. I apply my everyday experiences in this class.										
46. The class is relevant to my life outside of the Polytechnic.										
47. In my class, I get an understanding of life outside of the Polytechnic.										
48. I apply what I already know to the work in my class.										

APPENDIX 2

The Attitudes Outcomes Questionnaire (AOQ)

Source of scales:

Attitudes Towards the Pedagogy - Modified from Enjoyment of Science Subject, TOSRA (Fraser, 1981).

Academic Efficacy – Modified from the Morgan-Jinks Student Efficacy Scale, (MJSES; Jinks and Morgan, 1999).

All scales were used in my study and included in this thesis with the permission of their authors.

Attitudes Outcomes Questionnaire (AOQ)

	ACTUAL				
I. Attitude Towards the Pedagogy	Almost Never	Seldom	Some times	Often	Almost Always
49. I look forward to attending classes daily.					
50. The learning activities in my class make learning fun.					
51. I am interested to do better work in my class all the time.					
52. I can develop my own style of learning in my class.					
53. I enjoy the activities carried out in my class.					
54. My classes make me want to learn more.					
J. Academic Efficacy	Almost Never	Seldom	Some times	Often	Almost Always
55. I am competent in performing the task in my class.					
56. I find it easy to get good grades in my class.					
57. My friends often ask me for help in my class.					
58. I find it easy to learn in my class.					
59. I am challenged to think and apply what I learn in my class.					
60. I help my friends in my class with their class work.					

APPENDIX 3

Information Sheet: Quantitative Data Collection

Quantitative survey: Instruction guide

Dear Graduate:

Introduction:

My name is Rodney Wong and I am a post-graduate student at Curtin University. This survey that you have received is part of my research for my PhD thesis on learning environments and is conducted online. The website for the survey is found at the end of this letter.

Purpose of the survey:

The aim of this survey is to investigate the learning environment at two polytechnics in Singapore. It intends to explore the patterns of preferences and perceptions of the classroom learning environments and student outcomes.

Informed consent

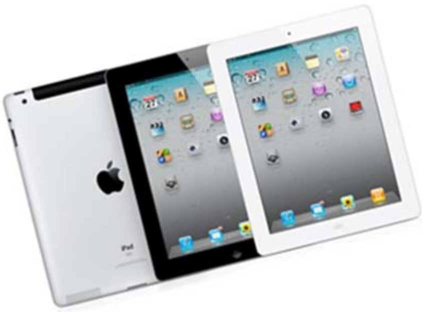
Your participation in this study is voluntary and you are free to withdraw at any time. When you have completed and submitted this survey online, I will be using your responses as part of my research.

Survey questionnaire

This is an online questionnaire comprising 60 items. It is anticipated it will take approximately 20-25 minutes to complete the questions. When all questions have been answered, the system will prompt you to submit online.

In the event a question is not completed, the system will not accept the submission and will prompt you to complete the missing item. Only after the submission has been accepted, will the system prompt you for your email address (which could be an anonymous Yahoo or Gmail with a particular pseudonym) or your mobile number. This action determines your intent to participate in the lucky draw, and will be used to contact you in the event you are the winner. The lucky draw will be held on 17 December 2011 and will be audited by two independent witnesses.

Lucky Draw:



In appreciation for your contribution towards this research, a lucky draw has been organized for all respondents taking part in the on-line survey. If you like to take part, please complete the survey forms electronically by ***Monday midnight, the 12th Dec 2011*** to qualify for the lucky draw, which has been scheduled for the ***17th Dec 2011***. The top prize is a Wi-Fi enabled 32 GB iPAD2 and 4 consolation prizes of a 4GB Thumb drive to each winner.

The winner will be notified by email or by sms. You will need to print out the e-mail or bring your hand phone with the sms message for verification and your NRIC number for our records and to collect your prize.

Confidentiality:

Any information provided will be kept strictly confidential. There are no names or identification marks required. In adherence to university policy, all data collected from the survey will be kept locked in a document folder on a server for at least five years at the university, before a decision is made to delete it.

University approval and contacts:

Please note that this study has been approved by Curtin University Human Research Ethics Committee, approval number SMEC-02-11as at 26 September 2011. If you have any questions or concerns on ethical grounds, you can contact hrec@curtin.edu.au or in writing c/o Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, WA 68453, or by telephoning +61 8 92662784.

Thank you for taking part in the survey and I look forward to your submission online.

Please proceed with the survey at the following website, and best of luck in the lucky draw. Please read the instructions before commencing the survey.

http://questionpro.com/t/AGpE7ZK5hT

APPENDIX 4

Information Sheet and Consent Form: Qualitative Data Collection

Curtin University

Information letter and consent form

Title of study:

Investigating the effectiveness of problem-based learning at a polytechnic learning environment and student outcomes.

Informed Consent Form

1. ***Purpose***: The focus group meeting in which you are asked to participate is part of my research to assess the learning environment at Republic Polytechnic using problem-based learning. The aim is to provide an overview of the quantitative findings analysed earlier.
2. ***Your participation:*** Before we commence, please sign the Informed Consent Form attached with this information sheet, and pass it to the researcher present. Before beginning in your focus groups, please spend the next 10 minutes jotting down your ideas and thoughts about the questions provided in a separate sheet and a blank sheet for your working notes. Please submit your working notes to the researcher at the end of the session. You may continue to add or delete comments in your working notes anytime during the meeting as and when ideas come to mind. You are requested to write your mobile number (without your name) at the top of the page which will be collected at the end of the focus group meeting, so that I will be able to contact you later to seek clarification and/or discuss the points or issues in your written notes that may not have been raised during the group meetings. (I believe every comment, idea or thought is important and I would like to understand them more).
3. ***Focus Group meeting:*** Your participation in this focus group meeting will be in a moderator-led discussion using the series of questions described in Part 2. For this meeting, you will be broken into groups of about five persons a group, where you will spend the next 45 minutes discussing the questions with group members. You are not required to answer all the questions. You may pass or not participate in any question that makes you feel

uncomfortable. At any time you may notify the researcher that you would like to stop participating in the interview. There is no penalty for discontinuing your thoughts and ideas. A presentation will be carried out by all groups before the end of the session.

4. ***Benefits and Risks*****:** The benefit of your participation is to contribute information of your perceptions and preferences to the learning community of your experience using problem-based learning at Republic Polytechnic. This may be useful information that may be helpful to the polytechnic (and your alma mater) and academics in charting its future directions and in creating the learning environments that will make learning more effective..
5. ***Confidentiality*****:** Your name will not be recorded and appear anywhere, other than the phone number you have provided in the blank written notes paper. Your name and any identifying information will not be associated with any part of the written report of the research. All of your information and interview responses will be kept confidential.

Please note that this study has been approved by Curtin University Human Research Ethics Committee, approval number SMEC-02-11 as at the 26 Sep 2011. If you have any questions or concerns on ethical grounds, you can contact hrec@curtin.edu.au or in writing c/o Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, WA 68453, or by telephoning +61 8 92662784.

Curtin University

Informed consent form

Title of study:

Problem-based Learning at the Polytechnic Level in Singapore: Learning Environment, Attitudes and Self-Efficacy

The purpose of this research project is to investigate the effectiveness of problem-based learning at the Republic Polytechnic. This focus group meeting is part of my PhD thesis with Curtin University and continues from the online questionnaires that you completed earlier.

Your participation in the focus group meeting is voluntary. You may choose not to participate. If you decide to participate in this meeting, you may withdraw at any time. If you decide not to participate or if you withdraw from participating in the meeting at any time, you will not be penalised.

The results of this study will be used for scholarly purposes only and may be shared with Republic Polytechnic and Curtin University representatives. No names will be used throughout the meetings and follow-up interviews.

By signing below you acknowledge that you have read and understand the information attached with this form, and you have agreed to take part in the focus group meeting and telephone interview session.

Signature: ____

Name: ______________________________ Date: ___________________

APPENDIX 5

Focus Group Meeting: Agenda and Question Guide

Curtin University

Focus group meeting: Agenda and questions

Agenda

(Note: Before the meeting begins, check if all participants have completed the PeBLEs and AOQs).

1. Welcome and introduction
2. Formation of small groups, format of group meeting and work instructions.
3. 10 minutes personal reflections on their experiences based on the following questions

The Human Relations Dimensions:

i. How has problem-based learning facilitated a cooperative environment where you feel you are supported by your peers and classmates? (Student Cohesiveness)

ii. How do you feel facilitators ensure the learning environment is conducive to effective learning, through fostering a sense of trust and belonging among group members? (Facilitator Support)

iii. How have your learning experiences with problem-based learning provided you opportunities to work collaboratively with others and contribute in various ways? (Cooperation)

The Personal Development Dimensions:

iv. How does problem-based learning encourage you to be active participants in the learning process? (Involvement)

v. How have the classroom practices using problem-based learning encouraged you to take responsibility for your own learning? (Young Adult Ethos)

vi. How and why do you feel that what is taking place in the class is relevant to your life outside the classroom? (Personal Relevance)

The System Maintenance and Change Dimensions:

vii. How do you perceive that the goals, which could be in the context of project outputs, expectations, or problems for the day, helped you in your learning goals? (Task Orientation)

viii. How has the clarity of the long-term goals, the amount of work and directions aided your learning? (Task Orientation)

ix. How has problem-based learning created an atmosphere in which you feel that you are treated fairly? (Equity)

4. Group meetings and presentation
5. Collection of meeting outputs
6. Session ends and thank you

APPENDIX 6

Ethics Approval from Curtin University

Curtin University

Memorandum

To	Rodney Wong, SMEC
From	Pauline Howat, Administrator, Human Research Ethics, Science and Mathematics Education Centre
Subject	**PROTOCOL APPROVAL – CHANGE OF TITLE**
Date	26 September 2011
Copy	Jill Aldridge, SMEC

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your Form B. Pursuant to your request the Committee has approved the change of title of your thesis from *Investigating the Effectiveness of PBL at a Polytechnic: Learning Environment and Student Outcomes*, to the new title *Investigating the Learning Environment in PBL Classes: Assessing Patterns of Learning Outcomes and Attitudes.*

Approval for this project is extended for the year to 29th January 2013..

Your approval number remains SMEC-02-11. Please quote this number in any further correspondence regarding this project.

Please note: An application for renewal may be made with a Form B three years running, after which a new application form (Form A), providing comprehensive details, must be submitted.

Thank you.

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

APPENDIX 7

Ethics Approval from Republic Polytechnic

Ethics Approval Code from Republic Polytechnic

Title of thesis:

Effectiveness of problem-based learning at a polytechnic:

Learning Environment and Student Outcomes

Project commencement

October 2011

PROJECT DURATION:

3 months, as part of my PhD research into learning environments and problem-based learning

PROJECT COST: Personal

GRANT REQUEST: N/A

External Funding Agency: NA

Target group: Students and Alumni members

Researcher:

Rodney Wong, Republic Polytechnic

Team members: NA

HSR APPROVAL CODE: CED-M-2011-049

Office of Technology Development

Republic Polytechnic

4 Oct 2011